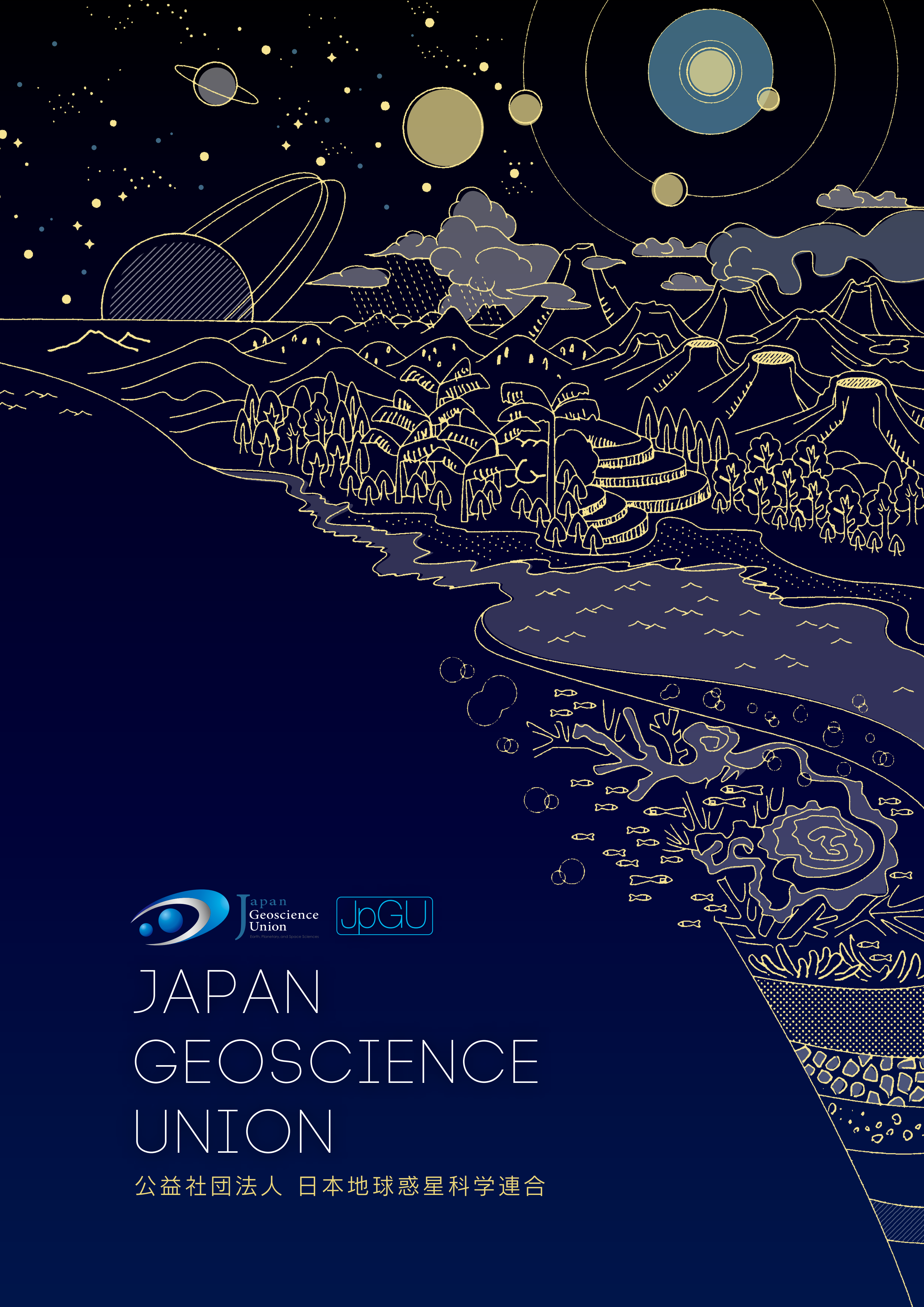

JAPAN GEOSCIENCE UNION

公益社団法人 日本地球惑星科学連合

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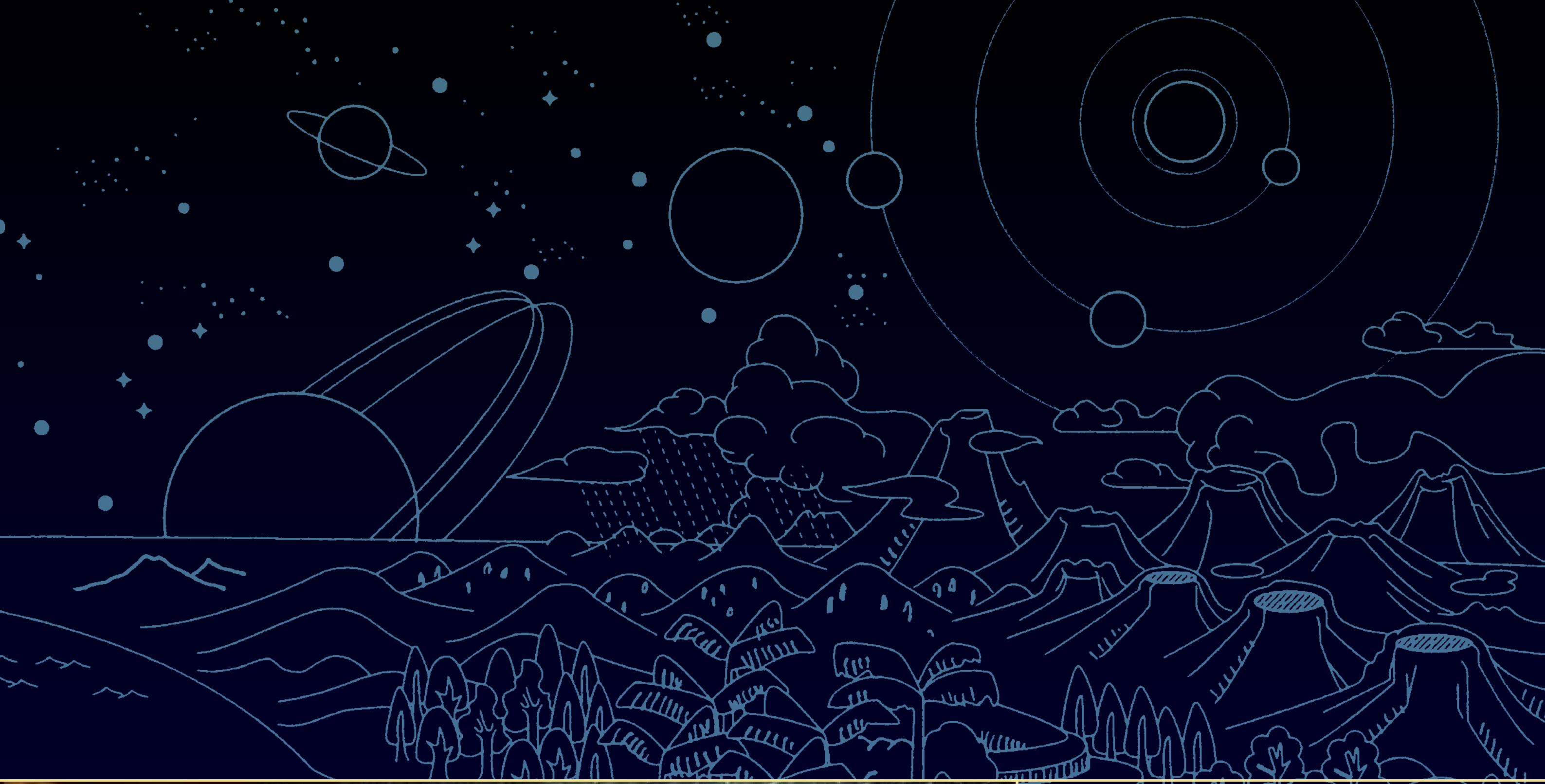
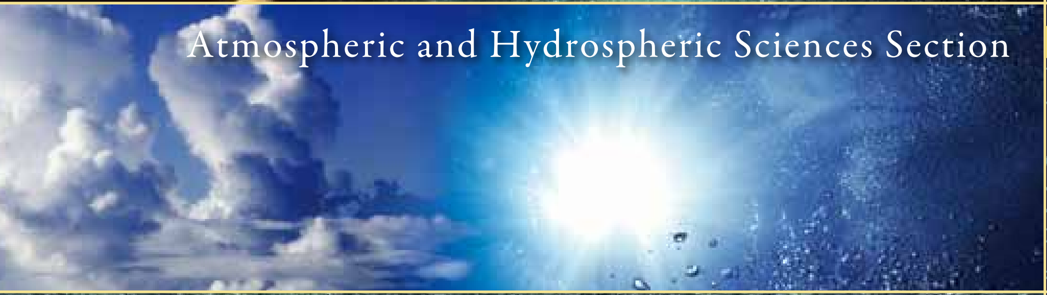
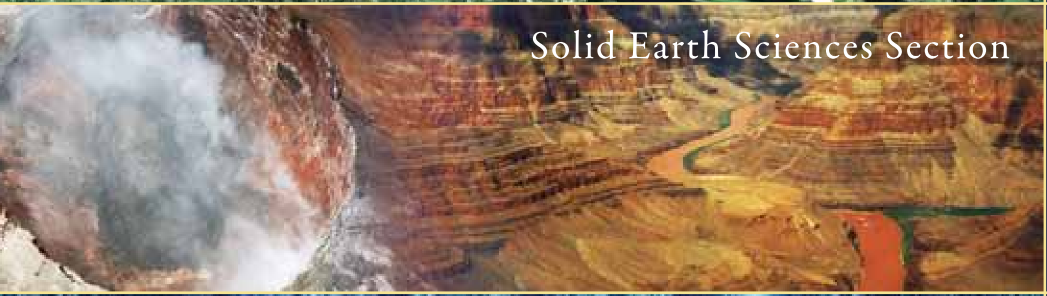






日本地球惑星科学連合
Japan Geoscience Union

The Japan Geoscience Union (JpGU) is the academic organization that represents the geoscience community in Japan. It consists of 50 member societies and over 10,000 individual members including researchers, technologists, students, educators, science communicators and interested members of the general public. Geoscience can be roughly divided into pure and applied areas, the first concerned with increasing our understanding of natural phenomena and the second with using this knowledge to help to deal with environmental problems, to mitigate natural disasters and so on. In this section we first provide a little more detail on these two facets of geoscience and then explain the JpGU and its activities.

Fundamental Geoscience

Geoscience is the area of natural science that deals with the Earth, the other planets and, on a larger scale, with the whole of the solar system. On the Earth it aims to understand the dynamics governing the evolution of both natural phenomena and social systems. It also aims to clarify the essential features that contribute to the existence and evolution of life.

The following is a list of some of the many diverse research areas where the geoscience community is hoping to provide new understanding:

- ◆Regarding the Earth as just one of the planets in our solar system, which in its turn is one of many many such systems in our galaxy, we seek to provide an objective understanding of the extent to which the factors that allow the Earth to host life are universal and to what extent our planet is special or unique.
- ◆We seek to understand the influence of variations in solar activity on space in the vicinity of the Earth and on the Earth's atmosphere. At the same time we are interested in the chemical composition and movement of material in and between the atmosphere, the oceans and landbound bodies of water, and, at greater altitudes, interactions with the ionosphere and the magnetosphere.
- ◆We aim for a unified understanding of the changes and evolution occurring inside the Earth and other solid planets. We want to understand these processes on a range of spatiotemporal scales, from almost instantaneous events such as earthquakes and volcanic eruptions to long-term phenomena such as the formation of mountain ranges or convection in the mantle.
- ◆We wish to analyze the mutual interactions between the Earth and the various human activities that occur on its surface, and collect and make available data on these interactions to provide a basis for future research.
- ◆We want to use numerical modeling on supercomputers to gain understanding of the complex multilayered hierarchical dynamics that governs the Earth and other planetary systems and thereby make predictions about these systems.

Right now a new academic discipline is being created, a discipline that unifies all this research and provides a big picture view covering timescales from the lifetime of the Earth to the daily lifestyles of human beings, spatial scales from the size of the solar system down to the molecular level, and includes the activities of living things from microorganisms to human beings. Using this approach we expect to be able to describe the behavior and evolution of planetary systems over the full range of time and length scales and thereby to make predictions for the state of such systems in the future.

Geoscience is built on the foundations provided by fundamental research, numerical modeling, and continuous observational investigation and management of the resulting data. As is the case in any field where numerical modeling is used, supercomputer related computer science is essential.

In addition to advancing this fundamental research, it is important that researchers actively engage with society in order to promote education that ensures that we all understand the Earth and our relationship with it.

Applied Geoscience

At the same time as we pursue the goals outlined above, we also have a duty to engage with society to help to deal with the following two major problems.

The Earth is faced with a variety of environmental problems: we must actively promote ideas and policies to help deal with these.




Since ancient times human beings have relied on the Earth and it's movement as a planet to support their activities. For example for millennia we have used time, the calendar and the locations of the stars in the sky as the basis for navigation. We are blessed that the Earth provides us with mineral ores and fossil fuels that support our civilization. The global environment used to be maintained by energy flowing from the sun and from processes occurring within the Earth. However in recent times the scale of human activity has expanded to such an extent that it is now influencing the natural environment. The Earth is a small finite planet. The global population has now reached seven billion people, and is currently predicted to exceed ten billion by 2065. The depletion of energy, food and water resources is becoming a major problem and the impact of their increasing consumption on the environment and on ecosystems everywhere is causing dramatic changes worldwide. Although we are all deeply concerned about the future of human beings on the Earth it is not easy to make predictions about this future. This is because the Earth is evolving on its own in various ways as well as being affected by the sun, and we currently do not understand the behavior of this complicated system in all its detail.

A whole range of events connected with human existence, including environmental problems such as global warming, desertification, water shortages, and landslides and debris flow are all caused both by the effect of human activity and by the planet Earth. As scientists we are duty bound to provide responsible information about the new system of the Earth and its human occupants.

We must work to make predictions about the scale of natural disasters, help to prepare for them and provide information about the best way to cope with disasters as they occur.

The Pacific plate subduction zone to the west of the Japan archipelago is the cause of much earthquake, tsunami and volcanic activity, and consequently Japan is one of the most seismologically active areas in the world. Further, the country lies in a unique position at the boundary of the Earths largest continent and its largest ocean. As a result of all this, Japan is fated with recurrent natural disasters. Accordingly the advancement of geoscience is both of major national interest and an area in which Japan can contribute to the wider international community. As the 2011 Tohoku earthquake and tsunami tragically demonstrated, our current level of knowledge and experience is still insufficient to deal with major natural disasters. Nonetheless, geoscience is able to offer data that can be used to make approximate calculations about the timing of recurrences of major earthquake and volcanic activity and to provide risk assessment for the accompanying natural disasters. Although these data are at present incomplete we accumulate additional information all the time, and this promises to provide a much more complete picture in the future.

About the Japan Geoscience Union and its activities

The Japan Geoscience Union was officially recognized as a public service corporation on the 1st December 2011. The JpGU acts as a forum for the exchange of information and the collection of opinions and ideas within the diverse geoscience community. Our academic activities are focused on the following five sections: space and planetary sciences; atmospheric and hydrospheric sciences; human geosciences; solid Earth sciences; and biogeosciences. Each of these sections is explained in more detail in the following pages. We also hold an academic meeting, the JpGU Annual Meeting, every year in the spring, issue a newsletter and work to provide relevant geoscience information to society at large. In 2014 we also launched a new geoscience open access e-journal, Progress in Earth and Planetary Science.

Geoscientific knowledge is relevant to many of the problems facing mankind and geoscientific research is indispensable if we wish to maintain the continued prosperity of our species. As a pure discipline, geoscience offers us a bird's eye view of the natural wonders of the planetary system in which we live. As an applied science it includes cultural and social elements which allow us to construct a new paradigm that offers the hope of resolving many of the problems facing mankind. In order to provide solutions and see them adopted by society, the geoscience community must continue with scientific research but also work to educate society at large and to communicate our message to the general public and our political leaders. As a representative of the geoscience community in Japan, the JpGU therefore aims to promote earth and planetary science research and also to increase the understanding of geoscience issues in the general public. In order to achieve these two goals we focus our efforts on the following areas: encouraging the exchange of information with researchers in Japanese geoscience societies; promoting collaboration with scientists in other countries; and public relations work to ensure that important information is communicated to society at large. By doing so we seek to ensure the continued vitality and importance of geoscientific research in Japan, the Asia Pacific region and worldwide.




日本地球惑星科学連合

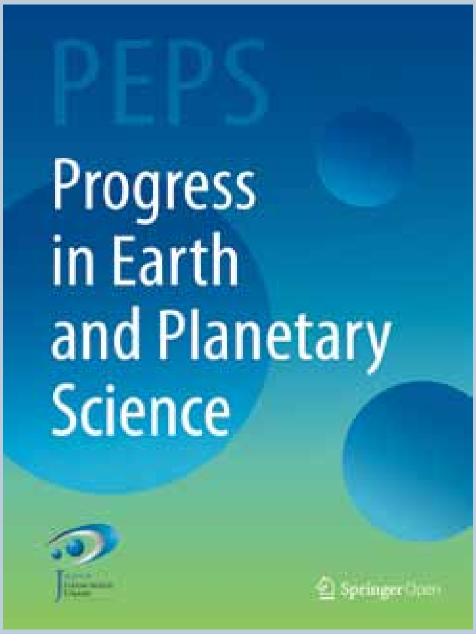
"Progress in Earth and Planetary Science"

The New JpGU Open Access e-Journal

April 2014 saw the launch of Progress in Earth and Planetary Science (PEPS), the new JpGU English-language open access e-journal. The JpGU and its fifty member societies hope that both the Japanese geoscience community and the wider global community will benefit by using this new journal to improve communication. As PEPS is an open access e-journal, all of its articles are available online and may be accessed by anyone for free. Researchers are also allowed to post the PDF files of their PEPS papers on their personal web pages. We feel that this is important: most academic research is paid for by the taxpayer and so it is surely appropriate that research results are freely available to all members of society. We hope that PEPS will also make a small contribution to reducing the ever-increasing amounts of money that university libraries have to pay for journal subscriptions. Finally, PEPS will also provide a secure archive to preserve its material for the future: all PEPS files will be backed up at a number of different large-scale data centers at different locations throughout the world.

Geoscience is a complicated area that deals with many different phenomena. The JpGU has decided that PEPS should cover all the fields of geoscience together with relevant related subjects. Accordingly PEPS is divided into the following sections: Space and Planetary Sciences; Atmospheric and Hydrospheric Sciences; Human Geosciences; and Solid Earth Sciences. It will also publish papers that deal with material from more than one of these sections, for example papers that discuss the various environmental problems now facing us. The JpGU would like to use PEPS to promote an integrated approach to geoscientific problems and we are particularly keen to encourage the development new concepts and ideas that unify different branches of the subject.

PEPS will publish material from authors based anywhere in the world in the following three categories: (1)review articles that cover recent developments in geoscience; (2)papers based on the very best presentations given at the JpGU Annual Meeting; and (3)high quality general research articles. Finally, one further advantage of PEPS is that, as it is an electronic journal, we able to welcome papers that include attachments such as animations, video material or large data files.



Progress in Earth and Planetary Science (PEPS)

- PEPS is an open access e-journal, and all articles are available for download free of charge.
- PEPS aims to become one of the leading geoscience journals.
- First published in 2014.
- Publishes general research papers, invited papers, review articles and articles based on the best material from the JpGU Annual Meeting.
- Article Processing Charge is 200 Euros for JpGU members and 1000 Euros for non-members. The JpGU will pay all charges for invited papers and review articles and for JpGU Meeting based articles.

「Progress in Earth and Planetary Science」 web site

http://progearthplanetsci.org/

Geoscience Roadmap

Geoscience is a field that includes both fundamental and applied research. Fundamental geoscience is a wide field that studies the solids, liquids, gases and plasmas that make up the solar system, the various life forms that inhabit it, and the interactions of each of these with humans and human society. We are particularly interested in the planet that we inhabit, the Earth, and we wish to understand its origins, evolution, present state and future, but we also seek to understand the other planets in the solar system and exoplanets in other solar systems throughout the universe.

Since the natural phenomena that we study are intimately connected with human activity and our very survival, applied geoscientific research concerns itself with how the relationship between human beings and the natural environment will develop in the future. We do this in order to make forecasts and to help to overcome the various natural disasters and environmental problems that will surely occur in the future. Here we present a roadmap for the balanced development of the two sides of our subject.

The Earth has not been the same since time immemorial. It did not exist, was formed and has passed through many different phases before arriving at its present form. It will continue to change in the future. Since we live on this planet, it is important for us to investigate this history and understand how it will evolve in the future. In order to do this we propose the following three point roadmap:

- **Firstly we must understand the Earth as a planet.**

We must recognize that the Earth may not be unique, understand its universal features and peculiarities, understand its history in the context of the history of the galaxy, and understand the variety of different planets in the solar system and in other solar systems in the galaxy.

- **Secondly we must understand in detail the mechanisms that govern the Earth, and use this understanding for the good of society.**

We must seek to explain the origins, evolution and present state of the Earth and thereby equip ourselves to understand its future development. We must understand the mechanisms that cause the Earth's environment, both internal and external, to change in order to make accurate predictions about the future. Finally we must understand the relationship between human activities and the environment, and apply all of our knowledge to natural disaster mitigation and to tackling the various environmental problems that we face.

- **Finally it is important that we understand the details of planetary environments that help support life.**

By understanding the co-evolution of life and the planetary environments it inhabits we will be better able to investigate the possibility that the universe may contain other planets that also support life.

The following five geoscientific disciplines are involved in working together to realize these goals:

Space and Planetary Sciences
Atmospheric and Hydrospheric Sciences
Human Geosciences
Solid Earth Sciences
Biogeosciences

If we are able to thoroughly understand each of these disciplines then we shall be able to make balanced progress in our study of geoscience as we have just described it. As the Japan Geoscience Union is a comprehensive academic organization devoted to making such progress, it is organized into five sections, each section corresponding to one of the fields above. The diagram on this page outlines the future vision of each section and outlines the areas where they should work together to achieve our goals.

Space and Planetary Sciences Section

宇宙惑星科学

What is Our Science Field?

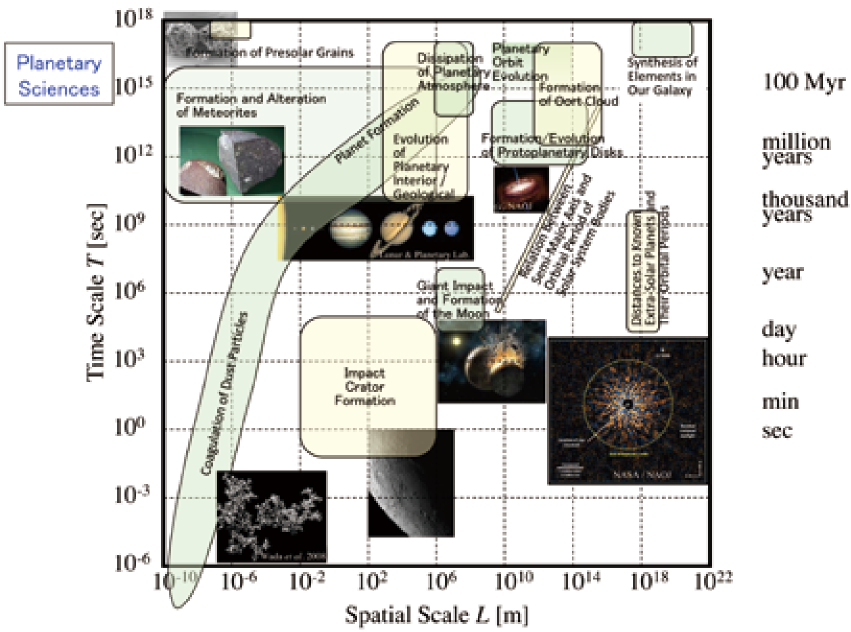
The aim of the Space and Planetary Science Section' s activity is to understand the current state of our solar system, and, in the future, to understand the fundamental rules governing the structure and evolution of solar and planetary systems throughout the universe. The study of the solar system involves the planets (their surfaces, interiors, hydrospheres, atmospheres, ionospheres and magnetospheres,) the space plasma, the solar wind that blows againt the planets and, of course, the Sun itself. This knowledge will tell us the current status of the solar system in the universe chasing time, the Earth and the life upon it, and thereby we will be able to understand its uniqueness and universality.

Recent Developments in Space and Planetary Sciences and Related Fields

As with other areas of geosciences, the space and planetary sciences have developed with our increasing ability to make direct observations and measurements of phenomena of interest.

Our study of this field began with observations of the Earth' s surface, and progressed as we began to understand the interior of the Earth and the atmosphere, ionosphere and magnetosphere surrounding it. It further developed as we became able to send space probes, to explore other planetary systems and the interplanetary space. A recent important development has come with the successive discoveries of various planets in outer solar systems. We have discovered not only that planetary systems are relatively common, but also that there are many such systems that are very different from our own solar system, for example in the case when a giant planet orbits in close proximity to the mother star. Based on these new observations we are currently constructing a new theory of the formation of planetary systems. One of the predictions of this is that there will be other planets that also possess the oceans which is essential to the existence of life on Earth.

In Japan a major development in space and planetary science has come with our ability to send exploratory missions to other planets and primordial celestial bodies and to investigate interplanetary space. As with other countries,



Temporal and spatial expansion of the Planetary Science

Giant gas planet orbiting in close proximity to the mother star (image)
©ESA, NASA, G. Tinetti (University College London, UK & ESA) and M. Kornmesser (ESA/Hubble)

Sample return capsule of HAYABUSA and collected particle ©JAXA

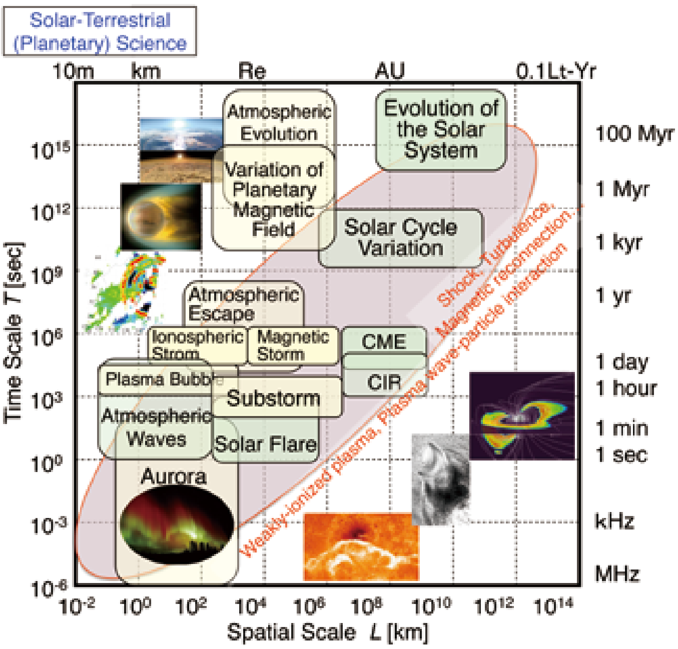
Japan began with space observations of the Earth' s ionosphere and magnetosphere and then joined international collaborations to undertake space borne observations of the sun.

Concerning the Sun-Terrestrial environment, following topics have been intensively studied, e.g., the transport of energy from the sun to the Earth' s magnetosphere; the time variation of the structure of the inner magnetosphere; and the process of magnetic reconnection which leads to particle acceleration giving rise to solar flares and producing the auroras seen on Earth. Japan feels justifiably proud of many world-class contributions in these areas.

In the field of planetary exploration on the other hand Japan lagged more than 30 years behind the leaders in the field, United States and the former Soviet Union. However in the 1980s Japan joined with the European Space Agency and the USSR in sending the Halley Armada to observe Halley' s comet. In more recent years the Hayabusa and Kaguya missions have taken Japanese space exploration to new levels. The Hayabusa mission explored the primordial celestial body Itokawa, provided proof of the reaccumulated rubble pile comet model and returned the first sample from an extraterrestrial body except the moon. Kaguya was the largest moon mission since Apollo program. It was the first mission to map the entire lunar surface, and generated high-resolution images and detailed topographic maps, gravity maps, maps of the distributions of radioactive elements and maps of the lunar magnetic field. These data will be extremely useful for future lunar missions and provided new information on both the origins of the differences between the moon' s near and far sides and on the composition of its mantle.

In 2015 the Japan' s Venus orbiter Akatsuki will go into orbit around Venus and begin to provide detailed information of the motion of the Venusian atmosphere, thereby helping to establish the field of planetary meteorology. Also in 2015 the ERG (Exploration of energization and Radiation in Geospace) satellite is scheduled for launch. This mission is designed to study the mechanisms whereby high-energy particles are accelerated and slowed down in the Van Allen radiation belt in the Earth' s Geospace. Finally the Hayabusa 2 sample return mission is due to be launched in the near future, with the aim of providing a sample of material from a carbonaceous C-type asteroid.

Turning our eyes to the Earth, there has been remarkable progress in research in the ionosphere and lower magnetosphere due to the combination of data from a network of various ground based observatories and orbiting satellites. We have been able to construct a three dimensional picture of the Earth' s magnetosphere from the micro to the macro scale using radar based at the North Pole, middle latitudes and on the equator together with a network of geomagnetic, optical, GPS and short wave radar observatories. We have analyzed the data from those observations assisted by the numerical experiments and modeling. Japanese sounding rockets have been sent into the ionosphere to study the mutual interaction between the neutral atmosphere and ionized plasma. This research ties together space and planetary science with the atmospheric and hydrospheric sciences, and, combined with numerical modeling of the interactions between the magnetosphere, ionosphere and atmosphere, has produced important results. The research of the interactions between the atmosphere and the ionosphere is expanding due to new data provided by the international radar network consisting of the MU Radar in Shigaraki, Japan, the Equatorial Atmosphere Radar in Indonesia, the Antarctic PANSY Radar and the Arctic EISCAT Radar. This knowledge has proved useful not only for providing a universal understanding of the mechanisms of planetary atmosphere variation, but has also given rise to the new field of near-Earth space science.



Temporal and spatial expansion of the Space Plasma Science

Aurora shining in the sky above SHOWA Antarctic base (courtesy of Prof. Makoto Taguchi of Rikkyo Univ.)

The Future of Our Study

- Exploration of planetary atmospheres and magnetospheres is developing and there are plans to send a number of probes to various planets in the solar system. These will lead to the study of both universal and specific phenomena in planetary atmospheres and magnetospheres.
- As more exoplanets are discovered, the new field of astrobiology, which investigates life-related or biological phenomena in the wider universe, is developing. The development of this new subject is likely to involve cooperative work involving planetary science, astronomy, plasma and atmospheric physics, and the study of interactions between atmospheres and oceans, as well as evolutionary history.
- Data provided by examination of extraterrestrial material brought back to Earth by sample return missions will, when combined with astronomical observations and input from theories of planetary formation, lead to substantial developments in the theory of the evolution of planetary systems. We should remind the importance of the ground based experiments that make these missions possible.

We expect that space and planetary science will continue to make great progress through the cooperation of many different researchers working on exploratory missions, ground observations, computer simulations, and laboratory experiments.

Atmospheric and Hydrospheric Sciences Section

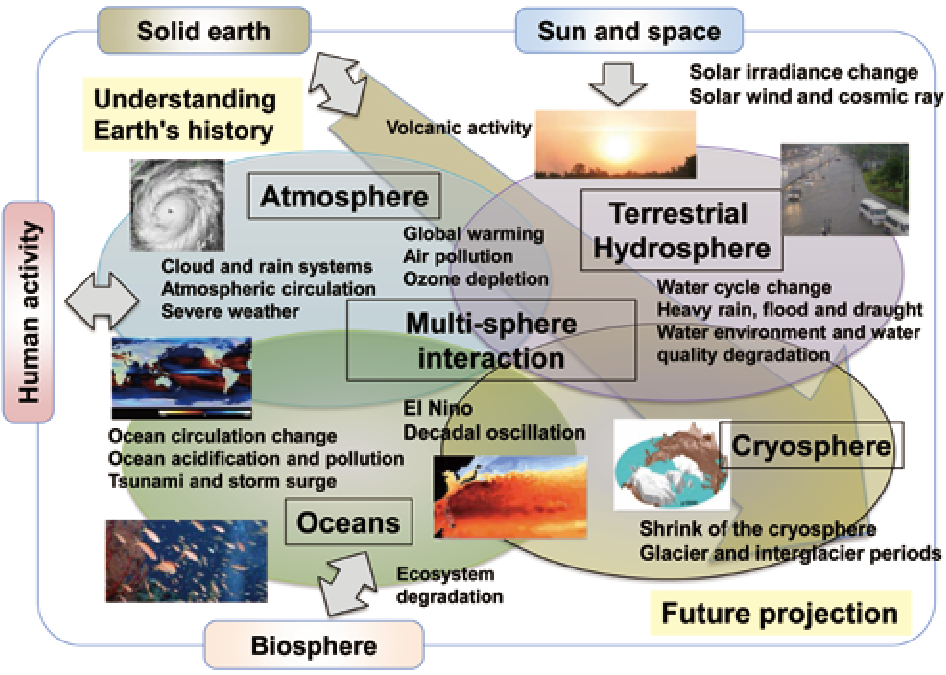
大気水圏科学

About the Atmospheric and Hydrospheric SciencesSection

The Atmospheric and Hydrospheric Sciences Section is concerned with the study of phenomena occurring at the Earth' s surface involving the atmosphere; oceans, rivers and lakes; and cryosphere. We aim to understand and explain past and current phenomena, to be able to make predictions about the future. The Earth' s surface is the home of the majority of life on this planet, including human beings: therefore the study of the interactions between the various spheres of the Earth' s surface and of the physical, chemical and biological processes that occur there is of great importance to society and not merely an academic exercise.

As with other areas of geoscience, the atmospheric and hydrospheric sciences involve both fundamental research in order to understand natural phenomena and also applied research focused on alleviating environmental problems and mitigating natural disasters. The pure and applied sides of the field each influence the development of the other. For example, there is a social need to research phenomena such as typhoons and prolonged heavy rain that can and do lead to large scale natural disasters: our detailed understanding

Flood in Bangkok 2012



Various phenomena related to Atmospheric and Hydrospheric Sciences of these phenomena is based upon the study of convective systems and the physics of moisture transport in the atmosphere. On the other hand, the study of the water cycle started as pure research, but given the current deterioration in water environment, governments and societies now encourage applied researches from view point of ensuring sound hydrologic cycle.

Recent Developments in Atmospheric and Hydrospheric Sciences and Related Fields

Currently the areas actively researched by atmospheric and hydrospheric scientists are increasing at a great rate. Society faces many environmental problems with much research being focused on many important areas including those connected with: moisture transport such as clouds, precipitation, heavy rain and typhoons; the interaction between the oceans and the atmosphere; the internal structure of the oceans; global warming and its relation to human activity; the chemistry of aerosols and ozone in the atmosphere; the carbon and nitrogen cycles; thermal circulation; the vegetation and ecology of the earth' s surface (including the ice sheets). As our understanding of these areas has deepened we have discovered that many of these important phenomena strongly interact with each other. Accordingly, in order to understand and make predictions about phenomena of interest, research must focus not just on the atmosphere and the hydrosphere, but rather treat the whole Earth as an integrated system. Researchers must now involve themselves not just with science and engineering but also consider social and economic issues as well. Additionally there are important points of contact with paleogeology, solar physics and space and planetary sciences.

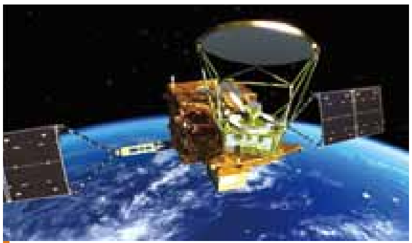

Program of the Antarctic Syowa MST/IS radar (PANSY) at Syowa Station and R/V *Shirase*

Currently Japan is one of the global leaders in atmospheric and hydrospheric research. Japan operates a wide net of land-based and ocean-based observation facilities and develops both large scale surface-based and satellite-based precision observational instrumentation. Using these, researchers have been able to study the historical development of a wide range of phenomena ranging from micro- to macro-scale. This is all supported by the development of large-scale computational facilities that are used to obtain quantitative spatiotemporal understanding of phenomena by advanced numerical modeling.

The Future

In view of the many issues that we face, in the future a wide range of continuous high precision measurements and model-based analysis of the resulting data will be more and more necessary. In order to do this we must consolidate and extend our networks (both surface and satellite based) that monitor climate, weather, oceans, hydrosphere, cryosphere and ecosystem in order to construct more detailed and reliable data. Further, it is important to extend our understanding of phenomena which are unique to each region of the globe: in particular in Asia a wide range of environmental conditions exist, and many of these lead to phenomena which have a large


Aerosol Radiative Forcing in East Asia (A-FORCE) aircraft campaign

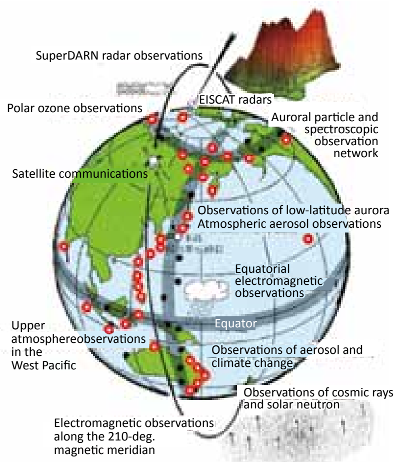

Global Change Observation Mission 1st - Water satellite "SHIZUKU"

impact on human activity.

Research direction and organizations worldwide realize that atmospheric and hydrospheric sciences are of fundamental importance to build a sustainable human society and to be able to make predictions about that society. In Japan there has been remarkable progress in global warming simulation and climate modeling using the Earth Simulator System and the K Computer, with, for example, world leading research on cloud convection using an ultra fine resolution global non-hydrostatic model to correctly predict dynamics. We must continue to build on Japanese excellence in computing and technology in order to further advance atmospheric and hydrospheric sciences, and thereby combine experimental observation with advanced modeling in order to provide the important information about natural phenomena that society needs.

Oceanographic Research Vessel Mirai and Tropical Atmosphere-Ocean/ Triangle Trans-Ocean buoy Network (TAO/TRITON)


The 3,035m deepest ice core at Antarctic Dome Fuji



Various upper atmosphere observations

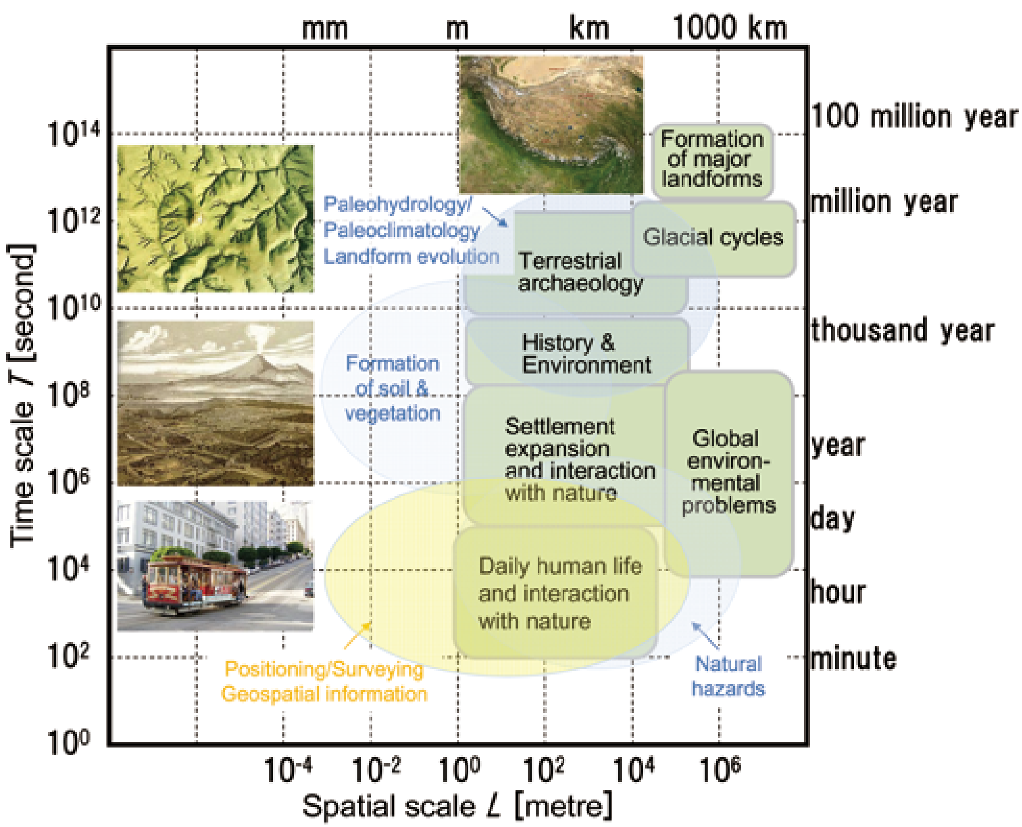
Human Geosciences Section

地球人間圏科学

About the Human Geosciences Section

The Human Geosciences Section is concerned with the science of investigating in the natural phenomena that occur on the surface of the Earth and their relations with human activities. The Section is involved both in the academic development of this interdisciplinary field, and in practical efforts to mitigate disasters such as the Great East Japan Disaster triggered by the earth quake/tsunami of 11th March 2011, and to alleviate environmental problems such as those related with global warming.

Human geoscience research is characterized by its wide views and skills rooted in many disciplines of natural sciences, engineering and social sciences with particular attention on the observation and prediction of the spatial/regional aspects of the phenomena. For this reason the research often involves field survey observation, measurement, recording and mapping, followed by data compilation, storage, management, analyses and modeling in order to make predictions and to give advice to the society on policy. While concerned with natural phenomena, we are particularly interested in the origin and evolution of phenomena that impact the human environment. Human

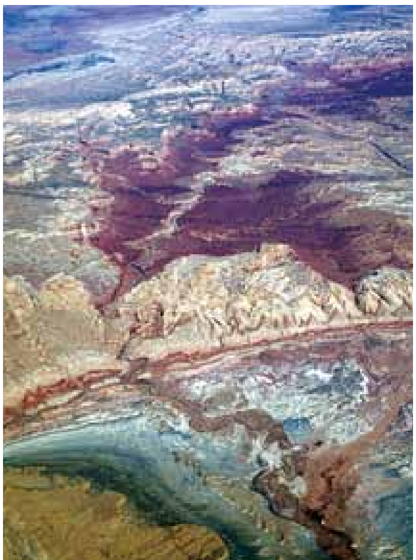


geoscience has connections with many fields of geoscience, namely physical geography, geomorphology, geology, applied geology, soil science, sedimentology, seismology, volcanology, quaternary research, oceanography and hydrology. It also has strong connections with humanities and social sciences including human geography, economics, political sciences, archaeology and history, and with agricultural sciences, engineering related with disaster prevention or mitigation. These are all important fields for understanding mechanisms of disasters and environmental problems and for evaluating the associated risks comprehensively, and then proposing strategies for their mitigation,

Recent Development of Human Geosciences and Related Fields

Human Geosciences see the nature and the environment not only as natural phenomena, but also as part of man-environment system, with special focus on causes and results of their changes, their future prospects and measures to be taken to counter unwanted changes.

Our understanding of the relationship between human society and the environment has been progressing enormously in recent years. For example, as progress has been made in reading data obtained from sampling of the ocean floor and the ice caps, we are now able to compare climate variation during the ice ages, the Holocene, and the period of recorded history. Comparing these data with the history of human civilizations is a hot area of research now. Evidence of liquefaction and geological and geomorphological examination of sediments left by tsunamis have provided much information about the scale and frequency of the past earthquakes and tsunamis. Thanks to the increasing cooperation of natural scientists, engineers and social scientists, new fields of disaster prevention and mitigation are now emerging. The mechanisms of landslides, land collapse or debris flows caused by earthquakes or severe rainfall have been studied by using networks of GPS-based observations, and are now understood to the point where a warning system of these disasters are nearing operational levels. In the field of social sciences, the relationships of disaster, regional information bases and social structure is under investigation. Other hot issues include land use planning and risk assessment. Significant progress is being made in developing techniques for investigating underground water and managing its pollution; for exploring and developing underground oil and gas; and for exploring and developing mineral resources on the ocean floor. And finally in the area of renewable energy, research on solar power, wind power, wave power and geothermal power continues to make great progress.


Land feature of native Americans' reserve in Utah, USA


Survey of 2008 Sichuan Earthquake site, China


Land use survey in China


Spatial analysis aided by GIS, Spain

The Future

Many of the pressing problems mankind faces now, such as environmental problems, large scale disasters, problems related with land use, coastal management, natural resources, and food, are all subjects of human geoscience. The Human Geosciences Section aims to work altogether with the many scientists from various disciplines who are making effort to understand, confront and mitigate these problems, and to seek 'science for Society'. Accordingly, the Human Geosciences Section aims not only to consolidate this new academic discipline, but also to organize symposia and other events for education and lifelong learning. Finally, by participating in the new international framework for global environmental research of "Future Earth" and by actively promoting a unified approach to natural disaster research and disaster mitigation research we hope to make a contribution to the creation of a sustainable human society.

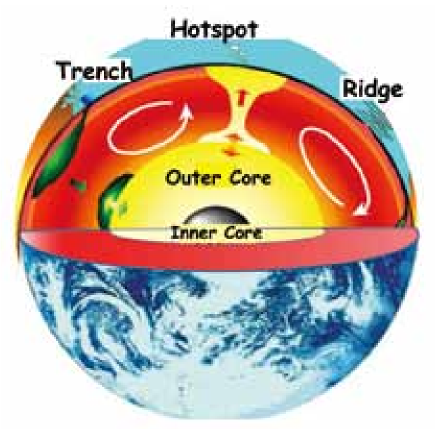
The field of human geosciences is attracting much attention both in Japan and worldwide. The JpGU Human Geosciences Section intends to help build this new field and realize its potential to become an essential field of research for the modern world.

Solid Earth Sciences Section

固体地球科学

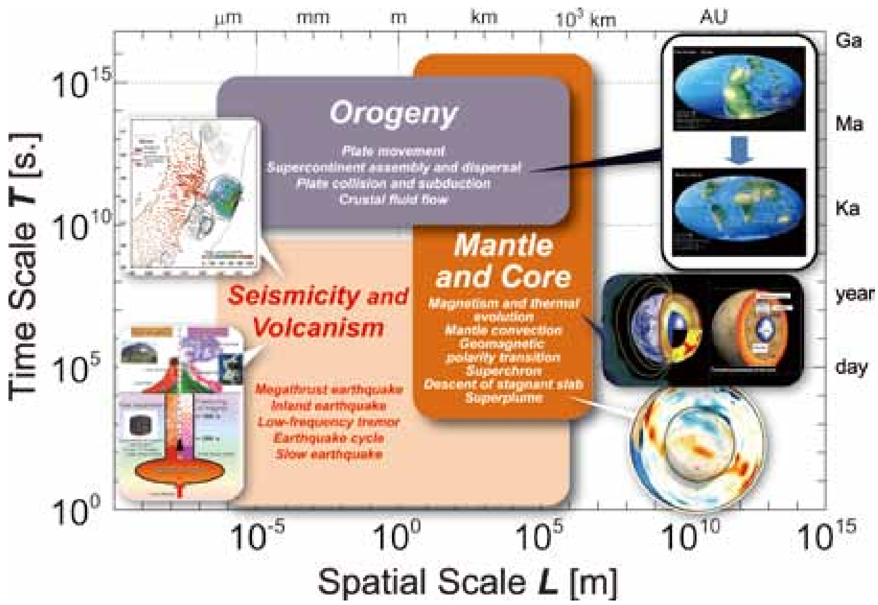
About the Solid Earth Science Section

The Solid Earth Science Section is concerned with understanding phenomena associated with planet Earth, from its solid surface to its center, covering timescales from its formation to the present day. Solid Earth science originally developed from foundations provided by geophysics, geology, mineralogy and geochemistry. In recent years increasing cooperation between these disciplines has helped to advance our understanding of the Earth.



Structures and dynamics of Earth's interior
(Image courtesy of Dr. Eiji OHTANI)

In the following we give examples of important topics of research in solid Earth science: short timescale phenomena occurring in the Earth's crust or upper mantle such as earthquakes, tsunamis, volcanic eruptions, and active deformation of the Earth's crust; longer timescale phenomena occurring at the Earth's surface such as topography formation, mountain building (orogeny) and the movement and evolution of continents and oceans due to tectonic processes; phenomena involving the



(Image courtesy of Dr. Takeshi Iinuma, Dr. Michihiko Nakamura, Dr. Hidenori Terasaki, Dr. Masayuki Obayashi, Dr. Yoshio Fukao, PALEOMAP Project, Arlington, Texas)

Eruption of Mount Semeru in Indonesia
(Image courtesy of Dr. Satoshi OKUMURA)

Mantle rocks exposed to the surface: the Horoman Ultramafic Rocks
(Image courtesy of Department of Earth Science, Tohoku University)

deep mantle and Earth' s core, including their interactions, and transport of energy and material; investigations of the state and structure of the mantle and core; the dynamics of the Earth' s interior, including mantle convection and the geodynamo; the relationship between processes in the Earth' s interior and their effects on the surface fluid layers; and unified studies of the evolution of the solid Earth that incorporate all the above processes. This list emphasizes the extraordinary breadth of disciplines encompassed by the Solid Earth Science section.

Recent Developments in Solid Earth Science and Related Fields

In the past ten years or so, much progress has been made in the study of phenomena occurring in the relatively shallow regions of the Earth' s interior. Some important examples are given below.

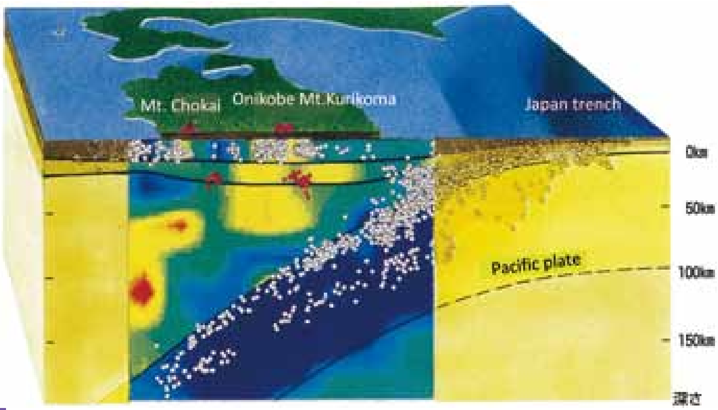
1. In earthquake studies a combination of the deployment of dense observation networks of both seismic stations and GPS geodetic sites with improved data management and processing alongside developments in experimental studies and numerical modelling have brought many new insights. In particular there has been great progress in understanding the earthquakes, crustal deformation and low-frequency tremors that ooccur at convergent plate boundaries. As we will discuss later, it is also clear that accurate earthquake prediction remains a very difficult problem.

2. In volcanology there has been significant progress in the three-dimensional modeling of eruption column dynamics and understanding of magma degassing and eruption styles. By drilling into volcanic conduits shortly after eruption the relationship between magma ascent and degassing has became clearer. Our ability to forecast volcanic eruptions based on observations of volcanic earthquakes and ground deformation has greatly improved.

3. In areas related to the transport of matter and energy in the Earths interior there has been progress in understanding of the large-scale transport of water and continental material to the deep mantle and its rise from the Earth' s interior; in understanding of the contribution of oceanic crustal material to magma generation; in understanding of the role of hydrothermal activity in material transport; in the quantitative understanding of the growth of accretionary prisms using data from deep sea drilling; and in research into seismically active belts exposed on land.

4. In fields related to the interactions between the solid Earth and its atmo-

Folding of rocks (image courtesy of Department of Earth and Planetary Sciences, Nagoya University)



The double seismic zone (Image courtesy of Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

Synchrotron X-ray spectroscopy

sphere and oceans, there have been advances in understanding the ways in which the uplift of the Himalayas has influenced the Asian monsoon and the development of drastic changes between dry and humid climates; the relationships recorded in the Earth' s geological record between global climate change—including Snowball Earth and greenhouse climates—and tectonic processes (movement of the lithosphere) including development of mountain ranges and distribution of oceans and continents; and transport and circulation of material in the Earth' s interior.

There have also been numerous important research achievements that improve our understanding of dynamical processes occurring in the deep Earth:

1. Ground breaking research in Japan recreated the temperatures and pressures of the lowermost mantle and discovered the post-perovskite phase.

2. High-pressure experiments indicate that the mantle transition zone is the largest possible water reservoir inside the Earth and great progress has been made in our understanding of water transport associated with plate subduction; of large-scale water circulation in the Earth' s interior; and of water distribution in the lower mantle.

3. Developments in seismic tomography have revealed details of the three dimensional heterogeneity of the seismic velocity structure in the Earth.

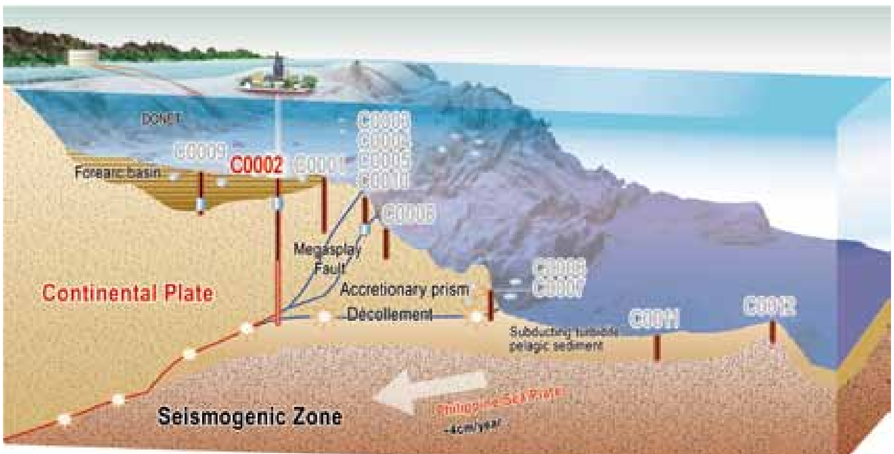
4. The discovery that the formation of the Earth' s core took the comparatively short time of a few tens of millions of years.

Although solid Earth science has made much progress in the areas outlined above, it is clear that major problems remain in the fields of earthquake forecasting and disaster prevention: this was made horribly clear by the enormous damage and loss of life caused by the 2011 Tohoku earthquake and tsunami. The current state of earthquake research does not permit us to use our knowledge of long-term earthquake activity to make sufficiently accurate medium-term predictions. It is clearly important to further incorporate geological timescale records of earthquakes and tsunamis in our disaster prediction efforts. It is also clear that developlement and construction of high-precision earthquake and tsunami observation networks on the seafloor and high-speed data transmission to carry warnings to the general public remain as important as ever.

The Future

As discussed above, the solid Earth science community is fully aware that two of the greatest problems it faces are the forecast of large earthquakes and any accompanying tsunamis, and the development of disaster mitigation strategies to deal with them when they happen. A major task facing the discipline is to continue the cooperative research between seismologists and geologists in this area. In recent years in Japan, drilling in the Nankai Trough and the hypocentral region of the Tohoku earthquake has started to elucidate the state of faults in the ocean trench megathrust earthquake zone, and we anticipate that our understanding of the slip mechanism of these seismic faults will improve considerably. Finally we would like to highlight the importance of the international scientific proposal to make use of a Japanese drilling ship to drill into and retrieve samples from the mantle.

In the field of volcanology, we expect to further clarify the behaviour of both magma and associated fluids and to use this to develop eruption models or scenarios that allow improved accuracy in the understanding of how volcanic eruptions evolve which, we hope, can be used to realize the development of accurate short-term predictions of volcanic eruptions. Furthermore, we expect research in volcanology to expand to cover longer timescales and greater spatial extents and thereby to provide new insights into the evolution of the Earth' s crust and into the dynamics of large-scale energy and material circulation within the Earth.



Drilling the seismogenic zone at Nankai Trough

©JAMSTEC

Deep sea scientific drilling vessel CHIKYU ©JAMSTEC

Laterally high-resolution secondary ion mass spectrometer (image courtesy of Dr. Yuji SANO)

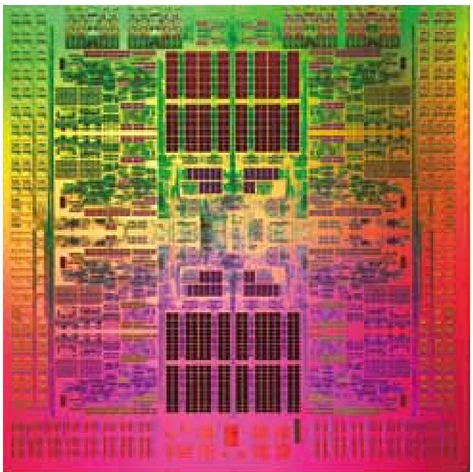
Research overlapping the boundaries between the solid Earth science and other disciplines, such as the interaction between tectonics and climate change and even links to biological evolution should also be encouraged.

We expect research into dynamical processes occurring in the deep Earth to make progress on a number of fronts:

- Recent improvements in seismic, electromagnetic and geodetic observations made on the ocean floor should further clarify the three dimensional characteristics of the Earth's interior.
- Ultra high-pressure material science now allows us to experimentally replicate conditions in the Earth's core. Using the quantum theory of electronic structure to determine electron distribution allows us to calculate many material properties from first principles. Combining these techniques should give a much better understanding of the properties of material in the Earth's deep interior and allow us to develop detailed explanations of the processes occurring in the mantle and the core.
- The study of flow related phenomena in ultra high-pressure solids and liquids together with the observation thereof using high luminosity X-ray and neutron sources is expected to increase our understanding of the extreme environments deep in the Earth's mantle and core.
- We expect the application of new observational techniques borrowed from physics to enable new progress in many areas. For example the observation of the Earth's interior using geo-neutrinos and muons should allow us to measure the inhomogeneity of the distribution of heat sources within the Earth; and muon imagery of volcanic edifices should improve our ability to monitor associated volcanic activity.

We also expect that the use of techniques developed in solid Earth science will enable progress in other related fields. For example:

- Spectroscopic analysis and precision image analysis of the surfaces of other planets; techniques used for measuring gravity, heat flow, electrical conductivity and seismic wave velocity distribution that were developed in solid Earth science; innovative techniques of chemical analysis developed for earth materials should all be useful in planetary exploration and analyses of materials brought back by sample return space missions.
- Ultra high-pressure materials research and first principles calculations developed for the study of the Earth's interior are likely to be useful for research into the interior structure and dynamics of Jupiter-type planets and exoplanets.
- Application of recently developed high-precision heavy element stable isotope analytical techniques to geological specimens will allow interpretation of the paleoclimate in much greater detail than is presently possible, and this is likely to lead to improvements in the accuracy of our forecasts of the future climate.
- Nanoscale sample analysis techniques will allow progress in elemental (including light element) and molecular isotopic analysis and biomarker analysis that will provide constraints for models of the evolution of life on Earth.



CPU of K computer (Courtesy of Fujitsu)

The multi-anvil high pressure apparatus installed in a neutron beamline of J-PARC (Image courtesy of Dr. Takehiko YAGI)

Biogeosciences Section

地球生命科学

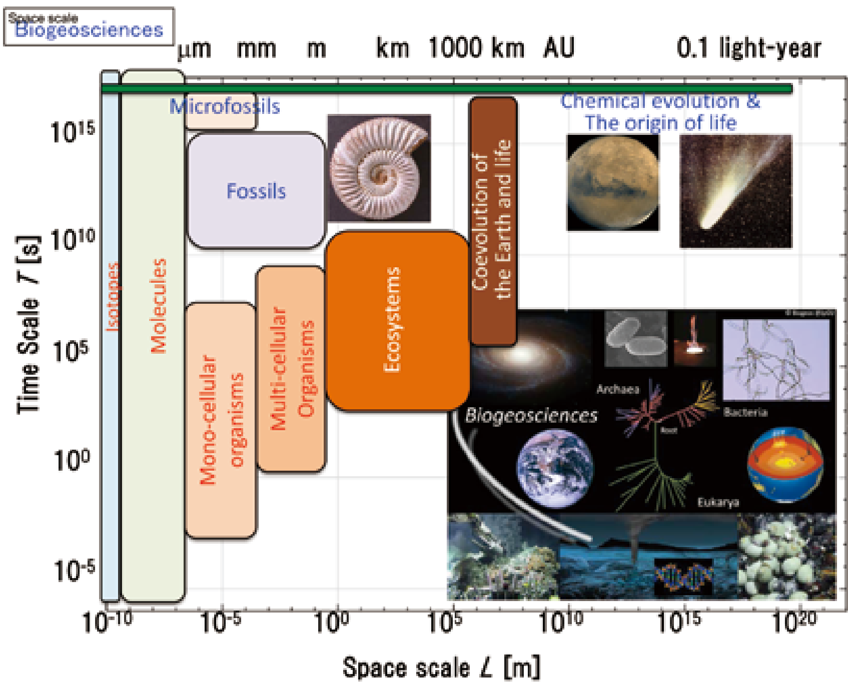
About the Biogeosciences Section

The Biogeosciences Section is concerned with investigating and clarifying the processes whereby the Earth and the living organisms on it strongly interact as they co-evolve. We research these processes for the entire period from the beginning of the Earth up to the present, and would like to give answers to the following kinds of questions:

- Why does life flourish on Earth?
- Why is life on Earth so abundant and so diverse?
- Is there life on other planets?
- How did life on Earth originate, complexify and diversify?
- What are the causes and processes governing extinctions and in particular mass extinctions?

We are also interested in the organic materials that are found in rocks, strata, and other geological formations, and in the biogeochemical processes whereby they mutually interact with rocks and minerals. The Biogeosciences also involve research into the origins of fossil fuels derived from living organisms such as coal, natural gas, oil, and gas hydrates.

The field of biogeosciences has made remarkable progress as the related fields of Earth, Planetary and Life Sciences develop. For instance, progress in the fields of Archaean Geology, Geochemistry, Geoelectromagnetism, Geomicrobiology, Drilling sciences, and several other areas of earth and planetary sciences have been indispensable in the study of the origins of life on Earth and its evolution during the Earth's earliest stages. Experiments using the techniques of synthetic organic chemistry and of gene recombination have made great progress



in understanding the composition and evolution of living material, and this has also promoted progress in the field of biogeosciences. Further, complete genome sequences of organisms from many different taxa and increased knowledge of the molecular mechanisms of metabolism have allowed progress in our understanding of the evolution of eukaryotes. Finally our understanding of the origin of life has advanced due to the discovery of primitive organisms living in extreme environments such as hydrothermal vents, cold seepages, anoxic or euxinic water masses, the ultra-hadal depth beyond 10,000m and deep subsurface biospheres.

Recent Developments in Biogeosciences and Related Fields

We list below some of the important research results and advances that are made over the last decade.

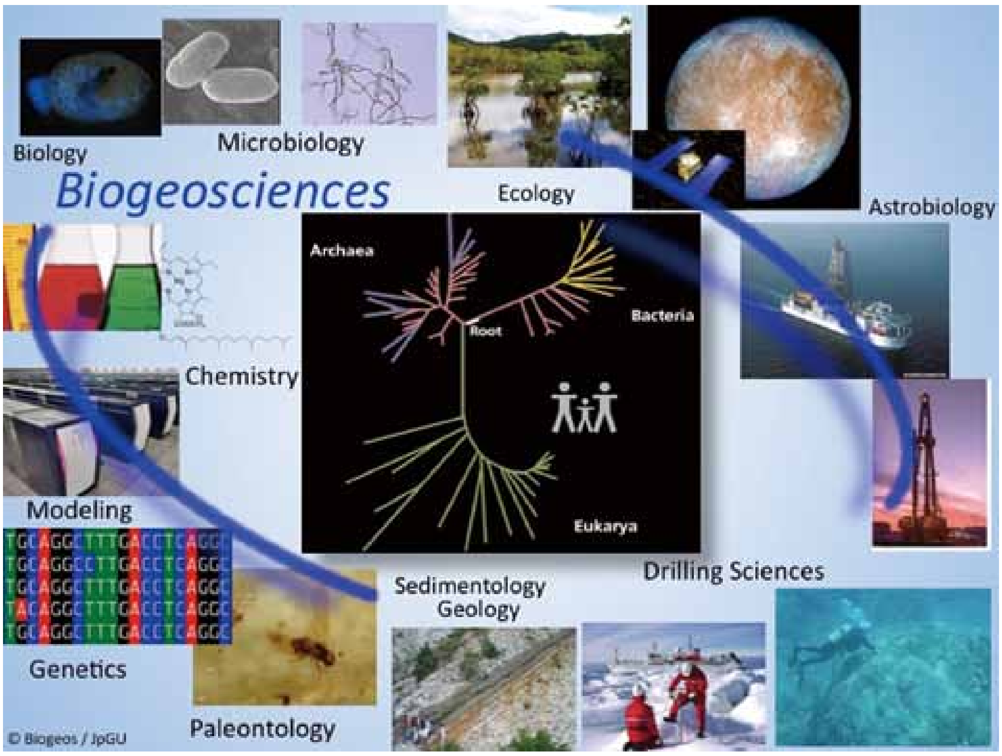
1. It has become clear that the contribution of organic material from extraterrestrial sources is important when considering the question of how bio-organic compounds were produced and organized by abiotic processes. Further, the study of chemical evolution has advanced with the verification that acetates are produced by the action of sulfur metal complexes in terrestrial hydrothermal environments.
2. Analysis of organic material from meteorites and comets has led to a detailed debate about the connections between extraterrestrial organic material and life.
3. Research into extremophiles on Earth and data from planetary exploration missions has caused increased interest in the possibility that life may exist on other planets and moons in the solar system such as Mars, Europa, Titan, and Enceladus.
4. The idea that life on Earth originated due to chemical reactions taking place deep in the oceans (rather than photochemical processes taking place on or near the Earth' s surface) has been gaining increased support.
5. DNA analyses have allowed the construction of a molecular genealogical tree, and this has revealed that very early in its history life was already divided into three groups: Bacteria, archaea and eukarya.
6. A new field, research into subsurface biospheres, is developing. Results from this field tell us much about the early evolution of life.
7. It is becoming clear that the increasing diversity of life on Earth is connected with events (including geological events) that have occurred in the Earth' s history.
8. Both evolution and extinction of eukaryotes are driven by changes in the environment on the Earth' s surface and it has become clear that this in turn is influenced by internal plate and plume activities of the Earth and by the repeated unification and breakup of continents and oceans over geologic history.

The Future

We expect that the following three areas will be central to biogeoscience research in the near future:

1. Clarifying the early evolution of life, understanding how the Earth became a suitable planet to host life, and increasing our understanding of the origin of life. Research into organic and biochemical processes occurring in space and on other bodies in the solar system will surely help our attempts to answer these questions. For example, in addition to looking for new life in extreme environments on Earth we should also search for direct evidence of the birth of some form of life in primitive extraterrestrial environments (such as asteroids, comets, Europa, Titan, Enceladus etc.).
2. By describing and recording the entire history of life on Earth we should attempt to further clarify why the Earth came to be filled with such a diverse range of life. We should also work to decode the entire genome sequences of model organisms that are key to understand the process of biotic evolution.
3. By clarifying the distribution of elements and material in the Earth and in living organisms we should be able to clarify the relationship between the evolution of the systems of material cycles in and on the Earth and the energy sources for the chemical reactions involved in abiogenesis.

The new field of Biogeosciences involves cooperating with the life sciences to push the frontiers in a number of areas (such as deep-sea exploration, space exploration and drilling deep into the Earth) and develop new experimental apparatus and analysis techniques. Great progress has already been made in this field. We are sure that the field of Biogeosciences will become one of core geoscientific fields in the near future.



Educational and Outreach Activities

The JpGU is very interested in improving the general public understanding of geoscience. We conduct educational outreach activities aimed at high school students and the general public, and are also involved in public relations on behalf of the geoscience community. We hope that by communicating geoscientific knowledge we can improve general scientific literacy. We also wish to inform the public of the role that geoscientific research plays in the life of society and in forming humanities worldview.

For example, the JpGU is involved in the development of primary, junior high and high school curricula, the training and ongoing education of teachers, and university and graduate school education. It actively engages with the Ministry of Education, Culture, Sports, Science and Technology by submitting wishes and proposals for new education guidelines for schools.

The most important task is to work with schools in order to improve both the level and the spread of basic geoscientific knowledge in the general public. Japan is faced with many natural disasters, but it is important not only to focus on these but also to raise awareness of the various environmental problems that we all face. In order to achieve these goals we must be involved not only with the education of pupils in schools, but also with the training and the ongoing education of teachers. Further we must help with the provision of engaging teaching materials and popular scientific literature explaining new geoscientific opinions and points of view. In 2005 guidelines were published outlining educational goals for universities, and in the light of these it is important to show a model of geoscience education that covers the whole process from primary school to university.

Further with the increasing number of study units required by universities and the lengthening of the teacher training period it has become difficult or impossible for science students to get a teachers license. This threatens to lower the level of science teaching in the future, and the JpGU is working with other scientific and mathematical societies by setting up a committee to address problems in science education: by working together we hope to improve math and science education across the board rather than focusing on math, physics, chemistry, biology and earth science individually. The JpGU also holds an annual symposium for everyone involved in earth science education in order to help improve mutual understanding.

Poster presentations by senior high school students

Since 2006 the JpGU has been holding a poster session for high school students

Awarding ceremony of
Poster presentations by senior high school students

as part of its Annual Meeting. In this session students prepare posters describing their geoscientific research. Recently there have been about 70 posters by students from about 40 schools from all over Japan, but the numbers increase every year and there have been some very high quality presentations. The JpGU also works with the Japanese committee of the International Geography Olympiad to help to organize the International Geography Olympiad and

International Earth Science Olympiad

International Geography Olympiad

the International Earth Science Olympiad as well as the domestic selection meeting to choose Japanese teams.

The JpGU also conducts various outreach programs aimed at the general public. For example we hold a number of public sessions at the JpGU Annual Meeting that anyone can attend for free: the poster session for high school students mentioned earlier is one such example. The program for these sessions varies from year to year, but we like to plan symposia concerned with popular topics or social issues such as Geoparks or geoscience education. At every meeting we also hold two or three "Geoscience Top Seminars" present some of the very latest geoscience research results in an easy-to-understand format. Since 2013 these seminars have been videoed and made available for viewing on the internet. We also offer sessions aimed at high school and undergraduate students where they can ask undergraduate and graduate students questions about geoscience, and where graduate students offer advice about geoscience careers.

Recently we have also been holding a public lecture meeting in the autumn and videos of these lectures are made available on the internet. We also participate in Science Agora (a government sponsored program in Japan where members of the general public can meet and discuss science related issues with experts), and arrange for geoscience specialists to give lectures at public and private functions. In the wake of the 2011 Tohoku earthquake and tsunami the JpGU together with the National Museum of Emerging Science and Innovation set up a web based Q&A session where members of the public could ask questions and hear expert opinion on earthquakes, tsunamis and issues concerning radioactive fallout from the Fukushima Daiichi nuclear accident. Finally we are involved in many smaller projects, such as working with the Hitachi Environment Foundation on the Environmental Science Café (where scientists discuss environmental issues with the public in a Café setting) or with Yokohama city on their plans for educating young people.

Public Lectures in 2012

Finally, as part of our publicity activities we publish the journal Japan Geoscience Letters, which is aimed at geoscience professionals and interested members of the public. Each edition discusses the latest geoscience

Japan Geoscience Letters (JGL)

trends and then focuses on two or three new topics that are discussed by experts in an easy-to-understand fashion. The journal is available for free to members of the public and is also available at the National Museum of Emerging Science and Innovation and other selected museums.

In this way we at the JpGU aim to improve geoscience education and understanding. We hope to expand these activities in the future by providing more internet based popular science articles and instructional materials.

The History of the Japan Geoscience Union

The history of the JpGU starts in 1990. After a number of trials in the 1980s, five of the current JpGU's member societies held a joint meeting of geoscience related societies in April 1990. Over 1,000 people attended this meeting and it became clear that there was a need to hold this kind of event on a regular basis. As a result several of the societies agreed to hold an annual joint meeting and a liaison committee was set up to coordinate communication between the societies and to prepare for the meeting.

Each of the universities took turns to set up an organizing committee for that year's meeting, and the annual joint meeting started to be held. By 1996 ten member societies participated and there were over 2,000 attendees. But as the meeting grew it became difficult to find suitably large conference facilities, and the burden on the university organizing committees became greater and greater. The 1998 joint meeting was the first to take place not on a university campus but was instead held at the Yoyogi National Olympics Memorial Youth Center. Also that year the participating societies stopped holding their own meeting sessions and the meeting became organized around common sessions: it moved from being a jointly organized meeting to become a single meeting for everyone involved in all of the fields of geoscience. In 2001 a major development occurred when the Geoscience Joint Annual Meeting Administration Organization was set up as the permanent organization to manage the meeting. Now a single body was responsible both for running the annual meeting and for handling communication between the member societies. From 2003 the meeting was held every May at the Makuhari Messe International Convention Complex some thirty kilometers east of central Tokyo. The number of participants and the number of presentations continued to grow every year.

The event that finally led to the formation of the JpGU was the 2005 reorganization of the Science Council of Japan. Due to this reorganization, the existing system of having a separate scientific council for each subject was abandoned and a need arose for a new scientific council to cover all of geoscience including geology, mineralogy, geophysics and geography. A working group was set up to ensure cooperation between the various geoscience related societies and, after much debate, the Japan Geoscience Union was launched at the May 2005 Geoscience Joint Annual Meeting. At its launch the JpGU had 24 member societies, but this number has steadily increased and presently there are 50 JpGU member societies. The Joint Annual Meeting was renamed the Japan Geoscience Union Annual Meeting, and under this new name it continued to grow. At the 2013 meeting about 7,000 people attended 180 sessions where about 4,000 papers were presented. In 2008 the legal rules governing corporate organizations were changed, and the JpGU took this opportunity to become a general incorporated association. In 2011 it was recognized as a public benefit incorporated association.

The Japan Geoscience Union is an umbrella organization that contains member societies devoted to fields including geophysics, geology, mineralogy and geography. There is no equivalent body in any other country. We aim to serve the Japanese geoscience community by helping to build mutual understanding, by collecting opinions and by creating consensus. At the same time we function as a contact point for communicating information and proposals to both governmental organizations and wider society.

Date		Meeting Title	Location	Meeting Committee Chairman	Number of Member Societies Present	Number of Sessions / Number of International Sessions	Special Sessions	Notes
1990	April 5-8	Japan Earth and Planetary Science Joint Meeting	Tokyo Institute of Technology	Masaru Kono	5	44 / 0	S 1	Working committee for Japan Earth and Planetary Science Joint Meeting established. 1990 Western Pacific Geophysics Meeting held in Kanazawa.
1991	April 2-5		Kyoritsu Women's University	Katsuhiko Ishibashi	5	50 / 0	S 3	
1992	April 7-10		Kyoto University	Norihiko Sumitomo	5 (Symposium co-hosts 3)	46 / 0	S 4	
1993	March 19-22		Tokyo Metropolitan University	Kashio Ishikawa	6 (Symposium co-hosts 6)	47 / 0	S 7	
1994	March 20-23		Tohoku University	Kenichiro Aoki	7 (Symposium co-hosts 6)	55 / 0	S 8	
1995	March 27-30		Nihon University	Isamu Nagao	8 (Symposium co-hosts 6)	51 / 0	S 8	
1996	March 26-29		Osaka University	Takamitsu Yamanaka	10 (Symposium co-hosts 4)	62 / 0	S 8	
1997	March 25-28		Nagoya University	Katsuro Ogawa	11 (Symposium co-hosts 5)	60 / 0	S 8	
1998	May 26-29		National Olympics Memorial Youth Center	Masaru Kono	15	57 / 0		
1999	June 8-11			Hideki Shimamura	16	63 / 0		
2000	June 25-28			Takeru Yanagi	17	53 / 0		
2001	June 4-8			Mitsuhiro Matsuura	18	88 / 0		Introduction of formal system for organizing joint meeting
2002	May 27-31			Gaku Kimura	19	86 / 0		
2003	May 26-29		Makuhari Messe	Hiroshi Shimizu	19	83 / 0	U 1, SS 1	23rd General Assembly of the International Union of Geodesy and Geophysics held in Sapporo
2004	May 9-13			Kazuro Hirahara	20 (Supporters 5)	87 / 0	U 2, SS 1	
2005	May 22-26			Yozo Hamano	25 (Supporters 8)	110 / 0	U 2, SS 6	JpGU Founded on May 25th.
2006	May 14-18	Japan Geoscience Union Meeting		Toshitaka Tsuda	40 (Co-sponsors 4) (Supporters 8)	109 / 0	U 4, SS 4	
2007	May 19-24			Toshitaka Tsuda	46 (Co-sponsors 4) (Supporters 8)	134 / 4	U 3, P 6	
2008	May 25-30			Naomoto Iwagami	47 (Co-sponsors 4) (Supporters 8)	135 / 7	U 4, P 6	JpGU becomes a general incorporated association on December 1st.
2009	May 16-21			Naomoto Iwagami	48 (Co-sponsors 4) (Supporters 8)	134 / 9	U 4, P 4	
2010	May 23-28			Kazuro Hirahara	48 (Co-sponsors 4) (Supporters 7)	167 / 32	U 4, P 3	
2011	May 22-27			Noritaka Yagasaki	48 (Co-sponsors 4) (Supporters 7)	174 / 41	U 9, P 4	JpGU becomes a public interest incorporated association on December 1st.
2012	May 20-25			Noritaka Yagasaki	48 (Co-sponsors 4) (Supporters 7)	177 / 42	U 7, P 4	
2013	May 19-24			Akira Ishiwatari	49 (Co-sponsors 4) (Supporters 7)	180 / 42	U 7, P 5	
2014	April 28-May 2		Pacifico Yokohama	Tatsuo Oji	50 (Co-sponsors 4) (Supporters 7)	194 / 44	U 10, P 7	

Special Session codes:S Symposium, U Union session, SS Special session, P Public session

Japan Geoscience Union

Gakkai Center Bldg. 4F
4-16 Yayoi 2-chome, Bunkyo-ku, 113-0032, Tokyo
Phone: +81-3-69142080
FAX: +81-3-69142088
http://www.jpgu.org/
Email:office@jpgu.org