Next-generation Technology for Ocean Resources Exploration

"*Zipangu-in-the-Ocean*" Program

"*Zipangu-in-the-Ocean*" Program –Seeking the Wealth of Mineral Resources in Our Seas

In the 13th century, the Italian explorer/merchant Marco Polo described Japan as *Zipangu*, that is, the island of gold in the "Travels of Marco Polo". In fact, Japan once was the world-leading producer of gold, silver, and copper, but now it imports almost all the metal resources it needs from abroad. Although these resources on land have been mined out, the seabed around the Japanese archipelago is still believed to hold a wealth of mineral resources. The goal of the Next-generation Technology for Ocean Resources Exploration ("*Zipangu-in-the-Ocean*") Project is to develop ocean resource survey technologies to launch a strategy in creating a world-leading ocean resource survey industry.

Program Director

Tetsuro Urabe Ph. D.

Professor Emeritus, The University of Tokyo
Executive Adviser,
Japan Mining Engineering & Training Center (JMEC)

Profile

Tetsuro Urabe graduated from the University of Tokyo in 1971 and received a Ph.D. in geology at the University of Tokyo in 1976. His professional career includes assistant professor, Geological Institute, University of Tokyo (1976–1985), chief geologist, Geological Survey of Japan (1996–2000), and professor, Department of Earth and Planetary Science, University of Tokyo (2000–2014). He was also a member of the United Nations Commission on the Limits of the Continental Shelf (CLCS) (2011–2017). Dr. Urabe is currently executive adviser at the Japan Mining Engineering & Training Center (JMEC) and professor emeritus at the University of Tokyo.

Research and Development Topics

1. Identification of Promising Ocean Areas for Investigation Based on Ore Genesis Research

We have developed a science-based methodology to narrow down potential areas for seafloor exploration to identify mineral resources. Such techniques will be developed through understanding of the mechanisms by which mineral resources are formed, as well as identifying distinctive indicators of mineral occurrence. We organize these techniques into a survey protocol for use by private enterprises, helping them to reduce exploration time and costs significantly.

2. Development of ocean resource survey technologies

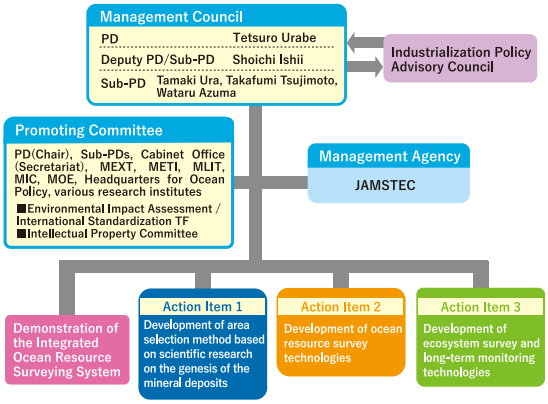
There have been no systems to date that enable us to detect seafloor massive sulfide (SMS) deposits concealed under the seabed. Accordingly, we have developed the world's first survey system enabling us to efficiently discover resources below the seabed, by combining the operation of multiple autonomous underwater vehicles (AUVs) for wide-range surveys with the remotely operated underwater vehicles (ROVs) for detailed data acquisitions. With these advancements, we will create new markets of ocean resource survey and development business.

3. Development of ecosystem survey and long-term monitoring technologies

Consideration for ecosystems and the environment is essential for ocean resources development. Assess risks to ensure a harmony between the development of ocean resources and the protection of the environment. Establish internationally granted standards for environmental impact assessment and environmental management, aiming to apply these technologies to other countries and win contracts for overseas surveys.

Implementation Structure

The project's Management Council consists of the Program Director (PD), Sub-PDs, and Research Topic Leaders. The Council manages progress of the project with a view to the exit strategies, guiding the project to solid results. With an aim of creating an ocean resource survey venture, the Council has gathered industry, academia and government together into an agile and strategic research framework. In a close partnership with JOGMEC, the Council promotes efforts from development of technologies to their tests under actual ocean conditions. Moreover, the Council is responsible for promoting the transfer of technology to private enterprise. The Promoting Committee consists of the PD serving as Chair, the Cabinet Office serving as Secretariat, as well as other experts and representatives from various ministries and agencies. The Committee utilizes operating expense grants provided to the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), making maximum use of the knowledge and expertise developed.



Exit Strategies

Create ocean resource survey industries

Develop competitive ocean resource survey technologies (low-cost, high-efficiency, rapid and safe) through joint efforts among the government, industry, and academia. Use policy to transfer new survey technologies and expertise to the private sector. Create a new ocean resource survey industry by meeting the needs of resource industries and organizations, such as the Japan Oil, Gas and Metals National Corporation (JOGMEC), which explore and develop ocean mineral deposits.

Establish global standards

Lead the world with top-notch technologies of efficient ecological survey and environmental monitoring and work for the internationally granted standardization of these technologies and methods. Export these low-cost survey systems and perform survey projects on contract with overseas entities.

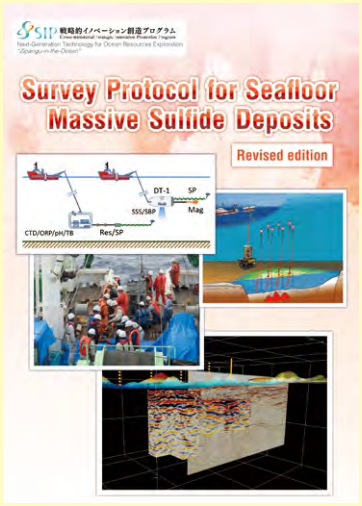
Progress to Date

Completion of survey protocol for seafloor massive sulfide deposits

In FY2016, we published a result booklet "The mechanism of formation of seafloor massive sulfide deposits—toward establishing survey method" summarizing the research results obtained from the investigation of the Iheya North Knoll and the Iheya Minor Ridge, seafloor massive sulfide deposits in the Okinawa Trough.

Based on the booklet, we summarized a series of effective flows for investigating SMS deposits into "Survey Protocol for Seafloor Massive Sulfide Deposits", which is easy for private companies to use, and published a new booklet as well as an electronic file of the protocol. This will enable us to start investigating marine resources such as new SMS deposits by narrowing down the promising area for investigation from the vast oceans, leading to the exploration and discovery of SMS deposits. With this protocol, private enterprises will be able to conduct integrated survey independently and it is expected that they will lead ocean resource survey in the international community due to their superiority.

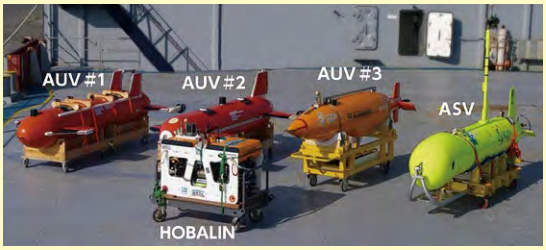
•Survey Protocol for Seafloor Massive Sulfide Deposits



Confirmation of the usability of AUVs, as a part of Integrated Ocean Resource Surveying System

We successfully surveyed a seafloor hydrothermal area in Wakamiko Caldera, in the Kagoshima Bay, using three fully automated cruising-type AUVs and one hovering-type AUV, simultaneously, which are monitored by an autonomous surface vehicle (ASV). Also, rather than using well-equipped research vessels owned by research institutes, this survey was performed using an ordinary workboat owned by a private company. In FY 2018, a multiple AUVs operation was conducted off west of Amami Oshima Island, as part of the Integrated Ocean Resource Surveying System, which narrows down the promising area for investigation through step by step exploration, from regional-, through semi-detailed-, to detailed-surveys. With reliable vehicle performance, we acquired high quality data such as high resolution seafloor bathymetry images and traces of hot water plumes. Proficiency in operation has acquired, and technology transfer to private companies has accomplished. In addition to the resource survey, environmental impact assessment survey has been conducted simultaneously, by utilizing hovering-type AUV for baseline ecosystem survey.

•The simultaneous operation technology of multiple AUVs which enables us to reduce survey cost and time.



International Standardization for Environmental Impact Assessment Technologies

Since the beginning of the project, a low-cost, long-term observation system of seabed organisms has been developed as a part of "Development of ecosystem survey and long-term monitoring technologies". Since such ecosystem survey technologies are indispensable for the future seabed mineral resources development, efforts were made to nominate those technologies as international standards to facilitate the global monitoring of deep-sea ecosystem.

We established a new working group in 2017 to register the technology developed in this project to International Organization for Standardization (ISO) in 2018.

In addition, we are making efforts to be able to contribute to revise the guideline for environmental impact assessment by the International Seabed Authority (ISA).

•Edokko Mark 1 monitoring system used for long-term monitoring. One of the environmental impact assessment instruments served for international standardization.

Program Director **Tetsuro Urabe** (Professor Emeritus, The University of Tokyo). **Interview**

Demonstration of the Integrated Ocean Resource Surveying System in the unsurveyed waters of the Okinawa Trough

The Next-generation Technology for Ocean Resources Exploration (“*Zipangu-in-the-Ocean*”) Project have developed the high-efficiency, low-cost ocean resource surveying system for the first time in the world toward an exit strategy. As a near-completion test of this project, we demonstrate the system in the unsurveyed waters of the Okinawa Trough in the final year (the 5th year).

“*Zipangu-in-the-Ocean*” is twelve times larger than the Japanese Archipelago

Fifteen million years ago, the Japanese archipelago was mostly under the ocean. It has been a rare place in the world where two oceanic plates subduct at the eastern margin of the Eurasia Continent. The plate subduction lead to submarine volcanic activity that resulted in the formation of island arcs. Magma of submarine volcanoes has generated hot spring (hydrothermal) activity and concentrated minerals, in other words, it has acted as a natural blast furnace. Receiving the benefit, Japan has more than 1,000-year history of mining gold, silver, and copper. However, most of the mines today have been exhausted; Japan imports nearly 100 percent of its metal needs from overseas.

But, turning our eyes to the oceans surrounding the archipelago, Japan has the exclusive economic zones (EEZ), which is more than twelve times larger than the area of Japan itself. There are many hydrothermal ore deposits and cobalt-rich manganese crusts in this vast ocean floor.

Tetsuro Urabe, Program Director of the Next-generation Technology for Ocean Resources Exploration Program states, “The *Kuroko* deposits for which Japan is famous —including zinc, copper, lead, gold, and silver—were all formed when most Japanese archipelago was submerged 15 million years ago. Even today, this same mechanism is creating new hydrothermal deposits similar to the *Kuroko* in the ocean floor around Okinawa and Izu-Ogasawara today.”

World-leading survey technologies with collective efforts of the government, industry, and academia

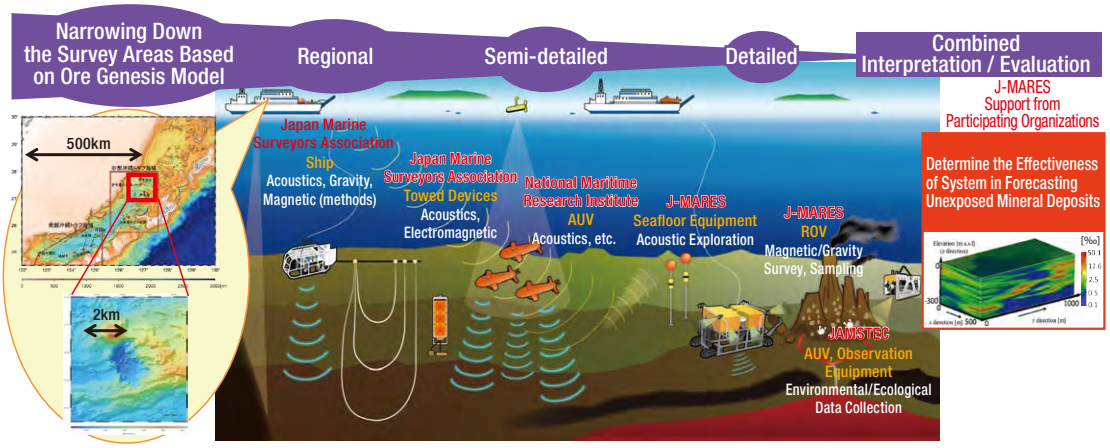
Although terrestrial exploration techniques, such as satellite-borne remote-sensing, geophysical methods, and drilling have already been well established, survey techniques for seafloor resources are still a tremendous technical challenge, particularly since visible light and radio waves do not penetrate down to the deep ocean. Cost is another issue. Drilling surveys, for example, can be about two-orders of magnitude costlier underwater than on land. In response to these circumstances, Japanese research institutes related to marine science and technology have jointly pursued the development of high-efficiency, low-cost surveying technologies in last four years, to reduce the number of exploration drillings in early stage of seafloor resource surveys.

One specific approach is to develop a technology to operate multiple AUVs simultaneously. Artificial seismic source waves (i.e., acoustic waves) are transmitted from a ship to receive reflected waves from sub-seafloor structures to examine the presence of mineral deposits. An self-potential anomalies related to sub-seafloor mineral deposits is measured simultaneously with anomalies in electrical resistivity also related to mineral deposits. Other techniques such as rock magnetism can reveal the existence or absence of hydrothermally altered rocks, since hydrothermal activity modifies the magnetic properties of rock.

Combining these methods and clarifying the goal to achieve the exit strategy, we exerted all efforts to accelerate the field tests. As a result, so far, we established “The Integrated Ocean Resource Surveying System” capable of searching mineral deposits up to 30 meters below the seafloor at a water depth of 2,000 meters, and we demonstrate the system capable for use in the actual waters.

Efforts in the final year

In the 5th year, the final year of the project, we perform actual near-completion test of the system: firstly from identification of promising areas for investigation based on ore genesis study



●Integrated Ocean Resource Surveying System

Next-generation Technology for Ocean Resources Exploration

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to, secondly, regional / semi-detailed / detailed surveys and sampling in the unsurveyed waters of the Okinawa Trough. This is part of a comprehensive validation of the efficiency, cost, and environmental impact of this technology, in an effort to establish the world's first system capable of detecting concealed SMS deposits in the vast oceans. PD Urabe is confident that "you can expect good results".

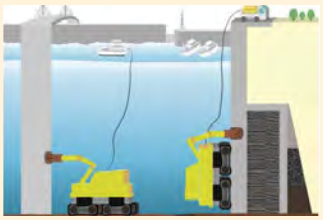
As a new initiative, it is now possible to display various big data obtained by research vessels in three-dimensional virtual space. This three-dimensional visualization system currently being developed enables multiple researchers to enter the virtual space, grasp the distribution of the ore body beneath the seafloor and discuss the data interpretation. Since it is possible to interpret the ore body that has been captured in two dimensions into three dimensions, it is expected to achieve dramatic technological development.

Toward Reliable, Eco-friendly Resources Development and International Cooperation

Looking to the future, PD Urabe states, "One of our exit strategies for next-generation technology for ocean resources exploration is to create an ocean resource survey industry. Taking the bigger view, however, we believe our initiatives will contribute to Japan's resource security and stable supply of metals. These technologies can be used to other purposes such as examine bedrocks on the seafloor for anchoring floating oil rigs. They could also be used to choose best locations suited for laying underwater cables.

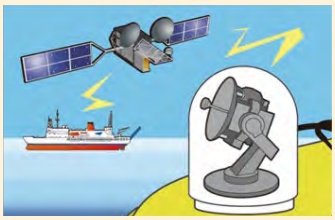
We have particularly high expectations to use our technology to develop ocean resources around small island countries. Island countries in the Pacific Ocean are limited in their land territories, but have an extensive continental shelf around them. Contributing to these island countries by providing not only resource development technology but also environmental protection technologies for them to protect their pristine environment could also create new industries and jobs. It would also lead to more diverse suppliers of resources for Japan. These are the future goals we want to accomplish."

Toward social implementation of the project accomplishments



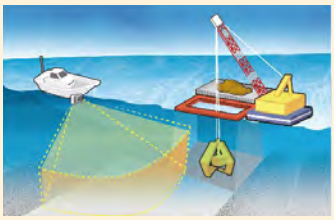
•ROV-mounted multipoint coring system

Enables to collect cores from multiple locations in the sea.
Utilization in marine civil engineering and port construction can be expected.



•High-speed satellite communication technology

Enables high speed, large capacity communication on offshore vessels.
Utilization in shipping industry, defense related industry, and marine survey can be expected.



•Acoustic video camera

Enables to monitor construction situation through 3D images even in turbid water.
Utilization in marine civil engineering, ocean construction, and marine survey can be expected.

•Onboard bioassay for seawater quality monitoring

Provides rapid evaluation of biological toxicity at deep-sea mining sites.
Utilization in oil and gas industry, environmental assessment, and marine survey can be expected.

We develop "The Integrated Ocean Resource Surveying System", commercializing the system for use in private enterprise, securing a stable resources supply, and contribute to international cooperation.