Report of Review Committee
for
Earthquake Research Institute
University of Tokyo
外部評価報告書

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平成１２年１月

東京大学　地震研究所

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1. Preface

At the request of Professor Toshitsugu Fujii, Director of the Earthquake Research Institute (hereafter, abbreviated to ERI), The University of Tokyo, a visiting review committee carried out a review of the activities of ERI. This is the report of the committee submitted to Director of ERI. However, some recommendations are addressed also to the Ministry of Education, Science, Sports and Culture (Monbusho), and the central administration of The University of Tokyo.

The following is the charge given to the committee.

External Review Committee is requested to review the items listed below and to give advice, comments and suggestions by submitting an official report to the Director of ERI.

(1) Research activities at ERI.
- (1-1) Do they conform to the missions set forth when ERI was reorganized in 1994 ?
- (1-2) Do the five Affiliated Research Centers fulfill the assigned missions?
- (1-3) Quality of academic staff in Divisions/Research Center as evaluated collectively ?
- (1-4) Are recruitment and promotion of academic staff done well ?
- (1-5) Is the visitor program functioning well ?
- (1-6) Is the review system working well ?

(2) Research activity expected of a shared institute of Japanese universities.
- (2-1) Cooperative Research Program.
- (2-2) Earthquake Prediction Program.
- (2-3) Volcanic Eruption Prediction Program.
- (2-4) Overseas Projects.
- (2-5) Domestic Projects.
- (2-6) Scientific leadership.

(3) Educational activities of ERI.

(4) Contribution to the society.
- (4-1) Cooperation with national/local governments and private sectors.
- (4-2) Public outreach.

(5) Research Environment.
- (5-1) Funding
- (5-2) Buildings and Facilities
- (5-3) Research Support System

(6) Future Plan envisioned by ERI.

2. Committee and Site Visit

2-1. Committees

The Members of Review Committee

Shun-Ichi Akasofu, Geophysical Institute, University of Alaska
Akira Hasegawa, Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University.
Kosuke Heki, Earth Rotation Division, National Astronomical Observatory
Kojiro Irikura, Division of Earthquake Disaster Prevention, Disaster Prevention Research Institute, Kyoto University.
Mizuho Ishida, National Institute for Earth Science and Disaster Prevention, Science and Technology Agency
Hiroo Kanamori*, Seismological Laboratory, California Institute of Technology
Ikuo Kushiro, University of Tokyo
Chris Newhall, Department of Geological Sciences, University of Washington and U.S. Geological Survey
Barbara Romanowicz, Seismological Laboratory, University of California, Berkeley
Selwyn Sacks, Department of Terrestrial Magnetism, Carnegie Institution of Washington
Kenji Satake, Earthquake Research Department, Geological Survey of Japan
Jiro Tomari, Science Section, The Asahi Newspaper

* Chairman

ERI Organizing Committee

Yoshio Fukao
Muneo Hori***
Takaya Iwasaki
Toshimi Kabeyazawa
Takehiro Koyaguchi**
Tomoko Murakami
Shun'ichi Nakai
Shuhei Okubo*
Hidefumi Watanabe
Teruo Yamashita

* Chairman
** Vice Chairman (until March 1999), *** Vice Chairman (since April 1999)

2-2 Site Visit Schedule

June 14 Monday

9:00-10:00	Introductory Meeting
10:15-12:15	Scientific Session
13:30-15:00	Scientific Session
15:15-17:45	Scientific Session

June 15 Tuesday

9:00-10:45	Scientific Session
11:00-12:15	Scientific Session
13:30-15:30	Committee Meeting
15:45-17:30	Briefing of ERI Report

June 16 Wednesday

9:00-11:00	Tour of ERI Facilities
11:00-12:00	Committee Meeting
13:30-17:45	Interview with Faculty Members

June 17 Thursday

9:00-12:00	Interview with Research Associates, Technical and Office Staff.
12:00-13:30	Interview with Students
13:30-15:30	Committee Meeting
15:45-16:30	Future Plan
16:45-17:45	Committee Meeting

June 18 Friday

9:00-11:00	Executive Meeting
11:00	Preliminary Oral Report to Director
12:00	Adjournment

3. Summary of Recommendations

1. The Faculty Council of the Earthquake Research Institute (hereafter, abbreviated to ERI) has made an innovative future plan. This plan emphasizes (1) research on the dynamics in Earth's interior especially in the Western Pacific Ocean, (2) basic studies on physical and chemical processes leading to an earthquake and a volcanic eruption, (3) development of a new research field to handle complex earthquake and volcanic processes using a concept of non-linear interaction, (4) research on disaster mitigation methods that take into account the complexity of earthquake and volcanic processes. In addition to these specific research programs, the plan emphasizes the importance of small embryonic projects which require long-term support.

The plan includes development of an efficient research support structure with an extensive training program.

The plan also emphasizes the importance of ERI's role in education. Their field-oriented, interactive observational program will provide students with the first-hand experience with natural phenomena, such as earthquakes and volcanic eruptions.

We reviewed the details of the plan and found it innovative and well thought out, and we believe that this plan will help ERI to achieve the stated missions in the best possible way. We encourage ERI to: (1) study the physics and chemistry of fluid-filled crust in earthquake research; (2) continue the research on socially useful short-term predictions of volcanic eruptions; (3) clarify the bridges between current scientific programs and mitigation; (4) plan eventual transfer of routine earthquake monitoring duties to government agencies. We endorse the overall concept presented in this plan, and strongly recommend that steps be taken immediately to implement it with periodical review and modification as needed.

2. ERI has had excellent directors, but their term is usually limited to 2 years. Considering the large-scale projects with long-term scientific and social implications, we believe that a longer-term tenure (e.g. 5 years) is desirable. It would enable ERI to assume a stronger leadership role, nationally and internationally, and to accomplish their missions more effectively. We recommend that the ERI Faculty Council should start evaluating the merit of a longer tenure of Director.

3. The ERI faculty members generally hold a very high academic standard in their own field. In order to further strengthen the impact of their research, more vigorous interactions between different disciplines are strongly encouraged. We recommend that the ERI faculty should implement an internal mechanism to promote such vigorous and productive interactions. Significant efforts on the part of individual faculty member would be required to accomplish this.

4. We recognize the significant efforts of the ERI faculty in recruiting the best scientists to their academic staff. Because future hires will lead ERI research in the next generation, every effort should be made to find the best candidates with outstanding academic qualifications. Furthermore, because of the high value of diverse ideas and experience in research and teaching, we recommend that ERI faculty look especially for well-qualified female and foreign scientists.

5. Many Research Associates presently at ERI are academically productive despite some routine duties. An internal mechanism should be implemented to periodically review their performance and ensure that they are given sufficient opportunities to further their academic career.

6. A highly-trained support staff is critically important for any research institutions. It is especially important for the institutions like ERI where large-scale observational programs are central to their research. We recommend a significant increase in the size of technical staff, especially a highly-trained technical staff for development of new instrumentation. If this is not possible within the general government policy to decrease the number of civil servants, some measures should be taken to allow ERI to hire non-permanent staff. The shortage of the support staff is a serious concern not only at ERI but also at other institutions. We encourage ERI Director to actively initiate or participate in whatever activities at national level to rectify this problem.

7. In view of the large investment for building the Ocean Hemisphere observation network, and the exciting results coming out from this project, every effort should be made to maintain the network after expiration of the present funding in 2 years. Coordination with other similar projects such as the "Super Plume" project supported by the Science and Technology Agency should be encouraged.

8. We recognize the efforts of the ERI faculty in the university's educational program by training a large number (currently about 85) of graduate students, teaching many courses (e.g. 70% of the courses on solid-earth geophysics in the graduate school of Earth and Planetary Physics are taught by the ERI faculty), and giving seminars at the College of Arts and Sciences. We encourage ERI faculty to continue this effort taking the advantage of their excellent field and observational programs.

9. The visitor program at ERI has been successful in broadening the scope of the ERI research programs, and in strengthening ERI's relationship to the outside research communities, both national and international. We commend ERI's academic and administrative staff for making this program successful. We recommend that continuing efforts should be made to streamline the program by training the administrative staff for taking care of the needs of foreign visitors.

10. ERI's outreach efforts should have at least 3 elements. First, for conducting effective research for mitigation, it is essential to work with local organizations such as utility, communication, construction, and transportation companies and emergency services organizations. The present structure in ERI is inadequate to carry out effective outreach activity in this area. We recommend that research-oriented engineers be hired to link between the user community and ERI mitigation researchers.

Second, ERI should work together with other government agencies (e.g. Japan Meteorological Agency, Science and Technology Agency) to facilitate access to data collected by different agencies.

Third, more effective outreach is desirable considering the strong interest of the public in the status of research on prediction and forecast of earthquakes and volcanic eruptions. Within ERI, "Earthquake Prediction Research" is interpreted as "Research on

Physical and Chemical Processes leading to Earthquakes", but this interpretation is not understood well among the general public. We commend ERI's efforts to utilize their web site for this purpose and encourage further expansion.

11. The main building of ERI was designed and constructed during the period 1963-1968 under the old Building Standard Law of Japan, and would sustain severe damage or nearly collapse during a large earthquake that may occur in the Tokyo area. We recommend that an immediate action be taken toward planning for rebuilding or retrofitting of the main building so that ERI will be able to function effectively during a major seismic event for emergency information services for the public and other government agencies. Also, to meet the ever-growing space needs, and to enhance collaboration with the Department of Earth and Planetary Physics, Departments of Civil Engineering and Architecture, and other government institutions, we recommend that the ERI faculty investigate the long-term plan discussed in section 5-9.

12. A novel use of "Shared Institute of Japanese Universities (SIJU)" is now developing at ERI. This emphasizes intellectual collaborative work (software-oriented approach) sharing all the data available rather than facility-oriented approach. This model of ERI as a “software” type of SIJU (data center, collaborative center) is well suited, for now, to ERI’s historically central role in Japanese earthquake and volcano science, and to its greater wealth in data and experience than in large facilities. To strengthen this function of ERI, we recommend that all the data under ERI control be made available freely in a timely manner to researchers at other institutions.

However, the central administration and Monbusho should also be aware that, in order to maintain its pre-eminence, ERI will need to modernize its research infrastructure (laboratories, machine shops, etc.) to keep pace with technological advances and with other universities and government agencies. The current level of funding for the SIJU is small and needs to be increased several-fold immediately, just to satisfy the demand for “software” type of collaboration, and substantially greater funding will be needed within the next few years for infrastructure (“hardware”) upgrades.

13. To coordinate the earthquake research efforts by various universities, we endorse the ERI's plan to create a coordinating committee with sufficient staff within the Earthquake Prediction Research Center. This committee will allow representatives from academic institutions to evaluate the scientific merit of the university programs and coordinate earthquake research efforts among them.

4. Historical Background

After the devastating Kanto earthquake in 1923, it was realized that, in addition to the traditional observational and empirical approach, more theoretical and analytical approach using physics and engineering is important for earthquake studies. This realization led to the establishment of the Earthquake Research Institute (ERI) under Monbusho on November 13, 1925, within Tokyo Imperial College. The missions of ERI were: (1) Scientific investigation of various phenomena associated with earthquakes; (2) Investigation of methods for prevention and mitigation of damage caused directly or indirectly by earthquakes.

After World War II, ERI was re-established as one of the research institutes of the University of Tokyo. ERI played a key role in Earthquake Prediction Program and Volcanic Eruption Prediction Program which started as national programs in 1965 and in 1974, respectively.

ERI was re-organized in June, 1994, as one of Shared Institutes of the Japanese Universities (SIJU), with the following major tasks.

1. Scientific research on earthquake and volcanic eruption.
2. Research on predicting earthquakes and volcanic eruptions.
3. Research on mitigating damage caused by earthquakes and volcanic eruptions.

5. Assessment and Recommendations

The assessments of the External Review Committee described in the following sections are based on the material provided by the Organizing Committee, site visit, and interviews with ERI staff. During the discussion of the Review Committee the responses from the former and present visitors to ERI summarized in section 6 were carefully considered.

The material provided by the Organizing Committee is very extensive and informative, and significantly helped the review process. We appreciate and commend the extraordinary efforts by Professor Okubo, Chairman of the Organizing Committee, and the members.

5-1. Director

ERI has had excellent directors, but their term is usually limited to 2 years (up to two successive terms are allowed). Considering the large-scale projects with long-term scientific and social implications, we believe that a longer-term tenure (e.g. 5 years) is desirable. This would enable ERI to assume a stronger leadership role, nationally and internationally, and to accomplish their missions more effectively. We recommend that the ERI Faculty Council should start evaluating the merit of a longer tenure of Director.

The selection process of Director is important. Although the details of the selection process are constrained by the university rules, the goal should be to find the best possible person to lead ERI to a world leading institution. The selection should be made on the basis of the candidate's scientific vision, and should not preclude foreign candidates.

5-2. Faculty and Research Associates

ERI faculty members hold generally a very high academic standard. Since the expertise of the External Review Committee does not cover the entire range of the disciplines covered by the ERI faculty, it is viewed inappropriate for the Committee to rate the individual faculty members. Our assessment on the basis of the quality of the published papers and international reputation is that the quality of the ERI faculty members is collectively above the national level; about 1/3 of them are judged to be at the international level, with several reaching a world-class standing. The productivity of a few faculty members, however, is judged below the national level.

Many of the research papers published by ERI researchers made important impacts in the field of their specialty. However, there is perception that the overall impact of ERI on Earth science in the international arena has not been up to what one would expect for its size, the number of Ph.D. researchers in many diverse fields, and excellent facility. ERI is as yet to play a stronger international leadership role with more creative research.

The following are believed to be the cause of this problem.

(1) The interaction between different disciplines is insufficient. This is also a common perception among the visitors to ERI (see section 6). One obvious reason for the lack of interaction is that many faculty members are simply too busy, but we also sensed from some of the presentations during the site visit that there seems to be a lack of in-depth scientific interactions among the researchers even within the same

discipline. We recommend that the ERI faculty should implement mechanisms which actively promote interdisciplinary interactions, especially involving junior researchers and students. Creative research is nurtured by interdisciplinary interactions. We suggest the following mechanisms.

a. To bring researchers from different disciplines together to work on a common problem. This has been done to some extent (e.g. OHRP), but the project to evaluate crustal stress, stated in the future plan, could be another good forum where theoretical, field, and laboratory scientists can work together closely .

b. Reduce the potentially bureaucratic barriers between different centers and divisions. Since it is only 5 years since reorganization, it would be premature to phase out some divisions and centers, but we recommend that the ERI faculty review the current structure periodically to ensure that interdisciplinary interaction is not hampered by the present structure.

c. Encourage internal review of manuscripts and proposals before submission.

d. Introduce informal brainstorm sessions involving Research Associates, postdoctoral fellows, visitors, and graduate students.

(2) Some faculty members appear to be over committed to external committees (i.e. government, international committees etc.). This is not necessarily bad, because the expertise of ERI faculty members is evidently highly demanded. However, the ERI's top priority should be given to research and education, and a proper balance has to be maintained between these primary functions and the external activities. ERI Director should play a more active role in reducing the faculty commitment to these external activities, if they are viewed excessive and counter-productive to ERI function. ERI Director may provide guidelines on the percentage of such activities for individuals.

(3) The support staff at ERI is not sufficient, considering the large-scale programs at ERI, and the faculty members are overloaded with too much clerical work (e.g. details of budget preparation, purchase order, negotiation for land acquisition etc.). This can be remedied by reassigning some responsibilities to technical staff and secretaries. However, efforts on the part of faculty members are needed to boost the morale of the support staff. They should be given enough opportunities to train themselves for challenging jobs.

Several visitors expressed concern that some Research Associates are overloaded with too much routine works, and have not been given enough opportunities for creative research. However, we found through the interviews that most Research Associates who conduct their own research programs are very productive despite a considerable amount of routine responsibility.

5-3. Current Research Activities, Research Divisions and Centers

Our assessment on the current research activities is based on the series of presentations given by ERI faculty members, the material provided by the Organizing Committee, and the published papers and the presentations at other meetings which some of the Review Committee members had chance to read or hear.

The reports on the individual research activities were prepared by subgroups of the Review Committee. Also, two subgroups of the Review Committee interviewed different segments of the staff (Faculty, research and technical staff) of the Centers and Research Divisions and each subgroup prepared its report. Thus, these reports are inevitably heterogeneous in length and content. The following subsections 5-3-1, 5-3-2, 5-3-3, and 5-3-4 contain these reports.

ERI has three missions: (1) Scientific research on earthquakes and volcanic eruptions; (2) Research on prediction of earthquakes and volcanic eruptions; (3) Research on mitigation of damage caused by earthquakes and volcanic eruptions. Most research projects in the Ocean Hemisphere Research Center (OHRC) and in Divisions of Earth Mechanics, Global Dynamics, and Monitoring and Computational Geosciences are focused on Mission 1. Research projects in four Centers (Earthquake Prediction Research Center (EPRC), Earthquake Observation Center (EOC), Earthquake Information Center (EIC), and Volcano Research Center (VRC)) are principally aimed at Mission 2. Studies carried out by the Division of Disaster Mitigation Sciences (DDMS) and EIC are devoted to Mission 3.

We realize that ERI faculty members have been extremely busy in various activities associated with the drastic reorganization of ERI in 1994. Although these activities were not directly related to research, they did not seem to have adversely affected the research productivity of ERI. In fact, the number of papers published by ERI researchers in widely circulated peer-reviewed journals has more than doubled since reorganization. The number of published papers is not necessarily a good measure of productivity, but the reorganization appears to be working positively to increase the overall productivity of ERI.

As we have mentioned in 5-2, if ERI faculty members make special efforts to promote cross-disciplinary interaction, thereby creating a more lively research environment, we believe that ERI will be a truly leading Earth science research institution in the world.

Since ERI is a university-affiliated research institute, they should promote creative, cutting-edge research that produces major, widely-recognized, sometimes paradigm-shifting advances in understanding of earthquake and volcanic processes. At the same time, ERI has specific missions toward mitigation of damage caused by earthquakes and volcanic eruptions. Thus, ERI faculty should try to maintain carefully a delicate balance between creative research and specific mission-oriented research.

5-3-1. Research Divisions

Division of Earth Mechanics

Research area in this division is diverse, covering recurrence of large earthquakes, micro-mechanics and its application to geoscience, modeling strain and stress associated with volcanic eruptions and noble gas geochemistry. There seems to be little interaction or collaboration within this Division, though there are some collaborations with other divisions and centers. We feel that more interaction within the division would stimulate

the program and increase productivity.

The number of graduate students with science major is relatively small and more active recruitment of graduate students is desirable.

Division of Global Dynamics

The research activities of this Division are diverse in subject, research method, and approach. The research projects are based on new ideas and significant experimental and analytical results on the generation of magma and material transport in the mantle have been obtained by Professors Fujii, Kaneoka, and Nakai. The purpose of the research of this Division is described as 'to understand the mechanism of phenomena related to earthquakes and volcanism on a global scale'. However, how their present research is related to the stated goal of the Division is not obvious. Also, collaboration and interaction among different groups within this Division do not seem strong. For understanding the global dynamics of the Earth in relation to earthquakes and volcanism, more collaboration would be needed among different groups within this Division as well as with relevant researchers of other Divisions and the Graduate School of Science of the University of Tokyo. This Division has hardware facilities such as multi-anvil, high-pressure apparatus and several different mass-spectrometers which will be more heavily used by outside users in the near future. Technical support for these facilities should be seriously considered.

Division of Monitoring and Computational Geosciences

The main activity of this Division is to develop a special instrument (hardware) or a creative algorithm (software) for special research projects. The examples are: ACROSS by Professor Higashihara, Gravimetry by Professor Okubo, Algorithm for earthquake generation by Professor Yamashita, Algorithm for studying near-source ground motion by Professor Miyatake, Laser interferometry by Dr. Araya. For the activity of this Division, improvement and renovation of the machine shop is critically important.

Measurements of gravity have been made by many institutions, but very few specifically study gravity changes associated with earthquakes and volcanic activity. A sudden change of a few microgal in gravity associated with fluid migration during the Ito swarm earthquakes observed and studied by Professor Okubo's group is unique. The study of earthquake source process by Professor Yamashita's group is regarded very highly. This study is done in collaboration with Professors Ohnaka and Shimazaki as a cross-disciplinary research. The development of ACROSS and the development of a seismometer and an extensometer using a laser interferometer has been done in close collaboration with Dr. Ohtake of the Laboratory for Technical Development and Support.

Every professor is working hard to recruit graduate students. In the field of earthquake source process, close collaboration between seismology and engineering is becoming important. Unfortunately, the university regulation does not allow professors in a science department to take students from an engineering department and vice versa, which makes the situation more difficult.

Division of Disaster Mitigation Science

This division conducts research for prevention and mitigation of disasters, especially damage to structures and urban facilities. The research themes of the current members are classified into (i) Earthquake engineering of building structures, (ii) Observational and computational studies on strong motions, (iii) Tsunami, and (iv) Historical earthquakes.

The researchers in this division have played active roles in earthquake engineering/strong motion case studies for recent large earthquakes: Hokkaido Nansei-Oki earthquake (1993), Kushiro-Oki earthquake (1993), Northridge earthquake (1994), Hokkaido Toho-Oki earthquake (1994), Hyogo-ken Nanbu earthquake (1995) and Kagoshima-ken Hokuseibu earthquake (1997).

The themes (ii) to (iv), i.e. observational and computational studies on strong motions led by Professors Kudo and Koketsu, and tsunami and historical earthquake research led by Professors Tsuji are summarized in 5-3-3.

The group led by Professors Kabeyasawa and Minami played a leading role as organizers and editors within the special working group of the Architectural Institute of Japan for the Hyogo-ken-Nanbu Earthquake. They clarified the relations between damage and seismic performance indices, and soil-structure interaction through damage survey. Seismic performance indices were evaluated for more than 100 buildings and a fair correlation was observed between the calculated performance indices and the damage indices. These works are important for disaster mitigation.

A monthly seminar on earthquake engineering hosted by the division offers public outreach to local government, utility, transport companies. We encourage this Division to continue this effort.

5-3-2. Centers

Ocean Hemisphere Research Center (OHRC)

The scientific goals of the Ocean Hemisphere Research Center (OHRC) are primarily focused on improving understanding of the Earth's deep structure as it relates to the dynamics that drive surface tectonic processes such as earthquakes and volcanoes.

The Ocean Hemisphere Project which was funded by Monbusho as a 5 year project will end in 2 years. The observation network for the Pacific which is being built under this project will be important for the future development of solid Earth sciences. This project has already produced exciting results as will be described in section 5-3-3. The network will function in full capacity when it is completed in 2 years. In view of its productivity and potential, it is important to maintain and further develop the network after the completion of this project in 2 years.

Earthquake Prediction Research Center (EPRC)

Earthquake Prediction Research Center is playing an important role in coordinating various cooperative projects with research institutions both in Japan and in foreign countries.

To improve coordination by various universities, we endorse the ERI's plan to create a coordinating committee with sufficiently large staff within the Earthquake Prediction Research Center. This committee will allow representatives from academic institutions to evaluate the scientific merit of the university programs and coordinates earthquake research efforts among them.

Earthquake Observation Center (EOC)

The main research activities of this center are: (1) Relationship between heterogeneous crustal structure and earthquake source processes, (2) Deep structure of active faults, and (3) Deformation process of the Japanese arc. They also developed a

satellite telemetry system and earthquake and tsunami observation system using dedicated fiber-optics. Their work on crustal deformation concerns with the relationship between crustal deformation and seismicity. They also developed a system for borehole observation. In the area of strong ground motion observations, they carried out strong motion observations in the Suruga bay, Izu peninsula, and the Ashigara plain test site.

Especially notable is the satellite telemetry system developed by this center in collaboration with other universities. The importance of this project will be described in 5-3-3.

The dedicated fibre-optics observation system for submarine earthquakes and tsunami made an important contribution in broadening the observation window to the oceanic area. They are mapping the details of plate-boundary seismicity and swarm earthquakes caused by magmatic activity using this system in the areas offshore of Ito and the Sanriku coast.

This center appears to have more technical staff compared with other centers and research divisions, but considering the large operation of this center, they would need more technical staff to conduct field experiments more effectively.

Earthquake Information Center (EIC)

The Earthquake Information Center develops and manages a distribution network which enables researchers to obtain wave-form data from micro-earthquake observatories and broad-band stations operated by various universities in Japan. The Center also develops software for wave form analysis and distributes it via Internet. In this sense, the Center is indispensable for all the seismologists in Japan. The Center has about 30 mailing lists of researchers, which provide a forum for exchange of information on seismicity and volcanic eruptions, and of opinions among them. The EIC Earthquake Note which was started in August, 1996, reports on the rupture process of major earthquakes determined from seismic body waves together with explanatory commentaries. This has been also used as a useful data source for the media. In this way, the Earthquake Information Center is performing a good public outreach.

The Center also developed a method to determine the moment magnitude from the beginning of P waves recorded with broad-band instruments, and a method for probabilistic forecast of aftershocks. Also an attempt is made at the Center to determine the locations of major asperities from the analysis of large earthquakes in the past, and use them to estimate the damage pattern expected for earthquakes in the future.

A research is being made to develop a real-time system in which the results obtained by real-time analysis of data are sent to users. The users can extract the information depending on their needs. Although this concept is now being developed only within the Center, it may eventually be developed to an Institute wide program for outreach.

Thus, the Center plays an important role as a center of SIJU, and also contributes significantly to society, providing key information on earthquakes. Unfortunately, the name of the Center (literally, Earthquake Prediction Information Center) implies that the major function of this center is to issue information on earthquake prediction. This occasionally causes some confusion among the public.

Volcano Research Center (VRC)

ERI has long been a leading research center in volcanology, and this leadership continues with the current faculty. Professor Ida leads the national program for the

prediction of volcanic activities (NPPVE) through Monbusho's Geodetic Council. Professor Watanabe's Izu-Oshima project is yielding new insights that will be summarized in section 5-3-3. At Unzen, Professor Nakada's scientific leadership among a large group of workers from many universities and government agencies provided a good basis for advice to public officials, and is taking good advantage of opportunities to study the degassing of viscous magma.

Some coordination between the researchers of VRC and those outside of VRC is evident (e.g. between Professors Kagiyama and Utada for geophysical prospecting of the Kirishima Volcanoes), but the coordination between, for example, the VRC and interesting work by Professor Kawakatsu on bubbles and long-period waves at Aso Volcano, or between Professor Nakai and the VRC on matters of chemical precursors to eruptions was not obvious during the presentation.

If an opportunity should arise in the future to add a member to the VRC, it would be desirable for ERI to consider a gas chemist. Gas drives volcanism, yet it is not studied at ERI. Ironically, the petrologic record of degassing is studied at ERI, but not much mention was made on gas itself. For now, the VRC needs to build collaboration with gas chemists at other laboratories such as the Laboratory of Earthquake Chemistry , Okayama Univ, Tokyo Institute of Technology, and the Geological Survey of Japan. If that collaboration works well, then it may suffice or even be preferable to adding a volcanic gas chemist to ERI. The important point is that the gas phase must also be studied, alongside geophysical change.

Future plans of the VRC include some broadening of its work, to include study of decades-long preparation for eruptions. For eruptions, there are fewer uncertainties in the short-term (days, weeks) than over periods of decades (intermediate-term). Decades in advance, some magma is still at depth and the course of its degassing is difficult to anticipate. A few volcanoes such as Izu-Oshima and Miyake-jima behave regularly enough that this intermediate-term forecasting may be possible; most volcanoes do not behave so regularly. However, once magma is on "final ascent," short-term forecasts can be made with some certainty. There are still many interesting problems in short-term forecasting which is societally more useful. We encourage the VRC researchers to work on forecasts on all time scales, and to relate them as much as possible.

5-3-3. Research Projects

Ocean Hemisphere Network Project

The Ocean Hemisphere Network Project (OHP) led by Professor Fukao is closely linked to the Ocean Hemisphere Research Center (OHRC). The OHRC's faculty and research associates have made important and original contributions recently to global tomography and the resolution of fine structures in the mantle transition zone. They have also discovered the existence of continuous background free oscillations of the earth which opens up a new field of investigations of solid earth/ocean/atmosphere interaction.

The OHP aims at establishing a network of seismic, geomagnetic and geodetic permanent as well as temporary stations in the western Pacific region, with a crucial component of ocean bottom observatories. The rationale for this program builds upon the unique position of Japan on top of a very active subduction zone, and one of the key foci is to improve the resolution of structure and deformation mechanisms of this major plate boundary system. Because most of the action takes place beneath the ocean, observational

capabilities have been hindered until recently, when progress in technology made it possible to install long-term geophysical observatories on the ocean floor.

A more general rationale is to "fill the gap" in the distribution of geophysical observatories in the western hemisphere. This represents a major contribution of global and international scale, and should be strongly supported.

For example, in seismology, elucidation of the detailed structure of the subduction zones of the western Pacific, the fate of the downgoing slabs beyond the 670 km discontinuity, can only be resolved with denser observations on both the land and ocean side of the trenches. The OHRC scientists (Professors Fukao, Utada, Kawakatsu, Yamano, and Morita) are leaders in this field. Also, the OHP network and its temporary components will provide crucial data for the resolution of small scale heterogeneity in the complex D" region at the bottom of the mantle, and the Pacific "Super Plume", whose role in the global mantle circulation is not yet well understood.

The OHP is at the forefront of international efforts to improve coverage of the globe; in particular, it is leading the way in terms of ocean bottom instrument development and deployment. In order to effectively fulfill its mission, it is essential that OHP continues beyond its current 5 year limit, as accumulation of sufficient data can only be achieved over decades of continuous observations. In seismology, this is because of the dependence on natural sources, and in geodesy and geomagnetism, because of the time scale of observed phenomena. It is also essential that the data collection, archival and distribution be organized efficiently and in a timely manner, both for the benefit of OHRC and Japanese scientists, and in order to effectively participate in the international data exchange program, which now calls for on-line "seamless" access to digital data from regional data centers. This is important in particular to ensure the OHP's international visibility, and increase its credibility, while reciprocally facilitating access for Japanese scientists to other complementary data sets.

For this to function properly, adequate manpower should be assigned to the OHP Data Center. The current situation is inadequate and inappropriate. The Data Center should be run by professional staff (i.e., computer scientists and at least one or, better, two assistants) and the research associate in charge should mainly play a supervisory role to ensure that the needs of the scientists are met. While theoretically functioning, it is currently often not possible to obtain specific current data sets from the OHP Data Center.

The current OHP project period is 5 years and it will therefore terminate in 2 years (end of FY 2000). Because of the nature of the observations, as mentioned above, data collection from well maintained stations, its archival and distribution must continue many years beyond that limit. Since ERI is a research institution, it is not desirable for ERI to assume the heavy responsibility of routine operation and maintenance of the fixed OHP network at the end of its current development period. We recommend that ERI should formulate a plan to transfer these responsibilities to more suitable institutions at the conclusion of the development period. In this manner, better quality data collection can be achieved in the long term, and the OHP scientists can devote themselves to the design of new research driven initiatives.

Scientific Use of Submarine Cables

This project led by Professors Fukao, Kasahara and Kanazawa broadened the observational window into the Earth's interior by developing a system for long-term continuous observation in the oceanic area. Although not every planned observation has

been started, the project is promising.

The western Pacific has many active subduction zones, but it has been a major observational gap. The ocean bottom observation of earthquakes, tsunami, geomagnetism, and electric potential using the decommissioned submarine cable is a challenging attempt to fill the observational gap. This project is an important element of the OHP project.

Also, the real-time observation would enable rapid information service for the public. The observation system for submarine earthquakes and tsunami using fiber-optics which has been deployed off-shore Ito and Sanriku is especially significant in this regard. In these areas, seismic activity is very high, and this system is providing key data for understanding the earthquake swarm caused by magmatic activity and seismicity along the plate boundary. The Sanriku area has produced many tsunami earthquakes. This project is expected to contribute to more accurate tsunami forecasts.

This fiber-optic observation system has been adopted in the Basement Observation System of the Science and Technology Agency, and a similar system is now being installed on the ocean floor around Japan as part of the Basic Observation Network.

Many of the research staff working on this project have sufficient experience in developing new instrumentation for ocean bottom observations. They are capable of developing the instruments and the system necessary for achieving the goals of this project.

Because of the nature of this project, it would be necessary to continue the project for at least 20 to 30 years, and efforts need to be made to secure funding for long-term maintenance of the observational system.

Scientific Drilling within the Caldera of Izu-Oshima Volcano

This is a good example of how focused, multi-disciplinary work on a single "mesoscale" geologic system can yield considerable insight into the past and future behavior of that system. Analysis of P-wave scattering defined a probable magma storage area at 10 km depth, with a diameter of several km. Borehole geophysical measurements, including density profiling, are being combined with petrographic and more detailed petrologic analysis of core to reconstruct the eruptive history beneath this intracaldera site. Seismicity and inflation through the 1970's, up to about 1980, indicated gradual magma resupply. After 1980, there was little additional seismicity or inflation, but thermal demagnetization and resistivity decrease occurred rapidly within the last few months before the 1986 eruption. The borehole, not drilled until after the 1986 eruption, promises to yield unique insights leading up to the next eruption, due a decade or so hence. Planned borehole instrumentation currently emphasizes geophysical monitoring. CO2(g) will be monitored from a teflon tube inserted to just above water table, which we believe is a good plan. We recommend that monitoring of conductivity and pH below water table be added to determine how much of the heating of groundwater derives from hot gases vs. hot magma.

Some of the scientific benefits of this hole have already been realized; more petrographic work is currently in progress (one Ph.D. thesis), and controlled source exploration is planned for 1999. It will be interesting to compare the seismic reflection results with a model of northeastward collapse that has been postulated on relatively limited geologic grounds. Even greater practical and scientific benefits will accrue the next time magma intrudes up into the groundwater table, high into the cone. 1-km deep drillholes into volcanoes are rare, and the volcanologists at ERI (in Japan in general) have special opportunities with this and a proposed Unzen hole. They seem to be making good

use of the opportunity, and we look forward to seeing further exciting results.

Telemetered Earthquake Observation

The group headed by Professors Hirata and Urabe developed a satellite telemetry system in collaboration with other universities. This system is an epoch-making development which would influence the development of future seismological observation in Japan. It made possible to retrieve real-time waveform data from any place in Japan, thereby significantly improve the utility of the data collected by university seismic networks.

A current plan is to use this satellite telemetry system for distributing, nationwide, the seismic data collected by all the permanent seismic networks including the newly developed Basement Observation Network. Another merit of this system is its utility for mobile seismic observations. In fact, this system was used in the dense large-scale cooperative seismic exploration study in the Tohoku District. This study contributed significantly to a better understanding of the heterogeneity of the crust of the Japanese arc.

This system will allow seismologists to develop a flexible seismic network suitable for the specific objective of their scientific project. We believe that the satellite telemetry system has excellent capabilities and will play a crucial role in carrying out the observational projects mentioned in the Future Plan. More efforts would be needed to enhance the capability and increase the mobility of the system.

Deformation of Japan Arc

This is a recent project which aims at determining the details of crustal structures by controlled-source seismic profiling, and relating them to fault structures, and ultimately to the deformation processes of the Japan Arc by integrating various data from broad fields in geophysics and geology. The groups of Professors Yoshii, Iwasaki, Hirata, and Satoh have conducted a large scale seismic refraction/wide-angle reflection and near-vertical reflection experiments in the Tohoku district as the first step of this project. The main objective was to relate the structural heterogeneity with deep structures of active faults and precise locations of earthquakes in the region. They have obtained crust and uppermost mantle structure with a significant lateral variation along the line crossing the Tohoku Arc, and have imaged the fault planes of active faults which reach down to mid-crustal depths. This is an important result and we encourage further studies.

The project involves modern controlled-source technology, and thus it provides good opportunities to students to learn the state-of-the-art crustal exploration technology. A better understanding of heterogeneity of the crust is important, but it is still too early to judge the real impact of this project. At some stage of the project, they should articulate more sharply how to relate crustal structures to deformation processes of the Japan Arc through integration of various data.

Study of Seismogenic Process I

Several researchers at ERI are studying seismogenic processes by various methods such as field investigation, data analysis, theoretical method, numerical simulation and rock experiment. These works cover almost every aspect of earthquake process, from nucleation to arrest of rupture, geometrical and dynamic complexities, recurrence of large earthquakes and evolution of fault system. Each of these studies, mostly performed by Professors Ohnaka, Takeo, Shimazaki, Seno, Yoshida, Miyatake, Yamashita and Hori and

their colleagues, has been published in international journals and is widely known. This area is one of the strongest seismological programs being conducted at ERI. Each of these studies is a basic individual research project. While the quality of science is very high, we felt that the program can be further strengthened. Interaction among the researchers and the scope of the research seem to be often limited. An effort to integrate the individual research and construct a more comprehensive model should be encouraged. Also studies of earthquake source should be more closely integrated in their mitigation program. While each study is academically valuable, its impact on society is weak. Considering the stated mission of ERI, ERI seismologists should make more conscious efforts toward utilizing their academic products for the benefit of society.

Study of Seismogenic Process II

This project includes a comprehensive research of the Izu seismic swarm using geomagnetic/electric, gravity, GPS, strain, tilt and other measurements by Professors Sasai, Okubo, Kato, and Ishii. Substantial efforts are made to integrate and synthesize the observed results toward a consistent interpretation of all the observations. A detailed simulation was performed to model an earthquake activity due to migration of ground water. This is an important result and we encourage further studies.

Strong Ground Motion Study

Only very few researchers such as Professors Kudo and Koketsu are involved in strong-motion research at ERI. They built a high-density strong-motion network in the Izu peninsula and the Ashigara basin, and obtained high-quality strong-motion data. From the Ashigara data, they clarified the complex ground-motion amplification characteristics, focusing and defocusing characteristics due to the basin structure. The data from Izu were effectively used for the study of volcanoes. They also studied near-source strong-motion data from the Kobe earthquake to assess the effects of both source process and crustal structure on the observed strong motion. They examined the relationship between the location of fault asperities and the damaged areas, and showed that rupture directivity and the shape of the basin structure contributed to generation of the destructive ground motions. This is not necessarily a unique contribution of ERI, but they played an important role in leading the strong-motion research in Japan.

They collected strong-motion data from a wide area in the Kanto plane, and showed that the distribution of long-period ground motion is controlled by the structural heterogeneity over a broad area, and the short-period ground motions are strongly influenced by local structures.

On the basis of these studies, they emphasized the importance of deep sedimentary structures for estimation of strong-ground motions. They also play a central role in international cooperative research projects. However, more efforts for utilizing their research for practical mitigation purposes are desirable.

Tsunami and Historical Earthquakes

The ERI program aims directly at reducing damage caused by tsunami, and contributed significantly to the study of recent tsunamis which caused many casualties. Whenever a large tsunami occurred somewhere in the world, the ERI group led by Professor Tsuji played a central role in the investigation team visiting the damaged areas, and published detailed reports. They also found secondary tsunamis which may have been

caused by slow aftershocks. They are working with the communities along the Sanriku coast, experimenting a monitoring and alert system using a ultra-sonic system.

In a joint study with other research groups, they uncovered the evidence for tsunami from a large earthquake in the Cascadia subduction zone which is believed to have occurred in 1700, and demonstrated the importance of historical documents in the study of earthquakes. They are continuing the efforts to find evidence for old tsunamis in the coastal sediments too.

Professor Tsuji is the only faculty member working in this area. If ERI is expected to play a leadership role in this type of research, we feel that more emphasis on this field should be given in ERI's future plan.

Modeling of Dynamics of Volcanic Phenomena

Five loosely related modeling projects were tied together by Professor Koyaguchi into a conceptual bundle that starts in the mantle wedge and works its way to the surface. In each case, observations from nature motivated relatively simple numerical modeling. The simplicity is appropriate to the sparse data. The current utility of these models is to provide quantitative testable hypotheses about the origin of these signals, and to suggest processes that might not otherwise have been imagined. The next task is to collect data for rigorous tests. We encourage close interactions and collaborations between theoreticians and field volcanologists.

Collaboration between the ERI group and foreign groups would also be very productive. We also suggest that the future approach would be for ERI modelers to apply their talents to problems of real volcanic systems, e.g. Izu-Oshima, Asama, or Kilauea. One big step toward a generic integrated model of volcanic activity would be to reproduce actual activity of the "lab" volcano.

Recycling of Materials on Global Scale

Material recycling on global scale is fundamental to understanding volcanism on large scale. For understanding the material recycling correctly and quantitatively, extensive geochemical studies including both trace element and multi-isotope analyses are needed, and several eminent groups in the world are conducting such studies. The group of ERI, led by Professor Kaneoka, has been carrying out studies on volcanic rocks and gases only with noble gas and Be isotopes. Although their work is of high quality and has contributed to understanding part of the material recycling, the information obtained has been limited. As future direction of this group, they intend to investigate relationships between noble gas and Be data and those of solid isotopes and volatile elements. Considering a very small number of researchers of this group, however, it would be difficult to conduct such extensive geochemical studies on this problem at present and in the near future. If ERI intends to continue research on the material recycling at international level in the future, hiring high-quality geochemist(s) as faculty, or much closer collaboration of this group with other geochemistry groups in the University of Tokyo (Earthquake Chemistry Laboratory and Divisions of Earth and Planetary Physics and Geology of the Graduate School of Science) and in other universities should be seriously considered.

Real-Time Seismology

Active research is being conducted at ERI to determine the earthquake parameters (location, magnitude, mechanism) and provide ground-motion information using real-time

data. This project was started with the realization that rapid and reliable real-time information is critically important for mitigating damage caused by earthquakes and volcanic eruptions. Professors Kikuchi and Takano and their colleagues have utilized the most modern methodology in seismology and developed several systems to produce useful real-time information. This is one of the important functions of ERI, and the efforts should be supported.

We encourage ERI to play a more proactive role in utilizing the real-time information for practical applications outside of the academic communities.

5-3-4. Prediction Programs

Within ERI, "Earthquake Prediction Research" is interpreted as "Research on Physical and Chemical Processes leading to Earthquakes", but this interpretation is not understood well among the general public. Also, it is often interpreted differently by different investigators within ERI, which also causes confusion. For both public and internal use, we recommend that ERI develop a summary of its future plans on earthquake prediction research, including a list of priorities for the next 10 years, how each component relates to each other, and how each of these relates to activities of the National Earthquake Prediction Program (NEPP), such as "Telemetered Earthquake Observation", "Scientific Use of Submarine Cable", and "Deformation of Japan Arc" in which ERI has been playing an important role since its reorganization as a SIJU. This summary will clarify the ERI position in "Earthquake Prediction Research" and would help eliminate the confusion among the public.

In this process, some current research toward earthquake prediction is still needed and some may have served its need and should now be phased out or redirected. An example of the latter may be laboratory studies that are being carried out in an attempt to relate fault constitutive relations to some precursory deformations before failure. These have provided valuable rock mechanical constraints on faulting on laboratory scales. Now, the challenge is to take information from these lab experiments and apply it to field-scale problems.

In contrast to "Earthquake Prediction", prediction of volcanic eruptions is a substantially more tractable problem, especially when one is concerned about large eruptions from closed vents. There are ample precursors, and the problem is often to sort out alternate explanations of those precursors, and thus to narrow uncertainties in outcome.

The general approach for future studies in eruption prediction is reasonable, with the possible exception of U-Th studies which do not seem very useful yet. Radiocarbon is far more useful in most instances, and easy to study. Details of what is undertaken in the "precise detection of volcanic anomaly" are not spelled out but are very important. ERI already has a good program with short-period seismometers and some geodetic measurements, but more emphasis on studies with broad-band instrumentation is desirable.

Discussion of gas monitoring was conspicuously absent during the presentation, yet it is an absolutely critical complement to geophysical monitoring. We recommend that ERI should either hire its own volcanic gas chemist, or collaborate with other groups in the University of Tokyo (Earthquake Chemistry Laboratory and Divisions of Earth and Planetary Physics and Geology of the Graduate School of Science), Tokyo Institute of

Technology, and the Geological Survey of Japan. Considering the limited number of faculty slots, serious collaboration should be sought out first.

ERI faces the question of whether they can afford to maintain observatories and unmanned monitoring at the 6 or so volcanoes that they currently manage, especially while these volcanoes are quiet. At present, ERI plans to continue to manage the observatories, but we recommend that they should also formulate, in case it should become necessary to reduce the number of the observatories, an alternative plan to transfer the responsibility to other universities which are geographically closer to the volcano. As senior technical staff at the manned observatories retire, decisions will have to be made about whether to continue manned observation. Scientifically, on-site monitoring and telemetered monitoring centralized in Tokyo would work equally well. However, in terms of societal benefit, it would really help to maintain manned observatories. One option would be to man the observatories by research associates who would enjoy and benefit scientifically from uninterrupted several years in the field.

Another important question is, if ERI decides to focus on a small number of "ERI" volcanoes, how should ERI respond to unrest at other volcanoes, e.g., Iwate, Kuju, etc.? The current policy seems to encourage participation in larger, multi-university efforts. Since responding to unrest can be disruptive in the short-term, but tremendously rewarding in the long-term, we believe that this policy is acceptable.

5-4. ERI's Procedure for Recruitment and Promotion of Academic Staff

In order for ERI to become a truly leading Earth Science research institution in the world, it is important to recruit the best possible candidates for faculty members (Professors and Associate Professors) and Research Associates by advertising positions in widely circulated media such as EOS of the American Geophysical Union, the Newsletter of the Seismological Society of Japan, the Journal of the Volcanological Society of Japan and other publications.

The ERI Faculty Council advertises the open positions in these publications and actively seeks out opinions of outside experts about the candidates for making the final decision. This has been a common practice at ERI (there are some exceptions under special circumstances) at least for the last 10 years, and is a significant improvement over the practice many years ago. We commend ERI's effort in improving the practice.

While 70% of the present faculty members (Professors and Associate Professors) received their Ph.D. from the University of Tokyo, 70% of them have held a position in other institutions. Such outside experience is good, because it will minimize academic inbreeding. However, the following issues need to be considered seriously.

ERI has neither female nor foreign professorial faculty members (Associate Professors and Professors), though there are 5 female Research Associates. Considering the obvious merit of bringing in fresh paradigms, broader perspective, and healthy debates, we strongly recommend that ERI should make conscious efforts to recruit women and foreign scientists with outstanding qualifications to their professorial faculty. Recruitment of women and foreign faculty members might require some special facilities (e.g. child-care facility, language training programs etc.), and we recommend that assistance from the university central administration and Monbusho should be actively sought in this regard.

Judging from the present age distribution of Research Associates, it is expected that

more than 15 Research Associates will be hired at ERI in the next decade. Because future hires of Research Associates will lead ERI research in the next generation, every effort should be made to find the best candidates with outstanding academic qualifications, including well-qualified female and foreign scientists.

The numbers of applicants for the open positions of Research Associates, Associate Professors, and Professors at ERI, are comparable to those at other universities in Japan; however, they are far below the numbers of applicants for similar positions at other comparably prestigious universities in the world. Women and foreign applicants are even fewer. We strongly recommend that the ERI faculty take a more pro-active approach to encouraging foreign and female applications - including advertising in many international journals and personal encouragement to good candidates to apply.

We recommend that an internal mechanism be implemented to periodically review the performance of Research Associates and ensure that they are given enough opportunities to develop their academic career without being swamped by routine duties. This same mechanism can be used for academic promotion of Research Associates.

The postdoctoral fellows at ERI are currently funded by both the Japan Society for Promotion of Science (JSPS) and the Center Of Excellence (COE) program. Those funded by the COE program are selected by the Faculty Council of ERI on the basis of the academic qualification of the candidate. Those funded by JSPS are selected by JSPS. We recommend an alternative system in which the ERI Faculty Council can take a more active role in the selection process of the JSPS-funded fellows.

5-5. ERI as a Shared Institute of Japanese Universities (SIJU)

Many collaborative projects have been conducted under the SIJU umbrella. A novel use of this program is now developing at ERI. This emphasizes intellectual collaborative work (software-oriented approach) sharing all the data available rather than facility-oriented approach. This model of ERI as a "software" type of SIJU (data center, collaborative center) is well suited, for now, to ERI's historically central role in Japanese earthquake and volcano science, and to its greater wealth in data and experience than in large facilities. To strengthen this function of ERI, we recommend that all the data under ERI control be made available freely in a timely manner to researchers at other institutions.

However, the central administration and Monbusho should also be aware that, in order to maintain its pre-eminence, ERI will need to modernize its research infrastructure (laboratories, machine shops, etc.) to keep pace with technological advances and with other universities and government agencies. The current level of funding for the SIJU is small and needs to be increased several-fold immediately, just to satisfy the demand for "software" type of collaboration, and substantially greater funding will be needed within the next few years for infrastructure ("hardware") upgrades.

Judging from the comments made by the staff during the interviews, we believe that the SIJU structure implemented by the reorganization has worked well. Although the workload has increased significantly, the morale of the technical staff is high. The main difficulty is that the reorganization was not supported by sufficient increase in manpower. In order to handle the increase in the technical and clerical work in conjunction with the reorganization, an increase of the technical and administrative staff is desirable.

We feel that the budget for the SIJU program is too small (only 1.8 % of the ERI's non-personnel budget); it is desirable to increase the budget so that this program can have a greater impact on the ERI's function. The contribution of the Center of Excellence (COE) program to this program appears significant.

We also recommend that the projects which were conducted under the umbrella of SIJU and have proved productive should be given special consideration in allocation of funds.

At present ERI has no lodging facility for the visitors under this program. Such facility would allow a more effective use of the travel funds budgeted for this program. We recommend that the university central administration take steps toward building lodging facility for the ERI visitors.

5-6. Educational Activity

We recognize the efforts of the ERI faculty in the university's educational program by training a large number (currently about 85) of graduate students, teaching many courses (e.g. 70% of the courses on solid Earth geophysics in the graduate school of Earth and Planetary Physics are taught by ERI faculty members), and giving seminars at the College of Arts and Sciences. The numbers of Master's and Ph.D. thesis have increased by 55% and 106% since reorganization, respectively, and many of them reflect the unique research programs at ERI. In the solid Earth science programs, many thesis projects take advantage of the extensive observational programs at ERI, and in engineering theses,

seismological studies are closely linked to design of buildings and structures. This reflects the merit of having both science and engineering programs within ERI.

ERI is providing field-oriented, observational courses for both undergraduate and graduate students of the Division of Earth and Planetary Physics of the Graduate School of Science. Considering that the field-oriented courses are diminishing in the University of Tokyo, such courses provided by ERI faculty are valuable. We strongly recommend that these field-oriented programs should be maintained and expanded in the future.

The number of students entering into the solid Earth science is decreasing. ERI's efforts to motivate students before they enter the graduate program should be continued. We encourage ERI faculty to continue this effort taking the advantage of their excellent field and observational programs.

5-7. Visitor Program

Judging from the responses from the visitors, we believe that the visitor program at ERI has been successful in broadening the scope of the ERI research programs and in strengthening ERI's relationship to the outside research communities, both nationally and internationally. We commend ERI's academic and administrative staff for making this program successful. We recommend that continuing efforts should be made to streamline the program by training the administrative staff for taking care of the needs of foreign visitors. The following are specific recommendations on the basis of the visitors' responses.

(1) Prepare a brochure (in English) for visiting scientists which explains clearly the basic rules and conditions of the visitor program.
(2) Provide technical and secretarial support for the visitors who need them.
(3) Schedule more informal seminars and discussion sessions, advertise them widely, and encourage cross-disciplinary participation.
(4) Some social function can be combined with the seminars to promote better interaction.
(5) Encourage and support the administrative staff to improve proficiency in English.

5-8. Outreach

ERI's outreach tasks should have at least 3 separate elements. One is with local organizations such as utility, communication, construction, and transportation companies and emergency services organizations. The present structure in ERI is inadequate to carry out effective outreach activity in this area. We recommend that research-oriented engineers be hired to link between the user community and ERI mitigation researchers.

Second is with other government agencies such as the Japan Meteorological Agency and the Science and Technology Agency. The main objective would be to facilitate easy access to data collected by different agencies. ERI should lead the effort for extensive data sharing.

The third kind of outreach is with the public. The ERI faculty has made significant efforts in public education through media appearances and public lectures. However, we believe that more effective outreach is desirable considering the strong interest of the public in the present status of research on prediction and forecast of earthquakes and volcanic eruptions. ERI is utilizing a web site for this purpose. This would be a perfect

place for clear statements of mission, definition of earthquake prediction research, current and future directions, relations between the various parts of ERI, etc. The web site is also a good place for effective public relations, getting students interested in earthquake and volcano studies. We commend ERI's efforts in this area. The VRC web page is very useful and in effect is the primary source of information on all current and recent volcanic activities in Japan. We encourage ERI to expand their efforts in this area.

5-9. Research Environment

Support Staff

The number of support staff has decreased because of the general government policy. Considering the importance of highly-trained support staff for carrying out the ERI programs, some changes are essential.

Several possible measures are: 1) Following the new guideline on employment of non-permanent staff (February, 1999), more temporary staff should be hired in Research Departments and Centers. However, proper personnel management would be needed. 2) Evaluate the existing programs (including research programs), and if some programs are deemed inactive, discontinue them so that retraining and reassignment of staff could be made to support the more important programs where technical support is needed. 3) Efforts should be made to improve the salary base commensurate with their technical skill and the working environment for the support staff.

We understand that the maximum salaries that would be available to technicians are too low to attract and keep the caliber of technical support that a high-tech operation like ERI requires. The inescapable fact is that modern science requires very high levels of technical support, from computer programming to sophisticated electronics design. The ideal is for the university and Monbusho to introduce a higher salary system for highly qualified technicians in the university. Introduction of this or some other system should be seriously considered by the university's central administration and Monbusho to improve promptly the conditions for technicians in the university.

Main Building

The main building of ERI was designed and constructed during the period 1963-1968 under the old Building Standard Law of Japan, and the building does not satisfy the current requirements for seismic performance. The members of ERI are expected to perform various functions in analysis, research, coordination and public information during a major earthquake in the Tokyo area, so that it is important that the seismic performance of the building must satisfy at least the current minimum requirements.

The seismic performance of the main building was evaluated in 1996 as part of review of the emergency management system. This review concluded that the building of ERI would be severely damaged or nearly collapse during seismic motion from a large earthquake that could occur in the Tokyo area. Even without earthquakes, we noticed during the site visit obvious signs of deterioration in the machine shop area. We recommend that the university administration take immediate action toward rebuilding or retrofitting of the main building so that ERI will be able to function properly during a major seismic event.

Space

In general the space available for research and education is very limited. The following are examples. (1) The Ocean Hemisphere Research Center currently resides in the building designed for satellite telemetry. (2) ERI has currently 5 open positions for Associate Professors; however no office space is available if these positions are filled. (3) The planned reorganization of the Graduate School of the Department of Earth and Planetary Physics would result in 20 to 30% increase in the number of students, and require 4 more student offices. (4) Storage space is very limited. The large equipment for ocean-bottom seismometers and almost 100 seismometers for exploration studies require extra storage space. (5) The present space for chemical analysis facility is too limited to function efficiently. We recommend that ERI Director request immediate action from the university central administration and Monbusho to solve these space problems.

On a long term, we feel that the space problem should be looked into with the following considerations. As the increase in the large equipment and facilities, ERI would face another space problem in a matter of a few years, even if the problems listed above were solved temporarily. Because of the nature of the ERI programs which have both academic and social implications, we feel that it would be advantageous for ERI to share some facility, space and personnel with the Department of Earth and Planetary Physics, and other government research institutions such as those of STA. At present, because of the planned merger of Monbusho and STA, and reorganization of the national universities, some uncertainty exists regarding the organizational relationships among these institutions. However, regardless of the final structure, we believe that close collaboration sharing facility and personnel would be extremely advantageous for effective use of academic products for mitigation of earthquake and volcanic risks. At least in the U.S., such close collaboration has proved extremely productive. In some U.S. universities, e.g., University of Arizona, new earth science buildings are shared by and have been partially financed by the U.S, Geological Survey.

Considering the seismic performance of the present building and the ever-growing space problem, we recommend that the ERI faculty seriously consider a proposal for a better and larger building that can be shared by the Department of Earth and Planetary Physics, Departments of Civil Engineering and Architecture, STA, and other agencies working toward a common goal, earthquake and volcanic risk mitigation.

Library

The library of ERI has the most extensive holdings of Japanese and foreign journals and books on earthquake-related science. We recommend that ERI make every effort to sustain this world-renowned library for seismology and earthquake engineering. The structural integrity of the library against earthquakes should be carefully examined.

Laboratory for Technical Development and Support (LTDS)

Despite the enthusiastic staff at LTDS at ERI, the present facility is inadequate to support cutting-edge research. Such research often requires development of equipment which is not commercially available. We believe that ERI deserves LTDS with modern machine/electronic shop.

Publication

The research results should be published in English in widely circulated international journals. Although this should be the common practice, the papers of local interest should be published also in Japanese.

Monthly Seminar (Danwakai)

The monthly seminars of ERI has been one of the most important academic events for many years. Several staff members (some retired) expressed concern that the seminars are not as active and lively as they used to be. In particular, participation of faculty members seems to have significantly declined in recent years. If this is true, ERI Director, upon consultation with the faculty, should take immediate action to revitalize it or implement an alternative forum for scientific communication and interaction for the ERI members.

5-10. Review System

The Annual Report has played an important role for reviewing the research programs at ERI and has improved communication of the ERI research activities to the outside world.

Review of research performance of the faculty members themselves is important. One way to conduct this review would be for ERI Director to implement a mechanism with which he can solicit opinions from internal and external sources. However, within the present government rules, such a review system may not be effective, and self-discipline on the part of each faculty member and peer review would be most important for academic health of ERI.

5-11. Future Plan

The ERI Faculty Council has made an innovative future plan. This plan emphasizes (1) research on the dynamics in Earth's interior especially in the Western Pacific Ocean, (2) basic studies on physical and chemical processes leading to an earthquake and a volcanic eruption, (3) development of a new research field to handle complex earthquake and volcanic processes using a concept of non-linear interaction, (4) research on disaster mitigation methods that take into account the complexity of earthquake and volcanic processes. In addition to these specific research programs, the plan emphasizes the importance of small embryonic projects which require long-term support.

The plan includes an efficient research support structure with an extensive training

program.

The plan also emphasizes the importance of ERI's role in education. Their field-oriented, interactive observational program will provide students with the first-hand experience with natural phenomena, such as earthquakes and volcanic eruptions.

We reviewed the details of the plan and found it innovative and well thought out. Although there is some weakness in the plan (see below), we believe that this plan will help ERI to achieve the stated missions in the best possible way. We endorse the overall concept presented in this plan, and strongly recommend that steps be taken immediately to implement it with periodical review and modification as needed.

The plan emphasizes a better understanding of volcanic processes on various time scales. There are interesting scientific problems related to long-term forecasts, though few mitigation measures are undertaken in response to such forecasts. An equal or even greater number of interesting problems remain for short-term forecasting, and many effective mitigation measures can be undertaken in response to short-term forecasts. We endorse the overall ERI approach of examining various time scales, provided that short-term work on volcanic eruptions is kept prominent in the Future Plan.

The plan emphasizes basic studies on physical and chemical processes leading to an earthquake. While the present research activities at ERI cover well the processes immediately following an earthquake (e.g. coseismic rupture process, wave propagation etc.), the expertise of the present ERI faculty is insufficient to tackle the long-term processes preceding an earthquake where the physics and chemistry of fluid-filled crust on all space and time scales is important. We recommend that ERI strengthen their expertise in this field by either bringing in a faculty member, redirecting the existing programs, or having much closer collaboration with other groups outside of ERI.

We noticed that the Future Plan lacks in the details on the plans for mitigation research. "Mitigation" is one of the important missions of ERI, and we feel that ERI faculty should articulate on how they are going to bridge the basic research on earthquakes and volcanic eruptions to mitigation of damage caused by them. For example, the future plan discusses from small-scale experiments on rock samples to a large-scale observational network of the Western Pacific (OHRP), and implies that these scientific programs will be connected to the stated goal of "mitigation" through assessing the state of stress in the crust. We feel that ERI needs to articulate on this connection so that public and Monbusho can understand better what approach ERI is planning to take to accomplish their specific goals.

In view of the increased coverage of seismic networks run by government agencies (STA, JMA), ERI seismic networks should be project-oriented rather than monitoring-oriented. However, for certain projects, long-term monitoring network can be important. ERI faculty council should review the merit of each of ERI-operated network regularly (e.g. every 5 years) to decide whether the network should be continued, transferred to other agencies or terminated.

The situation for the networks for volcano studies is different. In view of the absence of major network operations by government agencies, some monitoring-oriented networks would be necessary.

6. Summary of the Response from the ERI Visitor

Before the site visit, there was some concern on the part of the Review Committee that the short site visit would not give the committee members enough time to fully assess the present status of ERI. To rectify this potential shortcoming of a site visit, we decided to conduct a survey, by sending a questionnaire, of the former and present visitors to ERI who have stayed at ERI for a considerable period of time doing research. We found the responses to this questionnaire extremely helpful to fully appreciate some of the important issues concerning ERI. The name of the visitors and the questions are listed in the Appendix.

Of course, every visitor has some special association with particular hosts at ERI; in this sense, their opinions may not be completely objective. Nevertheless, we found a common thread in the opinions of the visitors on many important issues. The following is the summary. On some issues, we noted significant differences of opinions among the visitors, and there are also some minority opinions. We tried to carefully consider them in proper context in making the final assessment.

Q-2-1 Faculty Members

Almost every visitor considers that the ERI faculty members(Professors and Associate Professors) whom they were associated with hold a very high academic standard, and are excellent researchers. Some of them were regarded as world-class scientists with the highest caliber. However, some visitors commented that many of the faculty members are over committed with committee meetings either inside or outside of ERI. This excessive commitment is viewed counterproductive for doing creative research. Also, many visitors observed that some faculty members are swamped with routine administrative paper works, perhaps because of the insufficient administrative staff.

Several visitors commented that scientific interaction between different disciplines is very limited. This lack of interaction gave the impression to some visitors that, despite the high caliber of the faculty, ERI is not a very lively research environment and its impact on Earth science is relatively small. Some visitors regard ERI as a world-class institution, but their impact could be strengthened by encouraging young researchers to explore cutting-edge ideas.

One visitor suggested that, considering the ERI's research program, ERI would benefit from adding more field geologists to the faculty.

Q-2-2 Research Associates

Research Associates are in general highly rated academically. However, some visitors commented that their work is often too rigidly constrained to the project of their group, and they should be encouraged to expand their repertoire. Several visitors had the impression that some Research Associates are overloaded by the jobs that should normally be left to a technical staff person.

Q-2-3 Technical Supporting Staff

Many visitors found the ERI technical staff very helpful; however
there were some instances where difficulties were encountered, partly because of the language problem.

Comments on secretaries vary considerably depending on the experience of the

individual visitor. Most visitors who needed secretarial help were satisfied, but some had difficulty getting any support. They felt that secretaries have not been given a chance to train and improve themselves, and they are not adequately trained and supervised as secretaries.

Q-3 Education

Most visitors commented that the ERI students are bright and well-educated in mathematics and sciences, but they would benefit from more active participation in discussion and seminars. In general, the visitors feel that the ERI's educational program is in good shape.

Q-4 Administration

Most visitors found the administrative staff courteous, friendly and helpful, despite occasional difficulties in communication. However, some visitors experienced difficulties with the paper work and practical matters before and immediately after their arrival. This could be due to the complex administrative system and the ambiguity in the administrative language in Japan. Some visitors suggest that a brochure for visiting scientists which explains clearly the basic rules and conditions of the visitor program would be very useful. Several visitors were apparently surprised by the large staff of the administration department. However, this is probably a matter of comparison with the institution of their home country where the administrative structure is very different.

Q-5 General

Several visitors found the ERI library staff very helpful. The ERI library is rated excellent with extensive holdings of Japanese and foreign journals and books. One visitor said that it is an international treasure which needs to be sustained.

Several visitors commented that the seminars are not advertised well, and not consistently well attended. They recommend that ERI should have more informal cross-disciplinary seminars encouraging active participation of young researchers and students.

A few visitors felt that some social events may promote more interaction.

Two visitors made an interesting comment on the ERI's function. Judging from one of the stated missions (earthquake prediction) of ERI, one visitor felt that ERI should embark on development and testing of prediction methods. The opposite opinion is that since the possibility of practical earthquake prediction is now in question, ERI should be merged with the Department of Earth and Planetary Physics to focus on more basic research. These opinions appear to be a result of confusion caused by ambiguities in the ERI's statement of their goals.

Many visitors recommend that special efforts be made to improve communication skills for scientific presentation.

Appendix

Letter to visitors from Chairman of the Review Committee

Dear xxxxxx:

I was asked to chair an external review committee of the Earthquake Research Institute (ERI), University of Tokyo. Knowing that you have stayed at, or are now visiting, the institute, we would very much like to have your input from your personal experience at ERI. Your candid opinion would help us to conduct a thorough and objective review process. To minimize the demand on your time, we have prepared a set of questions attached to this mail. Please send your response directly to me before March 31, 1999. We would of course welcome any comments you might have. Your response will be treated confidentially only within the committee. Your comments will be summarized in the final report without any specific reference to your name. Your name will appear on the list of visitors.

Best regards,

Hiroo Kanamori
Chairman of the Review Committee of ERI
Seismological Lab., California Inst. Technology
Pasadena, California, U.S.A.
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Questionnaire

[Q-1]
- (1-1) Your Name:
- (1-2) Your Affiliation and Position.
- (1-3) Period of Stay at the Earthquake Research Institute, Univ. Tokyo.
- (1-4) Major field of your study.

[Q-2] Staff
- (2-1) How do you rate the Faculty Members
- (2-2) How do you rate the Research Associates.
- (2-3) How do you rate the Technical Supporting Staff.

[Q-3] Education
- (3-1) Your impression on the training/education of graduate students.
- (3-2) Your impression on the cooperative research with Postdoc. fellows.

[Q-4] Administration
- (4-1) How do you rate the Administration staff.

[Q-5] General
- (5-1) Advice and recommendations in general.

List of visiting scientists who responded to our questionnaire.

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