外部評価報告書

Report of the External Review Committee

2006 年 5 月

May 2006

東京大学大学院理学系研究科

地球惑星科学専攻

Department of Earth and Planetary Science

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Contents

[I] Report of the External Review Committee of the Department of Earth and Planetary Science, University of Tokyo, March 2006

This report summarizes the deliberations of the External Review Committee for the Department of Earth and Planetary Science, University of Tokyo held on 9 to 10 March, 2006. Report of the educational and research activities of the Department was produced by the Department and distributed to us prior to the meeting of the Committee. The members of another Review Committee, which was commissioned earlier in April, 1999, were also requested to submit their comments to the above Report. We used their comments for reference but drafted our recommendations entirely based on our own viewpoint. Names of the Members, Schedule of the Meeting, and comments of the earlier Committee members are attached to this report as Appendices.

1. Overview

Since the last Review was held seven years ago, Departments of Earth and Planetary Physics, Geology, Geography, and Mineralogy have merged and Department of Earth and Planetary Science has been established. Groups of scientists who specialize in various disciplines of Earth and Planetary Science have been assembled in a single group, and can now address this science multilaterally in complementary manners. Fortuitously the Building #1 of the Faculty of Since was expanded in the same time period and most of the offices and laboratories of the new Department are located in the common building. We note with satisfaction that new research programs have already been initiated that are based on collaborations among various disciplines of Earth and Planetary Science, and hope that these initiatives will expand where unique research topics are explored and collaborative programs are launched.

Overall quality of research in this Department is high and above average in most disciplines. However, we believe that we could ask more to the University of Tokyo considering that it is at the helm of the Japanese academia. We would expect the Department of Earth and Planetary Science in this University to be on the forefront of research world-wide and produce young researchers who will play leading roles in the international science community. While continuation and pursuit of research in traditional areas and by traditional means are no doubt meaningful, we hope that the Department would make best efforts to identify the disciplines where critical advances are expected and encourage their development.

The Head of the Department should play a leadership role in promoting the research programs strategically in the Department. From this viewpoint, the current tenure of one year for the Department Head is untenable. The Department should give more than several years of tenure and delegate stronger functions to the Head by electing a person highly qualified in both science and management. At the same time an Executive Group should be formed by representatives of research groups to assist the Department Head and accelerate the decision making. Administrative staff of the Department should also be strengthened to reduce the burden on the Department Head.

The most important mandate of this Department is to educate creative and leading scientists and contribute to advances of Earth and Planetary Science in the international arena. We could even say that

whether or not the Earth and Planetary Science in Japan can compete with other branches of science depends on the activity of the graduates from this Department. To assist future planning of the education program we strongly recommend that the Department conduct a survey of the graduates and see how successful the Department has been in producing leading and influential scientists. We also note that the requirement for the Ph.D. degree of publishing at least one paper in refereed international journals represents a minimal condition of an independent researcher and should not be compromised. This probably implies that students should be carefully screened for admission to the Ph.D. course, and it may be worth considering reduction of the ratio of students in Doctor to Master course.

This Department is the core member of the 21th Century COE Program “Predictability of the Evolution and Variation of the Multi-Scale Earth System” and has been driving this program vigorously. In spite of the limited funding, this Program has been producing pioneering results on the subject of variations of the Earth system. It has also strengthened measures to foster younger generation of scientists by establishing a course on Predictability in Earth Science and by introducing the overseas internship program. These measures have played an important role for identifying and promoting outstanding scientists while educating a large number of students. Accomplishments of this COE Program have received high marks at the interim review held in 2005. We hope that unique findings on the Earth system variations continue to flow out from this Program and the fostering of the younger generation will be strongly promoted.

Members of this Department have played very important roles in uniting the community of Earth and planetary scientists as well as in outreach activities aimed at citizens. Specifically, we laud their resilient, unselfish efforts to hold a joint meeting of a large number of national societies on Earth and planetary science that have culminated in the establishment of Japan Geoscience Union in 2005. We believe that establishment of this Union has a great significance to future of the Earth and planetary science in Japan as it collectively represents the whole geoscience community in the Japanese academia.

2. Review of Each Group in the Department

2.1 Atmospheric and Oceanic Science Group

The Atmospheric and Oceanic Science Group consists of four subgroups, Atmospheric Physics, Physical Oceanography, Climate Dynamics, and Ocean-Atmosphere Material Circulation Physics. The group has been conducting and publishing highly original contributions. Examples include formation mechanisms of the Okhotsk High, Siberian High and storm tracks, the dynamical mechanism of super-rotation of the Venusian atmosphere, global distribution of vertical diffusion intensity in the ocean, the dynamics of El Nino and the Indian Ocean Dipole mode, and formation and transport of nitrogen oxides in the atmosphere. This group ranks internationally among the top in research activities and achievements in this field, and it has also been successful in producing a large number of brilliant students. The group is conducting research under the strong cooperation with other institutions in the University such as Center for Climate System Research (CCSR) and Ocean Research Institute and with outside institutions such as JAMSTEC. Members of this group have taken a strong leadership in these cooperative research activities.

Position of the professor for Atmospheric Physics subgroup had been vacant for a while until a new appointment was made last year. One professorial position for Ocean-Atmosphere Material Circulation Physics subgroup is still vacant. In spite of these vacancies the other faculty members have made significant achievements. Traditionally, the atmospheric science subgroup has been strong in atmospheric dynamics, but in cooperation with institutions such as CCSR, the subjects covered by the Department has been expanded to include the whole current topics of interest in atmospheric science such as modeling, meso-scale meteorology, radiation and atmospheric chemistry. This subgroup is expected to play a central role in Japanese science community in this field. Since environmental issues such as global warming, ozone depletion and large-scale atmospheric pollution are becoming important, association of atmospheric dynamics with trace material science would become more and more important. Taking this international trend into account, this subgroup is expected to produce world-level research results in the areas of its member's specialty. For Ocean-Atmosphere Material Circulation Physics subgroup, studies on density change and transformation of materials in the atmosphere and ocean due to advection and transport, as well as on the materials themselves, are expected to be developed.

The Physical Oceanography subgroup has been carrying out studies on various physical processes in the ocean, including multi-scale turbulent diffusion processes from geostrophic turbulence to small-scale turbulence, temporal and spatial variability of ocean surface mixed layer, and others. Recently, they have been focusing on the topic of global distribution of the strength of vertical turbulent diffusion which is considered to control the deep general ocean circulation, and obtaining quite interesting results. Namely, the energy provided to the ocean by atmospheric disturbances and oceanic tides seems to be cascaded down to the small-scale turbulence by way of internal wave-wave interactions which have a strong latitudinal dependency, and hence the strong vertical turbulent diffusion is limited to the low-latitude areas. They showed those features for the first time on the basis of both theory and observations. In the future, the areas of strong vertical turbulent diffusion, which are called "turbulent diffusion hot spots," are expected to be identified globally, and the new view of the deep general ocean circulation would be established.

The Climate Dynamics subgroup has been involved in topics of interannual variations like El Nino, decadal and interdecadal climate changes, and predictability of global-scale climate changes. Recently, they have been intensively carrying out studies on the large-scale interaction between the ocean and atmosphere in the equatorial region with a close cooperation with JAMSTEC. The Indian Ocean Dipole mode phenomenon, which was originally discovered by this subgroup, has been studied intensively, especially on the role of intraseasonal oscillation in its development and decline, its relationship with El Nino, its effect to the global climate, its long-term modulation, and others, on the basis of data analyses and numerical modeling. They have also provided interesting results on intraseasonal variations associated with coastal Kelvin waves and equatorial waves in the Indian and Pacific equatorial regions. They have also comprehensively revealed existence of the annual El Nino other than usual El Nino in the Pacific equatorial region. All these results are on the forefront of the physical oceanography and climate change research internationally, and their further contributions are expected in the future.

The Atmospheric and Oceanic Science Group developed an atmosphere-ocean coupled model called UTCM (University of Tokyo Community Model). Although this kind of coupled model exists in many institutions in the world, this model is unique in its educational role. Usually, the coupled models are so complex and difficult for students to understand, so that the models are treated as black-boxes. However,

the UTCM is designed to be modified and improved by students. Through the use of this model, it is expected that the cooperation between atmospheric subgroup and oceanic subgroup will be promoted, as well as between this group and other groups such as Earth and Planetary System Science Group. We highly appraise this unique approach.

An increasing cooperation within the group is desired for further developments. The seminar by all members of the group is held regularly once a month. Such a seminar is very important for cooperation among staff members and for young students to obtain wide viewpoints. We hope the cooperation will be enhanced through the seminar.

This group has been conducting world-class research, and we hope that the group keeps research activity high and produces young brilliant scientists.

2.2 Space and Planetary Science Group

The Earth used to be the only planet where such basic properties as internal dynamics and magnetic field could be known. However, since mid 20th century there has been a very substantial growth in observations on other planets, and the Earth science has evolved into the planetary science. Not only planetary science has a wealth of extremely interesting scientific problems, but comparative studies of the Earth and planets provide important clues to understanding of the Earth itself. The name of this Department can be taken to reflect the expansion of the scope of the Earth science, and is supposed to attract students wishing to learn the subject from the broadened perspective.

However, according to the materials provided to the Committee, there seems to be few faculty members in the Space and Planetary Science Group who are specialized in research in solid bodies of the planets. Only meteorites are studied. Research based on meteorites aims at clarifying the evolution of various planets out of the condensation and evaporation processes and it is tied to understanding of the formation of the Earth in the early solar system. We appraise achievements that have been made on mineral composition of meteorites, stable isotope, radio isotope, and rare earth elements/minor constituents by analysis and laboratory experiments. However, now that organic substances have been detected in space that could have important bearings on the origin of life, we recommend that the scope of the research be expanded, unlimited by the objective and methods of the foregoing activities. We also recommend that the important results be shared broadly by close coordination with Earth and Planetary System Science Group, Solid Earth Science Group, and Geosphere and Biosphere Science Group.

It has come to our attention that planetary science as well as Earth science with the planetary perspective takes rather small part of the research programs in this Department. Part of the reason could be the recent departures of several planetary scientists from the Department, but at present the name of the Department does not represent its substance. We are afraid that some students are being disappointed.

Exploration of planets and small bodies in the solar system is expected to be carried out as one of the principal targets of the space development in the 21st century, and the planetary science will be pursued actively as an international endeavor. We hope that this Department will promptly take effective measures with the aim of taking a leadership role in this fertile field of research, including employment of faculty members from overseas.

Japanese scientists have been on the forefront of research of space that extends from the Earth's exosphere/ionosphere and to the magnetosphere and heliosphere, and scientists of this Department have been recognized as leading members of the international community. They have studied such key processes as reconnection and collisionless shock, and their interest is extending from the Earth's magnetosphere and the heliosphere to ionospheres/magnetospheres of Mars, Venus and Mercury as well as space around the Moon. They also take part in the Venus mission of Japan and it can be expected that collaboration with atmospheric scientists in the Department will develop.

Processes like particle acceleration by the collisionless shock wave are universal processes that play key roles not only in the magnetosphere and heliosphere but also in astrophysical objects, so that outcome of the space research can be used in astrophysics for the clarification of the cosmic phenomena as well. In general, Earth and planetary science has close connection with other disciplines of science, and developments of interdisciplinary collaboration are to be encouraged in other areas as well so as to deepen and broaden the research conducted in this Department.

2.3 Earth and Planetary System Science Group

The uniqueness of this group is that it addresses the Earth system with special attention to the aspects related to the stability and instability of the system. Members of this group are conducting world-class research on formation, stability, and dynamics of the Earth systems as well as the ecology and relation to the human activity. They are conducting high level studies also on early environments of the solar nebula, formation and evolution of the Earth and planets, and core formation. They are also studying the formation conditions of the habitable planets, snowball Earth, interaction of the mantle and core, and mantle convection. They also conduct challenging international projects of the interdisciplinary character aimed at clarifying the early Earth system. Very interesting studies on the catastrophy of the asteroid impact at K-T boundary and on the relation of the uplift of Himalaya area to Asian monsoon, that is, a linkage between tectonics and climate, are currently in progress. The relation of Asian monsoon with the human activity and environments is also one of the important research topics conducted in this group. The presence of this group that has world class achievements is a unique feature of the Department of Earth and Planetary Science.

This group is strong also in education. It organizes several interdisciplinary seminars such as Earth and Planetary System Science Seminar, Earth and Planetary Science Colloquium, and Earth Environmental Science Colloquium. They also conduct several complementary disciplinary seminars by collaboration with the staff of the other groups. This system is working well for improving education of graduate course students.

We have high expectations of the pivotal role this group can play in this Department. Members of this group are expected to lead the effort to summarize and synthesize research activities and their achievements of the whole Department from the viewpoint of the system science. They are expected to organize the research efforts across the groups and serve as an intermediary or leader to establish unique projects that exploit the potential of the whole Department. We also note that participation of graduate students in such programs will give them precious experiences in designing their research from the

viewpoint of the synthesis.

2.4 Solid Earth Science Group

This group conducts education in three separate subgroups that cover Earth's interior, generation of earthquakes, and geomorphology. The research in this group addresses topics on processes in the Earth's deep interior and plate boundaries. Main topics on the Earth's deep interior are the structure and dynamics of the mantle and the magma processes. The surface tectonics and geography and the focal process of earthquakes are the major topics on the plate boundary processes. The staff of this group conducts high-level studies by using a variety of tools such as theory and calculation, field survey and field observation, and experimental works in the laboratory. Some of them have obtained excellent results in their respective research fields, and some have built unique programs on the above topics.

However, some of the issues pointed out at the previous Review Committee remain unsolved. Collaborations among the staff in the sub-disciplines in this group are limited and still in an early stage of development. Research being conducted in the field of the Earth material science by the staff in several diverse groups of this Department has not been well coordinated and education in this field also seems to suffer as a result. More effective cooperation with geochemists in other Departments is also needed.

We believe that members of this group have high potentials for making excellent research in geophysics, geology, and petrology. However, as it stands, they are working independently essentially without collaboration even within this group, although there are clearly several topics to which the members have a common interest. This situation is not only unsatisfactory for improving the research but also would make the group a weak contender in seeking financial support as long as the group does not have an effective system for designing comprehensive research proposals. Since the government encourages submission of strong proposals on research projects and is prepared to provide substantial funding, this group needs to build effective structures or systems to meet the challenge.

In order to improve the current situation of the research and education and to build one of the world centers of Earth and planetary science by using the capability of the members, it is important to introduce systems where the members interact strongly while maintaining independence. They need to expand their capability by forming projects by combining capabilities of individuals. We can find some seeds for such a development in the research conducted by some individuals in the group, which can be expanded to leading research projects. The performance of this group could be enhanced significantly by strengthening the interaction among the members when they form subgroups. We hope that this group will be able to educate students in such environments and produce scientists who can lead the world community.

2.5 Geosphere and Biosphere Science Group

This group has its principal aim to understand the mechanisms behind the coevolution of the Earth and life and to find the correlations between organic and inorganic matters in Earth history. The group conducts researches in material science, sedimentology, mineral deposits, and evolutionary paleobiology and has

made significant contributions at the international level. The group has made additional efforts to relate diverse subjects and research methods by having a departmental seminar. This has resulted in a diversity of courses and other learning opportunities for students. In the last external evaluation the Review Committee suggested that the research group should explore a new field, Earth microbiology. The research group has studied the microorganismal community in deep sea vents and methane-hydrate as a result of microorganismal activities. These have been highly evaluated as a marriage of new approaches both from geology and from paleobiology. The current Review Committee would like to see further development of this field of research. There is a need for more close and active collaboration between scientists in geophysics, environmental studies and paleobiology.

The origin of life and its early evolution are one of the most important issues for mankind. We would like to see this group start exploring this field and eventually becomes one of the world leaders in this field. In trying to understand the surface environment of the early Earth and early life on it, we have become aware of the importance of anaerobic and thermophile archaeobacteria and of considering the system of circulation of chemical elements. This group took part in an international joint project called “Archean Park”, which studied the physical, chemical and biological conditions of underground microbes in hot-water seabed activity, but participation from this group was limited to a few researchers. In order to make more significant contributions, the group should further the study of biology of extreme conditions and strengthen paleobiological studies while maintaining fieldwork-based geological studies. These changes would help the research group to define its research and educational goals. One option to consider is to transfer geo-material research to the Solid Earth Science Group.

In most part of the over-four-billion-year history of life, life meant microbial life. It is, however, essential to look at the evolution of higher organisms in the last 600 million years since the Cambrian explosion in order to discuss the future of the planet. The University of Tokyo has been one of the world's leading institutions in paleobiology with a strong background in comparative biology of extant species. This group has made important contributions in studies of predator-prey interactions as a crucial component of evolution. We encourage the group to develop collaborations between paleobiology and other field of studies. Needless to say, the history of life from its origin to modern times has been influenced by environmental changes on the surface of the planet. These changes are the result of a complex system which involves the mantle and core of Earth as well as its crust, water and atmosphere. With the increase in our knowledge of meteorites and other planets, the possibility is emerging that the existence of life may not be unique to our planet. The study of the origin of life has significance beyond the Earth.

This research group is expected to act as one of the world leaders in the studies of the origin and evolution of life. This goal can be achieved by redefining the research activities and placement of competitive scientists. We encourage the group to train graduate students to be leading scientists in this cutting-edge field.

3. Structure of the Department

It seemed to the Committee that most of the researchers in this Department are granted a broad range of autonomy, regardless of the official hierarchy. In a sense this is welcome, since independence of mind is the very basis of original research. However, in case the autonomy should develop so far that interaction among the researchers is weakened, it could adversely affect improvement of the research quality through mutual interaction and build-up of large-scale programs. The optimal situation should be that independent minded researchers share the common objectives, actively interact, and join their forces to build an ambitious program.

This Department has a number of adjunct faculty members from the Research Institutes and Centers in and outside the University of Tokyo. Their presence has been instrumental in expanding the area of research and diversifying the methods of research, but we would like to make sure that the same criteria are used for their appointments as for the faculties of the Department.

The previous Review Committee recommended strengthening of the geochemistry group. The situation now is that there is a geochemist in the Earth and Planetary System Science Group, and two geochemists from the Laboratory for Earthquake Chemistry and several of them from the Research Institutes in the University have joint appointment with this Department. Thus, although geochemists do not form a single unified body, there are a reasonable number of geochemists in this Department.

The previous Committee also pointed out the weakness in the structure of the Department, namely, the number of positions of the Jokyo (Assistant Professor or Research Associate on the university payroll) had declined, there was shortage in the administrative and technical staff members, and the faculty members were overburdened by administrative tasks. These have had serious negative effects on the improvements of education and research. Unfortunately, the situation has not changed very much since then, and the times the faculty has to spend for management appear to have increased due to shortage of the supporting staff. In fact the same situation is commonly seen nowadays in Japanese national universities everywhere, and becoming an increasingly serious obstacle to scientific research in Japan. The issue is obviously larger than this Department is to deal with, but we hope that it will make best efforts to remedy the situation through strategic planning.

We believe that several of the items noted in this Report require prompt attention, and hope that action will be started soon.