Earth and Planetary System Science

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Outline of Earth and Planetary System Science Group

The Earth and Planetary System Science Group aims to establish a new scientific field which stresses the viewpoint of studying the planet Earth as well as other planets as a single system composed of intimately coupled multiple domains. We will treat individual phenomenon on and within the earth and other planets from this point of view to understand stability, variability, and evolutionary trends of the planetary system and their surface environment. Our group consists of the following four subgroups: Analysis of the Earth and planetary system, Evolution of the Earth and planetary system, Dynamics of the Earth system, and Dynamics of the Earth's surface environment.

Analysis of the Earth and planetary system

This subgroup aims to specify operational processes of the interactions between multiple domains of the earth and planetary system by means of theory, observation and experiments, and to explore the mechanism to stabilize and maintain present condition of the system.

We investigate dynamics and evolution of the earth and planetary interiors. For the investigation on the fluid motion of the core, joining the Ocean Hemisphere Network Project, we are constructing networks of geomagnetic stations both on islands in the Pacific and on the sea floor. The long-term observation (more than a year) and paleomagnetic studies are

planned. Theoretical study on modeling the geomagnetic variations due to the disturbance of the earth's rotation is carried out. Laboratory experiments are also made, of which results are compared with the theoretical investigations to infer that the thermal insulating effect of the continents with tectosphere affects the pattern of the mantle convection.
We want to reveal the mechanisms that yield the characteristics of each terrestrial planet. The surface processes on the earth and planetary system are strongly dependent on interactions among multi-spheres, which includes planetary climatology, planetary tectonics, and early evolution of the planets. We theoretically investigate the feedback among the surface reactions and atmospheric chemistry. The role of plate tectonics on the surface environment is also investigated. Thermal and mechanical evolution of Moon's and other planets' crust and lithosphere, surface processes in the early evolution of planet are also our concern, particularly the formation of Martian atmosphere during accretion.
Stability, variability, and evolutionary trends of the Earth and other terrestrial planets, specifically their climates and surface environments (atmosphere, ocean, biosphere, crust, and upper mantle) are investigated from theoretical viewpoints, such as energy transport and geochemical cycles between the subsystems of the planets, on a variety of timescales. Relationships and constraints among the atmospheric, volcanic, and thermal evolution are studied. We develop models of geochemical cycle of carbon on various time scales to reconstruct the climate evolution in a long range and climate change in short scale during the Earth's history.

Evolution of the Earth and planetary system

This subgroup aims to investigate evolution of the earth, solar, and satellite systems from the viewpoints of material, chemical, thermal, and mechanical evolution by means of

theory, observation and experiments, and to clarify the roles of each domain and interactions among them during the course of the evolution of the systems.

Planetary craters played a particular role on the dynamic, tectonic, and chemical evolution of the earth, solar, and satellite systems. With the aid of knowledge on volcanology and sedimentology, planetary craters are analyzed to deduce its formation mechanism, which includes the observation on Martian craters as the Mars Imaging Camera group of Nozomi Japanese probe. Other geomorphologies and thermal evolution of mars and icy satellites are studied including the development of phase diagram of materials. These studies require better understanding on volcanology and physical properties of magmas on the earth, and therefore, vesiculation, magma transport, and rheology and elasticity of partially-molten rocks are experimentally and theoretically studied.
Chemical evolution of the solar and earth systems is one of our major concerns, particularly chemical evolution of condensed phase through interactions between gas and liquid. These study give information on evolutionary time scale through kinetics of reactions. It includes an inverse approach such as petrologic, mineralogical, and isotopic study on chondritic materials to find critical records on the process took place in the early solar nebula. We also make a forward approach such as modeling of reaction processes that are responsible for the observed chemical characteristics. It includes various kinetic processes such as evaporation, condensation, crystallization and melting. Experimental studies on the kinetic reactions are carried out to get reaction parameters.

This subgroup aims to reconstruct past changes of global system on various temporal and spatial scales on the basis of geological and observational analyses, and to explore their relations among multiple domains by quantitative evaluation of energy transport and chemical cycling.

We want to understand the dynamics of global climatic and environmental systems, their stability, and the mechanism(s) which stabilize the global surface environment as habitable for lives based on the reconstruction of past changes from geological records synthesized with theoretical studies. The research targets includes i) the centennial- to millennial-scale abrupt climatic changes, and their dynamics with special emphasis on testing stability of global climatic system under Quaternary interglacial conditions and exploring possibility of near future abrupt climatic changes in response to increasing greenhouse warming caused by human races, ii) the stability and recovery processes of global environmental systems against catastrophic perturbation associated with asteroid impacts such as K/T impact, and iii) the dynamics of global ocean anoxia during Phanerozoic and their possible relation with abrupt climatic changes and mass extinctions.

Dynamics of the Earth's surface environment

This subgroup aims to understand regional as well as temporal variability of the surface environment on the earth where interaction of multiple domains is very active, and to explore causes of such variability through analysis and reconstruction of the surface environment using climatological, ecological, geomorphological and geological methods.

Monsoon is a particular climate system generated by multiple interaction among land, ocean and atmosphere on the earth surface. One of the main topics is the global-scale climatology on the seasonal and interannual changes of monsoon during recent observation period, mainly over the Asian monsoon region. Also we analyze the global-scale heavy rainfall, which will contribute to the disaster prevention, as well as to the paleo-climatology related to reconstruction of past fluvial geomorphic process.
Coral reefs and coastal processes give information on the

biological, physical, chemical and geological interactions, which can be understood through field monitoring. Ecological zonation of reef creatures is compared with physical parameters and this relation is traced back to the geological past. Carbon and nutrient cycles accompanying with community metabolism are monitored and compared with CO flux. The role of coral reefs /coastal ecosystems is one of our main topic with relation to the global changes. We also investigate the environmental changes by corals/coral reefs with timescales of 100 to 100,000 years by excavating coral reefs and coastal plains. By applying geochemical method, the research leads to evaluate the role of tropical oceans in the long-term climate changes.

The mechanisms and regional diversity of the earth surface processes interacting climate, water, topography, vegetation, human activities are analyzed by taking field observation data. The response of the earth surface to the environmental changes in various temporal and spatial scales in the past, present and future is studied.

Web page of Earth and Planetary System Science Group