Applying flying boat for Geosciences

*Urumu Tsunogai[1], Mitsuo Uematsu[2], Hajime Obata[2], Hiroshi Tanimoto[3], Shinsuke Kawagucci[4], Hiroshi Shinohara[5], Fumiko Nakagawa[1]

1. Graduate School of Environmental Studies, Nagoya University, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. National Institute for Environmental Studies, 4. Japan Agency for Marine-Earth Science & Technology, 5. Geological Survey of Japan, AIST

In this talk, I would like to present and discuss the possible applications of flying boat for promoting Geosciences, especially in the fields studying hydrosphere and atmosphere.

Keywords: flying boat, Master Plan 2017

Research on Ocean Ecosystem by Flying Boat

*Joji Ishizaka[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

Since using the flying boat it is possible to fly to stations on the sea at a high speed with taking the surrounding information and to have measurement by instruments taking water samples, it is expected to be an ideal marine platform with high mobility. Here, I will discuss about the expectation for 1) response to sudden phenomena such as typhoons and aerosol events, 2) local phenomena such as phytoplankton increase (bloom) associated with eddies and fronts, and 3) calibration and validation of satellite ocean color remote sensing.

Keywords: Flying boat, Ecosystem, Phytoplankton

A couple of thoughts on field observations for atmospheric and marine chemistry research with flying boats

*Hiroshi Tanimoto[1], Sohiko Kameyama[2], Yuko Omori[3]

1. National Institute for Environmental Studies, 2. Hokkaido University, 3. University of Tsukuba

Field observations of the atmospheres and the oceans are needed for better understanding of the atmosphere-ocean interactions and biogeochemical cycles of trace species of environmental importance. The research community has largely relied on the use of research aircrafts and/or research vessels, but there is a technical or logistical gap between these approaches. The observations with flying boats may fill the gap to be complement with those with aircraft and ships. We will discuss new insights that flying boat observations can deliver to the atmospheric and marine chemistry research in the coming decades.

Keywords: flying boat, atmospheric chemistry, marine chemistry

Volcano monitoring using a flying boat

*Hiroshi Shinohara[1]

1. Geological Survey of Japan, AIST

The most important feature of flying boats is the ability for quick and flexible observation in the air and on the sea at large distance from the main land. In order to conduct urgent observation of the eruption activity in the remote sea area, it is expected that the characteristics of the flying boats described below are needed, and flying boats are expected to open up various possibilities for volcano research in the sea area.
In the event of sudden disasters such as eruption, grasping the phenomenon and its transition from the earliest stage is necessary for countermeasures against disasters and for earth science research, and urgent initial observation is required. At the same time, a preliminary observation from a safe area to grasp the situation beforehand is also necessary to prevent secondary disasters during the observation. In an eruption activity in a sea area, observation using a ship can be performed after grasping the situation by aircraft observation. Since observation on the sea can be promptly carried out by a flying boat after grasping the situation from the air, a flying boat is suitable for the quick initial investigation of sudden disaster in the sea area, including volcanic eruptions.
I myself mainly performed observation of the composition and flux of volcanic gas. A flying boat, which can fly at various altitudes at relatively low speed, is also suitable for these observations. At present, the volcanic gas observation using an aircraft is carried out by borrowing ordinary Cessna aircraft, but the equipment needs to be installed only in the aircraft not outside according to the aeronautical law, and observation conditions are limited. In order to obtain optimum observation conditions, it is desirable to modify installation of observation equipment including remodeling of the aircraft in advance. Improvement of flying boats aimed at earth science observation enables observations under optimum conditions.
The biggest feature of the flying boat is that it is possible to landing water. In the survey of volcanoes in the sea area, usually ships are used to install instruments such as ocean bottom seismographs, to sample seawater and sea floating matter, and to perform landing operations using rubber boats, etc. All these operation is possible from the flying boat on the water. Compared to ships, the flying boat moves more rapidly, so that the site work can be started quickly, visual observation from the aerial before the arrival of the water allows us to judge the situation immediately before, and it can be evacuated from the site quickly when a danger was detected during the work. Installation of continuous observation equipment is indispensable for grasping changes of volcanic activity. In the case of Nishinoshima eruption, observation of the activity changes was initially depends on visual observations repeatedly by jet aircraft, making it difficult to grasp quantitative trends and detect detailed changes. After that, the frequency change of the eruption was grasped by continuous infrasonic observation at Ogasawara which is 130 km away, and the ocean bottom seismographs were installed around Nishinoshima only after 2015. Continuous observation data such as ocean bottom seismographs are not only necessary for quantitatively evaluating activity changes, but also are essential data for understanding of eruption processes. Recently, observation method of ocean bottom crustal movement is put into practical use. Also, using a wave glider that can autonomously navigate the sea surface with wave power alone. Utilization of a flying boat is indispensable in order to promptly deploy these devices to the surrounding sea area after volcanic activity activation. In order to realize the urgent volcano monitoring in the remote sea area, in parallel with the development of these observation methods, it is desirable to develop observation methods using flying boats.

Keywords: Flying boat, volcano monitoring, volcanic gas

Prompt recognition of submarine volcanic activity based on detection of mantle-derived volatiles in seawater collected using a flying boat

*Hirochika Sumino[1], Urumu Tsunogai[2], Takanori Kagoshima[3], Kaori Kawana[1], Toshiya Mori[4], Takeshi Ohba[5]

1. Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo, 2. Graduate School of Environmental Studies, Nagoya University, 3. AORI, The University of Tokyo, 4. Geochemical Research Center, Graduate School of Science, The University of Tokyo, 5. Department of Chemistry, School of Science, Tokai University

The submarine volcanic eruption may cause significant damage to inhabitants of nearby islands and ships traveling in the vicinity. Even during relatively quiescent periods, some submarine volcanoes regularly emit hydrothermal fluids together with gas plumes that reach the ocean's surface [1]. The release of such fluids from the earth’s interior is thought to have a great impact on the ocean environment. Therefore, understanding submarine volcanic activity is necessary not only for the earth sciences but also for disaster prevention. However, while the large-scale emission of hydrothermal fluids from a submarine volcano can be observed via discoloration of surface seawater, what is actually going on on the ocean floor is difficult to be inferred from the surface. Therefore, it is desirable to find a new method of collecting samples from submarine volcanoes quickly and safely, and evaluating submarine volcanic activity.
The volatile components, particularly helium emitted from submarine volcanoes are observed diffused into upper seawater. Above mid-ocean ridges, for example, dispersions of mantle helium over a wide range extending over 1,000 km have been detected [2]. The amount of helium degassed from the earth’ interior has been estimated from the mantle helium distribution in the ocean [3]. Furthermore, the mantle helium emission can also be used to place limits on the amount degassed of other volatiles [4]. Helium is chemically inert, so its isotope ratio ($^3He/^4He$) is unaffected by the physical and chemical conditions such as temperature, pressure, and pH and the isotope ratio of mantle helium differs by an order of magnitude from that of ambient seawater, which is almost atmospheric in composition. These features make helium an extremely sensitive and highly reliable geochemical tracer for oceanic hydrothermal fluid emissions.
In this presentation we will propose the use of a flying boat to conduct seawater sampling and the use of $^3He/^4He$ ratio analysis for the prompt detection of submarine volcanic activity. Sampling at depths of 100 m or more is routinely conducted with a Niskin water sampler [5] or hosepipe [6], so a flying boat could be promptly dispatched to areas where discoloration or foaming has been observed at the ocean surface, where quick multipoint sampling at depth would be conducted. Using the maneuverability of the flying boats, $^3He/^4He$ isotope ratio analysis could be conducted at the laboratory the next day to make it clear whether or not new hydrothermal fluids are being emitted. If the flying boat could remain for a relatively long period of time in the target area, depth profiles at multiple locations would be taken to obtain a three-dimensional profile of the distribution of mantle helium, and to estimate scale of the magma responsible for the degassing from the overall amount of emissions.
Besides helium, carbon isotope ratios of carbon dioxide and methane as well as nitrogen isotope ratios can provide important limits regarding the origin of dissolved volatiles in seawater [1, 5, 6]. We are promoting the development of method to collect and analyze bottom water in the vicinity of submarine volcanoes and of on-site isotope ratio analysis techniques using portable mass spectrometers [7] and laser-based isotope ratio spectrometers [8]. Through combining these new technologies with prompt sampling using flying boats, we would like not only to further our understanding of the degassing history of the earth and the primary causes of changes in ocean environments, but also to contribute to disaster prevention by providing prompt detection of submarine volcanic activity.

[1] Wen *et al.*, *Sci. Rep.* 2016. [2] Lupton & Craig, *Science* 1981. [3] Bianchi *et al.*, *EPSL* 2010. [4] Kagoshima *et al.*, *Geochem. J.* 2012. [5] Nishimura *et al.*, *Geochem. J.* 1999. [6] Notsu *et al.*, *JVGR* 2014. [7] Jensen *et al.*, JpGU-AGU Joint Meeting 2017. [8] Rizzo *et al.*, *GRL* 2014.

Keywords: isotope, helium, submarine volcano, flying boat, volatile elements

Sample recovery of microgravity experiments using sounding rockets opens up new sciences

*Yuki Kimura[1]

1. Institute of Low Temperature Science, Hokkaido University

In order to understand how cosmic dust particles form in the gas outflow from evolved stars, we have performed microgravity experiments using S-520 sounding rockets of JAXA. In the microgravity condition during a parabolic flight of the rocket, cosmic dust particles are synthesized from a hot vapor in a specially designed experimental chamber and its nucleation environment is observed by means of a double-wavelength Mach–Zehnder-type laser interferometer. The deviation of the interference fringes tell us the nucleation temperature and concentration, which are similar nucleation conditions of natural cosmic dust particles formed around evolved stars such as supernovae and asymptotic giant branch stars [1]. After the experiment, the S-520 rocket fall onto the Pacific Ocean and sink into the water together with the produced particles. Based on the result of this in-situ observation, nucleation theory determines either sticking probability or surface free energy. Both physical parameters of nanometer sized particles are crucial to expect formation of cosmic dust particles. Nevertheless, we have only a data of bulk surface free energies and expect one for sticking probability to discuss material evolution in the universe. In a previous project using the sounding rocket S-520-28, we succeeded to determine a sticking probability of iron nanoparticles and show the difficulty of the formation of metallic iron dust in the ejecta of a supernova [1]. If we could recover the produced particles, surface free energy can also be determined after measurement of the particle size using a transmission electron microscope. Then, formation of cosmic dust particles can be expected more precisely using nucleation theories and our insights on the material evolution accompanying with stellar life will be deeper.
In addition, time-resolved infrared spectra of the particles during nucleation and growth under the microgravity environment have also been measured to understand the origin of infrared features astronomically observed. We succeeded to observe infrared spectra of alumina particles in intermediate state in a project using the sounding rocket S-520-30. Unfortunately, however, the polymorph of the produced alumina particles could not be determined because the sample is into the deep ocean. Currently, to recover the sample and payload after sounding rocket experiments, we have to find international corroborators in US or Europe. Actually, we and other Japanese scientific teams are making working groups and started projects of international collaborations under some complex systems. If a flying boat will be served in a Japanese scientific community and can be used to recover the payload, our characteristic sciences in Japan will be opened up more easily and progressed more rapidly.

[1] Y. Kimura, K. K. Tanaka, T. Nozawa, S. Takeuchi, Y. Inatomi, Pure iron grains are rare in the universe, Science Advances, 3 (2017) e1601992. DOI: 10.1126/sciadv.1601992..

Acknowledgment: This work was supported by a Grant-in-Aid for Scientific Research (S) from KAKENHI (15H05731).

Keywords: Dust, Nucleation, Nanoparticle

