Geological Survey of Japan Cruise Report No. 23, p. 61-65, 1994

V. SURFACE SEDIMENTS IN THE PENRHYN BASIN, SOUTH PACIFIC (GH83-3 AREA): DESCRIPTION BY SMEAR SLIDE OBSERVATION

*Chi-Won Lee**

Introduction

I took part in the Cruise GH83-3 to determine the mineralogy of detrital, authigenic, volcanogenic, and biogenic components of the surface sediment with smear slides under a petrographic microscope.

The box cores and piston cores were taken at 28 stations by R/V Hakurei-Maru within an area bounded by 12°S to 14°S latitude and 158°W to 160°W longitude. The cores and free-fall grab samples were collected on a small scale in the detailed survey area, which was suggested by seismic interpretation.

Every 10 cm-interval of box cores (penetration of around 40 cm) and 50 cm-interval of piston cores (average penetration, around 500 cm) were sampled for smear slides. Also, samples collected by free-fall grabs at 146 sites were provided. This preliminary report was written on board during the Cruise GH83-3.

Method

Smear slides of bulk sediment were studied on board with a petrographic microscope. Estimates of relative abundances of the constituents by smear slides method do not yield absolute percentages. The technique is useful, however, for recognizing relative differences among the sediment samples and establishing abundance trends of both inorganic and organic constituents (Piper *et al.*, 1979). The smear slides were prepared according to Nishimura's suggestion (1981).

Result

More than 300 smear slides from piston cores, box cores and free-fall grab samples were studied. Clay minerals and zeolites make up the bulk of surface sediment in Cruise GH 83-3. Fish debris is significant constituent of surface sediment and locally its content exceeds 20% of bulk sediments. The fine-grained fraction less than 60 μm commonly makes up over 95% in the sediments and decreases with increase of zeolite content.

*Marine Geology Division, Korea Institute of Geology, Mining and Materials. 30 GaJung, Yu-Sung, Dae Jeon, Korea 305-350

Keywords: deep-sea sediment, smear slide, fish debris, Mn micronodule, zeolite, clay mineral, Manihiki Plateau, Hakurei-Maru, Penrhyn Basin

Siliceous microfossils : The siliceous microfossils are rare in the surface sediment of the study area. Rare broken radiolarians and silicoflagellates were found in several smear slides. Rare spicules and no diatoms occur in surface sediment of the survey area. Some microfossils are crystallized. The absence of siliceous remains in surface sediment may result from the lower primary productivity in surface water of the survey area.

Calcareous microfossils : Calcareous microfossils occur only in topographic high area (Free-fall grabs FG659 and FG660, Box core B97). The content of calcareous microfossils in these samples is 5% to 15% of bulk sediment. The water depth is shallower than 4750 m.

Fish debris : Fish debris, which is usually transparent, makes up major part of coarse fraction in some samples. Fragments of fish debris of silt size are also common. Most of fish debris are fragmented and some teeth-shaped, needle-shaped and hook-shaped fish debris were found. Some teeth-shaped fish debris exceed 600 μm in long axis. Prismatic crystals of apatite suggest that some fish debris may have undergone dissolution and/or precipitation (Hein *et al.*, 1979).

Manganese micronodules : Dark brown to opaque, spherical to irregular particles composed of Mn-Fe oxides were found in coarse fractions in many slides. The manganese micronodules make up most coarse fractions in some samples (Core P399). Some of micronodules are less than 40 μm in size. The content of micronodules exceeds 40% of bulk sediment in some samples (for example, Free-fall grab, FG648). Some fish debris are coated by oxide layer. The sharply irregular micronodules may be broken while the smear slides were prepared or the fragments of manganese crusts and macronodules. Manganese micronodules reported in this paper may be overestimated because some opaque minerals are hardly distinguished from micronodules under a petrographic microscope.

Zeolites : Zeolites are major constituents of coarse fraction of surface sediment in the study area. Only rod-shaped zeolites were found in smear slides. The length of zeolites is commonly 60 to 120 μm and up to 180 μm. The zeolites found here are usually translucent to transparent, and some zeolites have pinkish and brownish color. The aggregation of zeolites is common: cross of two zeolite grains and irregularly aggregated forms of several grains. Some zeolites have two or three small spines which are transparent and some have dark inclusions.

Zeolites occur in more than 90% of smear slides. The content of zeolites ranges from 0.5% to 70% of bulk sediment. The occurrence of zeolites in piston core samples is classified into three types: high occurrence (more than 5% of bulk sediment) through whole samples (Cores P396, P405 and P408), rare occurrence (less than 1% of bulk sediment) in all samples (Cores P398, P400, and P409) and partially high abundance above the hiatus (Cores P397, P406, P407, and P411).

The highest occurrence of zeolites is 70% of bulk sediment (Core P405, at 590 cm depth). Zeolites occur abundantly 10 to 50 cm above the hiatus in the piston core

samples where the content of zeolites is less than 1% in other part. Zeolites decrease sharply just below (within 20 cm downcore) the hiatus.

Clay minerals: The term of clay mineral described here means the individual particle less than 2 μm in size. The clay minerals are major component of bulk sediment. The content of clay minerals are 30% to 99% and commonly more than 95% of bulk sediment.

Others: Mica-like transparent flat plates were found in most slides in small amount. Some of them exceed 250 μm in size.

Few benthic foraminifers occur in several samples except for sediments from topographic highs. The surface of foraminiferal tests are severely attacked by dissolution.

White to brownish yellow cast were found in some samples. Some of them show radiolaria-like internal structure.

Fecal pellets were rarely found in smear slides even though some bottom photos show large fecal pellets on sea floor.

Unknown spherical and bright red minerals (commonly 20 to 60 μm in diameter) were frequently observed in small amount. They have two typical optical properties under crossed nicol: isotropic and anisotropic.

Round opaque minerals consist of minor constituents in coarse fraction of some samples. They may be magnetite or hematite.

Discussion

Sediment overlying basaltic basement is about 150 m (Nishimura *et al.*, Chapter III of this volume). Most sample locations are below the CCD. Pelagic clay and zeolitic clay are dominant sediment types in the survey area. The surface sediment consists of clay minerals, zeolites, fish debris and manganese micronodules. Siliceous remains were very rarely found, and calcareous microfossils were found only in the sediments related to topographic highs. Minor unknown constituents such as mica-like flat plates, white to brownish yellow casts, fecal pellets and opaque minerals were locally found.

The absence of siliceous remains in surface sediment of the survey area may not result from rapid dissolution in the upper part of surface sediment, but from the low primary productivity of surface water in the study area. Berger (1970) showed that the abundance of siliceous debris in the Pacific sediments co-vary with the primary productivity in surface water. Micropaleontological study of piston cores from the Wake to Tahiti (Takayanagi *et al.*, 1982) reported that the siliceous microfossils occur only within the area (between 10°N and 10°S), where the primary productivity in surface water is high.

Von Stackelberg (1979) reported that zeolites occur abundantly near the hiatus of piston core samples in the equatorial North Pacific and immediately below the hiatus more abundantly than just above the hiatus. Zeolites of piston core samples (Cores P397, P406, P407, and P411) occur abundantly only just above the hiatus. The higher occurrence of zeolites 10 to 50 cm above the hiatus in the piston core samples may be

related to the episodically lower sedimentation rate.

Zeolites studied in the equatorial North Pacific (von Stackelberg, 1979) is originated from siliceous skeletons, not from volcanic glasses. There is no positive correlation between occurrence of zeolites and dissolution of siliceous remains in this study area.

Rare volcanic materials such as biotite were found in smear slides and pumice nucleus of manganese nodules is also very rare in this survey area. In the neighboring areas, a high content of volcanogenic detritus and zeolites is frequently observed (Bäcker *et al.*, 1976). The volcanogenic detritus is derived from New Zealand (Meylan *et al.*, 1975)

The color of manganese micronodules depends on their metal contents. Iron-rich micronodules should show darker color under a petrographic microscope.

Fish debris in the sediment lacking of available siliceous or calcareous microfossils should be analyzed for biostratigraphy.

Conclusion

The surface sediment of the GH83-3 area consists of pelagic and zeolitic clay. The composition of surface sediment is relatively uniform.

Zeolites occur in most sediments, ranging from 0.5% to 70% of bulk sediment. The content of zeolites is up to 70% in piston core samples (Core P405, at 570 cm depth). The higher occurrence of zeolites just above the hiatus in piston core samples may be related to episodically lower sedimentation. Zeolites in this study area may be originated from volcanic materials. The more intensive studies of zeolites such as morphology and mineral composition will reveal the origin of zeolite and the relationship between occurrence of zeolites and manganese nodules in this study area.

Fish debris is a conspicuous constituent of surface sediment. Fish debris is commonly fragmented. Some fish debris are coated by manganese oxide layer. Apatite crystals and flakes suggest some fish debris have undergone dissolution and precipitation.

The low abundance of siliceous remains in surface sediment may be resulted from low primary productivity in surface water of the study area.

Calcareous microfossils are found in the sediment related to topographic highs.

Further studies of X-ray diffraction, scanning electron microscope and energy dispersive X-ray anaysis may reveal clay mineralogy and mineral composition in more details.

Acknowledgement

I thank to the Geological Survey of Japan for providing samples and facilities for this study. I would also like to thank Dr. A. Nishimura for his helpful guide and discussion, and Drs. M. Nohara, A. Usui and Y. Saito for their kind help during the GH83-3 Cruise.

References

Bäcker,H., Glasby, G.P. and Meylan, M.A. (1976) Manganese nodules from the Southwestern Pacific Basin. *NZOI Oceanographic Field Report*, no. 4, p.88.

Berger, W. H. (1970) Biogeneous deep-sea sediment: Fractionation by deep-sea circulation. *Geol. Soc. Am. Bull.*, vol.81, p.1385.

Meylan, M. A., Backer, H. and Glasby, G.P. (1975) Maganese nodule investigations in the Southwestern Pacific Basin, 1975. *NZOI Oceanographic Field Report*, no.4, p.24.

Nishimura, A. (1981) Deep-sea sediment in the GH 79-1 Area: their geological properties. In: Mizuno, A.(ed.), *Geol. Surv. Japan Cruise Report*, no.15, p. 110- 142.

Hein, J. R., Ross, C. R., Alexander, E., and Yeh, H. W. (1979) Mineralogy and Diagenesis of Surface Sediments from DOMES Areas A,B, and C. In: Bischoff, J.L. and Piper, D. Z. (eds.), *Marine Geology and Oceanography of Pacific Manganese Nodule Province*, Plenum Press, N. Y., p.365-396.

Piper, D. Z., Cook, H.E. and Gardner, J.V. (1979) Lithic and Acoustic stratigraphy of the equatorial North Pacific: DOMES Sites A,B, and C. In: Bischoff, J.R. and Piper, D.Z. (eds.), *Marine Geology and Oceanography of Pacific Maganese Nodule Province,* Plenum Press, N. Y., p.309-348.

Takayanagi, Y., Sakai,T., Oda, M. and Hasegawa, S. (1982) Micropaleontology of piston cores, Wake to Tahiti. In: Mizuno, A. and Nakao, S. (eds.), *Geol. Surv. Japan Cruise Rept.*, no.18, p.238-263.

von Stackelberg, U. (1979) Sedimentation, Hiatuses, and Development of Manganese Nodules: VALDIVIA Site VA-13 / 2, Northern Central Pacific. In: Bischoff, J.R. and Piper, D.Z. (eds.), *Marine Geology and Oceanography of Pacific Manganese Nodule Province,* Plenum Press, N. Y., p.559-586.