Cruise summary

1. Cruise Information

Cruise number:	NT10-11
Research vessel:	R/V Natsushima
Title of cruise:	Hyper Dolphin research dive, Deep-sea research, FY2010
Principle investigator:	Blair Thornton, Institute of Industrial Science, The University of Tokyo
Proponent:	Tamaki Ura, Institute of Industrial Science, The University of Tokyo
Title:	A preliminary survey to measure the thickness of ferro-manganese crust deposits using a parametric acoustic array
Cruise period:	June 25, 2010 (Yokosuka, Japan) July 7, 2010 (Guam) (13days)
Survey site:	#5 Takuyo seamount

2. Overview of the observation:

A survey of ferro-manganese crust deposits was performed at #5 T akuyo seamount (23°00'N, 153°20'E), northwest Pacific using the *ROV Hyper Dolphin/RV Natsushima* between June 25, 2010 and July 7, 2010. Ferro-manganese crusts occur throughout the Pacific on seamounts, ridges and plateaus in areas that have been kept free of sedimentation, at least intermittently , for millions of years. The crusts are formed by oxidised minerals that precipitate out of the ambient seawater to form a continuous layer of deposit that extends over several tens of kilometres, blanketing an underlying rock substrate. The crust layers are typically between 10 and 200mm thick, consisting mainly of Fe and Mn oxides, but are rich in Co, Ni, Cu and contain traces of Pt and rare metals, making them the focus of much attention as a potential mineral resource for mining. The main purpose of the cruise was to test the performance of a parametric acoustic array, which has been developed under the 'Program for the development of fundamental tools for the utilization of marine resources' of the Japanese Ministry of Education. The acoustic probe is designed to measure the thickness of manganese crusts, and investigate new survey techniques by mounting the sensor on a mobile underwater platform, and continuously mapping crust thickness remotely from low altitudes. It is considered that combining the proposed acoustic remote sensing system with conventional survey methods, such as shipboard multibeam survey , ROV sampling and drilling, would potentially accelerate manganese crust survey and lead to more accurate estimation of the volume of mineral resources over a large scale, as well as contribute to a better understanding of crust deposits from a scientific perspective on both local and regional scales.

The acoustic probe was mounted on the ROV Hyper Dolphin together with a 3d seafloor mapping device, a compact drilling system, downhole camera and an underwater diamond saw . The mapping device measures millimetre order resolution seafloor bathymetry together with colour information to create a detailed 3d colour

reconstruction, or 3d pixel map, of the seafloor in order to identify areas with crust cover. The compact drilling system drills a 35mm diameter hole in the seafloor into which the downhole camera system can be inserted to visually confirm the internal structure of the hole. The diamond saw is a sampling device designed to assist in the sampling of manganese crusts.

A total of three dives were performed, with one dive cancelled due to bad weather conditions. 300kg of rock/crust samples (n=20) were obtained and have been cut and divided into samples for geological (chemical, mineralogical) and engineering (acoustic and mechanical) investigation. During the first dive, HPD#1144, acoustic measurements were performed on a flat crust outcrop that had been discovered during NT09-02 Leg 2. Acoustic thickness measurements, mapping, drilling and sampling were successfully performed in this region. The acoustic reflections from the crust substrate interface were found to be extremely strong in this area and the crust thickness could be measured acoustically to be in the region of 90 to 100mm. The acoustically measured thicknesses were found to be in close agreement with the samples obtained in this area. Sampling of the rock substrates revealed that altered and fresh basalts commonly cemented by phosphate rock with extremely high acoustic impedances were abundant in the surveyed area. Drilling was performed to a depth of 100mm, penetrating the crust layer . During the second dive, HPD#1145, a small slope between 1250 and 1150m depths towards the central region of the seamount was investigated with acoustic measurements and mapping performed along several 100m long transects near the shoulder of the slope. A large variation in seafloor morphology and sediment cover was found along the slope. Sampling of the area revealed a lar ge variety of rock substrates, including phosphatized calcareous conglomerates, phosphatized limestone and phosphatized hyaloclastites. Drilling operations were performed and the downhole camera was successfully inserted into the drill hole. However , due to misalignment of the lighting system inside the camera, no observations of the internal hole wall could be made. Finally , during the third dive, HPD#1146, a sampling mission was performed in the northern region of the seamount. Manganese crust cover was found in all of the observed areas, with samples obtained from water depths of around 3000 and 1250m.

During this cruise, acoustic measurements of manganese crust thickness were successfully achieved for the first time at sea. Strong reflections could be obtained near the interface between the crusts and their substrates in the case of hard rock areas with fresh basalts and phosphatized limestone, and it was demonstrated that acoustic measurement of crust thickness was possible for the types of high impendence substrate observed during this cruise, assuming that the acoustic rock properties in the crusts themselves are relatively homogeneous. The 3d visual mapping of the seafloor was found to be a very powerful tool to quantitatively assess the detailed size and nature of the seafloor morphology and it was demonstrated that this kind of acoustic and visual survey of manganese crusts, combined with sampling, forms an ef fective and powerful tool to better understand the nature of manganese crusts on a lar ge scale. A reconstruction made using data obtained during this cruise is given as an example in figure 1. It is intended that the experience gained during these three dives will enable engineering feedback to make further improvements to the various payloads deployed during this cruise.

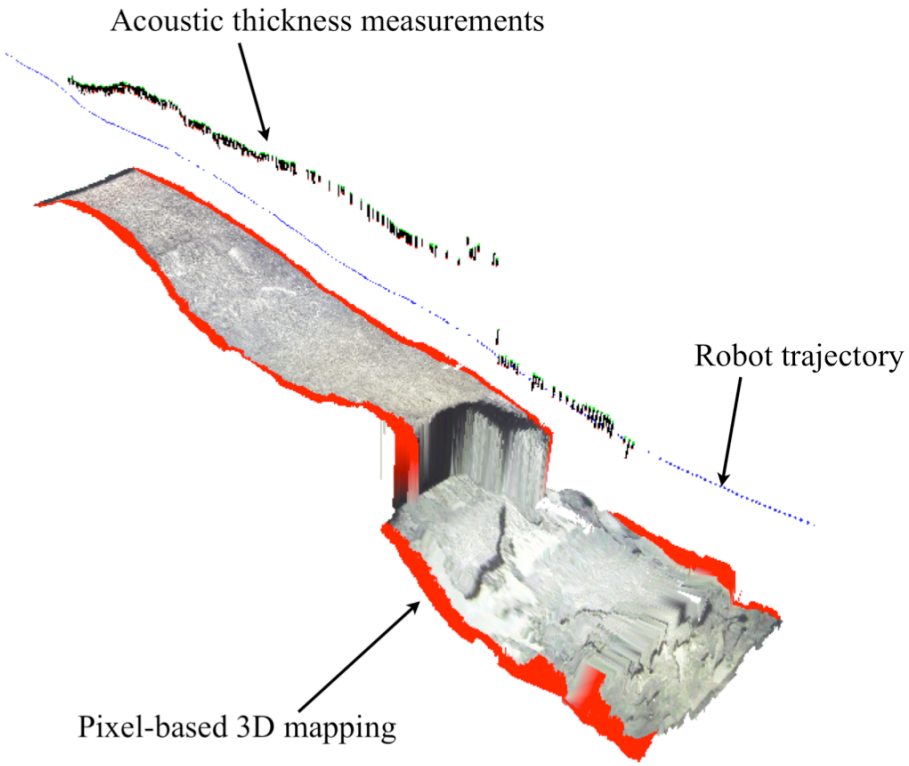

Fig. 1 3d digital GIS reconstruction of ferromanganese deposits based on acoustic sub-bottom and visual mapping data obtained during HPD#1144, NT10-11

Finally, it should be mentioned that this cruise follows NT09-02 Leg 2 as the second multi-disciplinary survey of manganese crust deposits at #5 T akuyo seamount and it is again recognized that collaborative projects between ocean engineers and marine geophysicists such as on this cruise are highly productive for establishing a sound scientific and engineering background, and it is necessary that such collaborative cruises focusing on oceanic ferromanganese crust deposits continue in the future.

We, the research party deeply appreciate the devotion of Captain Hitoshi T anaka, Chief of ficer Akihisa T suji, Chief engineer Hiroyuki Shibata, Chief radio of ficer Tokinori Nasu and the crew of the R/V Natsushima, Commander Kazuya Mitsufuji and the Hyper Dolphin T eam, and Marine T echnician Shinichi Hosoya. The success of this cruise could not have been achieved without their contribution and skill. A special debt of gratitude is extended to T eppei Kido and Kazuhisa Itou for their assistance in the design and interface of the payload sensors used during this cruise. The fact that all the research equipment functioned as intended from the first dive is a testament to their hard work and devotion. We also appreciate JAMSTEC for providing us with ship-time and or ganizing this cruise. This research is partly supported by MEXT (Ministry of Education, Science, & Culture) through 'Program for the development of fundamental tools for the utilization of marine resources'.