Geological Characterization of Co-rich Ferromaganese Crusts over the Northwestern Pacific Seamounts

Usui, A., Sato, H., Nishi, K.
Department of Geology
Kochi University
Kochi, JAPAN

Graham, I
Radiochemistry Lab.
GNS Science
Lower Hutt, New Zealand

Thornton, Blair
Inst. Industrial Sciences
Univ. Tokyo
Komaba, Tokyo, JAPAN

Okamoto, N.
Dept. Deep-sea Mineral Resources
Japan Oil Gas & Metal Resources Corp. (JOGMEC)
Toranomon, Tokyo, JAPAN

Tetsuro Uraba
Emeritus professor
Univ. Tokyo
Hongo, Tokyo, JAPAN

And scientific parties of the Cruises, Natsushima, Kaiyo, Shinkai 2000, and Hakurei-maru II

ABSTRACT—WE, JOINTLY WITH UNIVERSITIES AND INSTITUTIONS (JAMSTEC, JOGMEC, GSJ) USING MARINE GEOLOGY VESSELS, SUBMERSIBLES, REMOTELY-OPERATED VEHICLE, AN OCEAN-BOTTOM DRILL MACHINE, DEEP-TOW TV CAMERA AS WELL AS CONVENTIONAL DREDGES AND CORERS, HAVE OBSERVED, SAMPLED, MEASURED, AND ANALYZED THE FERROMANGANESE CRUST DEPOSITS AND CHARACTERIZED THE MORPHOLOGY, COMPOSITION, AGE, AND GROWTH HISTORY. THE RESULTS DEMONSTRATE THE DIVERSITY IN DISTRIBUTION AND NATURE OF THE DEPOSITS AND RELATIONSHIPS TO MICROTOPOGRAPHY AND GEOLOGICAL ENVIRONMENT.

KEYWORDS—FERROMANGANESE CRUST; SEAMOUNT; NW PACIFIC; ROV; MINERAL RESOURCES)

INTRODUCTION

We have studied the topography, geology, nature of the bottom material of the seamounts using delicate sampling devices and measurement tools, and characterized their distribution patterns of the metal-rich ferromanganese deposits from chemical, mineralogical, and microbiological characteristics of ferromanganese oxide deposits underlain by substrate rocks and sediments.

When comparing the occurrences of these crusts with the substrate geology over the seamounts from a wide area in the northwestern Pacific basin, the thickness of the ferromanganese crusts, the compositional variations of metal elements, and the microstratigraphic growth patterns are basically controlled by the oceanographic conditions and geological history of the seamounts. The required parameters for abundant crust deposits are, 1) long life of the seamounts, 2) early and fast subsidence below the shallow water, and 3) stable geological environment through time without any active volcanism, pelagic sedimentation, diagenesis, or mass wasting. The diversity in bulk composition and abundance of the deposits are on the other hand the integrated results of variable physical and chemical depositional conditions.

We emphasize in the paper that geological consideration is necessary and advantageous when exploring, estimating the

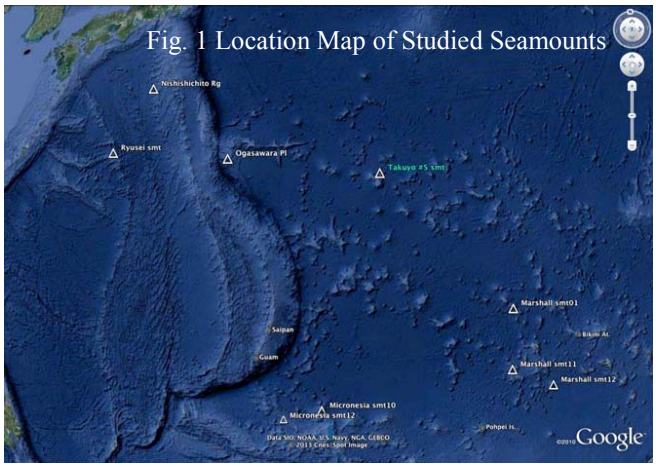

Fig. 1 Location Map of Studied Seamounts

978-0-933957-40-4 ©2013 MTS

suitable deposits and developing the environment-friendly mining system in future if supported by combined geological oceanographic data.

AREA OF STUDY

We studied mainly the two areas in the vicinity of the Marcus seamount, and the Takuyo #5 Seamout in the Pacific plate in the Northwestern Pacific Basin.

Takuyo-#5 Seamount (an isolated large flat-topped seamount near the Marcus Island over the Pacific Plate).

We dove at 7 areas and collected 712kg of rock and crust samples (n=113), 13 sediment cores, and 13 seawater

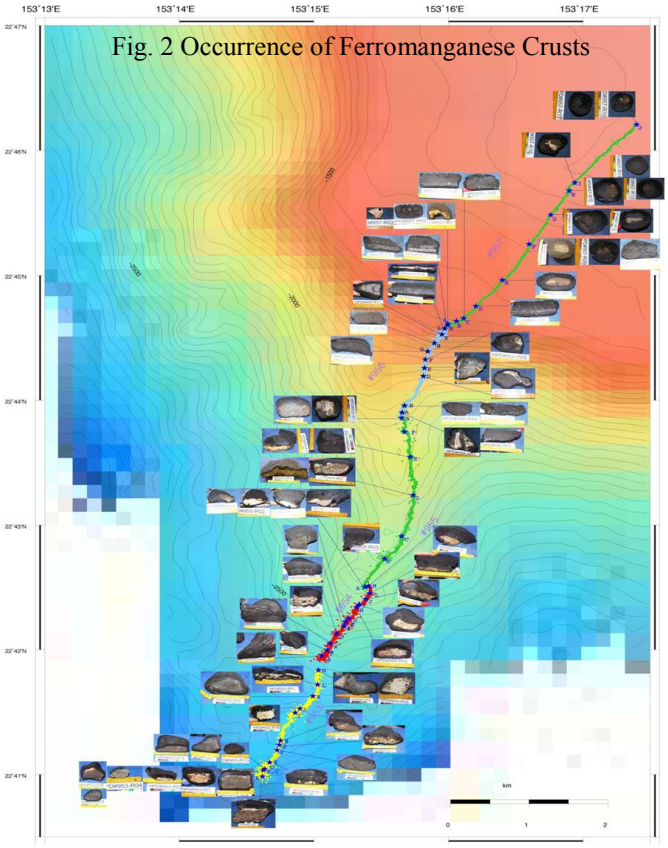

Fig. 2 Occurrence of Ferromanganese Crusts

samples. Rock and 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 common on the ourcrops of the slopes at depths between 3,000m and 1,000m of the seamount. The thickness is the greatest near the shoulder of the seamount where flat slabs of Mn-crust cover the wide flat bottom conglomerate limestone bed. The summit of the seamount (D=950m, 22-57'N, 153-23'E) is characterized by limestone outcrop with fully covered with thin Mn-crust.

On the other hand, steep slopes or escarpments that surround the seamount at depth between 1,500m and 2,500m are characterized by thick Mn-crust on the surface of basltic lava, pyroclastic rocks, and gravels/talus deposits. The thickness and abundance decrease with depth partly because of increasing coverage of terrace sediments running down the slopes beneath 2,000m. In other words, the occurrence of Mn-crust is controlled by substrate rock facies and the stability of the substrate. It is also likely that the seawater characteristics may contribute chemical composition; modern oxygen minimum zone of the area appears at a depth around 900m near the summit (0.9 mg/l) and increase to 2.4 mg/l at 3,000m depth. It is ascertained that the Mn-crust occurs also beneath sediment cover at flat-top portion of the seamount. It is difficult to distinguish sediment-covered crust from thick sediment from vision images only.

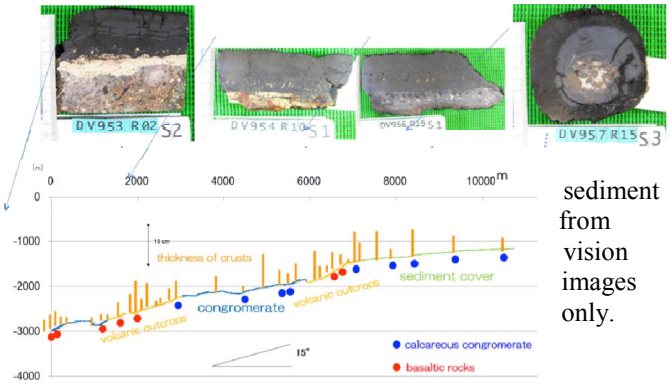

Fig. 3 Variation of thickness of crusts.

Ryusei Seamount (a conical seamount in the Kyushu-Palao seamount chain)

We tried to collect samples without damage or break of samples, with continuous measurement of C-T-D-pH-DO. In-situ samples were taken for geochmisty, mineralogy, microbiology, and physical engineering study on the ferromanganese crusts.

We mapped the entire occurrence of the hydrogenetic ferromanganese crusts (including nodules) during two dives along a total 2.5 km track within water depths between 2200 to 950 meters on the southwestern slope of the seamount. Total 29 ferromanganese samples (178 kg in wet total) were taken at 19 stops. The thickness of ferromanganese crusts ranges from less than 1 mm to 95 mm in maximum, whereas 19 samples were apparent crusts over substantial rock outcrops not a rolling stone or nodules. The apparent rock outcrops that occur more than 60% on the total track were fully coverage with ferromanganese crusts with more than 60 mm average thickness.

The overall occurrence of the crusts were much more than we expected, where the maximum thickness occur around the water depth range between 1500 and 1050 m. The samples were variable in thickness and in water depth. DO varies from

2.7(2200m) to 1.2 mL/L(1000m) . The apparent sediment cover is generally very thin mostly less than 20 cm, but very rarely greater than 50 cm. As a result, the areal distribution and thickness range of ferromanganese crusts in the upper slope of the seamount were much more than we expected.

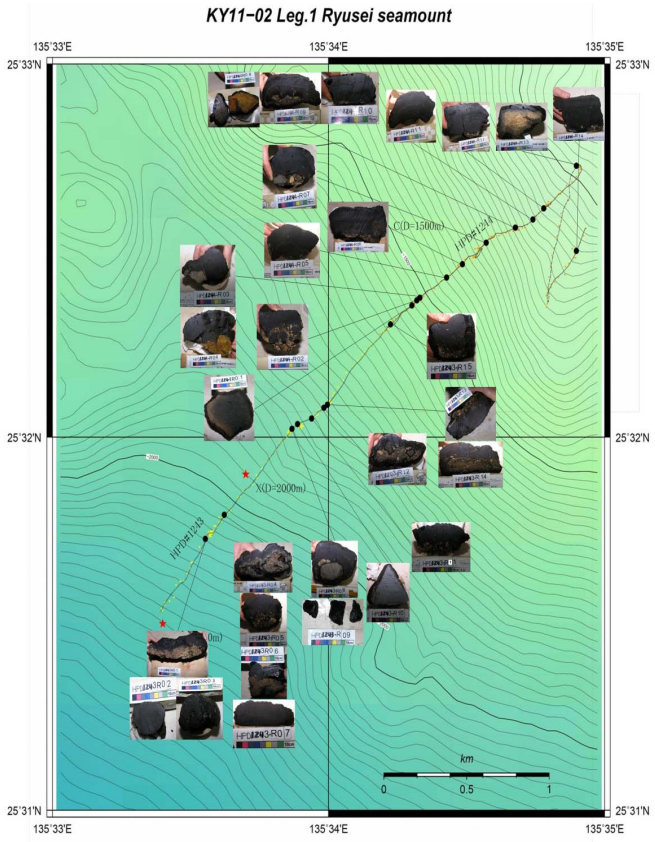

Fig. 4 Variation of occurrence of crusts in the Ryusei smt.

Compositional variation of the crusts in place and in time during growth stages.

Based on XRD mineralogy and ICP/AES&MS chemistry, a correlated secular compositional variations were found over crust columns between remote stations in a seamount. The growth rate is rather constant between 4-7 mm/m.y. The variation patterns are mostly similar amount the areas. The most dependency of elemental characteristics is seen on the colums taken from each Mn crusts in a single seamount, though a secular dependency and water dependency is more clear. These features again suggest that the ferromanganese crusts are precipitated from seawater, thus are related to water chemisty and physics. The thickness, equivalent to abundance of the crusts, is more related to elapsed time of growth and stability of substrates.

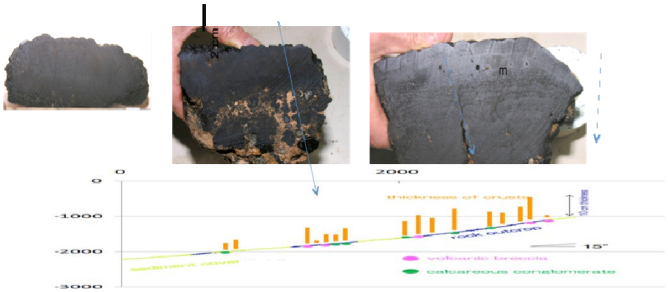

Fig. 5 Variation of thickness of crusts in the Ryusei smt.

SUMMARY

1) The ROV sampling and in-situ measurement of physicochemical parameter is one of the best methos for delicate characterization of the crusts.

2) The compositional variation is well controlled by hydrogenetic nature of the crusts, which controls the depth dependency of chemical composition of iron and manganese oxide precipitates.

3) The geological and mineralogical characterization is most applicable and necessary in evaluating the resource potential of the crusts.