EXTERNAL REVIEW REPORT
FOR
EARTHQUAKE RESEARCH INSTITUTE
UNIVERSITY OF TOKYO

September 2009

Section 1. Preface

In 1999, Earthquake Research Institute, the University of Tokyo composed Future Plan (FP99) for about ten years, and conducted the first external review. The review committee was chaired by Professor Hiroo Kanamori and consisted of 4 overseas and 7 domestic members, and the report was submitted in 2000. Four years later in 2003, the second external review was conducted by the domestic members of the previous committee chaired by Professor Kojiro Irikura, and the report was submitted in 2004.

Earthquake Research Institute had promoted its research activities and managed the administration along with the above Future Plan and review reports. In 2009, ERI reviewed the activities of the last ten years and composed new Future Plan (FP09) as well as reorganization plan. For the purpose of seeking comments and recommendations on their research activities and new future plan, another external review was conducted.

Section 2. Items to be Evaluated

The external review committee was requested to evaluate the following items.

(1) Research performance along the science plan
(2) Management after corporatization
(3) Human resources and education
(4) Outreach and international activities
(5) Shared-use features for national universities
(6) Future Plan (FP09) and reorganization plan

Section 3. Member of External Review Committee

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Professor
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Chris Newhall
Professor and Volcanology Group Leader
Earth Observatory of Singapore
Nanyang Technological University

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Section 4. Schedule of External Review Committee

January 2009 Appointment of External Review Committee Members

May to June 2009 Preliminary review based on documents

June 17 to 19, 2009 External review Committee at ERI

June 17

15:00 – 18:00 First Committee Meeting
(in Japanese with simultaneous interpretation)
Introduction of committee members
Overview of ERI (Director)
Report of preliminary review results

18:00 – 20:00 Reception

June 18

9:30 – 12:00 Presentation of Science Performance and Future Plan
(English)

Review of Science Plan of 1999 (Shingo Yoshida)
Comprehensive understanding of earthquake phenomena and advancement of earthquake prediction (Hiroshi Sato)
Comprehensive elucidation of volcanic eruption and eruption prediction (Minoru Takeo)
Understanding Earth's internal activities through a multifaceted and integrated approach (Hisashi Utada)
Development of innovative observation technologies (Akito Araya)
New development of disaster prediction science, as a comprehensive science (Kazuki Koketsu)

13:30 – 17:00 Presentation on management
(in Japanese with simultaneous interpretation)

Management system of ERI (Naoshi Hirata)
Human resources and education (Hitoshi Kawakatsu)
Outreach and international activities (Kenji Satake)
Shared-use institute and collaboration (Setsuya Nakada)

Future Plan 2009 and reorganization plan (Shingo Yoshida)
Discussion

17:00 – 18:00 Meeting of Committee members

June 19 (in Japanese with simultaneous interpretation)
8:00 – 11:30 Meeting of Committee members
11:30 – 12:30 Report to ERI director

June to September 2009 Composition of Report

September 2009 Submission of Final Report

Section 5. Summary of Recommendations

Earthquake Research Institute made Future Plan in 2009 (FP09), which includes science plan, management and other functions, and reorganization plan. The external review committee mainly reviewed the Future Plan and make following recommendations.

1. The new science plan of FP09 aligns with the directions of FP99, and the research policies are assembled into 5 items from 8 items, in which basic and applied research fields are combined together in the fields of earthquake and volcanic eruption prediction researches. Considering the recent progress of the basic research on the earthquake phenomena and volcanic activities, we endorse the new science plan, and recommend a reform of ERI organization corresponding to the new science plan.

2.1 "Comprehensive understanding of earthquake phenomena and advancement earthquake prediction" is well thought out, and we recommend ERI to promote this plan. Regarding the comprehensive understanding of earthquake generation process, we recommend to consider research areas such as dynamical complexity of the earthquake rupture process, relationship of slow transient phenomena to dynamic (inertial) ruptures, evolution of stress in seismogenic zones, or in mine studies. We encourage to systematically promote collaboration and

integration of theoretical, experimental and observational studies toward the goal.

2.2. "Comprehensive elucidation of volcanic eruption and its prediction" should be kept up. Strive to maximize synergy between the various volcano projects. Continue to introduce new monitoring methods such as muon radiography, as responsibility for routine monitoring gets shifted to NIED, JMA, and GSI. Join in IAVCEI's WOVOdat project. Consider the need for volcano outreach to the metropolitan area.

2.3. Regarding "Understanding the earth's internal activities through a multifaceted and integrated approach", we recommend to maintain the Ocean Hemisphere observation network, to keep developing innovative ocean bottom instruments. We support the multidisciplinary approach and international collaboration. We recommend ERI further pursues the investigation of the dynamics of water circulation in subduction zones and in the mantle as well as the understanding of LAB (Lithosphere-Asthenosphere Boundary). This multidisciplinary effort must also include numerical simulation, laboratory experiments on solid-liquid composite systems, polycrystalline and soft materials as well as isotope geochemical studies in order to quantify the material transfers within the Earth deep interior.

2.4. "Development of Innovative Observational Technologies" is essentially necessary for ERI. The activity is expected to support trials for new technology development. The development should be checked with reference to the requirement from the practical observation research.

2.5. "New Development of Disaster Prevention Sciences, as a Comprehensive Science" matches ERI's mission. We recommend that ERI set specific objectives for physics-based disaster prediction science, formulated as projects of 3 to 5 years duration that will result in new capabilities for disaster mitigation and emergency management. These projects should be formulated to (a) promote interdisciplinary research within the geosciences, and (b) engage practicing engineers and other technical communities, including disaster managers.

3. ERI's management is functioning well to activate the research and

education activities of the institute. Despite the best efforts for recruiting faculty, number of female and foreign faculty members is still small. If ERI is oriented for internationalization in the future, further efforts such as introduction of a new special system for foreign researcher would be required. Regarding research support system, we recommend that ERI should actively call on the university administration to work toward the solution of challenges such as the aging of the technical support staff. We expect ERI to make further efforts to improve research support system such as employment of technical support staff by the use of external funding and effective utilization of outsourcing.

4. About human resources, the proposed "Cultivation and Education Promotion Office" will be a key to resolve many issues on education, internationalization, student support and cultivation of PD. Employing foreigners as PD should be taken accounted. Together with the declining the number of PhD students, lack of post-PD positions is a serious problem in many fields in Japan. The only solution is to establish various career-paths including job positions in private companies. To educate the PhD student to be acceptable to the private companies, education for the PhD students should be reconsidered. Role assignment between ERI and Graduate School of Science is important. ERI should look for unique roles for the education of graduate students not only of the University of Tokyo but also of other universities, which include intern-ship

5. Current outreach of ERI is much wider and proactive than it was 10 years ago, thanks to the valuable new Outreach office. Current, mostly non-technical outreach activities should be continued. Also, more could and should be done to nurture two-way technical communication between scientists and the engineering, planning, and policymaking communities. As soon as research evaluations of probabilistic forecasts reach a sufficiently mature stage – in the low probability environment for earthquakes but in a higher probability environment for volcanic eruptions – outreach could introduce these to the public. For volcanoes, we also recommend that ERI explore with JMA and NCCPVE an expansion of technical outreach, especially for the Tokyo area.) The added technical outreach might be handled by existing staff if a non-technical staffer could handle some of the pre-university and public

outreach.

6. The Committee recommends that ERI seek sustained support for international partnerships that will provide new opportunities for comparative studies of earthquake and volcanic systems. Priority should be given to reciprocal partnerships that can bring new resources to joint programs of research and education. Personnel exchange program may be more effective for graduate students or early-career researchers (especially assistant professor level) from a long-term perspective. An educational program such as lectures with credits or double-degree program may be negotiated with partner institutions.

7. ERI plays a significant role as the shared-used institution and promotes the collaboration among universities and research organizations engaged in the related research throughout Japan. We endorse the operation system that ERI has developed for effective implementation of the research activities expected as the shared-used institution. As the representative of the concerned research community, ERI shall do its best to keep the partner universities as vital as possible.

8. Basic policies for reorganization are challenging, they are, forming flexible project teams, nurturing leadership for junior members, internationalization and globalization, central role as a shared-use institute in Japan, and strengthening research infrastructure, supporting system, and outreach activities. Following are general comments.
   1) Needs and roles of project centers and science management centers are clear.
   2) For research divisions, project laboratories and project divisions, their positions in the organization must be more clarified
   3) ERI's external accountability of science plans needs to be considered.
   4) We request continuous efforts toward the original goals of reorganization by readjusting the plan when problems arise.

Section 6. Evaluation and Recommendations

1. From Science Plan 1999 to science plan 2009

In 1999, Earthquake Research Institute (ERI) made a 10-year future plan (FP99) for the first time after the reorganization to a shared-use institute for Japanese universities in 1994. The basic research policies of FP99 consists of the following 8 items: "study of Earth's internal activities that cause earthquake and volcano phenomena", "evolving a new view of earthquakes", "elucidation of volcanism and magmatism from materials science approach", "elucidation of elementary processes of the Earth's interior and their non-linear interactions", "research and development for new observational technologies", " research and development of a crustal activity forecasting system", "research and development for earthquake disaster mitigation system" and "volcano eruption prediction research as an universal science." These items include both basic research and applied research fields. An external review conducted in June,1999 highly rated the content of FP99, and the plan has formed the basis of ERI's policies until now.

ERI has three missions: (1) Scientific research on earthquakes and volcanic eruptions;(2) Research on prediction of earthquakes an volcanic eruptions; (3) Research on mitigation of damage caused by earthquakes and volcanic eruptions. With the research policies of FP99, ERI researchers have been pursuing leading-edge, multifaceted research on earthquakes and volcanoes, and significant progress has been made in the various aspects of earth sciences related to the ERI's mission. In addition to this achievement, as a Shared-use Institute for national universities, ERI has been playing a leading role in promoting the earthquake and volcanic eruption prediction research project and has achieved many significant results such as the understanding of the generation process of interplate earthquakes.

After 10 years from FP99, ERI has recently revised its future plan (FP09). The new science plan of FP09 aligns with the directions of FP99, and the research policies are assembled into 5 items from 8 items, in which basic and applied research fields are combined together in the fields of earthquake and volcanic eruption prediction researches. Considering the recent progress of the basic research on the earthquake phenomena and volcanic activities, we endorse the new science plan, and recommend a reform of ERI organization corresponding to the new science plan.

2-1 Comprehensive Understanding of Earthquake Phenomena and Advancement of Earthquake Prediction

Located near subduction zones, Japan has repeatedly suffered from earthquake damages. For this reason, aiming to reduce the earthquake damages, the earthquake prediction research project has been promoted by the cooperation of seismologists and the institutes such as universities, Japan Meteorological Agency, Geographical Survey Institute, Japan Coast Guard, National Research Institute for Earth Science and Disaster Prevention and National Institute of Advanced Industrial Science and Technology. Furthermore, after the 1995 Kobe earthquake, the Headquarter for Earthquake Research Promotion was set up, which enabled the development of the nationwide dense seismic and GPS observation networks. Because of this development, an unprecedentedly large number of high-quality data has become available. As a result, significant progress has been made in understanding generation process of interplate earthquakes and shallow inland crustal earthquakes in the Japanese subduction zones, such as verification of the asperity model for interplate earthquakes, detection of deep low-frequency tremors, ultra low-frequency earthquakes and slow slip events occurring on the plate boundary of the SW Japan subduction zone, detection of a band of inland strain concentration zones, and advances in understanding of the stress concentration mechanism that leads to inland earthquakes.

As a Shared-Use Institute for national universities, ERI has been playing a leading role in promoting the earthquake prediction research project and has achieved many significant results. These include verification of asperity model by waveform inversions of recurrent earthquakes on the plate boundary, mapping asperities of the 1923 Great Kanto earthquake by waveform inversions and by seismic reflection profiling, observational studies on stress and strain accumulation process for shallow inland earthquakes, numerical simulation of seismic cycles based on rate- and state-dependent friction laws, theoretical study on effects of fluid flow and frictional heat generation on the dynamic fault slip, monitoring frictional strength by transmitted acoustic waves, detection of a clear pre-slip and AE activity before a small earthquake on its fault in a South African deep gold mine, integrated simulation of ground motion and tsunami, development of estimation method of porosity and geometry of the liquid pores from seismic tomography and many others.

The new future plan (FP09) is to take one step further from these

researches and aims at the comprehensive understanding of earthquake phenomena and advancement of earthquake prediction based on it. Specifically, the plan promotes 1) Quantitative modeling of plate boundary earthquakes, 2) Construction of earthquake prediction models, 3) Elucidation of strain accumulation and concentration processes in crust, and 4) Comprehensive understanding of earthquake phenomena. This is a challenging research plan, and is important considering the mission of ERI. The plan is well thought out, and we recommend ERI to promote this plan.

In order to press on with this research plan, it is particularly important to improve comprehensive understanding of earthquake generation process. The following are examples of fertile areas of research that could yield new understanding of earthquake generation process:

1) Dynamical complexity of the earthquake rupture process
   - Dependence on constitutive relations for fault friction (e.g., enhanced dynamical
     weakening at high slip velocities)
   - Geometrical complexities (e.g., rupturing of a fractal fault system)
2) Relationship of slow transient phenomena to dynamic (inertial) ruptures
   Area of exciting new discoveries based on high-resolution seismic and geodetic data, primarily from Japan. The Japanese subduction zone is possibly the best natural laboratory for these investigations, because it is the best-instrumented and displays a full range of infraseismic and subseismic phenomena.
3) Evolution of stress in seismogenic zones
   Earthquake phenomena cannot be fully understood without much better knowledge of the lithospheric stresses that drive fault ruptures. However, stress is very difficult to observe, and major controversies abound (e.g., regarding stress magnitude and scale of heterogeneities). New observational techniques are required; developments are underway at ERI. Fault-system modeling that assimilates seismic, geodetic, geologic, and other types of data is required.
4) In-mine studies
   They provide data at scales intermediate to laboratory and tectonic-scale studies. Recent ERI studies in the South African gold mines have made significant new discoveries (e.g., regarding acoustic emissions and pre-slip strain).

We recommend that the above research areas are taken into account for carrying out the present research plan. Moreover, we encourage ERI to systematically promote collaboration and integration of theoretical, experimental and observational studies toward the goal.

2-2 Comprehensive Elucidation of Volcanic Eruption and Its Prediction

Volcano research within ERI is concentrated within the Volcano Research Center but has contributions from researchers in other divisions as well. The general level of productivity is high, and ERI researchers are widely recognized in the international volcano community. The vice-director of ERI, Prof Nakada, is also President of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).

In response to a recommendation from the 1999 review, ERI has established collaboration with an excellent volcano gas chemist from GSJ/AIST.

Since 1999, notable achievements of ERI volcanologists have included:

1) Research on H_2O and CO_2 contents of very small melt inclusions in products of the 1707 Fuji eruption, indicating that the eruption was preceded shortly by a large influx of CO_2 gas.
2) Petrologic study of the deep plumbing of Fuji, and active source seismic tomography that can be related to deep LP earthquakes and relative dense, solidified intrusions at shallower depth.
3) Leadership in the Unzen drilling project, the first-ever drilling into a still-hot conduit at a volcano that had just erupted. Inferred patterns of degassing were complicated – which is valuable information.
4) Radar interferometry, gravity, seismic, geologic, and other observations of the Miyakejima eruption of 2000.
5) Documentation of periodic magma resupply at Izu-Oshima, marked by elevated CO_2, inflation, and LP seismicity.
6) Forecasting and study of the eruptions of Asama in 2004 and 2008-09. Gravity measurements showed interesting volcanic signals and also hydrologic complications. A new technique, muon radiography, defined a low-density area high in the cone of Asama (in 2009), and if sampling rates can be increased, the technique will become even more useful.

7) Studies to use time-sequential stereoscopy for measures of gross deformation.
8) Advances in the quantitative theory of magma storage, ascent, and eruption, including explosive-effusive transitions, constrained by experimental and field data.

Future plan proposed by ERI:

1) Geophysical, petrologic, and model studies of magma supply, crystallization, vesiculation and degassing and relations to eruption precursors and phenomena. The plan recognizes the importance of monitoring precursory and eruption processes by observation network, and assimilation of observational data and modeling results. Modeling degassing of magma in the shallow conduit or simulation of fluids or plumes will be done by using computing power such as the Earth Simulator.
2) As a Shared-use Institute, continue sharing observational and monitoring instruments, analysis equipments, volcano observatories and obtained observational data.

Comments and Recommendations:

1) Keep up the good work! We recommend continuation of projects as proposed.
2) Strive to maximize synergy between the various volcano projects. This is easiest when researchers rally around a fresh eruption or crisis, but some can also be promoted in the project planning process.
3) Continue to introduce new monitoring methods as responsibility for routine monitoring gets shifted to NIED, JMA, and GSI. This is a positive adjustment to the general shift of routine monitoring away from universities. Specifically with respect to muon radiography, we think the method would have forecasting value if use of more collectors or some other adaptation could increase sampling frequency.
4) Join in IAVCEI's WOVOdat project, to bring the collective monitoring experience of the world's volcano observatories into a central, freely-accessible "epidemiological" database of volcanic unrest. Out the outset, participants will be net contributors of data, but over succeeding years they will be net recipients and users. ERI could join with NIED and JMA in this effort for Japan.

5) Consider, with relevant government bodies, whether there is need for more volcano outreach to the metropolitan Tokyo area. (see recommendation under Outreach)

2-3 Understanding Earth's Internal Activities through a Multifaceted and Integrated Approach

Research projects in the Ocean Hemisphere Research Center (OHRC) and in research divisions of Earth Mechanics and Global Dynamics mainly contribute to this theme of research, and combination of the approach of geophysicists and geochemists is very important to elucidate the activities of earth's deep interior.

It had multifaceted goals, with an instrumental part (maintenance of the Ocean Hemisphere Network, development of new instruments) and a more scientific part devoted to the investigation and the understanding of the deep internal activity of the Earth down to the core, with a special focus on the oceanic part of the Earth, and primarily on the Pacific Ocean.

ERI is mainly taking part of observational geophysics and is making a multidisciplinary research by integrating seismic, electromagnetic data, other geophysical data (SG, GPS,….), geochemical data and physical investigation of soft materials. It is the first group of scientists in the world able to deploy large arrays of ocean bottom instruments (BBOBS, OBEMs) and to combine complementary techniques.

Scientists of these groups obtained world-class achievements and impressive results, for example on the high-resolution imaging of the subducting slab and on the structure of the oceanic lithosphere and upper mantle down to the transition zone. They also obtained fundamental results on the dynamics of water circulation in subduction zones and in the transition zone. An important part of the activity is also devoted to the stagnant slab project (SSP) in order to understand why slab is stagnant beneath most part of Japan and China, but not in other subduction zones. The new projects NECESSArray in North-East China and on "Normal Oceanic Mantle" are following the same lines and complements the SSP project.

Geochemistry group in research divisions carries out researches on geochemical evolution of the Earth and phenomena related to volcanic activities, and obtained significant results related with material transfer in a subduction zone, mantle transition zone, and the core-mantle boundary. In

the last ten years, micro-isotope analyses have made great progress in the world. The group in ERI has addressed the frontier issues on such as uranium-thorium radioactive disequilibrium dating, uranium-lead dating of zircon, behavior of fluid using isotope ratios of light elements such as Li and Be, core-mantle interaction using tungsten isotope tracer. The group has tackled these issues with continuous improvements of analytical methods and has obtained successful results. The group has conducted many cooperative researches on dating studies and has played an important role in a shared-use institute for national universities.

ERI conducts many collaborations in that topics with other groups in Japan such as JAMSTEC and abroad. As already mentioned above, ERI is the most advanced institution in the world on ocean bottom instrumentation. It plays a key role at the international level, with a very productive interaction between seismologists, geomagneticians and other geoscientists. More specifically, OHRC was recently (in 2006) very positively evaluated and science is progressing very well since then.

Recommendations

1) We recommend to continue the effort **to maintain the Ocean Hemisphere observation network for the next decade.** After more than ten years of network operation, ERI's scientists obtained very exciting and world-class results. This network is really unique and made ERI a leader in ocean bottom investigations and even in global geophysics and geochemistry.
2) We recommend to keep developing **innovative ocean bottom instruments** (BBOBS-NX; EFOS, …)
3) We support the **multidisciplinary approach of ERI which enables to integrate measurements on the sea floor** provided by BBOBS and OBEM. Future plans must be done in close collaboration with JAMSTEC and other groups around the globe.
4) We recommend that ERI further pursues **the investigation of the dynamics of water circulation in subduction zones and in the mantle as well as the understanding of LAB (Lithosphere-Asthenosphere Boundary).** This multidisciplinary effort must also include numerical simulation, laboratory experiments on solid-liquid composite systems, polycrystalline and soft materials as well as isotope geochemical studies in order to quantify the material transfers within the Earth deep interior.

5) We recommend that ERI continues its efforts towards **international collaborations** in order to explore the deep structure in other parts of the world.

2-4 Development of Innovative Observational Technologies

Development of new observational technology is essentially necessary for ERI, because it requires certain amount of budget to keep the development-oriented research before it can get external funding. In the field of solid-earth geophysics ERI is the only institution for it. Therefore, the activity of the Advanced Technology Development Center, which is proposed in the science plan, is expected to support trials for new technology development.

Remarkable achievements have been made in the development of new technology for the last ten years. Ocean bottom seismic observation system is, among them, especially successful. Large scale ocean bottom seismic observations are now widely available owing to the high reliability of OBSs. Development of long-term OBSs and a compact-size ocean bottom cabled seismometer have also enabled wide variety of seismic observation in ocean area.

A laser-strainmeter, which is tested in ideal environment of Kamioka, has been proved have high sensitivity, wide frequency coverage, low noise level and high stability at an earthquake shaking. The laser technology has been applied to the observation in other area, such as ocean bottom tiltmeter. It is expected that this technology is more widely applied in the context of practical observation research and road-maps to the practical stage should be indicated.

Muon radiography has been developed for practical observation in the difficult environment of volcanoes. This is due to the development of compact sensor system that requires no or little electric power consumption. Improvement of time resolution of the system is very much expected in future.

The future plan for the new technology development is appropriate, but the development should be checked with reference to the requirement from the practical observation research.

2-5 New Development of Disaster Prediction Science, as a Comprehensive Science

The *raison d'être* for ERI as a mission-oriented institution is to assist in the mitigation of earthquake and volcanic disasters by predicting their occurrence and effects on society. While ERI does not have operational responsibilities for disaster mitigation and emergency management, it has contributed substantially to the science basis of current operational capabilities. Continuing such contributions is a keystone of its mission.

Disaster mitigation and emergency management are problems that require a comprehensive, predictive understanding of earthquakes and volcanic eruptions as emergent behaviors of complex natural systems. Element [5], *New development of disaster prediction science as a comprehensive science*, is an essential component of the Future Plan, because it provides the "system-level" focus for the basic research aimed at achieving this goal.

Recent accomplishments have highlighted the prospects for physics-based disaster prediction. Generation and propagation of seismic waves and tsunamis have been simulated in 3-D finite-difference method, and the results were contributed to hazard maps published from the Japanese government; Safe-design of RC buildings was examined indepth using E-Defence, a 3D full-scale shaking table; and integrated earthquake simulation, including seismic wave propagation, nonlinear structure response and evacuation process, has been implemented.

We recommend that ERI set specific objectives for physics-based disaster prediction science, formulated as projects of 3 to 5 years duration that will result in new capabilities for disaster mitigation and emergency management. These projects should be formulated to (a) promote interdisciplinary research within the geosciences, and (b) engage practicing engineers and other technical communities, including disaster managers.

Fertile areas for such projects include earthquake forecasting, prediction of volcanic eruptions, prediction of earthquake strong ground motions and volcanic ashfalls, and end-to-end simulation of large-scale disasters. Earthquake forecasting deserves particular emphasis in this regard.

3. Management of the Institute

The management system of ERI is evaluated as well-functioning in terms of stimulating research and education activities of the institute as a whole. As described below, they tried every possible means to address the variety of challenges attributable to the external environmental changes such as tight financial condition of the government in recent years and aging society with fewer children, and succeeded at minimizing the negative impact of those issues.

Since national universities were turned into corporations in 2004, they have undergone gradual but seminal changes in the research environment such as cut of government subsidies (1% each year) and cut of personnel. It's to their credit that ERI has actively considered and implemented measures to handle those changes, for example, closure or consolidation of facilities for which alternative is available, promotion to raise external funding, proposal of new projects within university, effective use of faculty positions, design and development of internal system and rules, and reorganization of technical support staff.

As for the faculty recruitment, they have also made utmost efforts to recruit the best and brightest researchers by posting the notice of open recruitment on their web page, EOS (American Geophysical Union's weekly newspaper), and Newsletters of Japan Geoscience Union, Seismological Society of Japan and Volcanological Society of Japan. The results are visible and many outstanding researchers are employed. However, regarding recruitment of qualified female and foreign faculty, which was pointed out in the 1999 external review, the number of the new recruits has remained low and their efforts don't seem to have paid off yet. If ERI is aiming to become a global leading research institute as stated in its future plans, we expect it to make greater efforts in order to employ more foreign researchers. We encourage ERI to, for example, closely examine the obstacles hindering the employment of foreign researchers and establish a new special system to clear the obstacles.

It is vitally important for organizations such as ERI to enhance the research support system by the technical support staff. ERI has fully

realized this and has steadily improved the system over the years, responding to the recommendation in the 1999 external review. More specifically, ERI has reorganized the technical support staff and established three offices under technical division in order to enrich the technical support system. We think these efforts should be highly regarded. Considering that the number of permanent position of technical support staff is anticipated to be reduced continuously, these reform efforts are critical. We expect them to make further efforts. Meanwhile, challenges still exist, such as the aging of the technical support staff. Since smoothing of the age distribution is needed in order to facilitate an inter-generational transfer of expertise from experienced staff to younger staff, we recommend that ERI should actively call on the university administration to work toward the solution. Additionally, we expect ERI will make further efforts toward the improvement of the technical support system, such as employment of technical support staff by the use of external funding and effective utilization of outsourcing.

4. Human Resource and Education

On education for graduate students, although more than half of the lectures on solid earth of Earth and Planetary Science major are given by the academic staffs of ERI, they have not had systematic action on this issue. The “Cultivation and Education Promotion Office” that is planned by ERI will be a key to resolve many issues on education, internationalization, student support and cultivation of PD.

As ERI has a lot of post-doc researchers and assistant professors, ERI has a larger responsibility to develop/foster their ability to be promoted even in other institutions or universities. Generally the activity of the assistant professors looks well and be promoted within reasonable range of their age.

Problems exist, however, for post-doc researchers, whose number is rapidly increased recently, partly because little screening is made in employing them. Employing of foreign post-doc researchers should be taken into account. Together with the declining the number of PhD students, lack of post-post-doc positions is a serious problem in many fields of science and technology in Japan. The only solution for this problem is to establish various career-paths including job positions in private companies. To educate

the PhD student to be acceptable to the private companies, education for the PhD students should be reconsidered. Role assignment between institute (ERI) and graduate schools (EPS) is important. ERI should look for unique roles for the education of graduate students not only of the University of Tokyo but also of other universities, which include intern-ship.

5. Outreach Activities

In response to the 1999 review, ERI substantially expanded its outreach program, establishing an outreach office and staffing it first from GSI and JMA but now with its own well-qualified staff.

Most of the work of the new outreach office is to the general public, to schools, and to the media. This is important work and appears to be progressing well. A museum of antique instruments in (appropriately!) the old building of ERI, combined with high tech plasma display and additional displays in the new building, gives visitors a snapshot of how earthquake and volcano science has evolved over more than a century. The monthly forum for civil authorities and media, though relatively small, gives ERI a place to raise hazard issues to those groups in non-sensational, educational ways.

The ERI outreach office plans some changes from traditional lectures to more interactive dialogue, particularly with secondary and university students. Such dialogue is likely to give valuable feedback to ERI experts about what is and isn't understood. In general, research evaluations of the most effective ways of outreach to students and other non-experts will surely be useful.

Another side of outreach is more technical, aimed at engineers, civil defense officials, business leaders, and policy makers. This side of ERI's outreach is not as visible, but equally important for ultimate mitigation of disasters. The discussion that follows overlaps in some aspects with discussion of Disaster Mitigation Science as an end-to-end "system science," because the downstream end is outreach and community response.

As we understand it, technical outreach by ERI is handled in at least two ways: (a) joint research with engineers, sociologists, and others to find

ever more effective transfer of technologies, and (b) participation of ERI scientists in MEXT's Headquarters of Earthquake Research Promotion (HERP) and/or the Cabinet-level Central Disaster Management Office. This applies specifically to earthquakes. Representatives of GSI, JMA, NIED, ERI and other universities, GSJ, and JAMSTEC meet monthly to review all earthquake-related data, to oversee production of the national seismic hazard map, a new long-period seismic hazard map, and 30-year probabilistic seismic hazard assessments. It is through HERP that new ERI technical results get passed along to government and at least some other users.

There is also some technical outreach re: earthquake hazard to the business community, e.g., to a group of large businesses located around Tokyo Station. We understand that other large businesses are also concerned with business continuity and consult ERI and researchers from other universities or research institutions. If we understand correctly, outreach efforts to government and to business are separate processes.

We heard from presenters that outreach to technical users regarding earthquake hazards is at a relatively early stage, not as far along as that to the public, but it sounds from subsequent discussions that there is already a well-established chain of outreach to more technical users, especially through HERP.

Outreach on volcanic hazards is a smaller effort, in response to a correspondingly smaller and less frequent hazard in the Tokyo area. However, light ashfall from Asama earlier this year and knowledge that the 1707 eruption of Fuji deposited quite a thick layer of ash in Tokyo argues that some outreach re: volcanic hazard is also needed. As we understand it, there is no direct equivalent of HERP for volcanic hazard. The closest analogy is the National Coordinating Committee for Prediction of Volcanic Eruptions (NCCPVE), led by JMA, but this group is not established by law and provides warnings but little or no other outreach. Locally, universities, local governments, public works (sabo) offices, and other government offices have prepared volcanic hazard maps and information for the public, e.g., around Usu, Fuji, Unzen, and Sakurajima. For a time after earthquakes deep beneath Fuji in 2001, there was an ad-hoc committee under the Central Disaster Management Office, and in Hokkaido there is a Standing Council

for Volcanic Disaster Mitigation that meets every few months. Although ERI is not officially responsible for volcano outreach through the abovementioned groups, it is a recognized leader in the Japanese volcanological community and, as such, can play an important role to catalyze volcano outreach, especially for the Tokyo area.

Another side of outreach to users, both technical and non-technical, is information about any changes that might indicate an increase or decrease in earthquake probabilities. Worldwide, there has been a swing of the pendulum from optimism to pessimism to realism about earthquake prediction. Few now believe that "prediction" of earthquakes with high levels of certainty will be possible in the foreseeable future, but many now believe that subtle patterns of crustal behavior may point to slightly elevated (or diminished) probabilities of earthquakes. In other words, "forecasts" in the low-probability environment may be possible. ERI is a participant (along with the Southern California Earthquake Center, ETH Zurich, Italy's Istituto Nazionale di Geofisica i Vulcanologia, and others) in the Consortium for Study of Earthquake Predictability (CSEP). In fact, "forecastability" would more closely describe this effort, and we see this as a positive alternative to undue optimism or pessimism.

There is also growing use of probabilities in forecasting volcanic eruptions. Probability trees are now developed during many volcanic crises worldwide, by a combination of expert elicitation and pre-crisis selection of parameters and thresholds that, if reached, will change probabilities of eruption. Volcanoes are complex systems and the use of probabilities in eruption forecasting has moved faster than the hard science behind that estimation, so now volcanologists are in "catch up" mode to make the process more rigorous. Fortunately for volcanologists, volcanoes exhibit many more – and more obvious—precursors than do earthquakes. Unrest weeks or months before an eruption might suggest only a low probability of eruption but that within hours to days of an eruption will often suggest high probability of eruption.

While we congratulate ERI on adding the outreach office, and are impressed that the staff show a rare combination of high technical qualification and great enthusiasm for non-technical outreach (e.g., to schools), we suggest that a good way to address the needs for additional

technical outreach would be for the current staff to shift focus toward more technical outreach and perhaps supervise a non-technical staffer who could lead school tours, etc. This would not require a complete separation of responsibilities – just a shift in the balance or emphasis.

Recommendations:

1) Current activities of the outreach office should be continued, and more interactive dialogue with students and other non-experts should be introduced and tested. Current outreach activities give ERI excellent public exposure, provide a valuable educational service, and may also stimulate more technical exchanges.
2) Continue active ERI participation in HERP and other processes by which technical research results can be transferred to technical users.
3) Consider an expansion of this effort to the business community if needed in cooperation with other organizations.
4) Continue ERI participation in CSEP, and promote dialogue within the HERP group about whether, when, and how best to move toward operational earthquake forecasting in the low-probability environment.
5) Given ERI's leadership in Japan's volcanological community, explore with JMA and others whether an expansion of volcano outreach by NCCPVE (or by a volcano analogue of HERP?) could or should be undertaken, especially for the Tokyo area. Probabilistic volcanic hazards assessment and even the pros and cons of probabilistic eruption forecasting could be discussed in an appropriate forum, as could ways to more widely disseminate information about the effects of ashfall and other volcanic hazards, and what businesses, government agencies, and the public can do to prepare for these hazards. ERI's role could be as a catalyst for discussion.
6) Consider shifting emphasis of current outreach staff to more technical outreach, while supervising a non-technical staffer to work with school groups.

6. International Activities

The understanding of geohazards in Japan can be improved by comparative studies of earthquake and volcanic systems in other tectonic environments. For this reason, FP2009 recognizes the need to strengthen

ERI's ties with comparable research organizations worldwide.

Since the 1999 Review, ERI has made laudable efforts to promote international collaborations. In particular, its International Visitors program, which sponsors the residency of a number of foreign scientists each year, has helped to establish ERI as a global center of scientific research. In the fiscal years 2005-2008, 23 scientists from 11 countries came to ERI for long-term visits, including those supported by the Shared-use Institute program, and 32 from 9 countries came for short-term visits. This program deserves continuing support and further development. In particular, long-term (> 3 month) visitors have not only interacted with ERI and other universities' staff but also produced collaborative works, as well as educational activities through seminars and lectures. In the future, more systematic invitations along institutional bilateral collaboration program may be promoted, as well as conventional individual-based personnel exchange.

Further expansion of ERI's global footprint can be facilitated through bilateral and multilateral arrangements with foreign research organizations that have a comparable focus on Earth systems and disaster-mitigation science. The Committee notes that Memoranda of Understanding have been negotiated, or are being negotiated, with organizations in several countries, including China, the United States, and France. Among them is a participation to Collaboratory for the Study of Earthquake Predictability (CSEP), a global project on earthquake prediction project lead by Southern California Earthquake Center. Bilateral systematic exchange of personnel with Chinese Academy of Sciences and IPGP (Institut de Physique du Globe de Paris) is in process and should be expanded.

The Committee recommends that ERI seek sustained support for international partnerships that will provide new opportunities for comparative studies of earthquake and volcanic systems. Priority should be given to reciprocal partnerships that can bring new resources to joint programs of research and education.

Personnel exchange program may be more effective for graduate students or early-career researchers (especially assistant professor level) from a long-term perspective. An educational program such as lectures with credits or double-degree program may be negotiated with partner

institutions.

7. Shared-use Facility of National Universities

Observations

To lead the Japanese research communities on seismology, volcanology, and disaster sciences, ERI plays a significant role as the shared-used institution and promotes the collaboration among universities and research organizations engaged in the related research throughout Japan.

The research network being developed by ERI to promote research on prediction of earthquakes and volcanic eruptions is effective and shall enhance the synergetic efforts toward the research goal.

The increased annual budget for the maintenance and operation of the network is congratulated.

Recommendations

We endorse the operation system that ERI has developed for effective implementation of the research activities expected as the shared-used institution.

It is noticed that the system to distribute the budget appropriated for the maintenance and operation of the network to partner universities that join the network was changed in 2009. The new scheme raises a concern that it may lessen the presence and activities of the partner universities. As the representative of the concerned research community, ERI shall do its best to keep the partner universities as vital as possible.

8. Reorganization Plan

Since 1997, ERI has been managed with 4 divisions, 5 centers and 2 observatories (one was closed in 2006). We evaluate that this organization structure has functioned well to perform research activities since the previous review in 1999. In response to the 1999 review, ERI has been attempting to promote interaction among different disciplines, to balance between creative, imaginative and leading research and special mission to mitigate earthquake and volcanic hazards. While the situation is improving, we point out that interaction between different research divisions and centers are not yet sufficient.

ERI in its Future Plan 2009 listed up the following basic policies for reorganization: forming flexible project teams, nurturing leadership for junior members, responding to internationalization and globalization, playing central role as a shared-use institute in Japan, and strengthening research infrastructure, supporting system, and outreach activities. These strategies are challenging as they attempt to manage dynamically beyond existing boundaries of Divisions or Centers. To carry out basic concepts (science plans) of Future Plan 2009, we expect that the reorganization based on such strategies should motivate researchers to promote research activities of ERI to lead Japan and the world.

In the reorganization plan, three categories are proposed: A-1) Project Center, Project Division and Project Laboratories, A-2) Science Management Centers, A-3) Research Divisions. The current five centers will be either Project Center or Science Management Center, based on their objectives and purposes. More specifically, Earthquake Prediction Research Center (excluding Planning Committee), Volcanic Research Center, Ocean Hemisphere Research Center are categorized as Project Centers. Planning Committee (a part of EPRC), Earthquake Observation Center and Earthquake Information Center become Science Management Centers because of their roles of research support. The existing four divisions are reorganized to Research Divisions. All the ERI researchers belong to one of the above Centers or Research Divisions.

As flexible and dynamic organization, Project Centers are not permanent but must be closed or created as needed. As preparation stages for Project Center, concepts of Project Division (~ 5 years term) and Project Laboratories (3 to 5 year term) are proposed. The issue is to manage the new system with flexibility and to establish a mechanism to reach the initial goals.

The reorganization plan is considered as a starting point toward goals of the science plan. Because of corporatization of national universities, reorganization can be made autonomously at the institute level, hence ERI is requested to continuously review and revise the management and organization when problems arise, in order to reach the original goal of reorganization.

Comments:

We request the following are considered for the reorganization.

1) Project Centers (approximately 10 year term). At the onset, Earthquake Prediction Research Center, Volcanic Eruption Research center and Ocean Hemisphere Research Center are planned. New Project Center will be added in the future. These are clearly defined for their purpose and function as they lead the projects along ERI's missions.

2) Project Divisions and Project Laboratories (several-year term). These are newly proposed as a mechanism to create and promote new projects across Centers or Divisions, to promote flexible and dynamic organization and nurture young leadership. This strategy is highly evaluated, but how they function is the key in the reorganization. Without full-time researchers, these are considered as "project" or "program" rather than a part of organization. Management for the entire ERI must be comprehensive yet detailed; for example, when researchers belong to multiple "projects", how the effort is divided for "projects" and division (or centers) needs to be clarified. Such management policies must be clearly defined and performed.

3) Science Management Center. Promotion of Earthquake and Volcanic Eruption Prediction as a central function of a shared-use research institute (Joint Usage/Research Center from FY 2010), International Collaborative Research Promotion as a response to internationalization and globalization, Observation Infrastructure as infrastructure and research support system, Solid Earth Database, Advancement of Technology Development, and Public Relation and Outreach Activities are considered for management of basic functions and supports. Each of functions proposed above is very clear. Steering committee must function well to oversee the relationship among the specifically-defined functions, and those with Project Centers or Research Divisions.

4) Research Divisions. To promote basic research and to offer base for researchers working in projects, four Divisions according to disciplines are proposed: Mathematical RD, Earth Measurement RD, Materials Science RD and Disaster Science RD. Research Divisions are based on disciplines and basic sciences, while Project Centers are targeting system-level science. How Research Divisions contribute to interaction

and collaboration across different fields – a concern of the previous (1999) External Review – could still be reexamined. The concept of organizational homes for researchers with skills (e.g., mathematical or analytical skills) that apply to multiple problems is fine, but how to encourage collaboration with the Project Centers should be considered well. Furthermore, reorganization among Research Divisions needs to be envisioned when a new Project Center is created in the future.

5) The basic concepts of research (Science Plans) are performed in various units of the three categories with various levels of commitments. The person or committee in charge of each of Science Plan must be clarified, as external accountability of the organization.