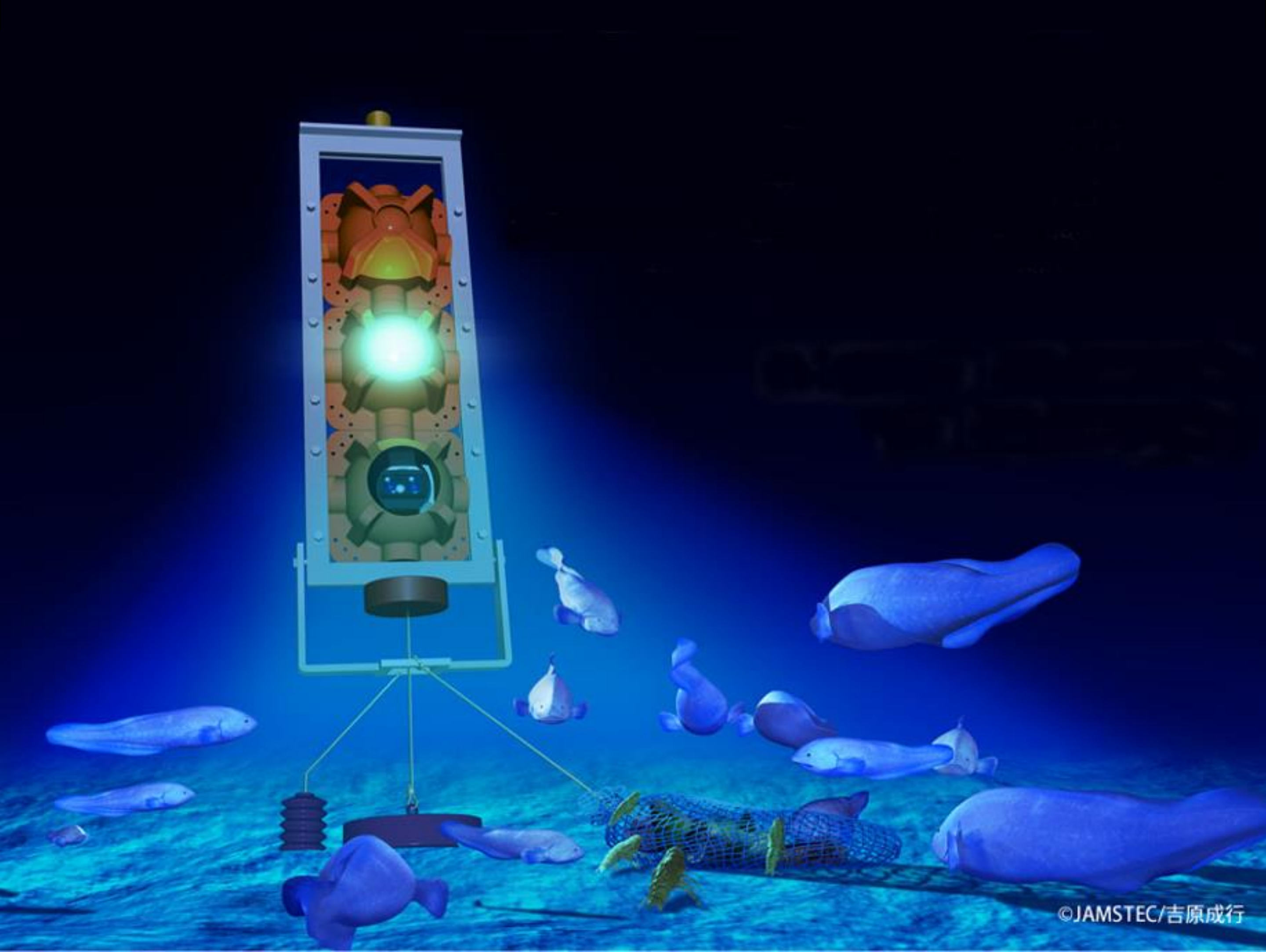
A free-fall small lander type of deep-sea exploration vehicle

EDOKKO MARK- Ⅰ

- The story of the relentless challenge
to reach the unknown world, the deep sea -



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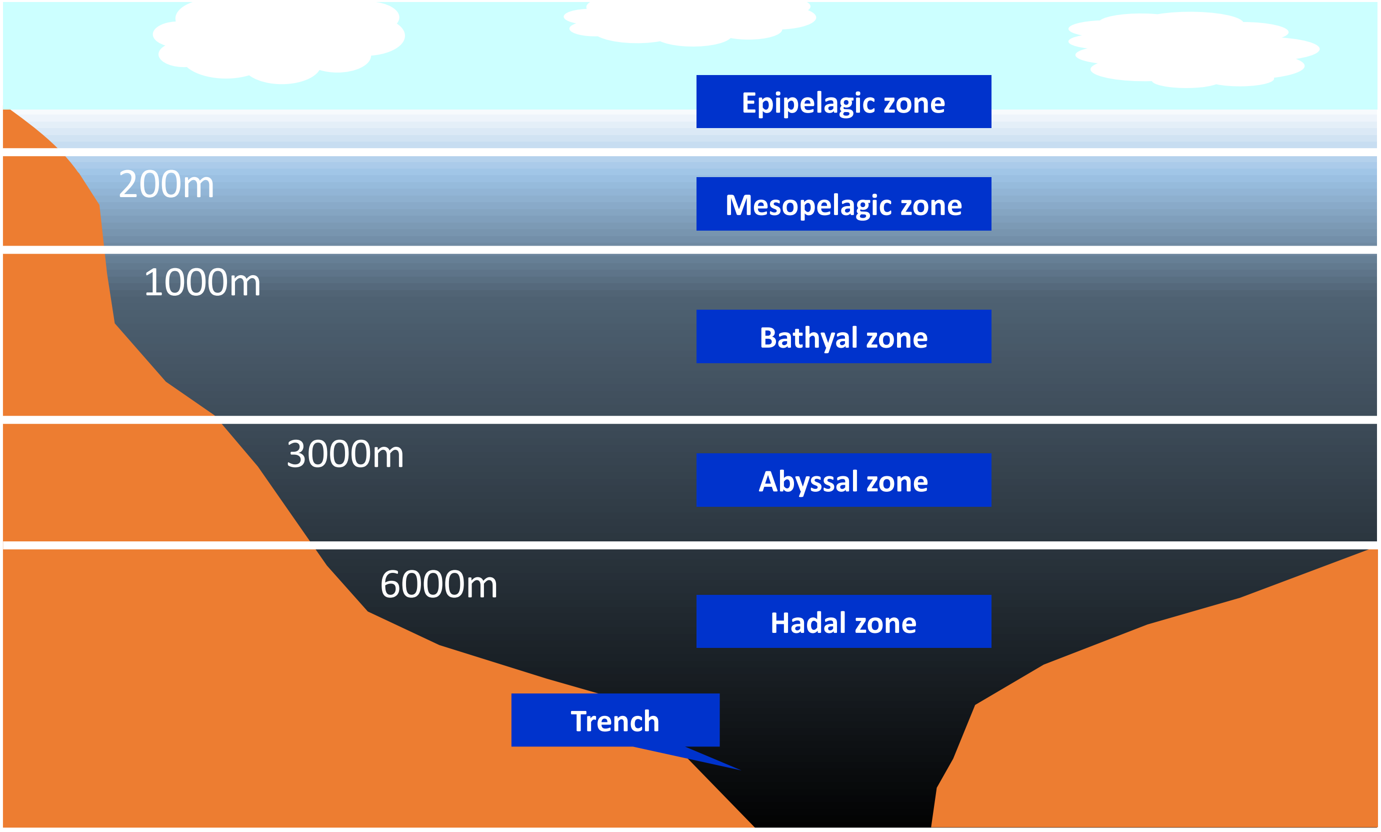
Ⅰ. The deep sea

The deep sea, the only place on earth that has not been reached by humans, and it is even more difficult to reach than space.

In this article, we will introduce this unknown world of the deep sea. We would also like to introduce the characteristics of a free-fall small lander type of deep-sea exploration vehicle, Edokko Mark- Ⅰ, and the various technologies that support Edokko Mark- Ⅰ.

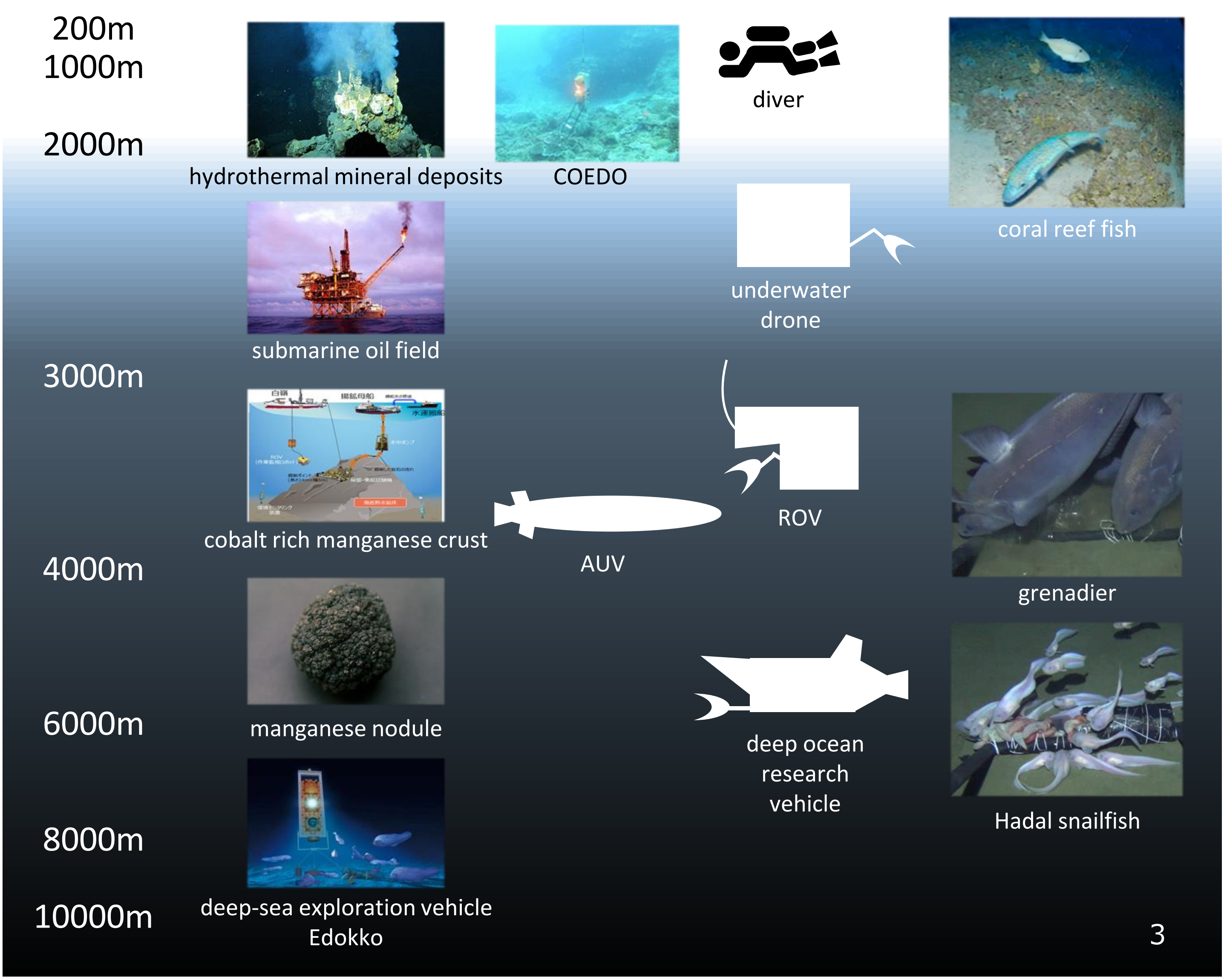
The ratio of the total area of the Earth's oceans and land is 7:3. As it is called the planet of water, the majority of the Earth is ocean. The area between 3,000 and 6,000 meters below the sea floor is the largest part of the ocean, and is said to account for 70% of the total ocean area. The deep sea is defined as a sea area more than 200 meters deep. Because the sunlight necessary for photosynthesis does not reach the deep sea, the environment and ecosystem are very different from that of the surface layer. In order to adapt to the harsh environmental conditions of high water pressure, low water temperature, darkness, and low oxygen, organisms have evolved in their own unique ways, and there are organisms with unique morphology and ecology. The term "deep-sea fish" is a general term for fishes that live in the deep sea, but there is no clear definition of the term "deep-sea fish" as there are many species that change their habitat depths during the growth process or routinely move vertically in search of food. The deep sea is difficult for humans to reach, but the garbage we throw into the sea can easily reach the deep sea. Plastic is not easily decomposed by seawater, and since it gets into the mouths of microorganisms and marine organisms, there are concerns about its impact on the ecosystem in recent years.



Ⅱ. Sleeping deep sea resources

The world of the deep sea contains many things that are still unknown, such as living organisms and undersea resources. At depths of 2,000 to 6,000 meters, manganese clusters, which contain copper, nickel, cobalt, and other elements in addition to iron and manganese, are widely distributed on the ocean floor. In addition, methane hydrate, a sherbet-like deposit of natural gas, lies beneath the seabed all over the world, including the seas around Japan.

Japan's land area of 378,000 km2 is the 60th largest in the world, but its territorial sea and exclusive economic zone (EEZ), which the Japanese government claims to own, is the 6th largest in the world at 4.47 million km2. It has been confirmed that there are abundant energy and mineral resources in its territorial waters. Since Japan is an island nation surrounded by the sea, if for some reason imports become impossible in the future and domestic reserves are consumed, all industries that use metals will come to a halt. Efforts to extract mineral resources in our own country and research are still ongoing.



2 Features of Edokko Mark- Ⅰ

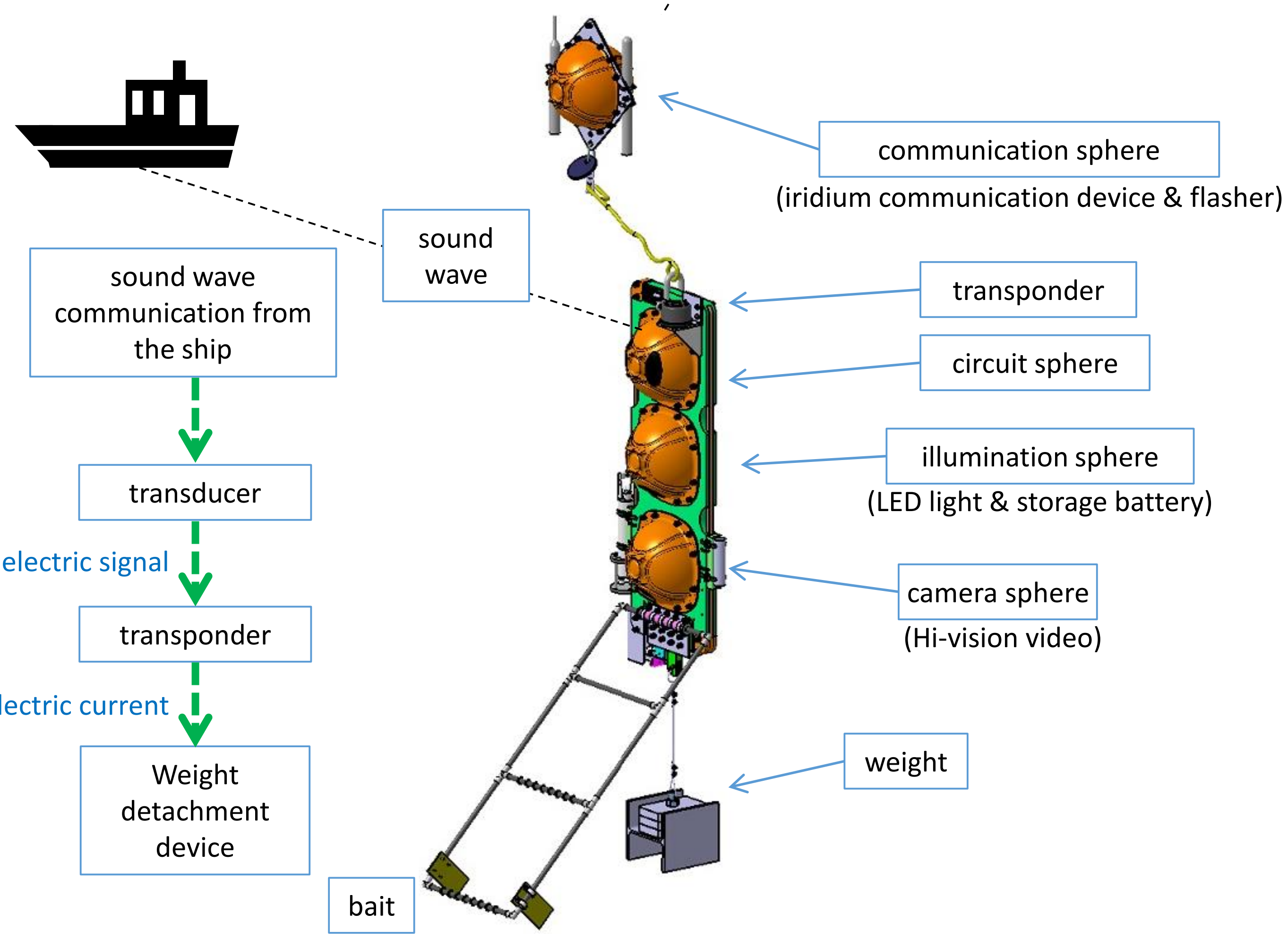
Ⅰ. About Edoko Mark- Ⅰ

Inspired by the “SOHLA-1" satellite developed by the Higashi-Osaka Space Development Cooperative Association, a group of small and medium-sized companies in Osaka, we came up with the idea that if Osaka is in space, Tokyo should aim for the deep sea.

Five companies, including Sugino Rubber Chemical, Hamano Products, Pearl Giken, Vacuum Mold Kogyo, and Okamoto Glass worked as a project team to develop the “Edokko Mark- Ⅰ”, a vehicle capable of unmanned exploration of the deep sea.

Edokko Mark- Ⅰ consists of a communication sphere, transponder, circuit sphere, illumination sphere, and camera sphere, and is submerged in free fall from the ship into the deep sea. In the water, it sinks about 50 to 60 meters per minute, and by sending sound waves from the ship to the transponder attached to the vehicle and determining the depth according to the speed at which it bounces back, it is possible to confirm whether the vehicle has landed safely on the sea floor.

Since radio waves cannot penetrate underwater, sound waves are used. By converting the sonic signals from the ship into electric current and detaching the weights, the vehicle that has completed its observation will float to the surface by its own buoyancy. After surfacing on the sea surface, the coordinates are confirmed by GPS, and the vehicle is recovered by the ship.



Ⅱ. COEDO and Edokko series

Edokko is available in two types: the standard HSG type and the 365 type which enables long-term ecological monitoring for 365 days. However, due to the weight of Edokko, it requires a large ship equipped with a crane to navigate.

COEDO was developed so that it can be handled manually without the need for a crane. COEDO is derived from "**Co**mpact and **E**nvironmentally **D**eep-sea **O**bservation Lander". There are two types of COEDO. COEDO Petite with a 10-inch glass sphere and COEDO 13-inch with a 13-inch glass sphere. They are lighter in weight in the air and can be handled by small ships and fishing boats, greatly improving operability. Although COEDOs are smaller, their basic functions are the same as those of the HSG and 365, and both are capable of shooting video with high-definition cameras. With this development, we were able to conduct the first joint diving experiment with a private company.

With the addition of COEDO to the lineup, we now have a wider range of options to meet your needs.

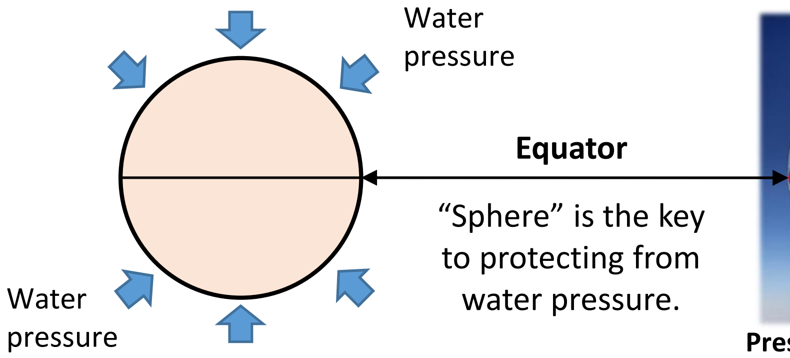
Model	COEDO Petite	COEDO	Edokko	
	10 inch	13 inch	HSG	365
Image				
Weight (in air)	28kg	51kg	85kg	200kg
Weight (in water)	-7kgf	-12kgf	-13kgf	-21kgf
Size	75x37x7.5cm	106x50x5cm	170x62x36cm	180x95x95cm
Lighting	LED 4,000lm			
Camera	Full HD 1080p/Time lapse			
Max. depth	4,000m	4,000m	8,000m	8,000m
Max. recording time	6h	10h	10h	44h
Usable temp.	-40℃～85℃			
Recommended use period	~3days	~7days	~90days	~365days

COEDO 13", Edokko HSG, and 365 models can be customized in various ways by attaching devices and other equipment to the outside of the vehicle.

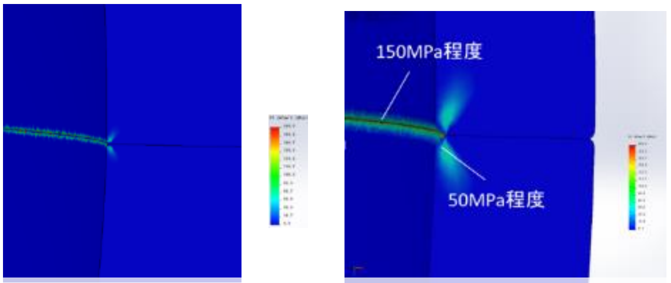
Ⅰ. Pressure-resistant glass sphere

In the deep sea, a pressure of 1MPa is applied for every 100m of depth. In other words, at a depth of 10,000 meters, the pressure becomes 100 MPa, which is equivalent to the weight of 1 ton on the tip of your finger. In order to prevent the cameras, lights, and batteries from being destroyed by the water pressure, they are installed in a pressure-resistant glass sphere, which makes it possible to conduct surveys in the deep sea.

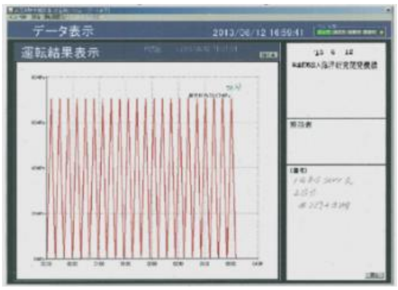
Our glass sphere lineup is 10", 13", and 17" in diameter and other sizes are also available upon requests. Glass sphere has holes in order to connect equipment inside and outside of the glass sphere. Even micro-defects can lead to accidents in the deep seafloor where water pressure is high. Our precision glass molding and high-precision processing technology minimize micro-defects that can lead to cracks and realize safe use even at a depth of 8,000m or more. We have been supplied more than 100 of our glass spheres, and they have never been broken and can be used repeatedly.



Pressure-resistant glass sphere



Optimization of equatorial machining by stress simulation



Repeated pressure resistance test (performed by JAMSTEC)

Glass sphere lineup

Model	Max. depth	Diameter	Thickness	Weight	Net buoyancy
GB-13-4000	4,000m	331mm（13 inch）	10mm	7.7kg	11kg
GB-17-6700	6,700m	432mm（17 inch）	14mm	18.2kg	25kg
GB-13-8000	8,000m	331mm（13 inch）	12mm	9.0kg	10kg
GB-10-8000	8,000m	250mm（10 inch）	9mm	4.0kg	4kg
GB-13-12000	12,000m	331mm（13 inch）	17mm	12.0kg	7kg

Ⅱ. Application development of glass sphere

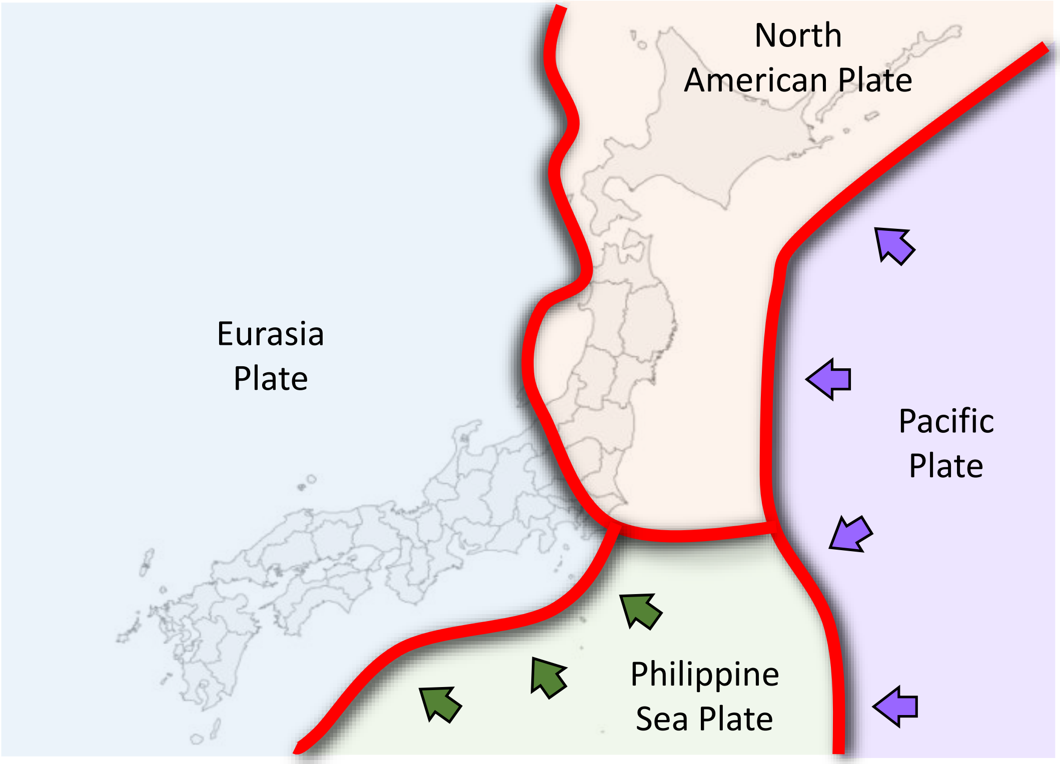
Our pressure-resistant glass spheres are used for various observation applications on the seafloor. There are two main applications.

The first is a self-floating ocean bottom seismograph, OBS (Ocean Bottom Seismograph). OBS are installed on the seafloor to observe and collect data on daily seismic activity on the seafloor, ranging from weak tremors that cannot be felt to huge earthquakes that can trigger tsunamis. OBS are also used for sonic surveys to determine the underground structure beneath the seafloor and the amount of oil and natural gas using artificial sound sources. In order to conduct seismic observations on the seafloor, it is necessary to have a pressure-resistant container that can hold the seismometer.

OBS is submerged in the seafloor with weights attached from a working vessel. At the time of collection, the weight is detached by transmitting a specific sound wave from the vessel, and the seismometer self-floats to the sea. Seismic observation on the seafloor is expected to play an important role in clarifying the mechanism of huge earthquakes that occur in the ocean.

The second is a submarine reference station, which is installed near the border of the four plates surrounding Japan. It is used to monitor the movement of the plates, which are sinking by several centimeters per year, by periodically going directly above them with an observation vessel and communicating with each other using sound waves.

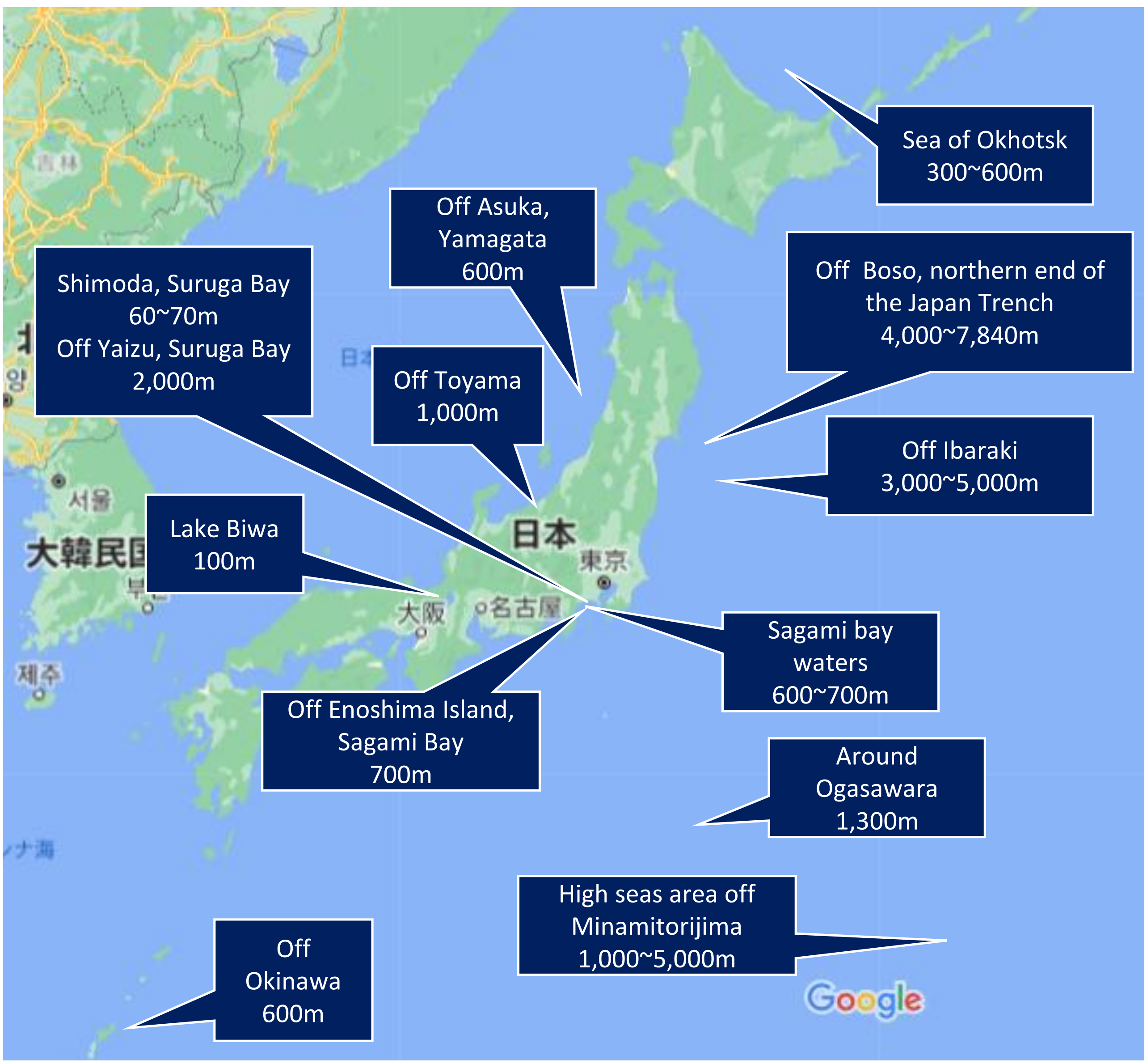
When the Great East Japan Earthquake occurred on March 11, 2011, the undersea plate moved on an unprecedented scale, moving several tens of meters both horizontally and vertically.



4 Demonstration experiment utilizing Edokko

Ⅰ. Sea area surveys

In November 2013, Edokko succeeded in shooting a video of a creature in the deep sea of 7,800m for the first time in the world in a deep sea experiment off the Boso Peninsula. Since then, it has been used for deep-sea surveys all over Japan.



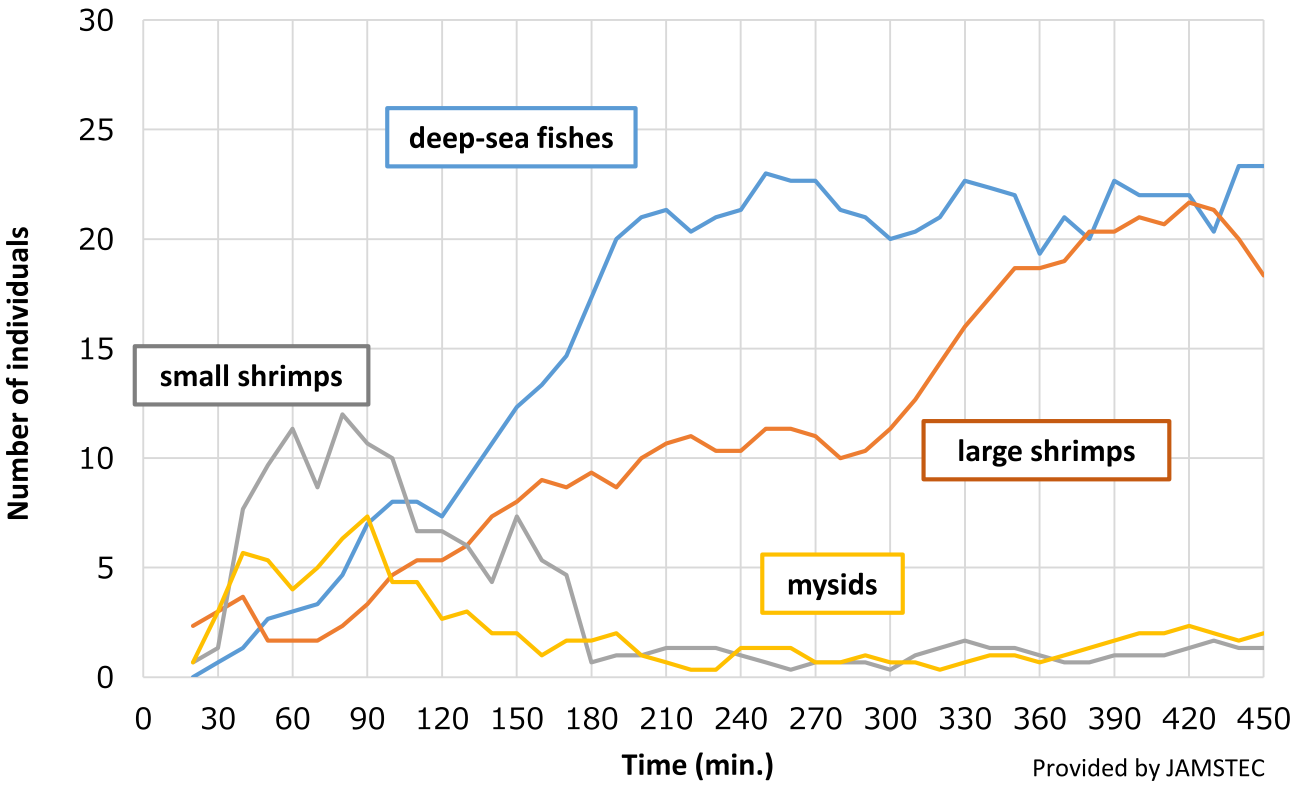
As of November 2021

Ⅱ. Research records on the deep sea floor

We have submerged Edokko Mark-Ⅰ in the deep sea and have succeeded in capturing images that provide clues to the mysterious world of the sea floor and the ecology of living creatures. The following are images taken at depths of 4,000m to 8,000m below the sea floor.

The graph below shows the gathering of organisms to the bait in a certain area of the ocean and the cyclical changes in the surrounding ecosystem. After 180 minutes of observation, the number of small shrimps and mysids gradually decreased, and the number of deep-sea fishes such as hadal snailfish and large shrimps increased. 450 minutes of observation did not increase the number of deep-sea fishes and large shrimps, indicating that only about 20 fishes live in this area.

One of the features of Edokko Mark-Ⅰ, which is suitable for fixed-point observation, is that we can see changes in the surrounding ecosystem along with the flow of time.



Provided by JAMSTEC

5 Operation support

Ⅰ. Assembly, loading, collection, maintenance

We will procure and assemble the various components necessary for the assembly of Edokko Mark-Ⅰ, and provide support for the actual handling of the vehicle on board.

Depending on the duration of the survey, we also support the dropping of the vehicle to the sea floor and its subsequent recovery. We can also do maintenance work for the next voyage.

Assembly

- Manufacture of pressure-resistant glass sphere
- Procurement of assembly parts
- Assembly / Packing / Shipping

Embarkation support

- On-site pickup of delivered goods
- Boarding and dropping of the vehicle
- Collection of the vehicle

Maintenance

- Receipt of returned goods
- Check the condition of the vehicle
- Replacement of faulty parts, Battery check

6 History of Edokko Mark-Ⅰ

May 2009	Yukio Sugino, the president of Sugino Rubber Chemical, drew up the first proposal and brought it to The Tokyo Higashi Shinkin Bank for consultation, and was introduced to the coordinator of the Shibaura Institute of Technology's Collaboration Promotion Department.
Jun. 2009	Obtained cooperation from Tokyo University of Marine Science and Technology and Shibaura Institute of Technology.
Aug. 2009	Attended a lecture on deep-sea research by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Observed an unmanned research vehicle composed of foreign-made parts. Proposed domestic production from Sugino Rubber Chemical.
Nov. 2010	JAMSTEC advised development of "free-fall submersible glass balls equipped with a video camera".
Apr. 2011	Edokko-1 Project Committee organized (4 core firms and 3 support organizations).
Oct. 2011	Selected as one of the projects for JAMSTEC's Special Program to Enhance the Utilization of Projects by Start-up Ventures.
Mar. 2012	High-pressure and underwater operation test at JAMSTEC.
Apr. 2012	Okamoto Glass joined Eddoko-1 Project Committee.
Jun. 2012	Video recording / operation test at Enoshima Aquarium.
Oct. 2012	Dive test completed successfully in Sagami Bay (to a depth of 50m)
May 2013	Succeeded in developing a glass sphere that withstand a water depth of 8,000m at Okamoto Glass.
Jun. 2013	Deepwater images captured successfully with a 3D full hi-vision video camera during the dive test in Sagami Bay.
Aug. 2013	Dive test completed successfully in Sagami Bay (to a depth of 710m).
Nov. 2013	Ultra-deep-sea dive test completed successfully in the Japan Trench (at a depth of 7,800m) using a newly designed vehicle.
Feb. 2015	The Edokko-1 Project Committee is dissolved, and Okamoto Glass takes over commercialization as the core company, forming the Edokko-1 Commercialization Group with four other companies.
Mar. 2015	Delivered the first practical product, EdokkoMark-1 HSG for hydrothermal vent area, to JAMSTEC in the first phase of the Cross-ministerial Strategic Innovation Promotion Program (SIP) (Next-generation technology for ocean resources exploration).
Mar. 2016	Delivered Edokko Mark-Ⅰ HSG to Japan Oil, Gas and Metals National Corporation (JOGMEC).
Mar. 2019	SIP Phase 2 (Innovative Technology for Exploration of Deep Sea Resources) begins using Edokko Mark-Ⅰ365 for long-term observation off Minami-Torishima Island at a depth of 6,000m.
Oct. 2019	SIP Phase 2, trainees from island countries visited Japan and conducted training using the Edokko Mark-Ⅰ HSG.
Jan. 2020	Edokko Mark-Ⅰ HSG installed on the seafloor off Ibaraki, started monitoring of marine life.
Mar. 2020	Conducted a deep-sea survey using the Edokko Mark-Ⅰ HSG-365 at 6,000 m off Minami-Torishima Island in cooperation with JAMSTEC to monitor marine organisms in the seafloor resource research area.
Jul. 2020	Test voyage off Toda, Shizuoka Prefecture, with COEDO developed to be smaller and lighter for use in coastal and deep sea.
Jun. 2021	Conducted a dive using COEDO in collaboration with JAMSTEC off the coast of Kuchinojima, Kagoshima Prefecture.
Sep. 2012	The first ISO standard that specifies a method for recording images and video of the seafloor in marine environmental surveys was established. Edokko Mark-Ⅰ, which meets this standard, is included in the Annex as a reference.
Oct. 2021	Conducted the first COEDO submergence experiment in collaboration with private companies off Okinawa and Ishigaki Island (at a depth of 100m) to promote the transition to the private sector, which is one of the themes of SIP Phase 2.

7 Okamoto Glass company profile

Company profile

Company name	OKAMOTO GLASS CO., LTD.
Founded	1928
Head office	380, Toyofuya, Kashiwa, Chiba, 277-0872, Japan
TEL / FAX	+81-(0)4-7137-3111 / +81-(0)4-7137-3112
No. of employees	170
Sales	4,409 M JPY（Mar. 2021, consolidated）
Business	Manufacture and sales of special-glass and multi-layer film products for optical devices.

Sales branch and affiliated company

OSAKA BRANCH OFFICE

Address	3-12-28, Minamisuita, Suita, Osaka, 564-0043, Japan
Business	Sales and procurement of optical, lighting and functional glass products

NIIGATA OKAMOTO GLASS CO., LTD.

Address	7587-1, Oaza-Yasuda, Kashiwazaki, Niigata, 945-1352, Japan
Business	Manufacture special-glass

OKAMOTO OPTECH CO., LTD.

Address	15F-1 No.79 Sec.1 Xintai 5th Road, Xizhi District, New Taipei City, 22101,Taiwan
Business	Sales and procurement of optical, lighting and functional glass products

SUZHOU OKAMOTO TRADING CO., LTD.

Address	Youngor International Center Room 2201, Industrial Park, Suzhou,215021,China
Business	Sales and procurement of optical, lighting and functional glass products

JAPAN 3D DEVICES CO., LTD.

Address	7587-1, Oaza-Yasuda, Kashiwazaki, Niigata, 945-1352, Japan
Business	Manufacture, processing and sales of electronic and optical products

NIKO OPTICS CO., LTD.

Address	3-18-3, Hashimotodai, Midori-ku, Sagamihara, Kanagawa, 252-0132, Japan
Business	Manufacture, processing and sales of vacuum deposition products

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Okamoto Glass Co. Ltd. E&E Division
380, Toyofuta, Kashiwa, Chiba,277-0872, Japan
Tel. ：+81-(0)4-7135-5240

Glass manufacturing plant
380, Toyofuta, Kashiwa, Chiba,277-0872, Japan

Thin film coating plant
1309, Takada, Kashiwa, Chiba, 277-0861, Japan

Okamoto Glass official website
https://ogc-jp.com/en/

Okamoto Glass | Search

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Edokko-1 Project Committee
Sugino Rubber Chemical, Ltd.
HAMANO PRODUCTS. Co. Ltd
Pearl Giken Co., Ltd
Vacuum Mold Kogyo, Inc.