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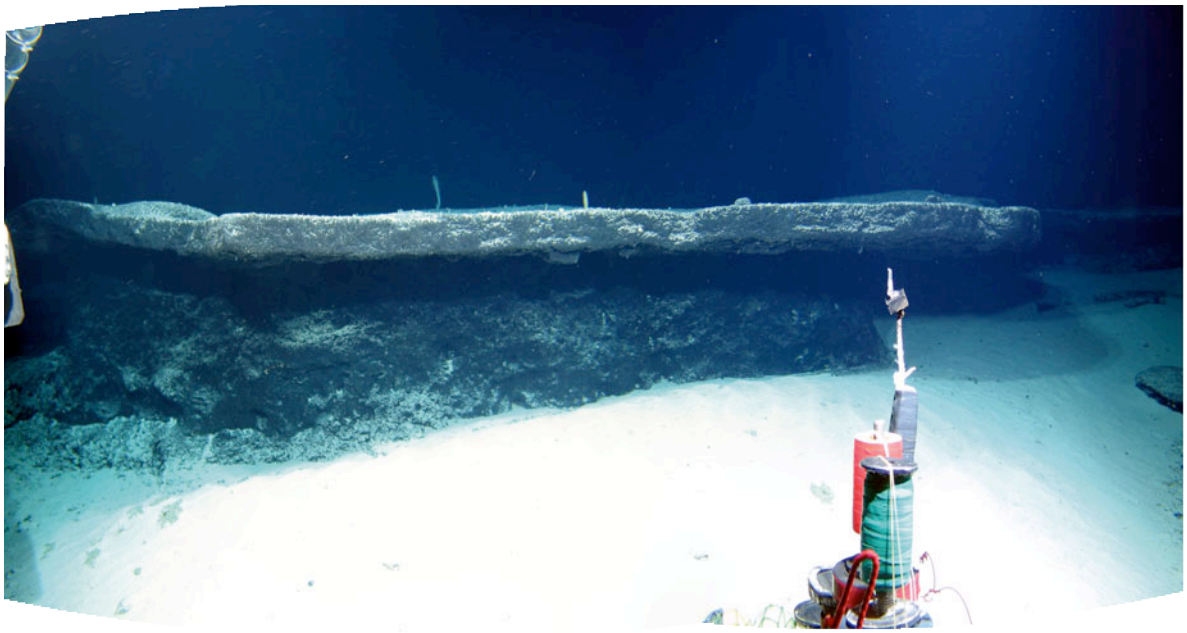
R/V Natsushima/ ROV Hyper Dolphin

Cruise Report

NT09-02 Leg.2
Northwest Pacific Area
(#5 Takuyo Seamount)



Feb. 8, 2009 (Saipan) – Feb. 24, 2009 (Yokosuka)

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

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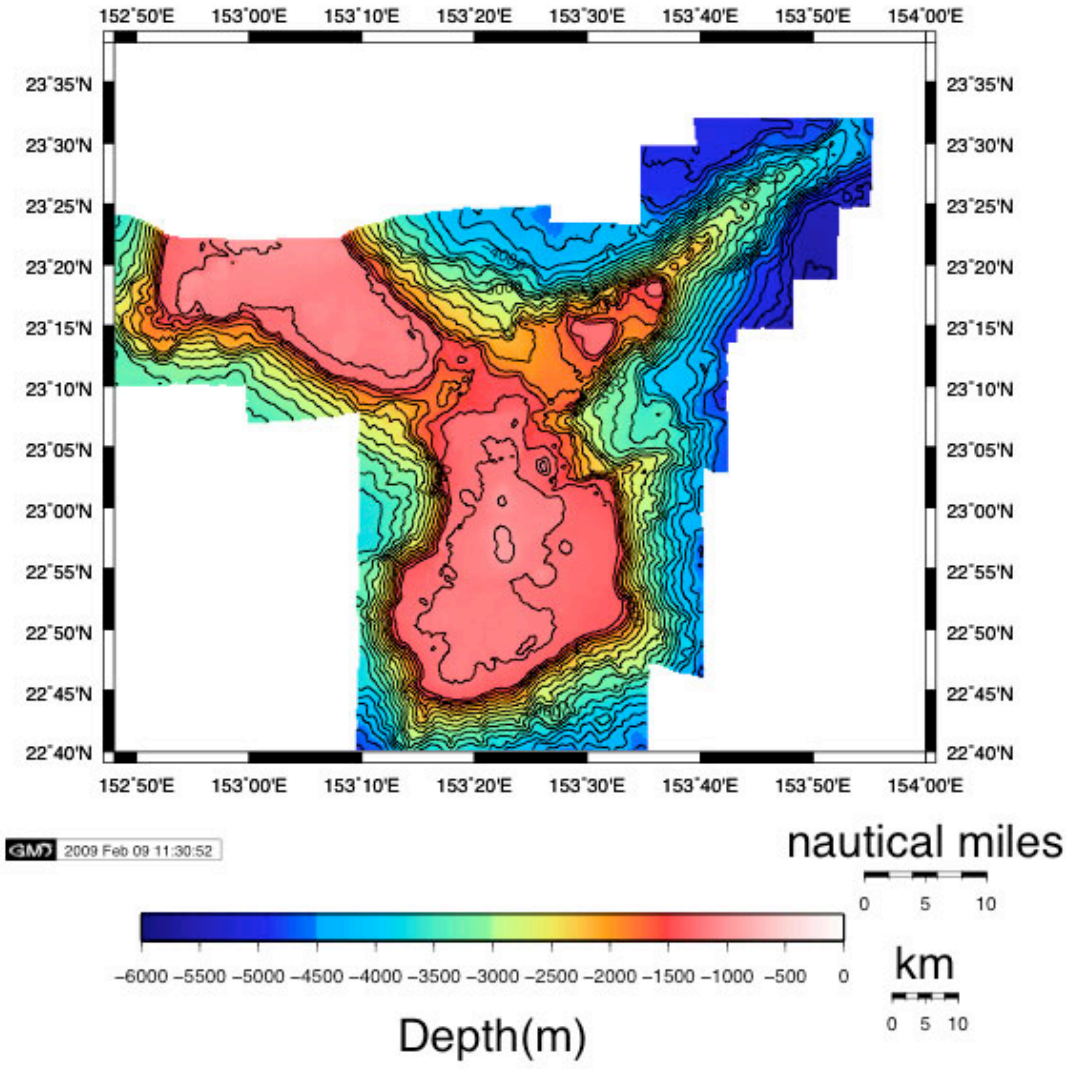

Fig. 1. Topographic map of #5 Takuyo Seamount, northwest Pacific.

1. Cruise Information

Cruise number: NT09-02 Leg.2

Ship Name: Natsushima

ROV: Hyper Dolphin

Title of the cruise: Northwest Pacific
(Manganese Crust Cruise to #5 Takuyo Seamount)

Chief Scientist: Tetsuro Urabe (Graduate School of Science, The University of Tokyo)

Representative Scientist: Tetsuro Urabe (Graduate School of Science, The University of Tokyo)

Title of proposal: Formation and metal-enrichment of ferromanganese crust as an interplay among fluid convection, seafloor environment and microbial activity of seamount in western Pacific basin

Cruise period: Feb. 8, 2009 (Saipan) – Feb. 24, 2009 (Yokosuka) (17 days)

Port call: Embark: Saipan, Mariana Island, Disembark: Yokosuka, Japan

Number of Dives: 7 (HPD-#953 - #959)

Research area: #5 Takuyo Seamount (23°00'N, 153°20'E)

2. Chief Scientist & Science Party

	Name	Affiliation	Position
1	Tetsuro Urabe*	Graduate School of Science, The University of Tokyo	Professor
2	Akira Usui	Graduate School of Sciences, Kochi University	Professor
3	Blair Thornton	Institutel of Industrial Sciences, The University of Tokyo	Research Associate
4	Mehul Naresh Sangekar	Graduate School of Frontier Sciences, The University of Tokyo	graduate student
5	Shingo Kato	Graduate School of Life Sciences, Tokyo University of Pharmacy and Life Science	graduate student
6	Jyunko Kita	Faculty of Life Sciences, Tokyo University of Pharmacy and Life Science	undergraduate student
7	Teruhiko Kashiwabara	Graduate School of Science, Hiroshima University	graduate student
8	Kaoru Kubota	Department of Earth & Planetary Environment, The University of Tokyo	undergraduate student
9	Atsunori Nakamura	Department of Earth & Planetary Environment, The University of Tokyo	undergraduate student
10	Akinori Karasuda	Department of Earth & Planetary Environment, The University of Tokyo	undergraduate student
11	Ayaka Tokumaru	Department of Earth & Planetary Environment, The University of Tokyo	undergraduate student

* Principal investigator

Land-based scientists

1	Akihiko Yamagishi	Faculty of Life Sciences, Tokyo University of Pharmacy and Life Science	Professor
2	Katsuhiko Suzuki	JAMSTEC	Group Leader
3	Takashi Ito	Faculty of Education, Ibaraki University	Associate professor
4	Yoshio Takahashi	Graduate School of Science, Hiroshima University	Associate professor
5	Ken Takai	JAMSTEC	Program Director

3. Observation:

3-1. Purpose of the cruise

We explored the occurrence of cobalt-rich ferromanganese crust (hereafter: Mn-crust) at the depth interval from 2,990m to 950m at #5 Takuyo Seamount (23°00'N, 153°20'E), northwest Pacific using *ROV Hyper Dolphin/RV Natsushima* between February 8, 2009 and February 24, 2009. The Mn-crust is chemical sediment that covers extensively the surface of seamounts or ocean plateaus with a thickness between 1 and 20 cm (e.g. Usui, 2007). Due to the high adsorption capacity of constituent manganese oxides, appreciable concentration of cobalt, copper, nickel, rare-earth elements (REEs), platinum-group elements (PGEs), and others are known to occur. This makes the Mn-crust as low-grade, giant deposit on the present-day seafloor which can be the resource of these metals in near future. Besides, the slow but steady accumulation rate (2-7 mm per million years) of Mn-crust for up to 50-60Ma makes it an excellent recorder of the oceanic environmental change throughout the Cenozoic era (von Stackelberg, 1979).

However, it has been surveyed mainly from resource point of view and scientific information has been quite limited. Most of the Mn-crust samples are recovered with dredges and the chemical compositions are often kept confidential. So we submit a proposal to use *ROV Hyper Dolphin* of JAMSTEC for detailed observation and sampling which enables us to examine depth variation in its occurrence, thickness, mineralogy, chemistry, and microbiology of the crust between 3,000m and 1,100m.

We selected a guyot (table-mountain) named #5 Takuyo Seamount (22°50'N, 153°20'E), the largest seamount within the Japanese EEZ around Minami-Torishima Island (Marcus Is.), because of its high metal contents reported by CoRMC Investigation Team (1990). As the occurrence and were poorly known due to the limited images and sampling, we tried to combine detailed imaging and sampling at various depth between 950m and 3,000m which are the summit and depth limit of the *Hyper Dolphin*, respectively.

One of the topics we are interested to investigate is age determination of the crust. Hein et al. (1992) studied a 47- to 60-mm thick crust from the Horizon Guyot in the central Pacific. The age of this crust was estimated to

be 18.5 Ma by $^{87}Sr/^{86}Sr$ dating, based on comparison with the standard seawater Sr isotope curve. They suggested that the current changed at 15, 11.5, 7.4, 6.4, 5.2 and 4.6 Ma in the area. However, this method is not used afterword due to the difficulty in extracting strontium properly from the sample.

Usui et al. (2007) conducted fine-scale $^{10}Be/^{9}Be$ dating on several ferromanganese crusts from different geological environments and indicated that the crusts have grown at relatively constant rates of 4–7 mm/my without any significant time breaks. We would like to compare these methods on the samples obtained during the present work. Besides, as it is the first time during the history of the Mn-crust research to obtain frequent samples from known depth, it is our main goal to examine any proxy that can indicate water depth (of the present-day ocean).

This cruise is characterized by interdisciplinary approaches including microbiology and engineering. It is estimated that microorganisms play an important contribution in growth of Mn-crust deposits. Uncontaminated samples are required immediately after recovery to the surface to examine the possibility. Ambient seawater and sediments are also necessary as reference and sampling with ROV Hyper Dolphin is suitable for these investigations.

The aim of the engineering group is to gain feedback for the development of autonomous ferro-manganese deposit survey technology. The final goal of this work is to develop a robotic, mobile sensor module, that will work cooperatively with an autonomous underwater vehicle (AUV) to map and survey ferro-manganese deposits over a wide area, and take in-situ measurements of its thickness in crust areas using a high frequency sub-bottom sonar. In addition to developing the necessary payload, real-time knowledge of the type of seafloor is essential to enable the module to adapt and modify its behavior during its missions.

3-2. Observation and sampling instruments

We tested two new payload instruments during the cruise; that is, laser profiling system and underwater diamond saw. The laser profiling system

was installed on the *ROV Hyper-Dolphin* to obtain centimeter order bathymetry data over different types Mn-crust deposit. The system consists of a sheet laser, a camera, a depth sensor and a Doppler velocity log (DVL), all of which were attached to a jig mounted on the aft end of *ROV Hyper-Dolphin*. The jig was constructed and mounted by members of the Hyper-Dolphin team during the cruise.

The latter is a sampling tool to cut off rocks to from outcrops. This worked excellent not only for collecting many samples from desired place but also for inspection of substrates of particular outcrops.

3-3. Cruise Log

NT09-02Leg2 Shipboard Log

Date	Time	Description	Remarks
07Feb09	20:00-21:00	Carried out onboard education & training for scientists	
08Feb09	9:00	Left SAIPAN for research area	Head for Takuyo No.5 seamount
	13:15-14:15	Practiced boat, fire, collision station drill	
	14:40-17:00	Scientific meeting	
09Feb09	9:00-10:00	Scientific meeting	Head for Takuyo No.5 seamount
	13:00-14:15	Scientific meeting	
	13:15-14:15	Practiced search at unauthorized visitor on ship board drill	
	18:00-20:00	Scientific meeting	
10Feb09	9:00-21:00	Lab set up and etc	Head for Takuyo No.5 seamount
11Feb09	6:00	Arrived at research area	
	6:07	Released at XBT	22-40.0318N, 153-13.6754E
	8:14	Launched HPD on the surface	HPD#953

	10:31	HPD landed on sea bottom (D=2990m)	22-40.984N, 153-14.617E
	16:21	HPD left sea bottom (D=2618m)	22-41.824N, 153-15.030E
	17:36	HPD floated	
	17:54	Recovered HPD & finished her operation	
	19:20	Com'ced MBES mapping survey	
12Feb09	5:00	Finished MBES mapping survey	
	8:19	Launched HPD on the surface	HPD#954
	9:52	HPD landed on sea bottom (D=2617m)	22-41.917N, 153-15.033E
	15:36	HPD left sea bottom (D=2213m)	22-42.509N, 153-15.407E
	16:39	HPD floated	
	16:53	Recovered HPD & finished her operation	
	18:35	Com'ced MBES mapping survey	
	19:30-20:30	Scientific meeting	
13Feb09	1:03	Finished MBES mapping survey	
	8:05	Suspended HPD submergence due to rough sea	
	13:00-17:00	Scientific meeting	
14Feb09	8:05	Suspended HPD submergence due to rough sea	
	09:00-12:00	Scientific meeting	
	13:30-17:00	Scientific meeting	
15Feb09	8:05	Launched HPD on the surface	HPD#955
	9:22	HPD landed on sea bottom (D=2209m)	22-42.504N, 153-15.381E
	16:25	HPD left sea bottom (D=1936m)	22-43.858N, 153-15.652E

	17:19	HPD floated	
	17:32	Recovered HPD & finished her operation	
	18:09-18:35	Carried out MBES mapping survey	
	20:04	Com'ced MBES mapping survey	
16Feb09		Finished MBES mapping survey	
	8:07	Launched HPD on the surface	HPD#956
	9:18	HPD landed on sea bottom (D=1934m)	22-43.865N, 153-15.653E
	16:34	HPD left sea bottom (D=1430m)	22-44.613N, 153-16.002E
	17:14	HPD floated	
	17:26	Recovered HPD & finished her operation	
	18:20-18:43	Carried out MBES mapping survey	
	19:29	Com'ced MBES mapping survey	
	20:30-21:15	Scientific meeting	
17Feb09	4:50	Finished MBES mapping survey	
	8:02	Launched HPD on the surface	HPD#957
	9:00	HPD landed on sea bottom (D=1434m)	22-44.610N, 153-15.996E
	16:52	HPD left sea bottom (D=1162m)	22-46.207N, 153-17.398E
	17:24	HPD floated	
	17:38	Recovered HPD & finished her operation	
	19:07	Com'ced MBES mapping survey	
18Feb09	5:00	Finished MBES mapping survey	
	8:05	Launched HPD on the surface	HPD#958
	9:19	HPD landed on sea bottom (D=1985m)	22-50.513N, 153-12.321E
	16:41	HPD left sea bottom (D=1329m)	22-50.474N,

			153-13.404
	17:20	HPD floated	
	17:36	Recovered HPD & finished her operation	
	19:33	Com'ced MBES mapping survey	
19Feb09	5:06	Finished MBES mapping survey	
	8:04	Launched HPD on the surface	HPD#959
	8:57	HPD landed on sea bottom (D=1085m)	22-56.505N, 153-21.062E
	15:09	HPD left sea bottom (D=953m)	22-56.239N, 153-22.681E
	15:39	HPD floated	
	15:54	Recovered HPD & finished her operation	
	16:00	Left research area & proceeded to YOKOSUKA	
20Feb09	9:00-21:00	Wrote cruise report & made Digest DVD	Head for YOKOSUKA
21Feb09	13:00-13:40	Ship cruise seminar	Head for YOKOSUKA
	15:00-17:00	Cleaned up Rock saw room	
	18:00-22:00	Made Digest DVD	
22Feb09	13:00-17:00	Cleaned up Laboratory	Head for YOKOSUKA
23Feb09	9:00-12:00	Wrote cruise report	Head for YOKOSUKA
	13:00-17:00	Made cruise DVD	
24Feb09	9:00	Arrived at YOKOSUKA	
	11:30	Scientists disembark from NATSUSHIMA	

3-4. Dive information

We conducted 7 dives and collected 712kg of rock/crust samples (n=113), 13 sediments, and 13 bottom seawater samples, respectively. Rock/crust samples are split for chemical (major, minor, & trace elements), isotopic (Os, Be, Sr), mineralogical, microbiological (DNA, FISH, culture experiment, etc.), and engineering (sound velocity measurement etc.) analyses. The sediments and water samples are served mainly for microbiological and mineralogical purposes as reference samples.

We found that the Mn-crust is ubiquitous at depth between 3,000m and 1,000m of the seamount. Its thickness has a maximum near the shoulder of the seamount where flat slab of Mn-crust covers limestone bed. The summit of the seamount (D=950m, 22°57'N, 153°23'E) is characterized by limestone outcrop and its platy floats which are covered by thin Mn-crust. On the other hand, steep slopes or escarpments that surrounds the seamount at depth between 1,500m and 2,500m are characterized by thick Mn-crust on the surface of lava, pyroclastic rocks, and gravels/talus deposits. The thickness and abundance decrease with depth partly because of increasing coverage of terrace sediments on calmer slope beneath 2,500m. In other words, the occurrence of Mn-crust is controlled by rock facies and the stability of the substrate. It is also plausible that the seawater characteristics may contribute the thickness and the chemical composition; oxygen minimum of the area exists at depth around 900m near the summit (0.9 mg/l) and increase to 2.4 mg/l at 3,000m depth.

It is also clarified that the Mn-crust occurs beneath sediment cover at flat-top portion of the seamount. We poked the sediment with a bar to check the existence of the crust at several locations. It is extremely hard to distinguish sediment-covered crust and sediment without this check even though the full-high vision image of the *Hyper Dolphin*.

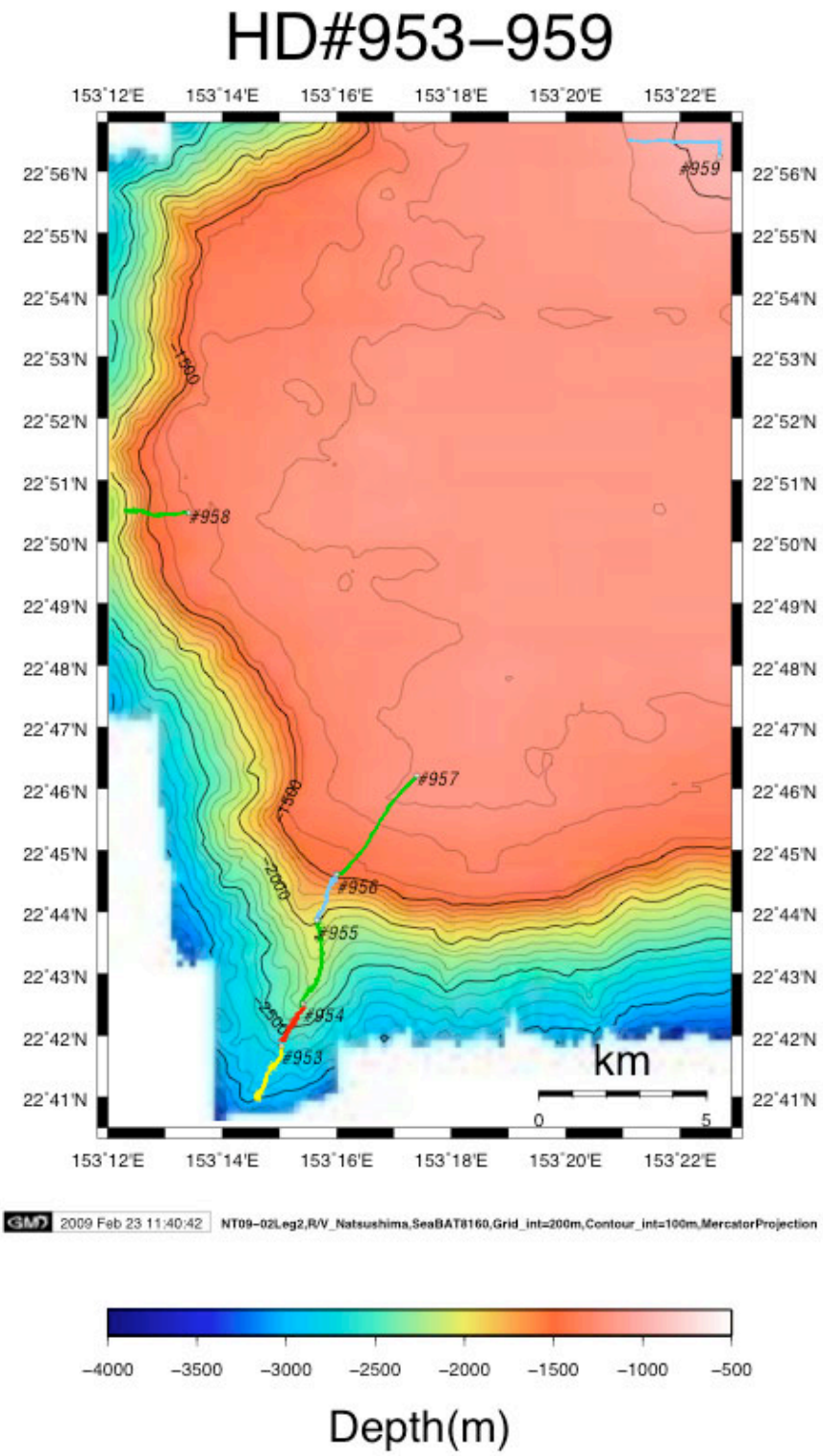

Fig. 2. Dive tracks of the NT09-02 Leg 2 at #5 Takuyo Seamont.

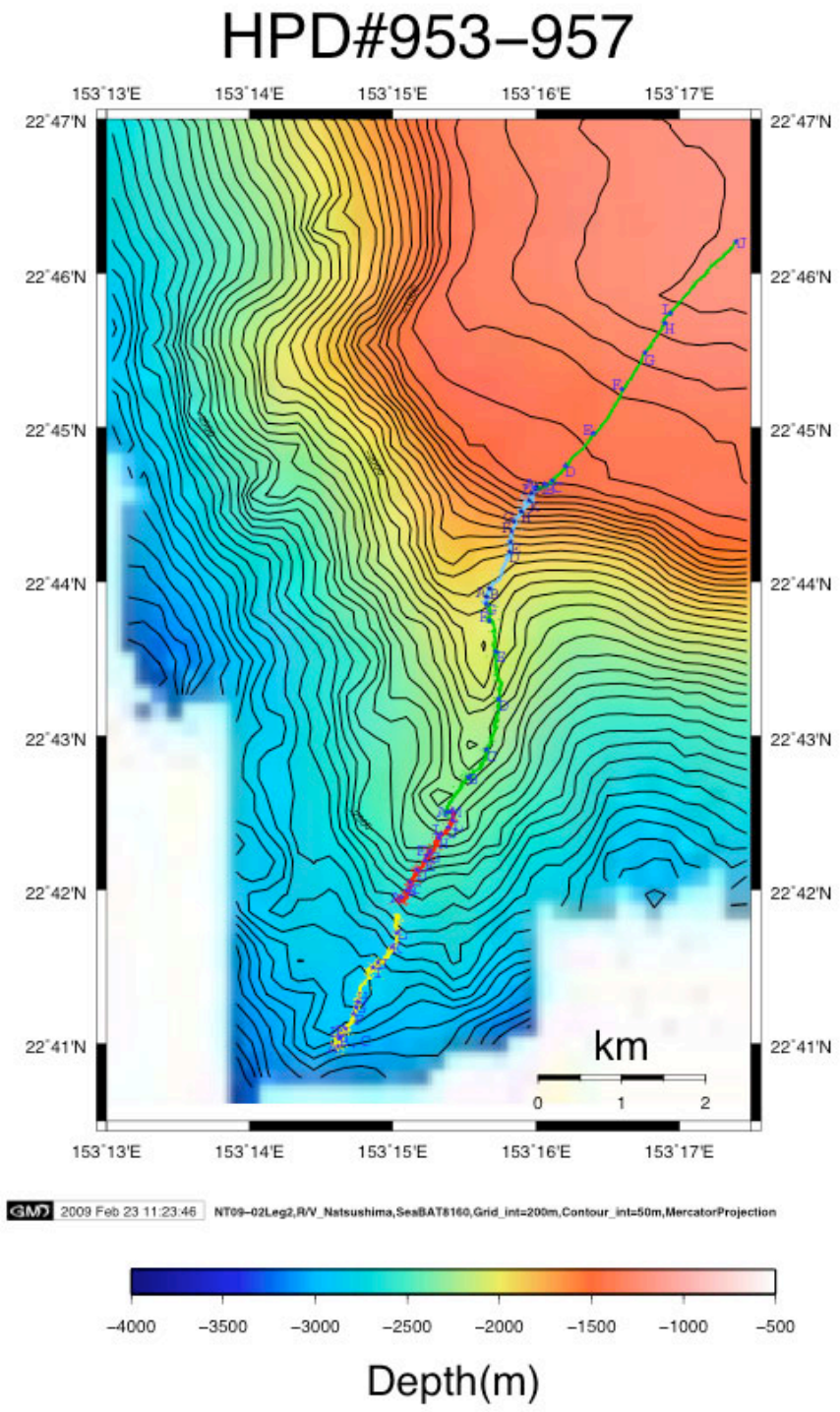

Fig.3. Enlarged tracks of five successive dives; from #953 (south) to #957 (north) .

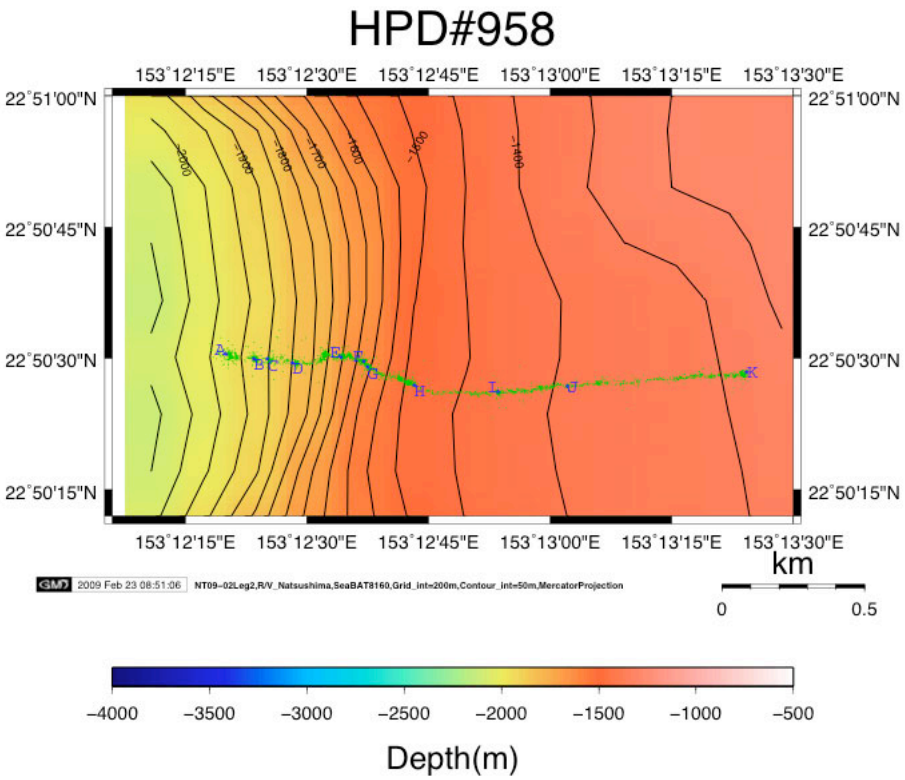

Fig. 4. Dive track of #958 on the west cliff of the #5 Takuyo seamount.

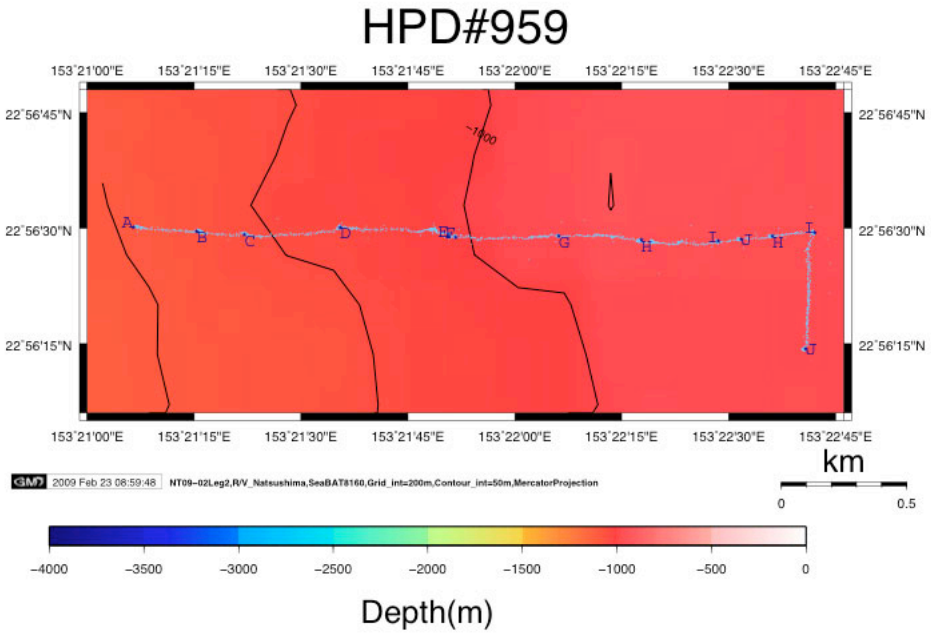

Fig. 5. Dive track of #959 on thesummit of the #5 Takuyo seamount.

It should be emphasized that the present cruise is the first and monumental one even in the world because of the following aspects; (1) large amount of Mn-crust specimens are collected systematically from known depth, (2) observation and inspection of substrate were made with clear and oblique image within a few meters above seafloor between 1,000m and 3,000m, (3) multi-disciplinary research among geology, mineralogy, chemistry, microbiology, and engineering was performed for the first time in the history of Mn-crust. The results of this cruise will be beneficial both for acientific and exploration points of view.

Acknowledgement: We scientific party deeply appreciate the devotion of Captain Koji Samejima, Chief Engineer Minoru Tsukada, and crews of R/V Natsushima, Commander Kazuya Mitsufuji and Hyper Dolphin Team, and Marine Technician Satomi Minamizawa. The success of this cruise cannot be achieved without their contribution and skill. We also appreciate JAMSTEC for providing us with ship-time and arrangement. This cruise is partly supported by MEXT (Ministry of Education, Science, & Culture) through TAIGA project, a New Scientific Research on Innovative Areas, Grants-in-Aid for Scientific Research.

4. Notice on Using

This cruise report is a preliminary documentation as of the end of the cruise. It may not be corrected even if changes on content (i.e. taxonomic classification) are found after publication. It may also be changed without notice. Data on the cruise report may be raw or not processed. Please ask the Chief Scientist for the latest information before using.

Users of data of this cruise are requested to submit their results to Data Integration and Analysis Group (DIAG), JAMSTEC.