

Exploration Technologies for the Utilization of Ocean Floor Resources — Contribution to the Investigation for the Delineation of Continental Shelf —

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1 Introduction

Ocean floors several thousand meters deep in the sea area far away from the seashore are thought to be a huge reservoir of resources. However, it is difficult at present to economically extract natural resources, such as petroleum, natural gas, metal minerals, living organisms, and microorganisms, from the seabed. Taking into consideration the situation that onshore resources are expected to run out in the future, the requirement is to develop technologies that enable commercial extraction of resources from the ocean floors. In order to realize economical extraction of resources, it is necessary to investigate the geographical and geological conditions of the ocean floors to obtain detailed information on offshore resources.

The present area of Japan's territory, an area that ranks the 60th in the world, is about 380 thousand square kilometers. However, the total marine area including territorial sea and exclusive economic zone (EEZ), over which Japan has jurisdiction is about 4.47 million square kilometers, which ranks the 6th in the world^[1]. Countries that rank higher than Japan are the U.S., Australia, and Canada - which are continental countries with long costal lines, and the two countries - Indonesia and New Zealand - which are island countries with the territories sprawling in wide sea areas.

Ocean floors to be investigated are classified into internal waters, territorial sea, continental

shelf (including ocean floors in EEZ), and deep sea floors. When certain conditions are satisfied, the UN Convention on the Law of the Sea permits sovereign rights for ocean floors under the high seas as the continental shelf of the coastal countries in accordance with EEZ. In order to investigate which sea areas of Japan satisfy the above-mentioned conditions, investigations of the delineation of continental shelf are being made by combining various kinds of seafloor exploration technologies. The investigation of geographical and geological structure is scheduled to be finished by the end of FY2007. And based on the results of these investigations, the information on the geographical and geological conditions of the continental shelf that are considered to expand beyond the limits of 200 nautical miles in the sea area around Japan is to be submitted to the "Commission on the Limits of the Continental Shelf (CLCS)" by May 2009 that was established based on the UN Convention on the Law of the Sea. Because of the time requirements, Japan is now accelerating the investigation for collecting necessary information for preparation of the report. The limits of continental shelf established based on the recommendations of CLCS are the final decision in accordance with the UN Convention on the Law of the Sea and have binding authority. The limits have significant meaning in that they define the boundaries of continental shelf under the water to which sovereign rights of the coastal countries extends. Some of the countries, like Japan, that have been conducting ocean floor investigation relating to

the delineation of the limits of continental shelf have already submitted information to CLCS, and how CLCS will make recommendations is drawing the world attention.

Among the ocean floor exploration technologies are bathymetry technology (measurement of seabed geography), seismic exploration technology (geological survey of seabed), bedrock sampling technology (seabed drilling), geophysical observation technology (measurement of gravitational force and earth magnetism). Furthermore, in the Promotion Strategies for the Frontier Field of the Third Science and Technology Basic Plan^[2], targets for research and development making use of diversified exploration technologies are shown relating to major subjects of ocean development, such as “elucidation of the inner structure of the earth” and “ocean utilization technology.”

This article focuses on ocean floor exploration technologies and describes the objectives and present status of the investigations using these technologies. Legal framework of the delineation of the continental shelf and the organization of the investigation are also overviewed. Finally, I will propose issues on future ocean floor exploration technologies, utilization of ocean floor resources, and long-term ocean floor exploration, which are related to the present investigation on the delineation of the continental shelf.

2 Ocean floor resources that are expected to be utilized

2-1 Ocean floor mineral resources

Mineral resources, such as manganese and copper, exist in high concentrations in the surface layers of sediments covering the seabed and seamounts. Japan Oil, Gas and Metals National Corporation (JOGMEC) has surveyed Japan’s mining concession of manganese nodules in the high seas to the south of Hawaii (obtained from International Seabed Authority (ISBA))^[3], and also carried out ocean floor investigation for cobalt-rich crust in the sea area more than 200 nautical miles south of Japan, which is out of EEZ, using “Daini-Hakurei Maru,” a specialized vessel for the exploration of deep sea mineral resources.

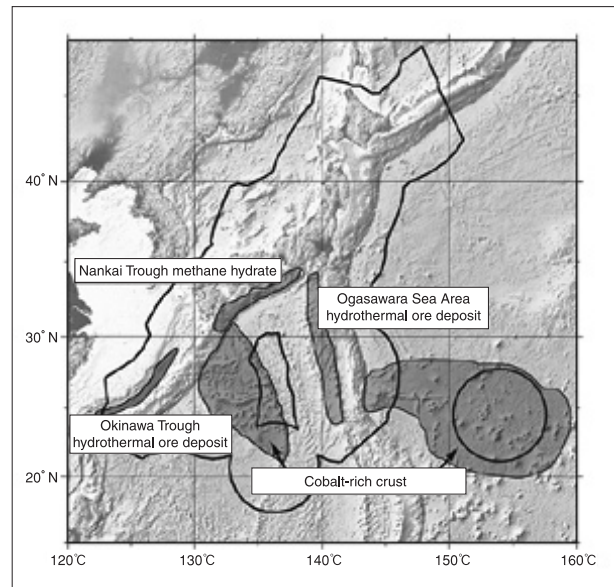


Figure 1 : Ocean floor resources in the adjacent waters of Japan (estimated)

The heavy line indicates the limits of EEZ.

Source: JOGMEC

While the major components of cobalt-rich crust are manganese and iron, the contents of cobalt and nickel are also high and platinum is contained in addition, which makes economical values of cobalt-rich crust very high. In the adjacent waters within 200 nautical miles, manganese crust and hydrothermal ore deposits exist in a large quantity, but these deposits contain less cobalt and platinum. The area where such marine resources exist sprawls beyond limits of Japan’s EEZ as shown in Figure 1.

2-2 Marine organism and microorganism resources

Organisms and microorganisms (including bacteria) living on the bottom of the sea as deep as 6,000 m, where the water pressure reaches 600 atmospheres, are quite different from those seen on the ground, and attracting attention as new marine resources. These organisms and microorganisms living in the deep sea have possibilities to be used for the development of useful materials and new medicines. For this reason, organisms and microorganisms living in the deep sea are noticed as the marine resources that come after petroleum and metal minerals. The role of microorganisms living in the deep sea in the formation of methane hydrate, which is expected to be utilized as energy resources in the future, is also being studied. The National

Committee for Oceanic Research of the Science Council of Japan proposed^[4] that technologies which enable long-term utilization of such resources without affecting the environment and ecosystem of the ocean should be developed. The Ministry of Education, Culture, Sports, Science and Technology is promoting frontier research on extreme-environment organisms as well as on crustal microorganisms as the subjects of technical development for utilizing living marine resources^[5].

3 Legal framework concerning the utilization of the ocean floors

3-1 Definition of continental shelf according to the UN Convention on the Law of the Sea, 1982

The UN Convention on the Law of the Sea of 1982 defines the “continental shelf” as the area that conforms to the geographical and geological conditions as shown in Figure 2. The “continental shelf” that is referred to here is a legal concept quite different from the geographical “continental shelf,” which refers to the area whose water depth is up to about 200m.

Paragraph 8, Article 76 of the UN Convention on the Law of the Sea^[6] stipulates, “Information

on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.” “Commission on the Limits of the Continental Shelf” is hereafter referred to as CLCS.

Article 76 of the UN Convention on the Law of the Sea stipulates basic conditions and restrictive conditions as follows:

- (1) Two basic conditions (either one is adopted according to the position) are as follows:
 - a. the thickness of sedimentary rocks is at least 1 percent of the distance from such point to the foot of the continental slope,
 - b. not more than 60 nautical miles from the foot of the continental slope.

In the absence of evidence to the contrary, the

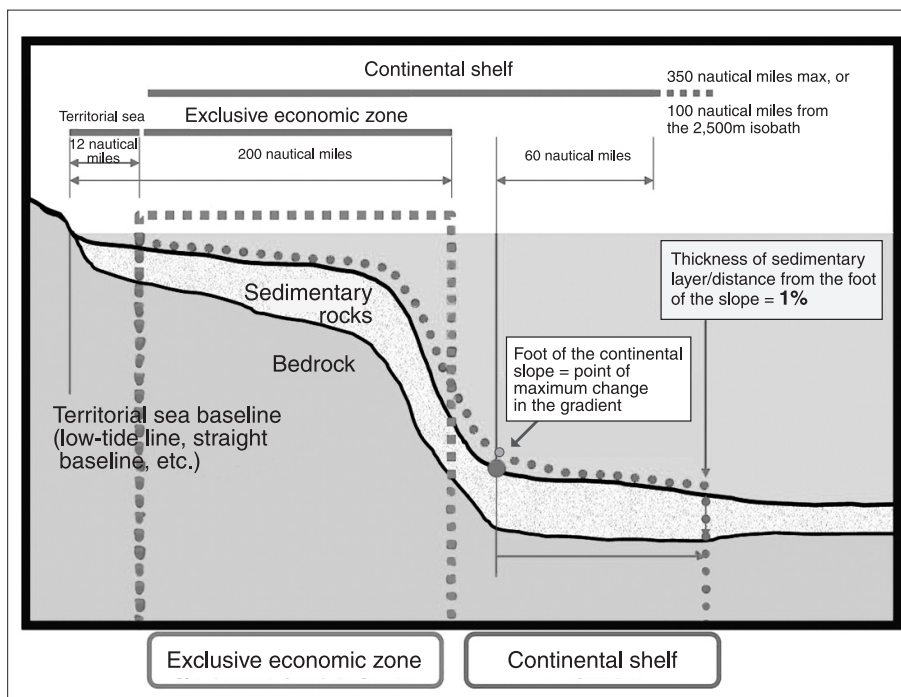


Figure 2 : Definition of continental shelf by the UN Convention on the Law of the Sea

Source: Japan Coast Guard Annual Report 2005

foot of the continental slope is determined as the point of maximum change in the gradient at its base.

- (2) Two restrictive conditions (either one is adopted according to the position) are as follows:
- c. not exceeding 100 nautical miles from the 2,500 meter isobath,
 - d. not exceeding 350 nautical miles from the baselines from which the breadth of the territorial sea is measured.

In 1999, "Scientific and Technical Guidelines of the CLCS"^[7] was established by the Commission on the Limits of the Continental Shelf as a guideline for its examination.

3-2 Classification of sea areas and significance of the delineation of the continental shelf

The ocean, which occupies about 70% of the earth's surface, is divided into internal waters, territorial sea, contiguous zone, exclusive economic zone (EEZ), and high seas in accordance with the distance from the territorial sea baseline and other conditions. Table 1 shows the rights and duties of the coastal states and the rights of countries other than the coastal

Contiguous zone

Beyond the 12 nautical mile limit (within EEZ) there is a zone 24 nautical miles from the territorial sea baseline called contiguous zone, in which area the coastal state can exercise the control to prevent and punish infringement of its laws regarding customs clearing, financial administration, immigration control, and hygiene control within its territorial land and sea.

states in each segment. Ocean floors farther than 200 nautical miles from the territorial sea baseline (the shaded portion in Table 1) belong to high seas, and the development of natural resources by individual countries in this area can be carried out by obtaining mining license from International Seabed Authority (ISBA). However, it became possible by the UN Convention on the Law of the Sea of 1982 that coastal states can establish prolongation of the continental shelf by submitting information on the fact that the seabed is a natural prolongation of their territories to the Commission on the Limits of the Continental Shelf (CLCS) and obtaining the recommendations of CLCS. Then,

Table 1 : Possibility of the expansion of sovereign right based on the UN Convention on the Law of the Sea

		Distance from the baseline			
Continental area		Baseline ~ 12 nautical miles	~ 24 nautical miles	~ 200 nautical miles	
Internal waters		Territorial sea	Contiguous zone* Exclusive economic zone (EEZ)	High seas	
Sea level	Sovereignty of the coastal state	Right of innocent passage (right of countries other than the coastal state)			
Undersea		Sovereignty of the coastal state	Development of natural resources, establishment of artificial islands and installations		
Seabed			Sovereign right for scientific research		
			Protection of marine environment		
Continental shelf			Development of natural resources	Development of natural resources	
			Sovereign right for scientific research	Scientific research	Deep sea floor
			Protection of marine environment	Protection of marine environment	

Shaded portion is the result of the prolongation of the continental shelf

the prolonged seabed of the continental shelf becomes a continental shelf whose sovereign right is owned by the coastal states just as the right for continental shelf of EEZ. However, since the sovereign right in the sea water as in the case of EEZ is not included, there are no changes in economic activities such as fishing.

3-3 Procedure for the delineation of continental shelf

Coastal states must submit the information on the limits that exceed the 200 nautical mile limits of continental shelf to CLCS within 10 years from the effectuation of the UN Convention on the Law of the Sea (according to the resolution of the Conference of the Contracting Parties to the UN Convention on the Law of the Sea, countries in which the law was put into effect by May 1999 are obliged to submit by May 2009, which is 10 years from May 1999), and CLCS provides recommendations. Since Japan put the treaty into effect in 1996, the aim is to submit the information by May 2009 as in the case of many other countries. Although the U.S. has not yet ratified the UN Convention on the Law of the Sea, actual investigation has already been started.

4 Ocean floor exploration technologies

4-1 Bathymetry technology (measurement of seabed geography)

A bathymetry technology using sonic wave is used for accurate measurement of seabed geography. Sonic waves transmitted in the water are reflected by objects in the water or seabed and return to the point of transmission. Using

Velocity of sound waves in the water

The velocity of sound waves in the water is about 1,500 m/s, which is four times faster than that in the air. Suppose the reflection of sound waves that have been transmitted right below the ship is received after six seconds, the water depth is about 4,500 m.

this principle, the distance to an object in the sea or seabed can be estimated. A device used for this measurement is called “sonar.” Sonar is used for such purposes as safe navigation of ships (to prevent stranding) and fish detection in fishery. For the accurate geographical measurement of the seabed, such devices as the “multibeam depth sounder,” which makes use of multiple highly-directive sound beams and “side scan sonar,” are used. The multibeam depth sounder equipped on the survey vessel of Japan Coast Guard is a “phased array” type, in which multiple sound beams are transmitted from the ship bottom and the wave front of the sound beams can be transmitted to the seabed in an arbitrary direction within 75 to left and right by shifting the phase of each sound beam. As shown in Figure 3, the seabed geography within a certain range can be measured at a sweep along the ship track.

4-2 Seismic exploration technology (geological survey of seabed)

When seismic waves produced by artificial forces, such as shock or explosion, are propagated in the water, reflected waves according to the geological conditions under seabed are observed at the sea bottom or on the seawater surface.

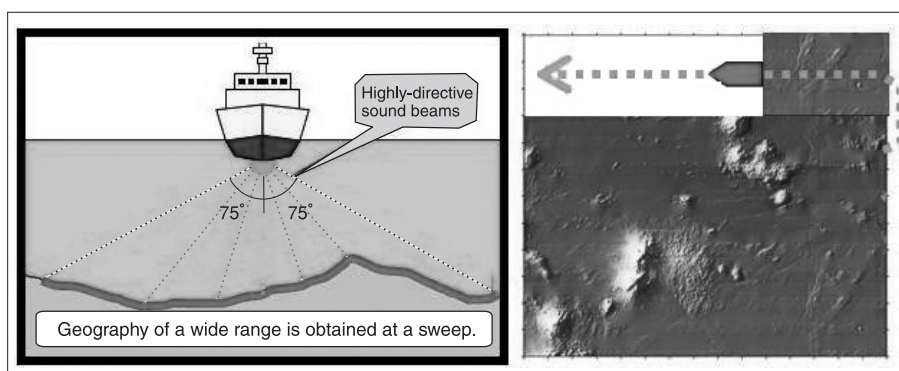


Figure 3 : Accurate measurement of seabed topography using sound waves

Source: Japan Coast Guard^[10]

(1) Seismic refraction survey

“Seismic refraction survey” is an exploration method to estimate the crustal structure under seabed in which receivers such as ocean bottom seismometers are placed at appropriate intervals along the traverse line, and seismic waves are transmitted to the ocean crust from an artificial earthquake generator, such as an air gun towed by the survey vessel, and the crustal structures are estimated from the time intervals for the seismic waves to reach the receivers. Sometimes in the survey of continental shelf, the traverse line exceeds 500 km, and more than 100 ocean bottom seismometers are used for the survey. Figure 4 shows a schematic diagram of such an exploration. This method is effective for the exploration of the base structure of thick crust. After the survey is finished, the ocean bottom seismometers are efficiently recovered by a function such as automatic surfacing mechanism activated by sound signals from the survey vessel.

(2) Seismic reflection survey

In the “seismic reflection survey,” the survey vessel tows an air gun and streamer cable (length: several hundred meters to several kilometers), and the geological conditions of sedimentary

layers and bedrocks of relatively shallow seabed are estimated from the seismic waves received by the channels of receivers that are installed at constant intervals onto the streamer cable.

4-3 Bedrock sampling technology (seabed drilling)

An effective method is to obtain actual samples of bedrock and analyze them to check whether the geological conditions of the seabed structure are continuous from the sea coast. In the survey for the delineation of continental shelf, drilling of the bedrock in the region to be surveyed is implemented by vessels for deep sea drilling to obtain rod samples of bedrock from the ocean floor. The bedrock samples obtained are as shown in Figure 5. Such samples are useful to improve the accuracy of the measurement and estimation together with other geological data obtained by other methods.

4-4 Geophysical observation technology (measurement of gravitational force and earth magnetism)

Geophysical observation technology is a method to estimate the internal structure and composition of seabed by measuring physical

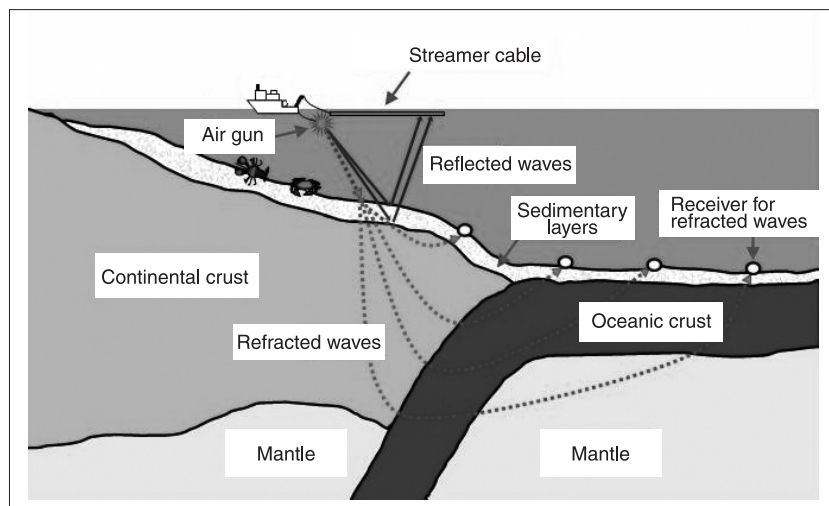


Figure 4 : Schematic diagram for the exploration of seabed structure using seismic refraction method
 Source: Japan Coast Guard^[10]

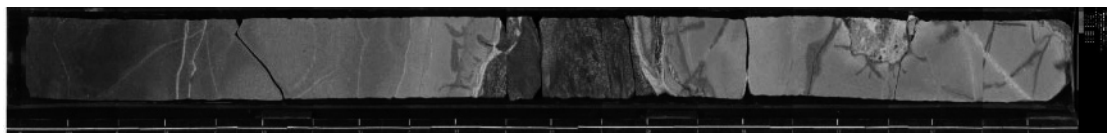


Figure 5 : Example of a rod sample obtained from the seabed rock (cross-section)
 Source: From the website of IODP

values, such as gravitational force and earth magnetism. On the ocean floor, there are continental crust and oceanic crust as well as transition zones that cannot be clearly classified. Accuracy of estimation can be improved by measuring various kinds of physical values in the surveying region.

(1) Gravimetric survey

In the gravimetric survey, measurement of gravitational force is carried out along the ship track using a gravity meter, as shown in Figure 6, installed on the vessel. Gravimetric survey is used as one of the means to obtain information on the structure under the ocean floor. Generally speaking, Bouguer gravity anomaly is small on the thick continental crust and large on the thin oceanic crust.

(2) Geomagnetic exploration

When undersea volcanoes erupt and magma spewed out of underground to the seabed solidifies, the status of the geomagnetic field at the time of eruption is recorded by the magnetic substances contained in the magma. Since the information

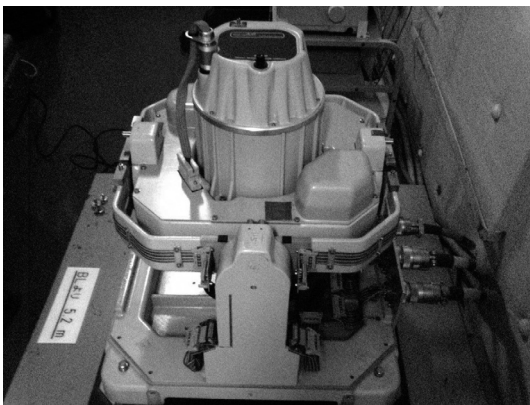


Figure 6 : Shipboard gravity meter of "Shoyo," a survey vessel of Japan Coast Guard

Bouguer gravity anomaly

Generally, the result of gravity measurement is affected by the elevation and geography of the measuring point. Bouguer gravity anomaly refers to the difference between the value corrected so that the conditions of elevation and geography are equalized and the standard value of the gravity at the measuring point.

on the seabed at the time when it was formed by measuring the earth magnetism of the seabed, the results of geomagnetic exploration are used as one of the means to study the continuity or uniformity of geological conditions. In geomagnetic exploration using a vessel, earth magnetism is measured along the ship track, as in the case of gravimetric measurement, using a proton magnetometer or the like.

4-5 *Subjects related to ocean floor exploration in the Third Science and Technology Basic Plan*

In the Promotion Strategies for Frontier Fields of the Third Science and Technology Basic Plan^[2], (i) research on the dynamic behavior of earth's interior using the deep sea drilling vessel, "Chikyu" and (ii) high-accuracy survey of crustal structure effective for the delineation of the continental shelf are listed as the major subjects of the "elucidation of earth's interior structure", and (i) drilling of the bedrock for the delineation of the continental shelf, (ii) exploration and development of petroleum and natural gas resources, (iii) exploration and development of deep sea mineral resources, (iv) research on the utilization of methane hydrate, and (v) development of elemental technologies for ocean platforms are listed as the major subjects of "ocean development technologies."

Among these subjects, the time limit to complete the investigation by the end of FY2007 is set for the crustal structure survey and the bedrock drilling for the delineation of the continental shelf.

5

Trends in the investigation of the delineation of continental shelf in foreign countries

5-1 *Status of investigation of foreign countries*

Russia submitted information based on the results of investigation in 2001 to CLCS. However, the CLCS recommendations issued the following year did not approve the prolongation of Russia's continental shelf and advised a resubmission of information. Russia has not submitted new information.

Subsequently, Brazil and Australia submitted

information in 2004, Ireland in 2005, and New Zealand, four European countries (France, Spain, United Kingdom, and Ireland on a conjoint basis), and Norway in 2006. CLCS reviews the submitted information at meetings that are held two to three times a year. The review of information submitted by Brazil, Australia, and Ireland has almost been finished and recommendations are scheduled to be issued at the 19th meeting of the Commission on the Limits of the Continental Shelf to be held in March 2007^[8].

5-2 Information disclosure strategy of New Zealand

New Zealand is an island country just as Japan, and submitted the information on the continental shelf delineation to CLCS in April 2006 after implementing investigations over ten years to verify that the surrounding sea areas are continental shelf extended from its own landmass. To prepare the report, geoscientists who had learned provisions of the UN Law of the Sea analyzed the investigation data and wrote papers, some of which have been published in internationally known journals. In addition, the fact that much information is disclosed on the website and through other

media indicates the country is adopting an active information disclosure strategy. Figure 7 shows the information of prolonged sea area that New Zealand submitted to CLCS. Since ocean floor geographical and geological conditions around New Zealand are quite complicated just as in the case of Japan, we should pay attention to the judgment that will be made by CLCS.

The political process that the government of New Zealand took that sympathy to its viewpoint is sought for by disclosing information to the world seems to be an effective measure not only for the prolongation of continental shelf but also for other issues on the global scale.

In March 2006, Japan held a conference for discussion of the scientific and technical aspects of the prolongation of continental shelf, and invited domestic and foreign experts including many CLCS members. The Japanese government should continue such positive activities.

5-3 Trends in the investigation of the delineation of continental shelf in Japan

(1) Japan's organizations for the investigation of the delineation of continental shelf

For the investigation of the delineation of continental shelf of Japan, the Japan Coast Guard takes charge of measuring the ocean floor geography; Japan Coast Guard and the Ministry of Education, Culture, Sports, Science and Technology (implementing agency: Japan Agency for Marine-Earth Science and Technology) take the charge of exploring the ocean floor crustal structure, and the Ministry of Economy, Trade and Industry (implementing agencies: Japan Oil, Gas and Metals National Corporation and National Institute of Advanced Industrial Science and Technology) takes the charge of bedrock drilling (boring). Coordination of the investigation work and comprehensive preparation of documents are carried out by the Coordination Office for Continental Shelf Surveys of the Cabinet Secretariat. Since the data on ocean floor geography obtained by the depth measurement is not sufficient for the preparation of information to be submitted to CLCS, estimated data on geological conditions of seabed obtained by seismic exploration and geophysical observation and the data on marine rock samples obtained by

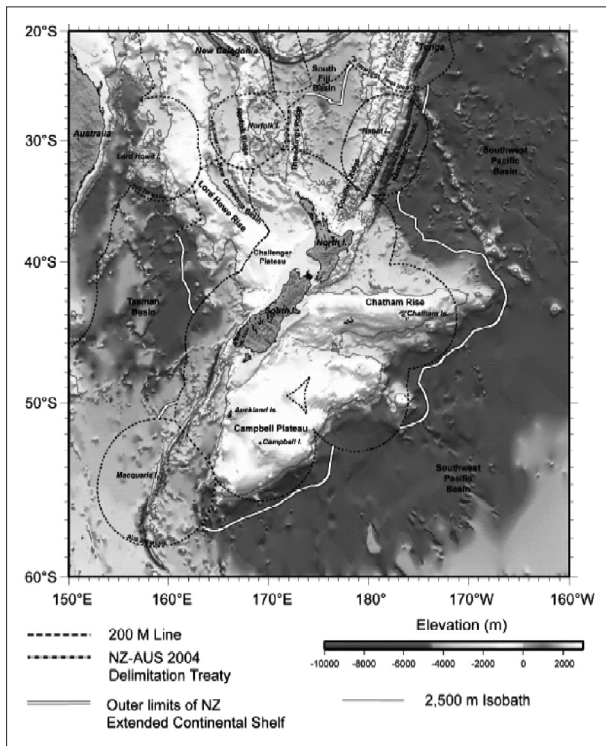


Figure 7 : Prolongation information of continental shelf that New Zealand submitted to CLCS in 2006

Source: Government of New Zealand^[9]

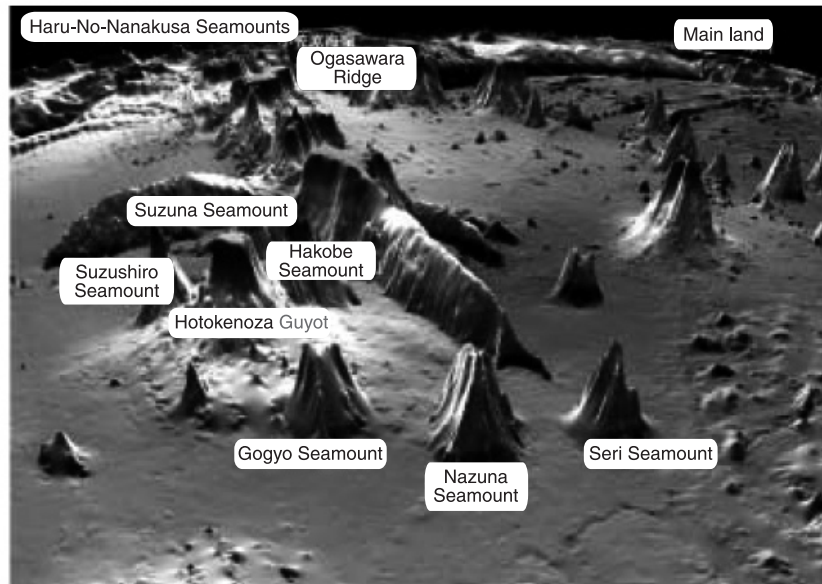


Figure 8 : Example of undersea geography discovered by the ocean floor investigation (Haur-No-Nanakusa Seamounts)

Source: Japan Coast Guard

drilling the bedrock are being comprehensively studied and analyzed by employing all the resources of relevant organizations including seabed exploration technologies, man power, and materials and equipment.

(2) Outline of ocean floor investigations implemented by related organizations

The organizations that take part in the investigation of the delineation of continental shelf are implementing measurement of depth and ocean floor geography, and investigation of geological conditions making use of seismic exploration and drilling of the bed rock using survey vessels of their own.

(i) Japan Coast Guard

Japan Coast Guard (JCG) is carrying out the investigation of seabed geographical and geological structure as part of daily operations, such as the assurance of security of water channels using the survey vessels “Takuyo” and “Shoyo”^[10]. Investigations of seabed geography have been carried out for about a million km of traverse lines between the start of measurement in 1983 and 2006 using multibeam echo sounding equipment, and detailed geography of sea areas including Kyushu-Palau Ridge, and Ogasawara Plateau that are considered to be important for the prolongation of continental shelf has been clarified. At the same time, gravitational force and

earth magnetism have been measured. During these investigations, more than 200 seamounts have been discovered. For example, the large number of seamounts in the sea area to the east of Ogasawara, shown in Figure 8, were named “Haru-No-Nanakusa Seamounts.”

In 2004, seabed geological survey was started using the nongovernmental geophysical survey vessel, “Tairikudana.” This vessel carries out seismic refraction survey using the multichannel reflection method using tuned air gun array and ocean bottom seismometer (OBS). The tuned air gun array provides accurate means for the crustal survey because the patterns of seismic waves can be arbitrarily adjusted.

(ii) Japan Agency for Marine-Earth Science and Technology

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) owns the ocean research vessel “Kaiyo” and deep sea research vessel “Kairei” and is exploring the crustal structure of seabed as part of geoscience research^[11]. In February 2005, for example, Japan Agency for Marine-Earth Science and Technology carried out exploration of the structure of the southern Izu-Ogasawara island arc using 110 ocean bottom seismometers and an air gun of large capacity. “Kaiyo” mainly conducted seismic refraction survey and “Kairei” mainly carried out seismic reflection survey using a streamer cable with a

total length of 5 km. Since the seismometers are placed in the sea checking the seabed geography in both of the exploration methods, the GPS equipment that helps grasp the dropping position and multibeam echo sounding equipment played important roles. Figure 9 shows the appearance of “Kairei.”

(iii) Japan Oil, Gas and Metals National Corporation and National Institute of Advanced Industrial Science and Technology

Japan Oil, Gas and Metals National Corporation (JOGMEC) and National Institute of Advanced Industrial Science and Technology (AIST) are implementing the seabed drilling to collect seabed rocks that may enable the prolongation of continental shelf using a boring machine system (BMS) installed on “Daini-Hakurei Maru,” a specialized vessel for resource exploration

for deep sea mineral resources. Japan Oil, Gas and Metals National Corporation makes survey voyages about six times a year, and the National Institute of Advanced Industrial Science and Technology makes survey voyages about once a year. The number of operating days of “Daini-Hakurei Maru” reaches as many as 290 days per year.

Figure 10 shows the outline of equipment installed on “Daini-Hakurei Maru.”

(3) Preparation of documents to be submitted to CLCS

The survey of the sea area was more than half completed by the end of 2006, and the committee of the government which was established in December 2004 to draft the information to be submitted to the United Nations, is now preparing the report to CLCS by January 2009. The data on seabed geographical and geological structure of Japan that have been obtained by the investigations conducted by various organizations are being comprehensively analyzed, and the schedule is to submit information that proves the prolongation of Japan’s continental shelf exceeding 200 nautical miles.

At the moment, efforts are concentrated on the data processing and scenario preparation for the prolongation of the continental shelf.

Since the information submitted to CLCS by



Figure 9 : Appearance of the deep sea research vessel “Kairei” of JAMSTEC

Source: website of JAMSTEC

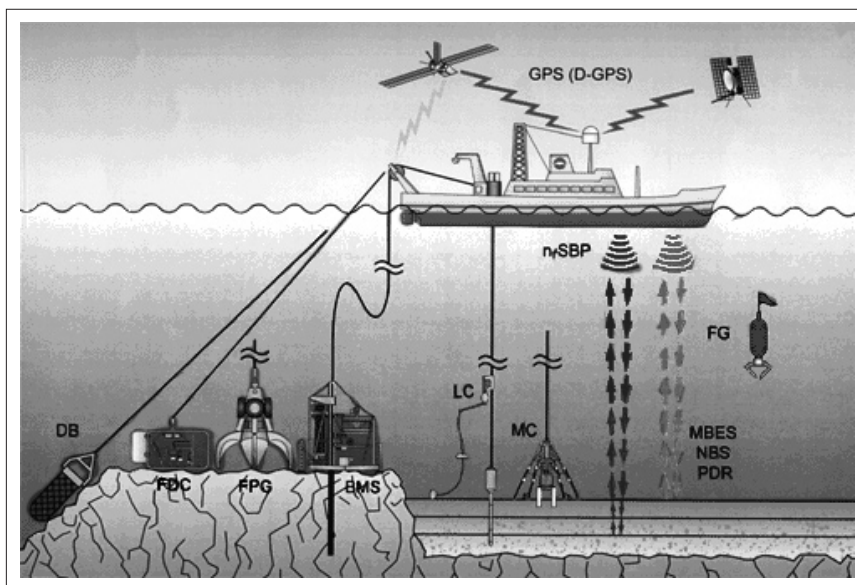


Figure 10 : Equipment installed on the specialized vessel for the exploration of deep sea mineral resources, “Daini-Hakurei Maru”

Source: JOGMEC

May 2009 is reviewed by the members of the Commission consisting of world leading experts in geology, geophysics, or hydrography, this is the first academic ordeal of the whole nation whether Japan can gain the understanding of the Commission and provide clear answers to questions from the Commission members. Prior to the submission of the information, the desire is to nurture international understanding regarding the results of investigation on the delineation of the continental shelf of Japan. In this sense, the New Zealand information disclosure strategy is an encouraging precedent for Japan.

6 | Proposals for the future ocean floor exploration and utilization

For future ocean floor exploration and utilization by Japan, the investigation for the delineation of continental shelf in the southern sea area, which is due in 2009, is nothing but an intermediate target. Japan, a maritime state that owns the sixth largest jurisdictional sea area in the world, must develop ocean floor exploration and utilization technologies from the long-term viewpoint, so that exploration technologies are applied to multilateral purposes, such as scientific research, resource exploration, and safety ensuring of the water channels.

6-1 *Subjects for the development of ocean floor exploration technologies*

In the field of ocean floor exploration, the advancement and sophistication of individual technologies, such as bathymetry, seismic exploration, bedrock drilling, and geophysical observation, have been promoted combined with the development of manufacturing technologies as well as information and communication technology that have been utilized for diversified fields of technology other than ocean floor investigation.

In addition to the present ocean floor exploration technologies, new technologies that will bring about new achievements must be developed and introduced. This includes the introduction of advanced technologies that have been put to practical use overseas, which Japan

does not possess. In the field of seismic survey, for example, three-dimensional seismic reflection survey will be applied to the exploration of seabed petroleum resources. For the development of seabed drilling technology, the research vessel for the implementation of earth's deep interior, "Chikyu," has been built. The riser drilling equipment installed on "Chikyu" that was originally developed for the offshore oil drilling will provide a means to establish economical resources development technology combined with the offshore platform. In order to be prepared for the utilization of new equipment that has not been typically used in Japan, such as the three-dimensional seismic reflection survey, riser drilling, and offshore platform, it is necessary to nurture human resources and establish comprehensive policies.

6-2 *Objectives of utilizing ocean floor resources*

Because of the high cost, utilization of ocean floor resources is not yet economically practical at this moment. However, since the supply of resources of various metals is becoming tight worldwide due to the rapid economic development of BRICs, technologies for obtaining metal resources from the ocean floor should be strategically developed as a measure to offset the risk of security assurance of the country.

The Basic Maritime Law has been being drafted since December 2006 aiming to submit the law to the Diet. The fundamental principles of the law are conservation of maritime environment, development and utilization of ocean floor resources, safety assurance, sustainable development and utilization, international collaboration and other related issues, and the intension is for Japan to play a leading role in the formation of international order of the maritime affairs. The Japanese government should establish policies that lead to an advantageous position in the future utilization of ocean floor resources.

6-3 *Themes in the continuation of sea area exploration*

The present target of ocean floor exploration is the southern sea area because the area is directly related to the national objective of the prolongation of continental shelf. However, it

is also necessary to promote the investigation of other sea areas such as Japan Sea that are not directly related to continental shelf prolongation. From the viewpoints of fostering and utilization of human resources in ocean floor exploration, the desire is to steadily continue the exploration activities on a long-term perspective. Ocean floor exploration cannot be carried out only by scientists. It requires diversified indirect supports including the navigation of the vessel, development and manufacturing of equipment, supply of commodities, such as drilling tools, establishment and management of training facilities for the human resources of ocean floor exploration. Therefore, comprehensive policies for sea area exploration should be established before taking individual measures.

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Abbreviation

<i>AIST:</i>	National Institute of Advanced Industrial Science and Technology
<i>BMS:</i>	Boring Machine System
<i>CLCS:</i>	Commission on the Limits of the Continental Shelf
<i>EEZ:</i>	Exclusive Economic Zone
<i>GPS:</i>	Global Positioning System
<i>ISBA:</i>	International Seabed Authority
<i>JAMSTEC:</i>	Japan Agency for Marine-Earth Science and Technology
<i>JCG:</i>	Japan Coast Guard
<i>JOGMEC:</i>	Japan Oil, Gas and Metals National Corporation
<i>SONAR:</i>	Sound Navigation And Ranging

References:

- [1] "Ocean and Japan, Proposals for the Ocean Policy in the 21st Century," Ocean Policy Research Foundation, January 2006. (Japanese)
- [2] "The Third Science and Technology Basic Plan, Promotion Strategies," Council for Science and Technology Policy, March 2006. (Japanese)
- [3] Hajime Hishida, "Approach to the Investigation of Undersea Mineral Resources by JOGMEC," January 2006 (Japanese): http://www.jogmec.go.jp/mric_web/koenkai/060124/briefing_060124_hishida.pdf
- [4] "Necessity of the Comprehensive Promotion of Ocean—Related Science—Proposals for Establishing Comprehensive Policies—," National Committee for Oceanic Research, Science Council of Japan, July 2005. (Japanese)
- [5] "Major Themes for Research and Development in the Field of Ocean," the Ministry of Education, Culture, Sports, Science and Technology, January 2006. (Japanese)
- [6] Article 76 of the UN Convention on the Law of the Sea: <http://www1.kaiho.mlit.go.jp/JODC/ryokai/houritu/tairikutana.htm>
- [7] "Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf," 1999

- [8] "Commission on the Limits of the Continental Shelf," the Ministry of Foreign Affairs, October 2006:
<http://www.mofa.go.jp/mofaj/gaiko/kaiyo/clcs.html>
- [9] Summary of Information submitted to CLCS by the government of New Zealand (Hydrographic chart is shown on p.8), April 2006
http://www.un.org/Depts/los/clcs_new/submissions_files/nzl06/nzl_exec_sum.pdf
- [10] Website of Japan Coast Guard relating to the continental shelf survey:
<http://www1.kaiho.mlit.go.jp/KAIYO/tairiku/tairiku.test.html>
- [11] Website of JAMSTEC relating to the continental shelf survey:
<http://www.jamstec.go.jp/jamstec-j/tairikudana/index.html>



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