A scientific challenge to the delineation of Japan's continental shelf

— Contribution to validating the Japan's rights over marine areas based on earth science —

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The national project of the Delineation of the Extended Continental Shelf was conducted by ministries of the government of Japan as one. The intention of the project was to summarize the information containing scientific basis on the outer limits of the extended continental shelf and to submit the application to the United Nations. The researchers of AIST in the field of marine geology carried out the marine survey, analyzed the collected rock samples and interpreted the results, and participated in the Task Force for the preparation of Japan's Submission. In this way, AIST contributed to the delineation of Japan's continental shelf by utilizing all the required resources as a professional marine geologist group. The information on Japan's extended continental shelf made up through the cooperation of concerned government ministries and agencies became the basis of the application which was finalized and submitted to the "Commission on the Limits of the Continental Shelf" of the United Nations by the government of Japan on November 12, 2008. And the government of Japan has received "the recommendations" as a result of the review by the commission on April 26, 2012. In this manuscript, the authors first explain the "continental shelf" and the "continental shelf of Japan." Then, they describe the background and the results of the participation of AIST researchers in the Task Force, which was really a rare opportunity in the sense that the utilization of scientific information contributed to the expansion of the legal rights over marine areas of Japan. Finally, they discuss the issues encountered in the operation of such a project.

Keywords : Continental shelf, United Nations Convention of the Law of the Sea, marine geology, submarine topography, Japan's Program for Delineation of the Outer Limits of Continental Shelf

1 Introduction

The mission of "the national project of the Delineation of the Extended Continental Shelf" (hereinafter, will be called the Continental Shelf Surveys) involved a series of projects in which the Japanese government and its ministries and agencies joined as one to conduct ocean surveys and to organize the results as application documents to be submitted to the United Nations (hereinafter will be called the UN). The aim of the mission is to delimit the extended continental shelf over which "the coastal state exercises sovereign rights for the purpose of exploring it and exploiting its natural resources on/beneath the seabed" past the 200 nautical mile limit, as determined by the UN Convention of the Law of the Sea[1] (hereinafter, will be called the Convention). The deadline of the submission of the application was determined by the date when the applicant coastal countries ratified the Convention, and the deadline for Japan was May 12, 2009 along with many other countries. Although the primary aim was that the application would go through the examination process smoothly, and the maximum range of the Japanese continental shelf would be maintained, within the limits set by the law, the second important hurdle was to meet the deadline of the submission as early as possible, because any submission of the coastal states would be put in the examination process on a first-come-first-served basis. As a result of years of collaborative efforts, the Japanese government submitted the application for the extended continental shelf for Japan on November 12, 2008, and after the examination process, the recommendations were received on April 26, 2012. This paper will first describe: "what a continental shelf is," "what kind of tasks were required in the Continental Shelf Surveys," and "what the results were." Next we describe what were the roles played by the researchers of the National Institute of Advanced Industrial Science and Technology (AIST) in this process, how the Continental Shelf Surveys were conducted, and how the researchers attempted to meet the objective of contributing to the application submitted to the UN based on scientific evidences. Moreover, we describe the issues in the application of the extended continental shelf, the difficulties encountered in the course of the project, and how these issues were overcome.

2 What is a continental shelf and what is the survey for the delineation of the outer limits of the continental shelf ?

The delineation of the continental shelf is the preservation of the maritime rights for Japan to develop the marine resources, or plainly speaking, it is the same as the expansion of the Japanese territory. On the other hand, the ocean must be managed, used, and protected as the common asset of humankind, and it must not be used selfishly as something

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that belongs to the coastal state exclusively. The delineation of the continental shelf is to create a system by which the rights to ocean development is executed and managed in an orderly manner, by determining the range of a country's jurisdiction as legally allowed by the Convention. This was a rare occasion where people involved in science could make a major contribution, since this delineation could be done based on scientific evidence, rather than disputing among the countries involved using military force.

To obtain and provide the scientific evidences to support the Japanese policy of maintaining the maximum extended continental shelf in accordance with the Convention is a good way of showing that science can be useful in supporting a policy that was formed in an international framework. Also, by submitting the application, it is an opportunity to present Japan's high capacity in science and technology. The surveys and researches conducted for the delineation of the continental shelf dramatically increase the geoscientific data in the candidate area of the Japanese continental shelf and the neighboring areas, and will also contribute to scientific understanding. The range of the extended continental shelf should be beneficial to the future society and to the people of Japan because, as written in the original definition of the continental shelf, it allows the natural resources to be explored and exploited wisely.

In the following subchapter, the "continental shelf" and the "delineation of the continental shelf" will be described.

2.1 Definition of the continental shelf according to the Convention

The continental shelf is a term defined in the Convention as representing the areal extent of the ocean in which a coastal state holds the rights and interests, and is a term that is often heard along with the generally well-known terms such as "territorial waters (closed sea)" or "exclusive economic zone (EEZ)." It is a term for "the area of interest in the ocean floor for the development of the resources in the ocean," and is probably easy to understand if it is called "the exclusive seabed and subsoil zone of marine resource development." On the other hand, the continental shelf is a term that is used widely in society and in geoscience (geomorphology and geology) as "the geomorphological region that is flat or that has a gentle slope and is, in general, 200 m or shallower in depth surrounding the continent or island states." Because this concept is held by many people, the "continental shelf" in the Convention has become somewhat confusing.

The concept of the continental shelf in the Convention has been built through historical discussion. In September 1945, immediately after the end of the World War II, President Harry S. Truman of the United States claimed its rights to the natural resources of its continental shelf regarding "the natural resources of the subsoil and sea bed of the continental shelf beneath the high seas but contiguous to the coasts of the United States as appertaining to the United States, subject to jurisdiction and control." Following this, other coastal states started to claim rights to the development of marine resources. In the first Conference on the Law of the Sea in 1958, the "Convention on the Continental Shelf" was adopted, and the continental shelf was set as "up to the depth of 200 m or to depth where the natural resources can be explored," and that the coastal states have "the sovereign rights for the purpose of exploring it and exploiting its natural resources in the seabed and subsoil."[2] The resource of interest at the time was offshore oil, and the depth at which it could be mined was limited to the geomorphological continental shelf as in a scientific term. Due to the advances in technology, the "depth that can be explored" became deeper than the geomorphological continental shelf, and the seabed natural resources expanded to the manganese nodules in the deep sea. In 1982, the term "continental shelf" continued to be used as the range over which the coastal states have "the sovereign rights for the purpose of exploring it and exploiting its natural resources in the seabed and subsoil" according to the Convention that set the laws for all issues regarding the ocean territory. This definition continues to the present.

As mentioned earlier, the "continental shelf" used in the delineation is defined in Article 76 of the Convention as a concept different from the geomorphological continental shelf. The definition is: "The continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance (paragraph 1, Article 76, the Convention)." The continental shelf that extends beyond the 200 nautical mile limit is determined by the method described in sections 4 to 6 of Article 76 (section 2), and the outer limits of the continental shelf is determined by "where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by coordinates of latitude and longitude (section 7)."

The outer limits of the continental shelf is set by either of the two methods quoted below that allow the extension of the limit[3] (Fig. 1).

- Fixed points at each of which the thickness of sedimentary rocks is at least 1 % of the shortest distance from such point to the foot of the continental slope.
- Fixed points not more than 60 nautical miles from the foot of the continental slope (the foot of continental slope is the point of maximum change of gradient at the base of the

continental slope).

Since the extension of the continental shelf may spread infinitely using the limit according to the above rules, it is set that either of the following limits may not be exceeded.

- It shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured.
- It shall not exceed 100 nautical miles from the 2,500 meter isobath (this does not apply to submarine ridges that are not the natural components of the continental margin, and the outer limit of the continental shelf shall not exceed 350 nautical miles in such a case).

These rules determine the outer limits of the continental shelf.

The geoscientific data such as geomorophology and geology serve as the basis for determining the "outer edge of the continental margin following the natural prolongation of the territorial land" and whether it is a "natural component" that determines the outer limits of the continental shelf.

The territorial sea is defined as 12 nautical miles from the territorial sea baseline and the EEZ as 200 nautical miles. These are determined solely by the spatial relationship (distance) from the territorial sea baseline that is set based on the standard in relation to the territorial land. However, the extended continental shelf, which is the continental shelf set beyond the 200 nautical mile limit, is characterized as follows: it is determined by the geomorphological and geological conditions; application must be submitted by the coastal state describing the basis and the range; and the determination is made according to the recommendations given upon examination of the application. If it is determined as the continental shelf, the coastal state may exercise "over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources (Article 77)" outside the 200 nautical mile EEZ where "the coastal state has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, … of the waters superjacent to the seabed and of the seabed and its subsoil (Article 56)."

2.2 Process of delineating the extended continental shelf

For the determination of the continental shelf, the coastal state must submit an application by preparing the information on the outer limits of the continental shelf including the evidences. On May 13, 1999, the "Commission on the Limits of Continental Shelf (CLCS)" created the "Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf (hereinafter, will be called the Guidelines)"[4] as a preparatory guideline for application. The Guidelines were created for the purpose of clarifying the scientific and technological evidences that were accepted in the application process for the CLCS to issue recommendations for the application. They were guidelines for the applicant coastal states on how to write the application. Also, they had the "objective of clarifying the interpretation of the scientific, technological, and legal terminologies in the Convention," and give several examples to explain some important concepts and terminologies. However, for several important issues, discussions and interpretations were carried on even after the Guidelines were published without establishing interpretations according to the Convention.[5] Moreover, due to the advances in science and technology, discussions became necessary for the data and evidence that were not conceived at the time when the Guidelines were drafted. The Guidelines clearly state that they do not offer descriptions for everything, and some issues must be considered on case-by-case basis, and in making the application, it was important for the applicant state to clearly

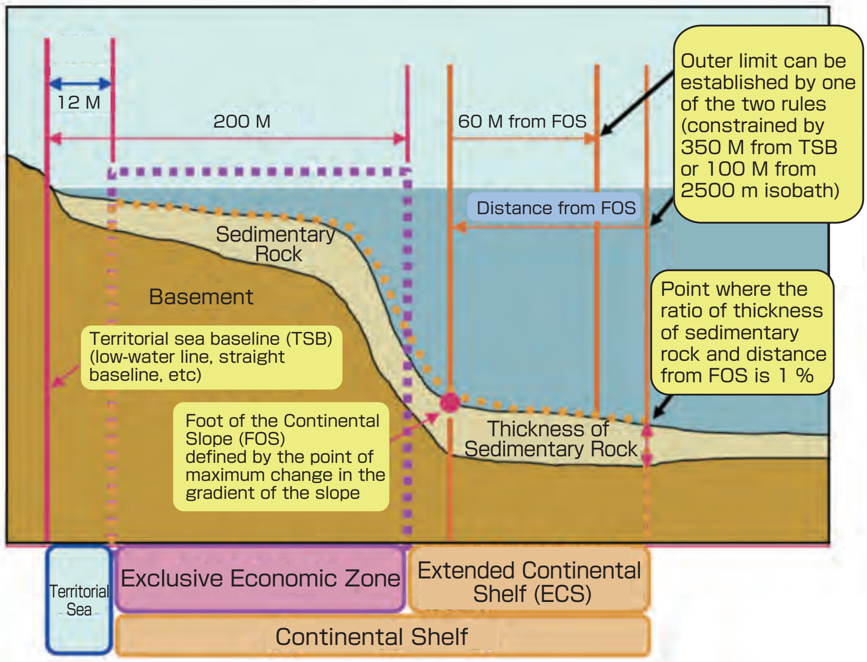

Fig. 1 Definition of the continental shelf pursuant to UNCLOS
The legal definition of the continental shelf is different from that of the geoscientific term "continental shelf."
M: nautical mile
Source: Press release from JCG (Oct. 31, 2008)[3]

analyze and describe the subject.

The time limit for submission was set within ten years after the ratification of the Convention, but for the states that ratified the Convention before the Guidelines, the deadline for application was set as ten years from the point the Guidelines were released. Since Japan ratified the Convention in 1996, before the Guidelines were publicized, the deadline for application was postponed to May 12, 2009 along with many other states.

3 Framework of the Continental Shelf Surveys

Soon after the Convention was adopted in 1982, the Hydrographic Department (currently, Hydrographic and Oceanographic Department), Japan Coast Guard started the survey of the continental shelf in1983 in a timely manner.[6] Russia submitted the first application to CLCS for the extension of the continental shelf in 2001, but the recommendations issued in June 2002 by the CLCS were harsh in terms of required contents and scientific evidences. Therefore, the Japanese government took the enhanced tactics for the Continental Shelf Surveys by offering solid scientific evidences in the application documents of the continental shelf. In 2003, the Advisory Committee consisting of the specialists of geoscience and law was established, and the Coordination Office for the Continental Shelf Surveys was set under the Cabinet Secretariat, to coordinate the overall process. The strategy for the Continental Shelf Surveys was discussed and drafted and the ministries and agencies of Japan joined together to embark on the survey.

As an institute that conducts comprehensive survey and research in geosciences, AIST joined the Continental Shelf Surveys and became involved in the project. The participation of AIST was due to the high research capacity of its researchers who had the experience and expertise in the target ocean regions, the survey technology that has been fostered over the years, and the high-level dating and chemical analysis technologies for the rocks in the region. There was also high expectation for the integrated efforts by the researchers in the delineation of the continental shelf.

The Continental Shelf Surveys involved a series of projects from survey to the drafting and the submission of the application, and Japan's Continental Shelf Surveys were designed and pursued just in the same way. Following is the description of 1) the overall coordination, 2) the survey, and 3) the preparation of the application documents (Fig. 2).

(1) Overall coordination

At the top of the organization of the Continental Shelf Surveys was the Headquarters for Ocean Policy of which the head was the prime minister of Japan. Under this headquarters are the interministerial working groups for communication, coordination, and discussion among the ministries and agencies that were responsible for the survey and the final draft

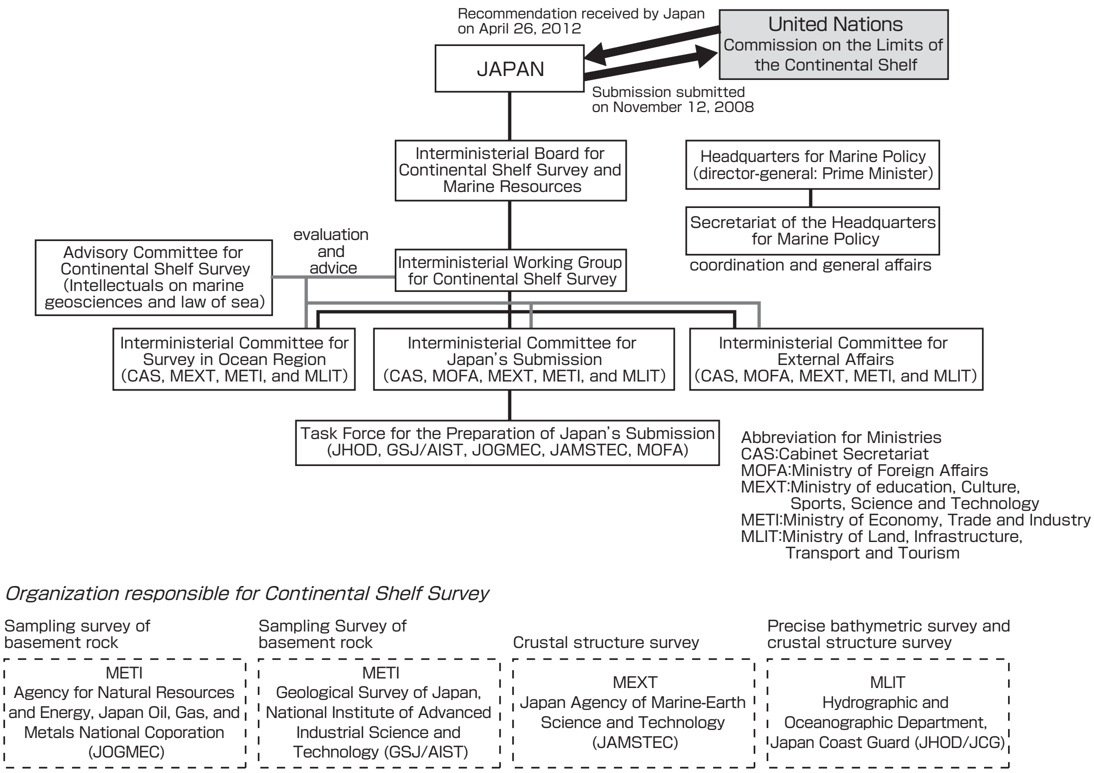

Fig. 2 Organizational structure for the Continental Shelf Surveys in Japan
In this figure and text, we used informal names for some of the committees and task force, which have formal names only in Japanese.

of the application, as well as the three committees including the “Interministerial Committee for Japan’s Submission.” The coordination among these committees was conducted by the Secretariat of the Headquarters for Ocean Policy (until 2007, this was done by the Coordination Office for the Continental Shelf Surveys). The Advisory Committee composed of the specialists provided recommendations to these committees from the academic aspects.

Although the Continental Shelf Surveys were organized as a joint effort of the government, the Coordination Office for the Continental Shelf Surveys (currently, Secretariat of the Headquarters for Ocean Policy) was the only administrative organization established as the coordinating secretariat.

(2) Survey

To establish scientifically firm evidence for the delineation of the Japanese continental shelf, three surveys (precise bathymetric survey, crustal structure survey, and basement rock sampling) were planned, with consideration on understanding the complex geomorphology and geology of the ocean area around Japan. The survey target had already been roughly narrowed down by the Hydrographic and Oceanographic Department, JCG (JHOD). The specific survey lines and the candidate points for rock sampling were discussed in the closed ad hoc team consisting of the researchers of the institutes conducting the survey and the researchers who were preparing the documents, and the results of the discussion were spelled out as the survey guideline after receiving comments from the Advisory Committee.

<u>Precise bathymetric survey</u> (institution in charge: JCG). To compile and analyze the bathymetric data to determine the continuity of the landmass to the outer edge of the continental shelf. All target areas were completely covered by multi-narrow beam sounding or swath bathymetry.

<u>Crustal structure survey</u> (institution in charge: JCG, JAMSTEC). The geological continuity was investigated and inferred from the crustal structure. To determine the crustal structure from shallow to deep parts, multi-channel seismic reflection profiling and seismic refraction profiling using ocean bottom seismographs were done along the same survey lines.

<u>Basement rock sampling</u> (institution in charge; JOGMEC, AIST). The geological continuity was examined and discussed from the constituent rocks of the geologic bodies. To sample the geologic bodies on site, drilling using the benthic multi-core system (BMS) set on the seafloor was employed as much as possible. Depending on conditions of the seafloor morphology and depth, rock samples were also collected by dredging. AIST was in charge of the dating, identification of trace elements and isotopes, and the analysis and interpretation of samples of all the regions.

Since the crustal structure survey and basement rock sampling were handled by multiple institutions, each institute was allotted its target regions in the surveys.

(3) Preparation of the application documents

As the working group that will draft the application documents, the “Task Force for the preparation of Japan’s Submission (hereinafter, will be called the Task Force)” was established under the Interministerial Committee for Japan’s Submission that was composed of the administrators of the ministries and agencies involved. The Task Force was composed of the members from: Ministry of Foreign Affairs (MOFA); Japan Coast Guard (JCG); Japan Agency for Marine-Earth Science and Technology (JAMSTEC); Japan Oil, Gas and Metals National Corporation (JOGMEC); and AIST. While the final goal of the Task Force was to prepare and draft the application, it was also in charge of coordinating the regional surveys as well as the analysis of the results of the surveys. The Task Force included the members from the institutes conducting the survey, and had a good understanding of the progress of the surveys.

The Task Force met as appropriate to discuss the integrating policy, to understand the current progress, to solve the mutual issues, and to keep the schedule. Smaller working group meetings consisting of a small number of people were also held to discuss specialties or individual regions and to tackle specific issues. The groups were composed of the members of various institutions, and since the work was done at the institutes to which the members belonged, the meetings where people could actually meet face to face, discuss, and make adjustment were important. There were more than 50 general meetings of the Task Force, and there were even more meetings of the smaller working groups.

From AIST, nine specialists of marine geology and geophysics (structural geology, petrology, stratigraphy, submarine resources, gravimetry, and magnetics) participated. The drafting of the application documents started with the study of what a continental shelf was. Then, the members of AIST set out to investigate the whole region based on the respective fields of science and technology, and worked on the scenario for individual regions to determine the outer limits of the continental shelf through analysis and integration of data. AIST was in charge of documenting the technologies used for obtaining the survey data and their analysis, and drafting the regional documents describing the evidences for the extended continental shelf.

4 Implementation and results of the Continental Shelf Surveys by AIST

The geoscience research sector of AIST that conducted the integrated geological survey and research forms the largest geoscientific research institute in Japan. In participating in the Continental Shelf Surveys, a continental shelf project team was established at AIST to handle the "regional survey," "analysis and interpretation of the rocks," and "preparation of the application documents." AIST has been conducting marine geology surveys for all areas of the seas around Japan till today, and has accumulated a large amount of geoscientific data and know-how for the geological survey in the regions. So, AIST has a well-grounded geoscientific foundation that enables it to look at and interpret any regions around Japan from the geological and geophysical point of views to integrate the data as a geological map. Because there are many specialized researchers and personnel who have the geoscientific knowledge of the regions relevant to the extended continental shelf, it was expected to make major contributions. Moreover, AIST has high standards in the techniques and researches of dating the rocks[7] and analysis and interpretation of the trace elements. Particularly in the dating the rocks in the region, it had the highest-level technology in the world for accurately calculating the formation ages by evaluating the degree of the weathering and alteration in marine environments.

Of the Continental Shelf Surveys conducted by AIST, "regional survey" and "analysis and interpretation of the rocks" are described in subchapters 4.2 and 4.3. For "preparation," AIST's contribution to the Task Force is described in chapter 5 in relation to the drafting of the application documents. These three tasks including the "preparation" were not individual activities but were closely related. It should be particularly noted that these tasks were carried out thoroughly and in a well-coordinated manner in every respect because AIST and many of its researchers were in charge of more than one task at the same time.

4.1 Activities of marine geology survey by AIST

The Geological Survey of Japan that was the predecessor to the geoscience sector of AIST is a research institution with 130 years of history since its establishment in 1882. Since its inception, the survey and research for the geology of Japanese land area has been done steadily, mainly for resources exploration. The geology of Japan has been clarified and published in various geological maps. In 1974, the Marine Geology Department was established staffed with a substantial number of experts in environmental coastal stratigraphy and limnology and a full spectrum of survey and research on marine geology began in Japan. It was also the time of a rising expectation in society for the development of marine resources such as manganese nodules. The R/V Hakurei-maru for geological survey that was launched also in 1974 has been used to study the offshore geology of Japan and its first achievement resulted in the series of publications of 1:1,000,000 marine geology maps of the waters around Japan, followed by the detailed scaling of the geologic structures, and the sedimentological maps of the waters surrounding the four main Japanese islands. As for the regions relevant to the Continental Shelf Surveys, the survey for the 1:1,000,000 marine geological map for the "Ogasawara Arc to Northern Mariana Arc," the survey for resources such as manganese nodules and geologic structures in the "Northeastern Philippine Sea," and the trial survey of the hydrothermal deposits in the "Izu-Ogasawara region" have long been conducted. In addition to the above mentioned basic data of the region, the research was enhanced through the participation in the Ocean Drilling Program (ODP), the survey by American universities of the related regions, the joint surveys with the Ocean Research Institute (current AORI), the University of Tokyo, and the open application researches and cruises of Japan Marine Science and Technology Center (current JAMSTEC). Through such surveys and programs, the capability of the AIST researchers was highly recognized particularly for the Izu-Ogasawara Arc and the surrounding regions relevant to the Continental Shelf Surveys.

4.2 Regional survey and sampling of basement rocks

For "basement rock sampling," the rocks were sampled from the seabed by boring as many samples as possible in regions where the geological background was supposed to be critical in clarifying the formation and ages of the rocks of each point, the formation process of the geomorphology and geologic structures, and the geological continuity. Of the government ministries and agencies involved, these surveys were under the authority of the Ministry of Economy, Trade and Industry (METI), and the institutes executing the survey were JOGMEC and AIST. Using the R/V Hakurei-maru No.2 that was equipped with a powerful tool BMS, basement rocks were sampled at over two hundred candidate sampling points successfully.

AIST was assigned to survey in the offshore of East Japan region, and about two 30-day survey cruises were conducted in 2005 and 2007. Compared to other areas with possibilities of continental shelf extensions, there were very few detailed bathymetric data in this area, so the survey included two missions at the same time, i.e. the selection of the candidate sampling points for BMS and the ordinary geological survey.

In the actual survey, basement rock samplings were done by BMS or by a dredge. In some occasions, sampling by BMS could not be done due to strong currents and water depth beyond its capacity, and dredging was used in such cases instead. Since this survey was concurrently conducted as the discussions at the Task Force progressed on land, the sampling points were chosen so that it would be directly helpful to the geological reasoning that was necessary as an evidence for continental shelf extension. Also, the surveys were done taking heed of the high survey skills of AIST formed through its experience in dredge sampling, e.g. determining the position of the ship for sampling in narrow points correlated well with the bathymetric and seismic data, and skills to evaluate whether the sampled rocks were constituents of the basement or not.

There is a seamount called Mogi Seamount formed in the cretaceous period in the Izu-Ogasawara Trench off the coast of Hachijo Shima Island. The axis of the deepest part of the trench was disrupted at the Mogi Seamount, and the western slope of this seamount was morphologically joined to the continental slope of the Izu-Ogasawara Arc. The body of this seamount was deformed by the large displacement structure due to the normal fault accompanying the subduction of the seabed on the Pacific side. In the Continental Shelf Surveys, we succeeded in determining the range of the body of this seamount by sampling (Fig. 3).

As a byproduct of the Continental Shelf Survey, recommendations were made to name the seamounts that were not previously named in this survey region, based on the newly obtained bathymetric data in 2005. In the GEBCO-Subcommittee on Geographical Names and Nomenclature of Ocean Bottom Features, three new seamounts were named Hotta Seamount, Kazuaki Seamount, and Takahiro Seamount.[8]

4.3 Analysis and interpretation of the basement rock samples

The greatest significance of basement rock sampling was to prove the close correlation among the individual geologic bodies (basement rock samples) through the geological development, including the geological continuity. This is the geological principle of argument that supports the assertion for geomorphological continuity. For the submarine landmass consisting of continuous elevations, this argument plays the role of a key evidence for discerning whether they are "submarine ridges" which are not natural components of the continental shelf, or "submarine elevations" which are natural components of the continental shelf. Since this identification is connected to the application of one of the two limiting lines, it has a direct impact on the breadth of the extended continental shelf.

AIST has been carrying out various ranges of geological surveys started well before the Continental Shelf Surveys, particularly in the Izu-Ogasawara and Mariana regions. There have been ample discussions and arguments on the geological development and the tectonic history of these regions.[9] On top of these accumulated knowledge and arguments, newly compiled "basement rock data set" that covered the whole area in an extremely systematic manner was prepared, utilizing the advanced technology for dating and trace element detection for the basement rock samples. The precise dating and the geochemical properties provided multitudes of new findings on the geological development and the mechanism of geologic body formation of this area. These were published as academic papers, and were also excerpted in the application documents submitted to the UN, and further analyses are in progress for more publications.

One good example was the proof of the geological continuity of the Kyushu-Palau Ridge through analyzing the rock samples from the ridge. This ridge was a series of topographic elevations that run, as the name implies, from Kyushu to the Palau Islands. As a whole, it could be identified as a narrow band of elevations, and small and large seamounts have grown along this band. Before the Continental Shelf Surveys, there were hardly any data set for chemical compositions that showed the ages and types of the volcanic rocks that formed the foundation of this ocean ridge. The spider diagram pattern of trace elements and the determination method of the origin and component of the magma by isotope composition were applied in the chemical analysis of the major and trace elements of the basement rocks sampled from the seamounts that form the ridge, and the geological equivalency was shown that all basement rocks were composed of the island arc volcanic rocks. It was also found that the radiometric age of the volcanic rocks was concentrated around 25~29 million years ago, immediately before the onset of the spreading of the Shikoku and Parece Vela Basins[10] (Fig. 4). The concurrency of the formation age and the property of the volcanic rocks of the island arc clearly showed that the Kyushu-Palau Ridge was part of the volcanic arc that composed part of the Paleo Izu-Ogasawara-Mariana Arc before the formation of the Shikoku-

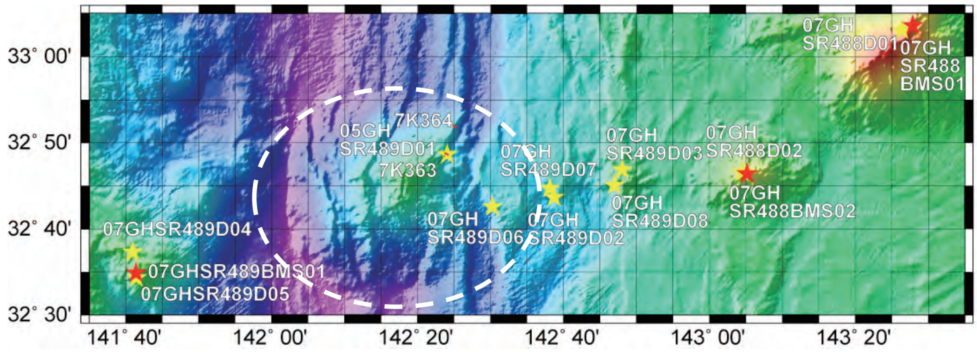

Fig. 3 Sampling of basement rock in the offshore region of East Japan (original map from Ishizuka)
Sampling points (red star – boring, yellow star – dredging) in the area around Mogi Seamount (surrounded by white dashed line) off the coast of Hachijo Shima Island

Parece Vela Basin, and that it was both geomorphologically and geologically part of the continuous submarine elevations.

Not only the basement rock data mainly of the igneous rocks of the area, but also other marine geological and geophysical data collected in the same survey by JOGMEC were analyzed by AIST and were published in papers.[examples are Refs. 11, 12]

5 Drafting highly reliable application and the submission of application

The Task Force that created the draft of the application documents started by considering what a continental shelf is, which contents should be included in the documents to be submitted for the continental shelf application, what is necessary, and how this should be tackled. Ultimately, the draft of the application was created by considering the geological and geomorphological properties of the ocean regions relevant to the Japanese continental shelf. Here, the issues in increasing the reliability and persuasiveness of the application and how they were overcome will be described, including the process of how the draft was written.

5.1 Understanding of the legal description

In drafting the application for the continental shelf, the bases were "the Convention," "Guidelines," "various documents of the CLCS," and others. Japanese is not one of the official languages of the UN. The Japanese translation of the Convention had already been published.[13] However in practice, in drawing the draft of the application documents in accordance with Article 76 of the Convention, it was necessary to consider the original writing rather than the Japanese translated text. On the other hand, there was no official Japanese version of the Guidelines. For the discussion and drafting of the application documents, and for organizing and explaining the research results in Japan, it was necessary to share a common understanding of the terminology and text of the Guidelines. The Task Force engaged in the discussions and creation of the translation for the Convention, Guidelines, and procedures. Except for the scientific terms, English to Japanese translation was done with the guidance from MOFA and the personnel who worked in the related sections, to study the strict legal terms and the conventional terms. This was an important process as a foundation that brought together people with different knowledge and experiences to jointly engage in the discussions and preparations.

5.2 Problem of terms in the Convention and Guidelines

Many "scientific terms" are used both in the Convention and the Guidelines. The term "continental shelf," for example, is a term that has a distinct legal meaning defined in the Convention, but it is also a "scientific term" defined

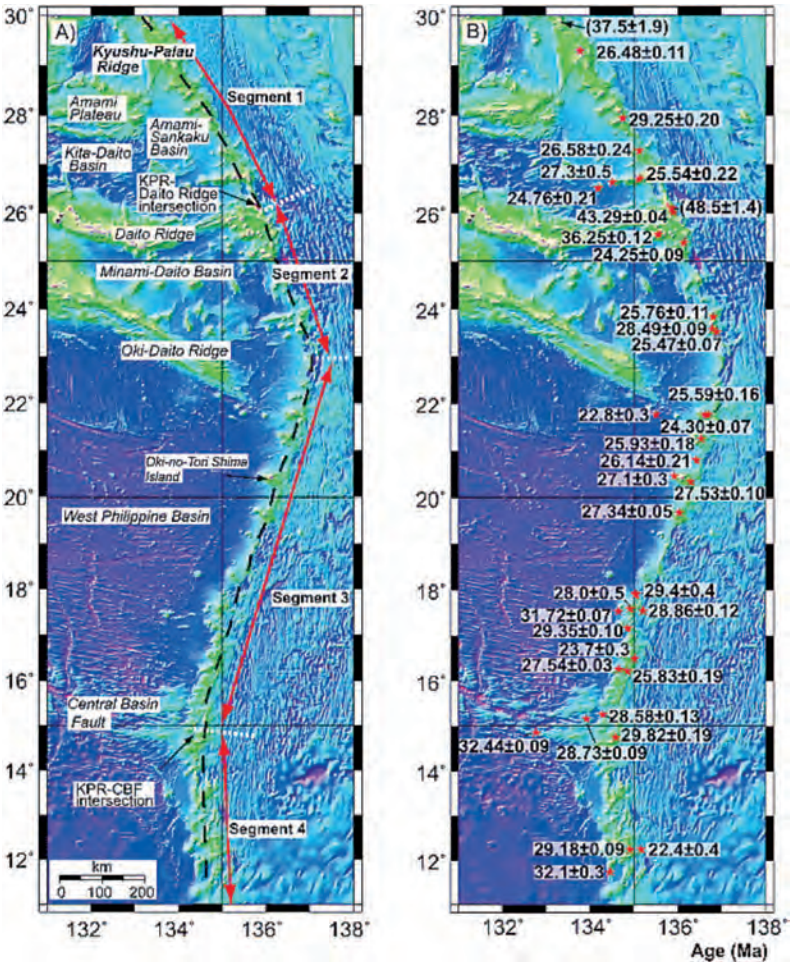

Fig. 4 Radiometric ages of volcanic activities of the Kyushu-Palau Ridge
A) Bathymetric features and their names, B) Distribution of $^{40}Ar/^{39}Ar$ age (in Ma; million years ago) of the volcanic rocks
Source: *Geochem. Geophys. Geosyst.*, 12, Q05005, Fig. 2[10]

differently in geomorphology and geology used commonly in society. When such "scientific terms" are used in the submission documentation or in determining the outer limits of the continental shelf, it is imperative to use them in the context of the legal meaning. In the early stage of the preparation work, the Task Force surveyed and discussed the historical arguments by CLCS and others, and the meaning and usage of those "terms" in the Convention and the Guidelines. The terms pointed and listed to be important by the Task Force are shown below.

・continental margin
・land mass
・continental shelf
・continental slope
・continental rise
・deep ocean floor
・oceanic ridge
・submarine ridge
・submarine elevation
・plateau
・rise
・cap
・bank
・spur

The following phrases comprise the heart of key legal concepts of the Convention with which our scientific discussion and evidences should comply.

・natural prolongation of the land territory
・natural components of the continental margin

Ultimately, for the use of the terms, importance was placed on the general reasoning that was described in the Guidelines. The terms were carefully chosen upon considering the characteristics of each extended continental shelf in the region of Japan, and their use was unified to avoid discrepancies when applying them as terms and concepts for the application documents by Japan.

5.3 Measures for the content and format of the application documents

Although we wished to engage in the drafting of the application documents by referencing the applications and recommendations of other countries, the detailed contents of the applications and recommendations of others were not disclosed when the Task Force started its work. Efforts were spent to collect information of the countries that applied earlier, and although we were able to know the outline, the details were unknown. From the autumn of 2008, the contents of the discussions and recommendations of the CLCS were disclosed, and the specifics of the discussions and recommendations between the CLCS and the applicant states during the examination processes are now disclosed.[14] However, when Japan was drafting the application, they were undisclosed and whatever was discussed at the CLCS was unknown.

In preparing the information for the continental shelf extension for the application to the UN, the structure of the documents and the content that must be described were presented in the Guidelines. The format of the documents and the number of copies that must be submitted were shown in the procedures. It consisted of three parts: the executive summary, the main body, and the supporting scientific and technical data. Only the executive summary was published on the website of the CLCS after the application was submitted. By interpreting the content of the abstracts that were submitted earlier, the frame of mind of the continental shelf decision and the basis of application were analyzed and used as references. The information on the outer limits of the continental shelf that must be written in the application included the interpretation of the paragraphs of the Convention by the applicant state, statement of the outline of the geomorphology and geology of the target region, and the most important information was the evidences of continuity from the territorial land to the continental margin based on geomorphology and geology. The documents must specifically include the information of the base of the continental slope, the position of the foot of the continental slope determined according to that information, and the range of the continental shelf considered according to the Convention and the Guidelines.

5.4 Convincing expression

In the work for creating the application for the Japanese continental shelf, focus was placed on presenting the maximum continental shelf by applying the Convention, starting with the interpretation of the paragraphs in Article 76 of the Convention that determined the continental shelf as discussed earlier and from the geomorphological and geological property of the target Japanese region. Therefore, the focus was placed on the final conclusion, or the decision of the foot of the continental slope and the interpretation and description of the continuity from the territorial land. However, in the preparation at the final stage and in the explanation after submission, the focus shifted to the explanation of the proof of geomorphological and geological continuity through the understanding of the temporal change of the geomorphological and geological features of the whole area and the individual target regions. Taking this into account, we decided to provide a simple explanation of the so-called historical formation process of the target regions by describing the present geomorphological and geological features and explaining how the features were formed. Therefore, importance was placed on the description of the background geomorphology and geology of each region, and figures were used to promote simple and comprehensive understanding.

For landform, since it is a "form," showing the diagram before describing by words was the requirement for achieving understanding. There was no definitive standard of how to show the geomorphological continuity, and the expression and the understanding obtained from it were important. The precise bathymetric survey in the Continental Shelf Surveys had been done over a long time, and the sounding data that covered almost 100 % of the target region were accumulated by the state-of-the-art bathymetric survey using the multi-narrow-beam echo sounder (SEA BEAM). Using these data, a characteristic method unseen in the application by other countries was used to determine the foot of the continental slope that was extremely important in determining the outer limit of the continental shelf (the method for this determination is written in the Guidelines). For geomorphology of land, the terrain reading by stereoscopic viewing of aerial photo or the 3D images created by the digital elevation mode (DEM) were used. For the geomorphology under sea, since seawater was in the way, the overall image could not be seen by flying over on an aircraft, looking out from a ship, or travelling on a submarine. However, the 3D image of the landforms could be created from the precise, wide-range digital depth data obtained in the Continental Shelf Survey. The landforms could be expressed by various methods such as the bathymetric map, contour map, or the shaded map. However, the 3D image was best for the understanding of the information of various landforms that included the whole geomorphology, the form and arrangement of the small geomorphological features, and the relationship of those features to the main geomorphology. Based on the experiences accumulated in the visualization technology of the geophysical data, the members at AIST contributed greatly in creating the presentation material using the advanced 3D visualization technologies such as geomorphologic 3D imaging and anaglyph[15] (Fig. 5).

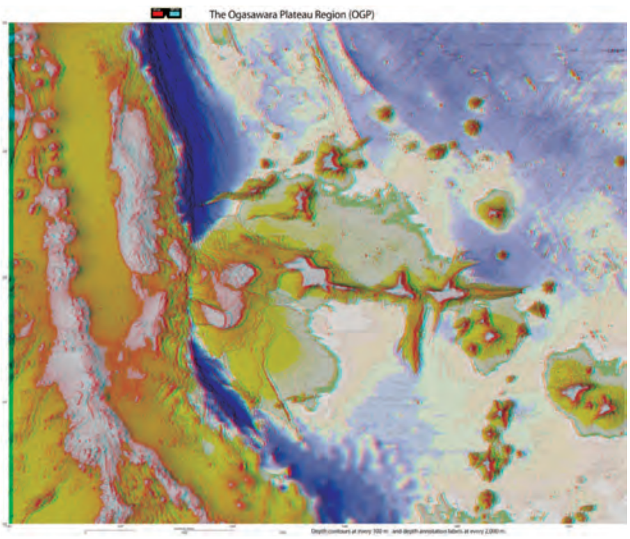

Fig. 5 Anaglyph 3D geomorophological map in the vicinity of "Ogasawara Plateau"

The dynamic form where the Ogasawara Plateau collides and accretes to the Izu-Ogasawara Arc from east to west, past the joint of the Izu-Ogasawara Trench and the Mariana Trench (can be seen in 3D when viewed using red-blue glasses)

Source: *AIST TODAY*, 9 (6), (2009)[16]

5.5 Discussion of the extension of the continental shelf based on the characteristic of Japanese geology

It can be imagined that the continental shelf in the Convention was defined based on the geomorphology and geology observed around the continental margins along both sides of the Atlantic. The description, "the continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the seabed and subsoil of the shelf, the slope and the rise (section 3, Article 76, the Convention)" clearly showed that tendency. The continental rise was a landform created by the continental breakup, denudation of the continent after the breakup, and the accumulation of the deposits of erosion at the lower part of the slope. It was a product of a passive margin. The foot of the continental slope was used as the standard point when determining the continental margin in the Convention, and when the continental rise was present on the outer side of the slope, the standard point was the upper limit of the continental rise. On the other hand, the topographic elevations in the target region for the extension of the Japanese continental shelf were those in active margins. They were island arcs and intraplate volcanoes, and these were formed by the accretion and collision in the subduction zone of the plates, island arc magmatism, and intraplate magmatic processes. The sediments accompanying the growth of the marginal zone, that is, the volcanic deposits due to the activities of island arc volcanoes and intraplate volcanoes, as well as the volcanic rocks such as the lava created the slopes with the progressive growth of the volcanic body, but these slopes were not continental rises. Considering the differences of the geomorphological and geological processes, careful explanation was provided in the application of the Japanese continental shelf to describe the consistency between the definition and interpretation of the Convention and the characteristics of geology of Japan.

The western slope (inner-arc slope) of the Izu-Ogasawara Arc forms a series of the geomorphology from the active volcanic chain of this arc to the Shikoku Basin (Fig. 6). How this inclined morphology is judged by the CLCS greatly affects the range of the continental shelf because it is related to the determination of the foot of the continental slope that is important in determining the continental shelf. Looking at the growth process of the Izu-Ogasawara Arc, it started from the volcanic activities that derived from the subduction of the oceanic plate at the trench in the Eocene Epoch. The growing island arc eventually formed an intra-arc rift due to the increased heat source accumulated beneath the island arc, and split into the island arc of the next generation (current Izu-Ogasawara Arc) and the back-arc of the remnant arc (Kyushu-Palau Ridge). The back-arc basin formed between the two features became the Shikoku Basin. At the extremities of the Shikoku Basin, rift walls were formed accompanying the separation between the island arc and the remnant arc, and this showed the characteristic of the passive marginal area.

Therefore, using the geological data and formation history, it was specifically explained that the slopes were formed as part of the series of island arcs in the west side of the Izu-Ogasawara Arc, a passive marginal area.

It is said that magnetic lineations are present in the relatively flat inner-arc slope area on the west of Nishi-Shichito Ridge that was the back-arc ridge of the Izu-Ogasawara Arc (Fig. 6 bottom). If this indicates the presence of an oceanic crust accompanying the spreading of the Shikoku Basin, the inner-arc slope of the Izu-Ogasawara Arc can be considered the ocean floor itself, or can be deemed the same as the continental rise of the deposits formed on the deep ocean floor. Therefore, it is possible that this upper limit will be identified as the base of the continental slope. However, by showing that the geologic body that composes the inner-arc slope is the volcanic complex (deposits and intrusive body) originating from the island arc, and that it is continuous from the volcanic body of the back-arc ridge in terms of geologic structure, it can be shown that this is geologically a series of slopes and that it is part of the continental slope that continues from the shelf of the islands on the Izu-Ogasawara Arc. The basement rocks collected from the region clearly showed the characteristics of the island arc volcanic rock as a result of the chemical analysis for major and trace elements. The results of radiometric dating showed that the volcanism in the region had been active during the period of the formation of the Izu-Ogasawara Arc since the end of the spreading of the Shikoku Basin, and that the period of the volcanism of the inner-arc slope has a tendency to be young easterly to the current volcanic front, that is, a series of island arc volcanic activities from the back-arc to the volcanic front during the development of the arc has been widely observed in the inner-arc slope.[17] One half of the split or the current Izu-Ogasawara Arc maintained active volcanic activity, and formed the volcanic body widely in the slope area of the back-arc and the sedimentary strata by the massive amount of volcaniclastic materials. The back-arc side of the island arc has two characteristics of active and passive margins, but it was concluded that the inner-arc slope was formed with the growth of the island arc by the island arc volcanic activity. This is an example of the characteristic of the geology of Japan and the discussion of the continental shelf extension.

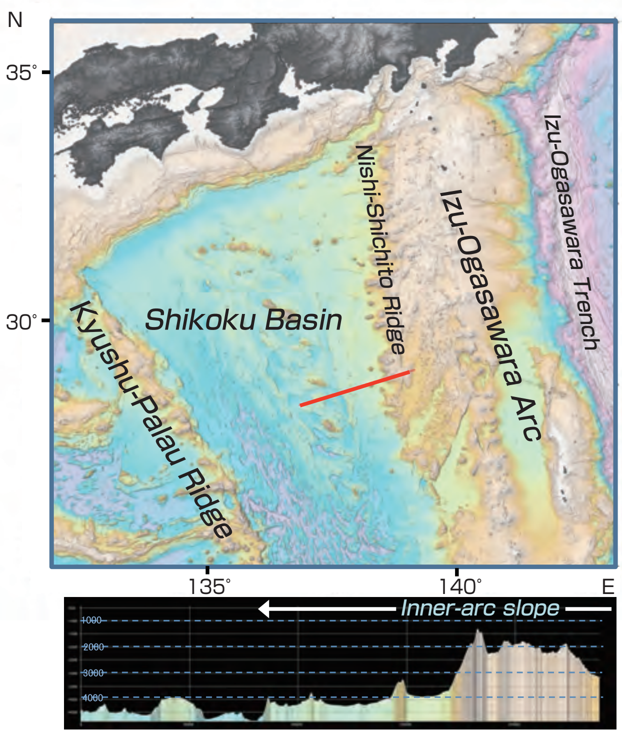

Fig. 6 Geomorphological map from the Izu-Ogasawara Arc to the Kyushu-Palau Ridge
The diagram at the bottom is the bathymetric profile along the red line of the top figure (the vertical exaggeration is 12 times).

6 Future prospects

6.1 Geoscientific issues after the Continental Shelf Surveys

Extremely detailed, varied, and massive amount of scientific data were accumulated for the southern submarine region of Japan in the Continental Shelf Surveys. These were described in the application documents as the information on the outer limits of the continental shelf and were used in the deliberation process. Some results were published in scientific journals, and further analyses and write-ups are being done for publication. Also, through these surveys, great results were born due to the synergetic effect of the data set of geomorphology, geology and crustal structure. Brief explanation of the future research topics in geosciences that should be pursued by the AIST researchers are as follows.

1. Geological development of the Izu-Ogasawara-Mariana Arc and the Philippine Sea: The work of constructing the structural geological development of the southern submarine region of Japan in the framework of global plate tectonics using the new data and interpretation of the Continental Shelf Surveys has not been completed. To propose a new detailed model from the diverse and massive data and their analyses is a major topic that must be done as the scientific fusion in the Continental Shelf Surveys.

2. Genesis and development of submarine volcanoes integrating the precise geomorphological and geological data: Because of the precise bathymetric survey that was done as a part of the Continental Shelf Surveys, the southern region of Japan has become an area with extremely detailed geomorphological information. In this region, there are topographic elevations formed by the intraplate igneous activity and island arc igneous activity, and basin floor formed by the spreading of the seafloor in the back-arc. The geomorphological features formed by the igneous activities are the main components. We hope for advancement of the research to clarify the details of the history of the wide-range igneous activities and the formation process of the individual volcanic bodies, by combining the geological ages and the

characteristics of the rocks from the basement rock sampling.

3. Geologic structure and igneous activity as constraints for genesis and process of the submarine mineral resources and evaluation of resources potential: With the move of the foreign companies to develop the hydrothermal deposits in the regions around Japan in the past few years, as well as increased price of rare metals in the world market, a move toward the development of the mineral resources is becoming active in Japan. There are known submarine hydrothermal deposits in the regions where the development and process of the geologic structure have become clear in the continental shelf survey, such as for the Japanese EEZ. For the future exploration of the submarine hydrothermal deposits, it is necessary to provide the geological and structural constraints of the mineral deposit location and the guideline for the exploration of new deposits that may be exploited in the future.

Moreover, there were improvements of the technologies for surveying and sample analysis, confirmation of the efficacy of the methods, and accumulation of technical know-how. These should be utilized when working on the above topics.

6.2 Application by Japan

The Japanese government submitted the application to the CLCS on November 12, 2008, and it was received. The "executive summary" that was the abstract of this application was shown on the website of the CLCS.[18] This showed the map of the ocean region for which the application for the extended continental shelf was submitted and the tables of the coordinates of longitudes and latitudes that set the outer limits of the continental shelf, and the applied provisions. The main body of the application documents that presented the evidences for the continental shelf extension was not disclosed. Since the main bodies of the application documents of other countries were not disclosed, comparison could not be made; however, it was certain that the quality of the scientific data including the full covered bathymetric information based on the multibeam sounding data, analysis of a number of rock samples, geological interpretation of the analysis data, and crustal structure exploration data using seabed seismograph were highest amongst the applicants.

The application for the Japan's extended continental shelf involved the total surface area of 740,000 km^2 over seven regions[19] (Fig. 7). These included the regions where adjustments with the neighboring countries were necessary, even if the CLCS recognizes it as the Japanese continental shelf. The extended continental shelf application by the Republic of Palau after the submission by Japan included the overlapping area within the Japan's extended continental shelf in the Southern Kyushu-Palau Ridge region. Also, the regions of Minami-Io To Island, Minami-Tori Shima Island, and Ogasawara Plateau regions might overlap with the American

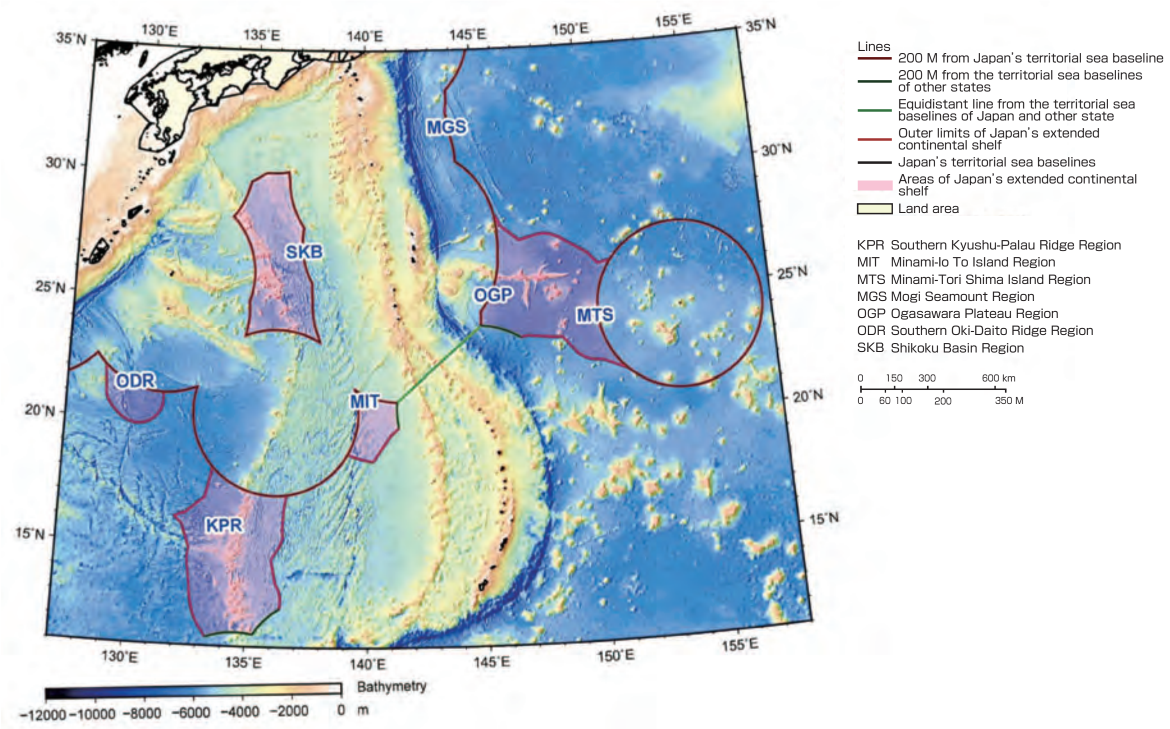

Fig. 7 Japan's extended continental shelf submitted to CLCS

Japan submitted the application for the extended continental shelf in seven regions (Southern Kyushu-Palau Ridge, Minami-Io To Island, Miami-Tori Shima Island, Mogi Seamount, Ogasawara Plateau, Southern Oki-Daito Ridge, and Shikoku Basin regions). The total surface area was about 740,000 km^2.[19]

Source: Commission on the Limits of the Continental Shelf (CLCS): Japan's submission to the Commission on the Limits of the Continental Shelf (executive summary)[18] extended continental shelf. The two countries have recognized the possibility of the overlap, acknowledged the fact that Japan would be applying for the extended continental shelf, and have informed Japan of this prior to Japan's application.[18]

The application by Japan was submitted as the 13th application. After submission by Japan, 37 applications were submitted by May 12, 2009 that was the deadline for many countries including Japan. The examination would be done, in principle, in the order of submission, and due to the number of members of the CLCS and its subcommittees, only three applications would be processed concurrently. If the submission by Japan was immediately before the deadline of May 2009, the start of examination would have been delayed, and we could not have predicted when the examination would start.

6.3 Examination and recommendations

The applications for the extended continental shelf are examined by the CLCS of the UN. There are 21 members of this commission, with regional balance of specialists from geology, geophysics, and hydrography. They are elected by vote at the Meeting of the States Parties to the Convention. For each application submitted by coastal state(s), a subcommittee consisting of seven members of CLCS is formed to conduct careful examination. The result of the examination is organized as recommendations, adopted and decided by the CLCS, and then publicized.

The examination of the Japan's Submission as the Japanese application documents started from the release of the application outline from Japan in the 23rd Session Plenary Meeting of the CLCS in March 2009. The subcommittee in charge of the Japan's Submission was established on September 2, 2009 at the 24th Session, and the full examination started there. The subcommittee examined for two and a half years from the 24th to the 28th Session, adopted the draft of recommendations in the 28th Session in August 2011, and reported it to the Plenary Meeting of the same session. At the Plenary Meeting, the examination of the draft of recommendations started in the 28th Session and the recommendations were adopted in the 29th Session on April 19, 2012. The Japanese government received the Recommendations on April 26, 2012.

The recommendations were given for the six regions out of the seven regions for which the application was submitted. The recommendations were postponed for the Southern Kyushu-Palau Ridge region. The extended continental shelf with a total surface area of about 310,000 km^2 was recognized, including the areas that required adjustment with the neighboring countries[20] (Fig. 8). This included the area that might possibly overlap with the American continental shelf as mentioned previously. The summary of the recommendations is disclosed on the website of the CLCS.[21]

After the submission of the application in 2008, the Task Force for responding to CLCS's examination on Japan's Submission (hereinafter, will be called the Task Force for responding

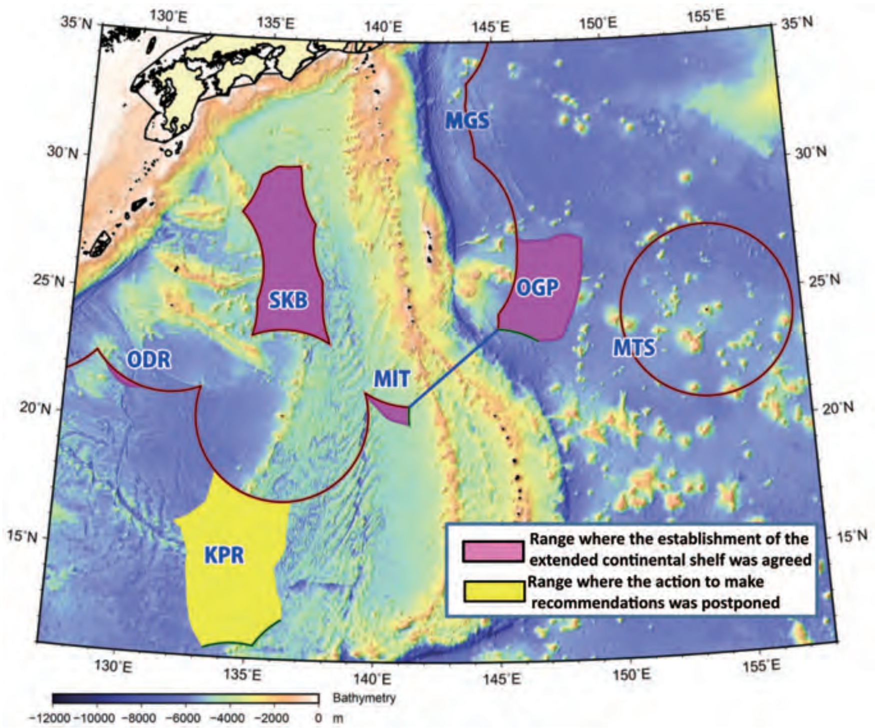

Fig. 8 Recommendation for Japan's extended continental shelf
Abbreviations for regions are the same as those in Fig. 7.
Source: Cabinet Secretariat: On the recommendations of the CLCS pertaining to Japan's extended continental shelf[20]

to CLCS's examination) started in January 2009. The main members of this new Task Force shifted from the Task Force for the preparation of Japan's Submission, including AIST members, and they prepared to answer questions and provide additional explanations in response to the examination of the Japanese application by the CLCS and its subcommittee. The activities included the creation of the answers to questions during the examination process, the presentation of the answers, and the participation as the Japanese representatives to the CLCS meetings held in New York.

7 Conclusion

Japan is surrounded by the sea and possesses the sixth largest EEZ in the world. If the Japanese government determines the outer limits of the continental shelf according to the "recommendations," the extended continental shelf will be obtained and the area in which the submarine resources can be explored will also increase. The "Basic Act on Ocean Policy" was enacted in 2007, and the Basic Plan for Ocean Policy was determined to reflect the law in the policy in 2008. Moreover, the "Plan for the Development of Energy and Marine Mineral Resources" was established in March 2009, and the surveys were promoted for the development of the resources in the ocean region. At the present point, the basic information on the Japanese EEZ and the continental shelf has not been organized sufficiently. Therefore, it is necessary to organize the information such as the geomorphology, geology, and the availability of resources, and to draw a long-term vision of the utilization and development of the resources and regions of the sea.

The members of the geoscience sector of AIST who participated in the Continental Shelf Project were diverse in terms of generation and role, and the sense of achievement in the Continental Shelf Surveys when the "recommendations" were issued and the meaning of the research activities in which they were involved differed. However, we believe that for the people who have engaged in the geoscience research to be involved in the scientific outcomes that helped maintain the international interest of Japan will become the starting point of future research activities.

Acknowledgement

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Dr. Kensaku Tamaki, who was Professor of the Graduate School of Engineering, The University of Tokyo and a member of CLCS, became ill during the CLCS meeting that was held in New York in April 2011, and passed away in New York. Dr. Tamaki worked at the Geological Survey of Japan. He was a friend to all of the authors of this paper, and we enjoyed his companionship during the survey cruise and research. He contributed greatly to the delineation of the Japanese continental shelf as a member of the Advisory Committee and as a member of CLCS, and has supported our efforts in many occasions. We present this paper with gratitude to the late Dr. Tamaki, as our activities for the survey for the Continental Shelf Surveys resulted in the "recommendations."

Finally, we shall list the names of the members other than the authors who participated in the Continental Shelf Project at AIST: Manabu Tanahashi, Osamu Ishizuka, Takemi Ishihara, Masato Joshima, Hajime Shimoda, Rie Morijiri, Eiji Saito, Tetsuo Yamazaki (Osaka Prefecture University from April 2008), and Yumi Tanaka. Dr. Osamu Ishizuka has granted us permission to use the original map of the offshore area of Hachijo Shima Island.

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Kokichi IIZASA

Completed the doctor’s course at the Graduate School of Engineering, The University of Tokyo in 1985. Doctor (Engineering). Joined the Geological Survey of Japan in 1986. Leader, Seafloor Geoscience RG, Institute of Geology and Geoinformation, AIST in 2004; Professor, Graduate School of Frontier Sciences, The University of Tokyo and Visiting Researcher, AIST from September 2009. Engages in the survey and research of the marine mineral resources, and discovered the submarine hydrothermal deposit in the Myojin Knoll in the Izu-Ogasawara region. In the Continental Shelf Surveys, worked as the manager and senior researcher in the regional survey by AIST for basement rock sampling. In the Task Force and the Task Force for responding to CLCS’s examination, was in charge of the write up of the technologies of sampling and analysis.

Discussions with Reviewers

1 Contribution of the AIST’s geoscience sector to the Continental Shelf Surveys

Comment (Shigeko Togashi, AIST)

This paper presents the “process of making contributions to the submission for the extended continental shelf submitted by the government based on scientific evidence” conducted by the AIST Continental Shelf Project, which was the continental shelf delineation survey conducted by the government as a whole. It is appropriate as a *Synthesiology* paper because it is an example where the scientists were directly involved in returning the results of research to society, all the way to the presentation at the United Nations.

Specifically, the paper describes the position of AIST research in the overall scenario, as well as the activities conducted by the AIST researchers in the Task Force of the government, concerning the “regional survey,” “analysis and interpretation of the rocks,” and “preparation” for which AIST was in charge as a general research institute of marine geology.

Comment (Masahiro Seto, AIST)

This paper is a summary of the results obtained by the full-force effort of AIST geoscience field, in the “continental shelf delineation survey” that was an important project of the government. It mainly describes how AIST was able to make contribution based on its technological and scientific potentials, and how new scientific findings were made. I certainly think it is appropriate as a paper to be published in *Synthesiology.*

2 Restructuring of the paper from the synthesiological perspective

Comment (Shigeko Togashi)

While the first draft was like a “commentary,” the paper has been dramatically improved by restructuring with attention paid to how the research was carried out and the methodology taken toward social contribution.

Comment (Masahiro Seto)

The first draft was like an activity report. The structure of the paper was changed after revision, the technological points in question were clarified, and I think it has improved much.

The comments on the first draft were as follows.

Comment (Shigeko Togashi)

Since the structure of the paper is like a “commentary,” please restructure the chapters and the descriptions, provide a scenario, and add descriptions of the research potentials and research results so it will be appropriate as a *Synthesiology* paper. Also, please consider the research methodology, and describe the positioning of AIST research in the scenario.

Comment (Masahiro Seto)

I think this paper is like a report of the activities of the AIST team. Please describe specifically what the technological and scientific potentials were that were the basis of why AIST joined this project for the delineation survey. You mention that the age determination and analysis/interpretation of the trace elements of rocks were evaluated highly, but it is hard to see what the technologies were and how these technologies were related to this survey.

Answer (Akira Nishimura)

I am grateful that you provided advice on the basic problem and on restructuring the paper in the first review, and that you carefully read and checked the details in the second review. I revised most of the points that you have indicated.

3 Roles expected for AIST and the challenging issues

Comment (Masahiro Seto)

I think it will be easier to understand if you organize the roles expected of AIST and the challenging issues in “1 Introduction.”

Please discuss specifically how AIST was able to determine the range of the extension with high reliability by integrating its potentials including the accumulated knowledge from basic research, and how it solved the new issues. I think the meaning of “challenge” will become clear if you describe what the technological issues were that posed new challenges in determining the extension range in the Continental Shelf Surveys, and what specific efforts were spent to overcome them.

Also, you write about the organizational changes such as the establishment of the Marine Geology Department in the “Role of AIST.” Here, I think you should describe what the potentials of AIST’s marine geology survey were, and in which scientific discipline AIST excelled as the best in Japan or as of world standard, to clarify the significance of why AIST participated in this survey.

Answer (Kiyoyuki Kisimoto and Akira Nishimura)

We simplified the “Introduction” and then wrote the roles in terms of “how we worked on the objective of conducting the survey for the delineation of the Japanese continental shelf, and thereby contributing to the making of the documents for the UN based on scientific evidences, and how we attempted to achieve the goal.” Moreover, the meaning and role of AIST’s participation to the Continental Shelf Surveys was described in the beginning of chapter 4, and the changes in the organization and the experiences in the past oceanic surveys were described as the pathways that built AIST's potentials. In subchapters 4.3 and 5.5, we described the case of "determining the extension range with high reliability" through the efforts by AIST.

Regarding the wording of "challenge" used in the English title and its Japanese equivalent "*chosen*," we'd like to elaborate a bit more about our rare experience of the Continental Shelf Mission, instead of giving a direct reference to an explanation, "technical issues as challenges," as follows .

The Japanese word *chosen* used here has closer connotation to the English word "challenge." meaning "a demanding or stimulating situation". In English, it probably can be rephrased: "the task was a scientific challenge for all geoscientists." In Japanese, it can be roughly translated to: "it was a rare occasion where the scientists took on the role of direct contribution based on the scientific and technological findings, for the extension and delineation (expansion of territorial land) that were goals that had not been handled before." It has a different nuance from (the challenge of assuming) the role of "making a discovery of a certain advanced technology or function" that is expected in ordinary scientific and technological efforts. When we explain our work on the continental shelf to a layperson, we do not say, "It's a challenge," but instead we say, "It's a rare opportunity for science." We came across the expression, "it is a scientific challenge," when we were working on various tasks and meeting people of the geological research institutes around the world in relation to the continental shelf. We were impressed that the word "challenge" could be used in such a situation.

It is not that any specific potential or capacity of geoscience research at AIST was challenged (of course, there was this factor), but the challenge was posed to AIST along with JHOD, JAMSTEC, and JOGMEC, which are institutes that hold national authority in the matter of geoscience necessary for the continental shelf delineation, and we were obliged to respond. There are more than 60 countries that submitted the continental shelf applications, and the examination for Japan was done as the 13th submission. The Japanese application was based on the overwhelming quantity and quality of bathymetric and geoscience information compared to other applications that had already been reviewed. Although USA, a major power in science and technology, has not yet submitted its application, the Japanese application stands out among other countries in terms of quantity and quality. However, it was not that the Japanese application was overwhelmingly advantageous. The geomorphological and geological background of Japan in the world was extremely "challenging" to prove and to convince others of the "extension of the continental shelf" in terms of the Convention. In that sense, "challenge" is used here with double meaning.

4 What the new findings and discoveries were

Comment (Masahiro Seto)

In the Continental Shelf Surveys, were there any new findings, discoveries, or inventions in geology or geophysics? The efforts you spent on the committees and documents are described in detail, but I think you should describe more of the technological aspects. For example, when you organized the basement rock data set, you found numerous facts about the mechanism of the formation of the geologic bodies and their temporal changes. Can you explain them a bit more specifically to the extent you can reveal to this journal?

Answer (Akira Nishimura)

I described them in subchapters 4.3 and 5.5.

5 Meanings of the "extended continental shelf" and "information on the outer limits"

Comment (Masahiro Seto)

You use the term "extended continental shelf," but that requires a definition. I think the "continental shelf to be extended" is better. Also if you can summarize what were the "information on the outer limits" necessary for applying for the extension of the range of the continental shelf, I think it would be easier to understand the issues and what you actually did.

Answer (Akira Nishimura)

When we first used the term "extended continental shelf" (subchapter 2.1), we stated the definition of the extended continental shelf as "the continental shelf beyond 200 nautical miles." Also at the end of subchapter 5.3, a simple explanation was provided for the "information on the outer limits of the continental shelf that must be written in the application."

6 Specific descriptions of technological issues

Comment (Masahiro Seto)

In the chapters "Regional survey" and "Analysis and interpretation of the basement rock samples," please discuss specifically what kinds of work and research were done in terms of the technological issues. In the "Regional survey," I think the selection of the points from which the samples were taken was important. Please describe specifically how AIST's knowledge and experience were utilized in selecting these points.

Answer (Akira Nishimura)

For the former, I added in subchapter 4.3: "The spider diagram pattern of trace elements and the determination method of the origin and component of the magma by isotope composition were applied."

For your latter indication, I added in subchapter 4.2: "Also, the surveys were done taking heed of the high survey skills of AIST formed through its experience in dredge sampling, e.g. determining the position of the ship for sampling in the narrow points correlated well with the bathymetric and seismic data, and skills to evaluate whether the sampled rocks were constituents of the basement or not."