Preliminary Report

of

The Hakuhō Maru Cruise KH 86-1

January 22 - March 7, 1986

Geological and Geophysical Investigation of Mariana,
Palau and Yap Arc-Trench Systems

Ocean Research Institute
University of Tokyo
1986

Preliminary Report
of
The Hakuhō Maru Cruise KH 86-1

January 22 - March 7, 1986

Palau - Yap - Cebu

Geological and Geophysical Investigation of Mariana,
Palau and Yap Arc-Trench Systems

by
The Scientific Party of the Expedition
Edited by
Yoshibumi TOMODA


かたお

PREFACE

The cruise KH86-1 was planned to carry out geological and geophysical surveys in the Marianas. At the same time, however, a possibility remained that the cruise might not be realized had there been no delay in the construction of the new Hakuho-maru. The delay in the new vessel project prompted a survey in the northwestern Pacific in winter. The consideration of the seastate led to a major change in the original plan. It was determined to survey in as calm sea as possible, that is, to go as far south as the ship time allows, and hence, the vicinity of the Yap and Palau Trenches were chosen as the survey area.

The stopovers were made at Palau, Yap, and Cebu (Philippine). The Yap Trench area, where most of the investigations were conducted, was very near the Yap Island within eyesight distance. The Yap portstop was the vessel's first in her career. We exchanged friendship with chiefs of the tribes among well grown coconut trees in a "green atmosphere", and watched the Yap dance at night danced with vigor in the squall that sparkled by lights.

We entered Cebu in the midst of the presidential election match between Aquino and Marcos. Everything was normal at Cebu. No change of researchers was made at Cebu because of the conflict in Manila. Drs. Isezaki and Tokuyama who were to return to Osaka and Tokyo via Manila, respectively, remained on board to continue the journey back to Tokyo. On the way back, the Halley's Comet was observed over the starboard.

The scheduling of the ship time for all the researchers was done by Dr. Y. Kono. This cruise report consists of manuscripts prepared by each researcher before arriving at the final port, Tokyo.

March 1986

Y. TOMODA

Chief Scientist of the Cruise

ヤシの木タコの木 バナナの木
空気の色はみどり色
酋長のフンドシ マダラ織り
小供のフンドシ 赤い色
小さな穴はヤシガニの家
ヤシ酒の味 何の味

CONTENTS


KH86-1
友田好文教授退官記念航海
PALAU - YAP - CEBU


安全第一

Scientists List of the Hakuho-Maru KH86-1 Cruise

TOMODA, Yoshibumi	Ocean Res. Inst., Univ. of Tokyo
FUJIMOTO, Hiromi	Ocean Res. Inst., Univ. of Tokyo
TOKUYAMA, Hidekazu	Ocean Res. Inst., Univ. of Tokyo
FUJIOKA, Kantaro	Ocean Res. Inst., Univ. of Tokyo
KOIZUMI, Kin-ichiro	Ocean Res. Inst., Univ. of Tokyo
FURUTA, Toshio	Ocean Res. Inst., Univ. of Tokyo
UCHIYAMA, Akinori	Ocean Res. Inst., Univ. of Tokyo
WATANABE, Masaharu	Ocean Res. Inst., Univ. of Tokyo
NISHIYAMA, Eiichiro	Ocean Res. Inst., Univ. of Tokyo
NAGUMO, Shozaburo	Earthquake Res. Inst., Univ. of Tokyo
TAJIMA, Koichi	Earthquake Res. Inst., Univ. of Tokyo
KASAHARA, Jyunzo	Earthquake Res. Inst., Univ. of Tokyo
KATAO, Hiroshi	Earthquake Res. Inst., Univ. of Tokyo
KINOSHITA, Masataka	Earthquake Res. Inst., Univ. of Tokyo
KINOSHITA, Hajimu	Dept. of Earth Sci., Chiba Univ.
SUYEHIRO, Kiyoshi	Dept. of Earth Sci., Chiba Univ.
TAMAI, Hiroshi	Dept. of Earth Sci., Chiba Univ.
NAGIHARA, Seiichi	Dept. of Earth Sci., Chiba Univ.
ISEKI, Shin-ichi	Dept. of Earth Sci., Chiba Univ.
KONO, Yoshiteru	Dept. of Earth Sci., Kanazawa Univ.
KURAMOTO, Shin-ichi	Dept. of Earth Sci., Kanazawa Univ.
ISEZAKI, Nobuhiro	Dept. of Earth Sci., Kobe Univ.
TAKEUCHI, Akira	Dept. of Earth Sci., Toyama Univ.
KIMURA, Gaku	Dept. of Earth Sci., Kagawa Univ.
KODAMA, Kazuto	Dept. of Geology, Kochi Univ.
MATSUGI, Hiroaki	Dept. of Geology, Kochi Univ.
YAMAMOTO, Satoshi	Dept. of Oceanogr., Ryukyu Univ.
KOGA, Kazuhide	Dept. of Earth Sci., Nihon Univ.
SENO, Tetsuzo	Inter.Inst. Seism. Earthq. Engin., Build. Res. Inst., Ministry of Constr.
MURAKAMI, Hideyuki	Kaiyo Denshi Co.

1. Introduction

Y. KONO

This is a preliminary report for the cruise of R/V Hakuho-maru of the Ocean Research Institute, University of Tokyo (cruise code KH86-1). The KH86-1 cruise has a commemorative meaning because this was the final cruise for Professor Yoshibumi TOMODA (Photo L) before his retirement in coming spring. He is a pioneer in gravimetry over the ocean who developed a physically simple and compact computerized gravimeter, i.e. T.S.S.G. This formally means the Tokyo Surface Ship Gravimeter, though it may better read as the TOMODA Surface Ship Gravimeter. The cruise started on 22nd January and finished at 7th March 1986 (45days) from Tokyo to Tokyo through Palau, Yap and Cebu with a short stay. During the period, he was celebrated his birthday. Thirty scientists from geophysical and geological fields joined together and they are introduced in the table of scientists on board and Photo U.

The cruise is specially designed to investigate the geophysical and geological problems around the Yap and Palau trenches. Full ship tracks and detailed tracks around the surveyed area are illustrated in Figs.1-1 and 1-2, respectively. Along the tracks, gravity, magnetic, and bathymetric profiles were recorded completely. Multi- and single-channel reflection profiles were also obtained by means of air-guns. Four ocean bottom seismographs (OBS) were deployed to observe 20-l air-gun signals and natural earthquakes. Heat flow measurements and deep sea photography were successfully carried out at 7 and 8 sites, respectively. Ocean bottom sediments and rocks were collected by means of a piston-corer, a gravity-corer, a dredger and a grab-sampler at 3, 3, 6 and 2 sites, respectively. A position fixing was also tested by using a three transponders network and the global positioning system (GPS). The ship's position was determined mainly by means of the Loran C and the Navy Navigation Satellite System (NNSS).

As mentioned previously, the following reports are preliminary one as they were prepared under limited condition during the cruise. Therefore, complete reports will appear separately in appropriate papers in future.

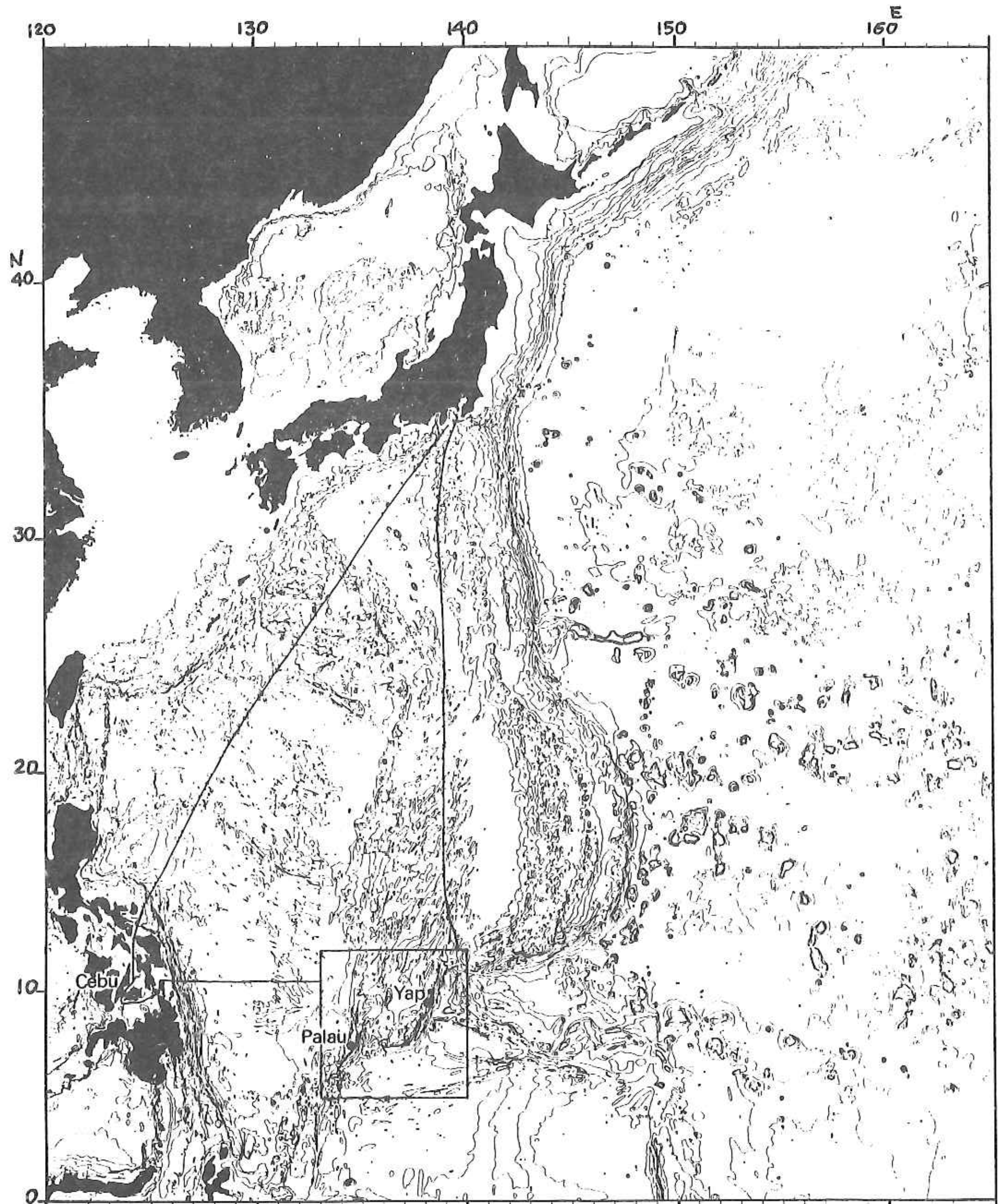


Fig. 1-1. Full ship tracks of KH86-1 Cruise.

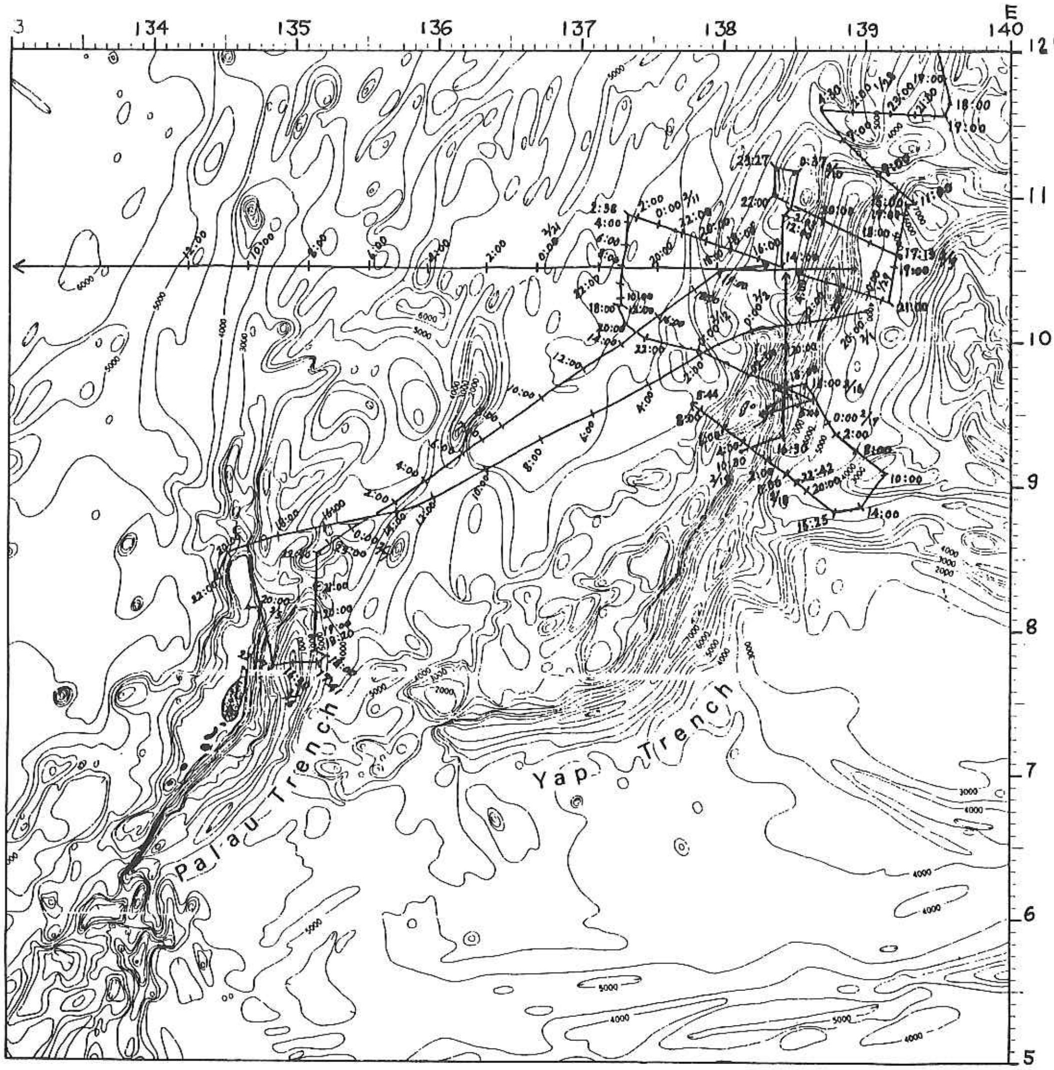


Fig. 1-2. Detailed ship tracks of KH86-1 Cruise around the Yap and Palau Trenches.

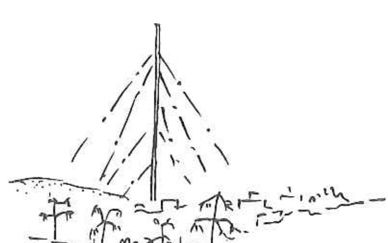
2. Position Fixing

T. FURUTA

Position fixing for the navigation and the station expeditions during the R/V Hakuho-Maru Cruise KH-86-1 was carried out by means of Loran-C receivers (Furuno LA-200, JRC JNA-760, and JRC JNA-902) as well as NNSS receivers (Hokushin-Magnavox HX-1107, and Magnavox 702A). In addition to these systems, a GPS (Global Positioning System) receiver (JRC JLR-4000) was operated to cross-check the positions obtained by Loran-C. Positions obtained by Loran-C were sent to micro-computer through the 20mA current loop data line, and recorded on the floppy diskette in every one minute together with Loran-C clock and the total magnetic force.

The Loran-C stations adopted were M-X-Y in the north of the latitude 20°N, and M-Y-Z in the south (M: Master in Iwozima, X: Hokkaido, Y: Okinawa, and Z: Yap). Ship's positions near the Yap Islands, however, were to some extent fluctuated, because the Z station was located very closely while the other two stations were considerably far away. The accuracy of Loran-C positions was usually better than 0.1 n.m., except the above cases.

Seven GPS Navstar satellites have been launched at present, and receiving duration of more than three satellites is about a half of day around the latitude 10°N. The positioning data obtained by GPS were also sent to another micro-computer and recorded on the floppy diskette for the off line data processing. GPS positioning data is quite usuful to calibrate the ship's position obtained by the Loran-C.



Loran C

3. Gravity measurements

3-1. Gravity Measurements at Sea

Y. TOMODA, H. FUJIMOTO, and K. KOIZUMI

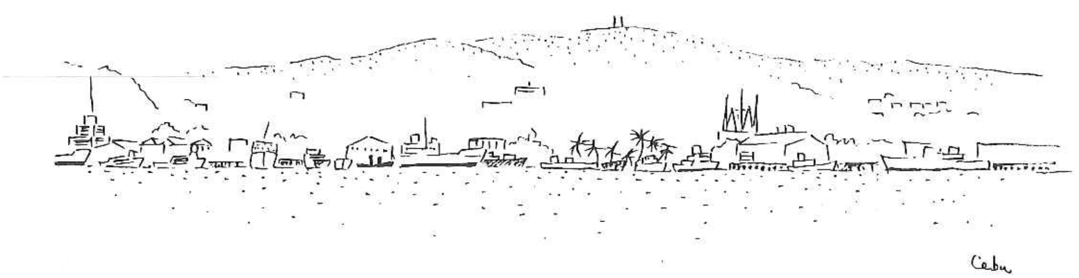
Gravity measurements have been carried out throughout the cruise by means of a Tokyo Surface Ship Gravity Meter (T.S.S.G.). A vibrating-string sensor (No. 68-7-6) is mounted on a vertical gyroscope. The on-line data processing is carried out by use of a board computer Data General MBC/3. The output is typed out and is recorded both on an analogue recorder and in a 5-inch floppy diskette with the aid of a handhold personal computer NEC PC-8201. The sampling interval of the vibration period of the string is about 20 msec, the width of the low-pass filter is 10 min, and the output interval is about 1 min. Gravity values are based on the IGSN 71.

The gravimeter system was already used in the gravity measurements on board the French research vessel Jean Charcot in the France-Japan cooperative project "Kaiko 1" in 1984. There were some troubles on the gyroscope during the Jean Chatcot cruises. The bearings of the gimbals for the gyroscope were found to cause the troubles and were exchanged for the new ones. There was no problem in the bearings suspending the rotor of the gyroscope; its friction showed a normal value of about 1 gcm. The gyroscope was then adjusted to keep vertical by horizontally rotating its direction. No trouble has been detected on the gyroscope in this cruise owing to the adjustment.

Eötvös correction in the on-line processing was calculated on the basis of the Loran-C navigation. The ship's position was determined every 4 sec by a JRC JNA-760 Loran-C receiver, and then an averaged value for a minute was calculated by the MBC/3. Eötvös correction was calculated by using the ship's positions within 4 min before and after the output time. Loran-C stations adopted in this cruise were those at Yap (Z) and Okinawa (Y) as well as Master. Because Loran-C positions obtained around Yap-Palau Islands were not so good, Eötvös correction must be recalculated with the aid of the NNSS data in the post-cruise processing.

Calibration of the gravity values was carried out on the basis of the gravity values in the following table determined by a LaCoste & Romberg gravimeter (G-124):

City	Observation points	Height	Gravity Value (IGSN 71)
Tokyo	Harumi UTYO Pier	3 m	979773.1 mgal
Palau	Bit in the pier	2	978367.1
	Junction to the port	3	978367.6
Yap	Bit in the pier	2.5	978467.9
	Triangulation point	2.1	978470.1
Cebu	Bit in Pier 1	3	978252.7
	Entr. Pier 1 warehouse	3	978253.2



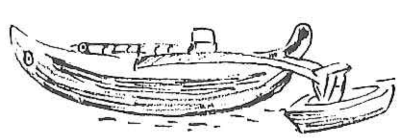
3-2. Gravity Measurements in Yap Island

H. Tajima, K. Koizumi Y. KONO and H. Fujimoto

Gravity measurements were carried out at fifteen points in the southern part of Yap Island by means of a LaCoste & Romberg gravimeter (G-124) on February 14, 1986. Distribution of the gravity points is shown in Fig. 3-2-1. Preliminary values of Bouguer anomalies are shown in the table below.

The measurements adopted simple loop method and gravity values below were based on the gravity station (g = 979762.30 ± 0.02 mgal refered to IGSN 71) at the Ocean Research Institute, the University of Tokyo. The gravity values were tentatively determined by using the scale value for G-124 given by the nanufacturer.

No.	JST	Lat.	Long.	Height	Dial	Gravity	FGA	BGA
1	08:56	9° 30.9'	138° 07.9'	2.5	2040.528	978467.9	296.7	296.4
2	09:23	29.8	05.6	26	2040.350	978467.8	304.3	301.3
3	09:52	29.3	05.1	13.7	2037.702	978465.0	297.9	296.4
4	10:17	26.5	04.3	1	2017.609	978444.1	274.5	274.4
5	10:37	27.7	04.2	10	2032.373	978459.5	292.0	290.9
6	10:47	28.5	04.6	15	2035.824	978463.1	296.8	295.1
7	11:15	29.0	04.8	11	2037.060	978464.4	296.6	295.4
8	12:02	30.2	05.0	0.37	2045.570	978473.2	301.6	301.5
9	12:27	30.4	06.5	15.7	2042.732	978470.4	303.4	301.6
10	12:52	31.2	05.0	0.43	2044.488	978472.2	300.1	300.0
11	13:07	31.1	05.7	36	2040.535	978468.1	307.0	303.0
12	13:24	31.1	06.2	95.3	2027.2	978454.2	311.4	300.7
13	13:41	30.7	06.8	18.8	2042.395	978470.0	303.8	301.7
14	14:02	30.8	07.7	2	2042.456	978470.1	298.7	298.4
15	14:25	30.8	07.9	3	2041.061	978468.6	297.5	297.2
16	14:34	30.9	07.9	2.5	2040.361	978467.9	296.6	296.3



Yap

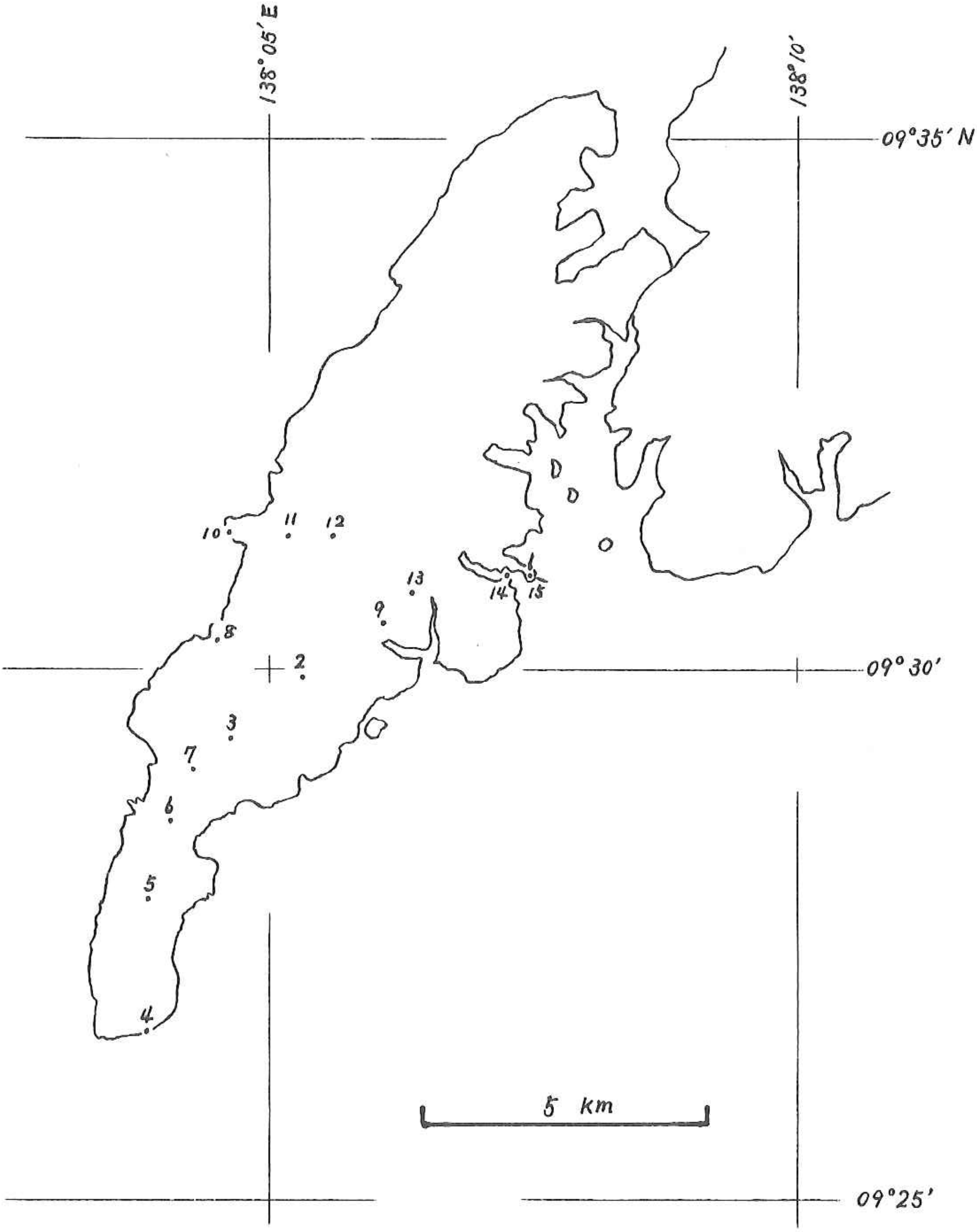


Fig. 3-2-1. Distribution of gravity points in southern Yap Island measured on Feb. 14, 1986.

4. Geomagnetic measurements

4-1. Geomagnetic Total Force Measurements

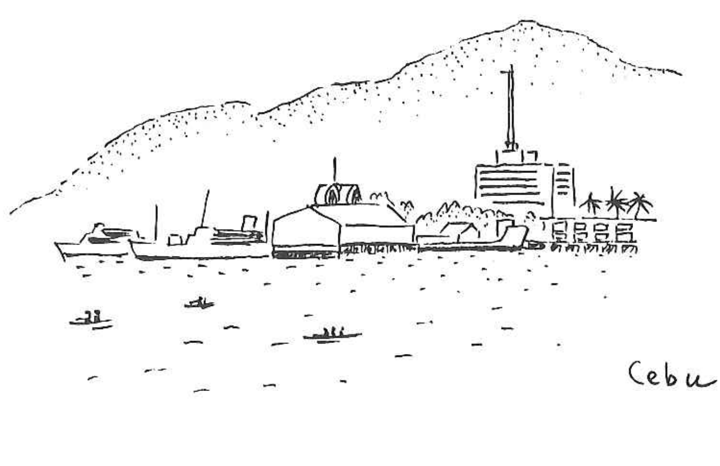
A. UCHIYAMA, T. FURUTA, and S. ISEKI

During this research cruise, the earth's total magnetic field was measured by the use of the proton magnetometer at every 30 seconds throughout the cruise expect when the ship was drifting.

The characteristic of this sensor (UTTY-1) is following.

* Resistance : 9.00 ohm (coil and cable)
  6.29 ohm (coil only)
* Inductance : 20.4 mH
* Coil : A coiled copper wire (1.0 mm in diameter) in 1000 turns.
* Liquid in the sensor : normal heptane
* Length of cable (from the stern to the sensor) : 200m

The connection between the cable and measurement instrument was soldered, without a connector.



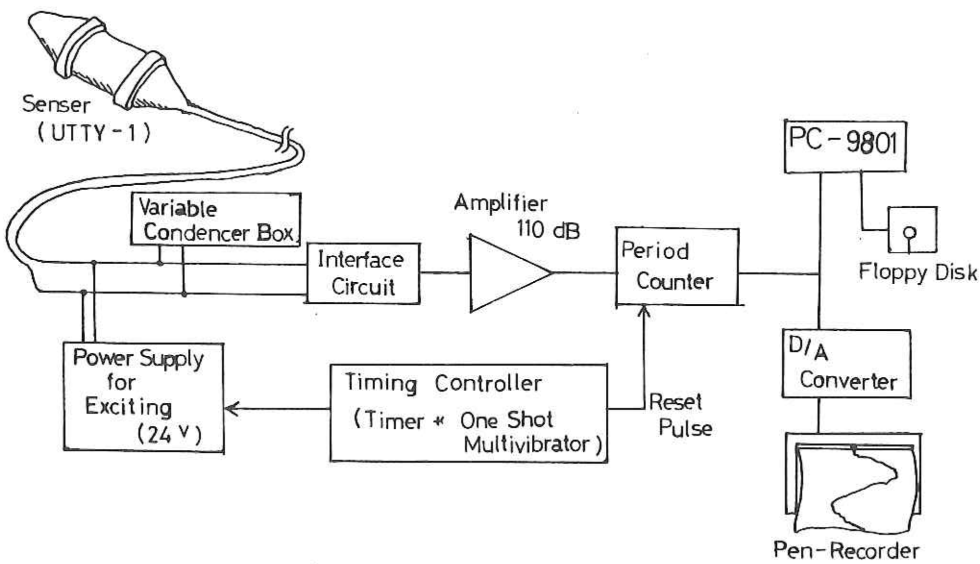


Fig. 4-1-1. Block diagram of shipboard proton magnetometer system.

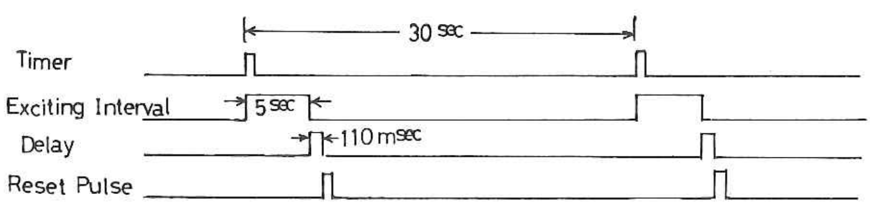


Fig. 4-1-2. Timing chart for one cycle data acquisition.

4-2. Three component magnetic anomalies in the Philippine Sea

ISEZAKI, N., SENO, T., and TOMODA, Y.

1. Introduction

A lot of back-arc basins develop in the western margin of the Pacific ocean. The Philippine Sea is the largest one of these basins.

There are several models proposed for the origin of a back-arc basin: a forceful diapir model (e.g., Karig, 1971), a secondary convection model (e.g., Hui and Toksoz, 1981), kinematic divergence models including retreating of the overriding plate (e.g., Uyeda and Kanamori, 1979) and roll-back of the oceanic plate (Molnar and Atwater, 1978; Seno, 1985). A variety of features of magnetic anomaly lineations in the back-arc basins, for instance, one-sided, two-sided lineations and multiple spreadings, suggest that the origin of the back-arc spreading may not be unique (e.g., Taylor and Karner, 1983).

In the West Philippine Basin, since magnetic anomaly lineations were first reported by Lee and Hilde (1971), many authors investigated the magnetic anomalies (Ben-Avraham et al., 1972; Louden, 1976; Watts et al., 1977; Mrozowski et al. 1982; Shih, 1981; Hilde and Lee, 1984). Identification of the lineations was different among authors. For instance, Ben-Avraham et al. (1972) and Watts et al. (1977) (one-limb model) proposed the Mesozoic age for the lineations, and in contrast, Louden (1976), Watts et al. (1977) (two-limb model), Mrozowski et al. (1981), Shih (1981) and Lee and Hilde (1984) proposed the early Tertiry age.

Models for the origin of the West Philippine Basin are also diverse (see Seno, 1986). Uyeda and Ben-Avraham (1972), Uyeda and McCabe (1983), Shih (1981), Ben-Avraham and Uyeda (1983) and Lee and Hilde (1984) proposed an entrapped origin for this basin. In contrast, Karig (1975), Kobayashi and Isezaki (1976), Lewis et al. (1982) and Seno and Maruyama (1984) proposed a back-arc basin origin.

In the Shikoku Basin, adjacent to the West Philippine Basin, there are magnetic anomaly lineations with a N-S trend created by the two-sided spreading (Tomoda et al., 1975; Watts and Weissel, 1975; Kobayashi and Nakata, 1978; Shih, 1980). The age of the lineations is the early Miocene; e.g., Shih's model ranges from about 24 Ma (anomaly 6c) to about 16 Ma (anomaly

5c). Although, the Shikoku and Parece Vela Basins seem to form one back-arc basin between the Kyushu-Palau Ridge and the Izu-Bonin and West Mariana Ridges, Mrozowski and Hayes (1979) presented a slightly different age for the magnetic anomaly lineations in the Parece Vela Basin, ranging from about 30 Ma (anomaly 10) to about 17 Ma (anomaly 5D).

In the KH86-1 cruise, magnetic surveys by STCM (Shipboard Three Component Magnetometer) were carried out in the southern most part of the Parece Vela Basin and in the West Philippine Basin. Fig. 4-2-1 shows the track lines. There are two track lines between the Yap and Palau islands, one E-W track line from Yap to Philippines, and one NE track line from Luzon to Tokyo. Because three component magnetic survey has never been conducted in these areas, we expect to obtain new informations on the magnetic anomaly identification in the Philippine Sea. It would help to solve the ambiguities on the origin of the Philippine Sea mentioned above.

2. STCM

STCM measures intensities of three components of a geomagnetic field through flux gate sensors settled on the deck. Three component geomagnetic anomalies have some characteristics that total intensity anomalies usually measured by a protpn magnetometer do not. For instance, (1) magnetic anomalies are easily examined whether they are lineated or not by a single anomaly profile, and (2) near the geomagnetic equator like the southern Parece Vela and West Philippine Basins, if magnetic anomaly lineations trend NS, there occur eastward and vertical-down component anomalies. Because the main geomagnetic field is almost horizontal, no total intensity anomaly is observed by a proton magnetometer. However, STCM can measure eastward and vertical-down component anomalies. For details about STCM, see Isezaki (1986).

3. Results and their tectonic implications

Fig. 4-2-2 shows the three component magnetic anomalies in the southernmost part of the Parece Vela Basin obtained during this cruise. In Fig.4-2-2a, X (north), Y (east), Z (vertical-down) components and the total magnetic force obtained by STCM along Line S9 (Fig. 4-2-1) are shown. In Fig. 4-2-2b, Y and Z components and the total magnetic force along Line S3 are shown. In Fig. 4-2-2c, Y and Z components along Line T1 are

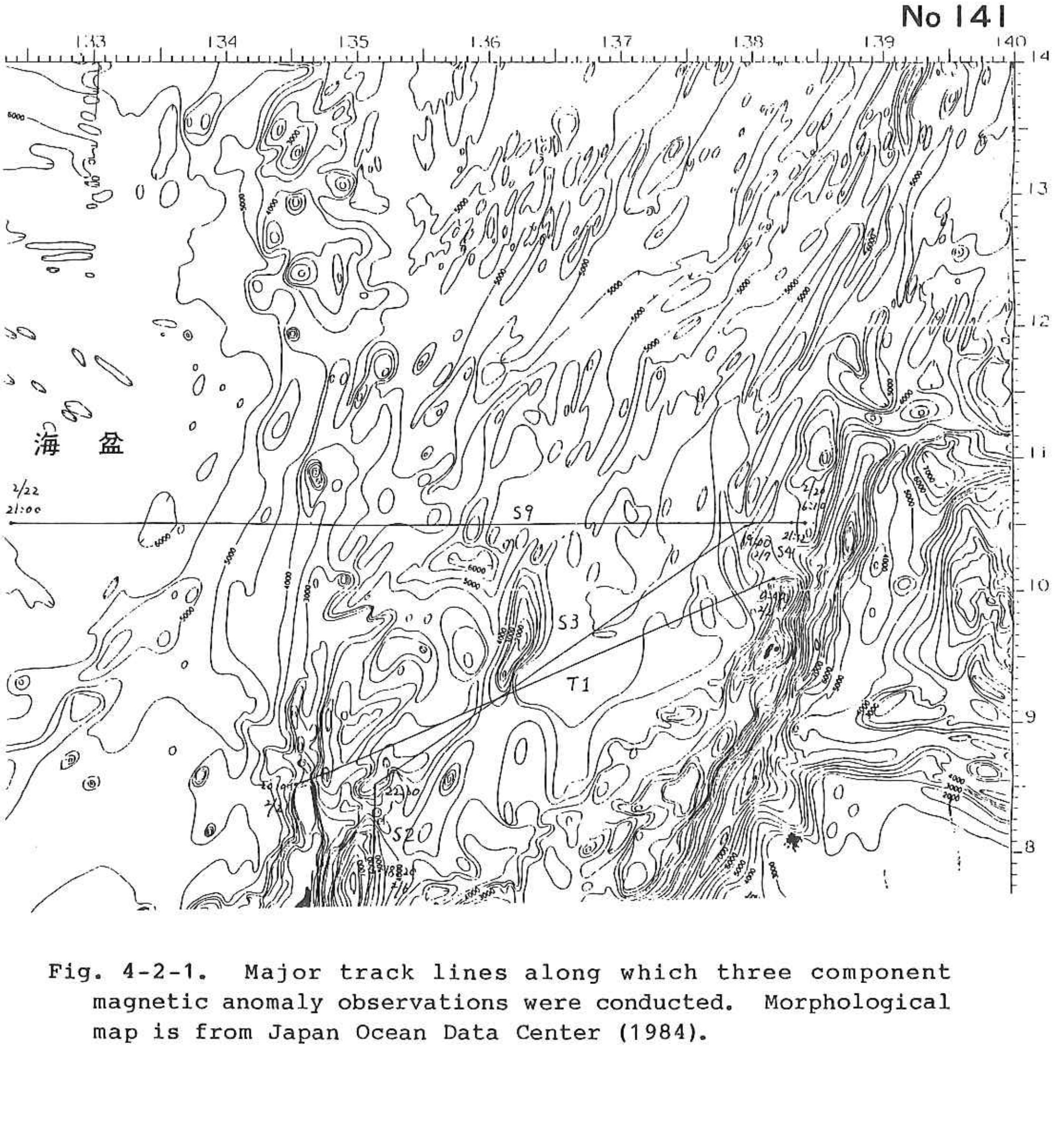


Fig. 4-2-1. Major track lines along which three component magnetic anomaly observations were conducted. Morphological map is from Japan Ocean Data Center (1984).

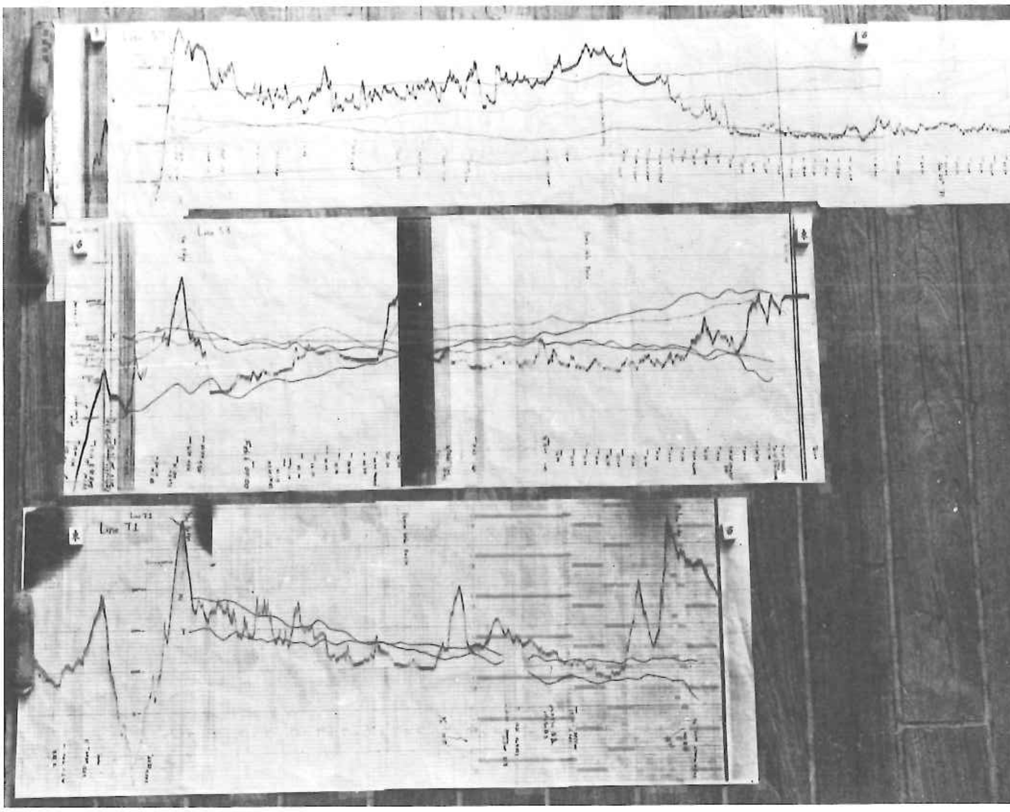


Fig. 4-2-2. Three component magnetic anomalies in the southernmost Parece Vela Basin. a: along Line S9, b: along Line S3, and c: along Line T1 (Fig. 4-2-1).

shown.

The total magnetic force is nearly constant along Line S3. In the eastern part of the basin, along this line, there is a small amplitude variation amounting 200 nT in Y component over the general trend. Z component shows less variation than Y component.

Along Line T1, there is an undulation in amplitude on the order of 200 nT with a large wave length. However, it is difficult to find a lineated anomaly along this line.

Along Line S9, there is no significant variation in amplitude in all the three components or in the total magnetic force.

Afterall, we cannot find any significant magnetic anomaly even by STCM in the southernmost Parece Vela Basin. The morphology of this part of the basin, between the Yap arc and the Kyushu-Palau Ridge, is different from the other main part of the basin between the West Mariana Ridge and the Kyushu-Palau Ridge. First we note that the Parece Vela Basin has a smaller width in this part than the main part. There is a ridge between 9 10'N and 10 10'N elongating in a NS direction. This ridge becomes broader to the south at the north of the Palau-Yap junction (Fig. 4-2-1). Further, there are morphological fabrics lineated in a NE-SW direction in the main part of the basin; however this feature is obscure in the southernmost part. The roughness of the seafloor between the Yap arc and the midst ridge is less than that of the main part of the basin.

We infer that the opening of the southernmost part of the Basin was immatured. The midst ridge could be an aborted arc fragment between the Yap and Kyushu-Palau Ridges. The fact that there is no significant magnetic anomaly suggests that spreading did not occur along a simple rift valley in the basin but a broad extension would have occurred between the Yap and Kyushu-Palau Ridges. The subduction of a possible westward extension of the Caroline Ridge might have prevented the Caroline plate from rolling back eastward and produced the immatured spreading in the southernmost part of the Parece Vela Basin.

References

Ben-Avraham, Z., J. Segawa, and C. O. Bowin, An extinct spreading center in the Philippine Sea, Nature, 240, 453-455, 1972.

Ben-Avraham, Z. and S. Uyeda, Entrapment origin of maginal seas, Geodynamics Series, AGU/GSA, 11, 1983.

Hilde, T. W. C. and C. H. Lee, Origin and evolution of the West Philippine Basin, Tectonophysics, 102, 85-104, 1984.

Hui, A. T. and M. N. Toksoz, Back-arc spreading: Trench migration, continental pull, or induced convection?, Tectonophysics, 74, 89-98, 1981.

Isezaki, N., Newly designed shipboard three component magnetometer. submitted to Geophysics, 1986.

Japan Ocean Data Center, Submarine Topographic maps in the north-western Pacifc, 1984.

Karig, D. E., Structural history of the Mariana island arc system, Geol. Soc. Am. Bull., 82, 323-344, 1971.

Karig, D. E., Basin genesis of the Philippine Sea, Init. Rep. DSDP, 31, 857-879, 1975.

Kobayashi, K. and N. Isezaki, Magnetic anomalies in the Sea of Japan and the Shikoku Basin: Possible tectonic implications, in "Geophysics of the Pacific Ocean and its margin", Geophys. Monogr., AGU, 19, 1976.

Kobayashi, K. and M. Nakata, Magnetic anomalies and tectonic evolution of the Shikoku inter-arc basin, J. Phys. Earth, suppl., 26, S39-S402.

Lee, C. H. and T. W. C. Hilde, Magnetic lineations in the western Philippine Sea, Acta Oceanogr. Taiwanica, 1, 69-76, 1971.

Lewis, S. D., C. L. Mrozowski, and D. E. Hayes, The origin of the West Philippine Basin by inter-arc spreading, in "Geology and Tectonics of the Luzon-Mariana Region", ed. by G. R. Balce and A. S. Zanoria, Proc. CCOP-SEATAR Workshop, 31-51, 1982.

Louden, K. E., Magnetic anomalies in the West Philippine Basin, in "Geophysics of the Pacific Ocean and its Margin", Geophys. Monogr., AGU, 19, 253-276, 1976.

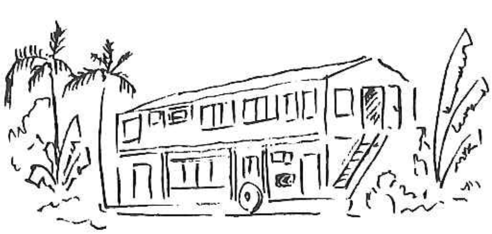
Molnar, P. and T. Atwater, Interarc spreading and cordilleran tectonics as alternates related to the age of subducted lithosphere, Earth Planet. Sci. Lett., 41, 330-340, 1978.

Mrozowski, C. L. and D. E. Hayes, The evolution of the Parece Vela Basin, eastern Philippine Sea, Earth Planet. Sci. Lett., 46, 49-67, 1979.

Mrozowski, C. L., S. D. Lewis and D. E. Hayes, Complexities in the tectonic evolution of the West Philippine Basin, Tectonophysics, 82, 1-24, 1982.

Seno, T., Age of subducting lithosphere and back-arc basin formation in the western Pacific since the middle Tertiary, in "Formation of Active Ocean Margins", ed. by N. Nasu et

al., Terra Pub., Tokyo, in press, 1985.
Seno, T., Tectonic evolution of the West Philippine Basin, in " The Cretaceous-Recent Evolution of the SW Japan Active Margin", Geol. Soc. London, Spec. Pub., in press, 1986.
Seno, T. and S. Maruyama, Paleogeographic reconstruction and origin of the Philippine Sea, Tectonophysics, 102, 53-84, 1984.
Shih, T. C., Marine magnetic anomalies from the western Philippine Sea: Implications for the evolution of marginal basins, Geophys. Monogr., AGU, 23, 49-76, 1980.
Shih, T. C., Magnetic lineations in the Shikoku Basin, Init. Rep. DSDP, U. S. Goverment Printing Office, 58, 783-788, 1980.
Taylor, B. and G. D. Karner, On the evolution of marginal basins, Rev. Geophys. Space Phys., 21, 1727-1741, 1983.
Tomoda, Y., K. Kobayashi, J. Segawa, M. Nomura, K. Kimura and T. Saki, Linear magnetic anomalies in the Shikoku Basin, northern Philippine Sea, J. Geomag. Geoelectr., 28, 47-56, 1975.
Uyeda, S. and Z. Ben-Avraham, Origin and development of the Philippine Sea, Nature, 240, 176-178, 1972.
Uyeda, S. and H. Kanamori, Back-arc opening and the mode of subduction, J. Geophys. Res., 84, 1049-1062, 1979.
Uyeda, S. and R. McCabe, A possible mechanism of episodic spreading of the Philippine Sea, in "Accretion Tectonics in the Circum-Pacific Regions", ed. by Hashimoto, M. and S. Uyeda, Terra Pub., Tokyo, 291-306, 1983.
Watts, A. B. and J. K. Weissel, Tectonic history of the Shikoku marginal basin, Earth Planet. Sci. Lett., 25, 239-250, 1979.
Watts, A. B., J. K. Weissel and R. L. Larson, Sea-floor spreading in marginal basins of the western Pacific, Tectonophysics, 37, 167-182, 1977.



5. Seismic Reflection Survey

E. NISHIYAMA, H. TOKUYAMA, H. TAMAI,
H. KATAO, S. KURAMOTO, and K. SYEHIRO

During KH86-1 Cruise, multichannel and singlechannel seismic reflection explorations were performed around the Yap trench and the adjacent area.

5-1. Singlechannel seismic reflection survey

Singlechannel seismic surveys were carried out with ship speed about 10 to 12 knots. A hydrophone streamer cable was composed of 500 meters lead-in cable, a weighted section of approximate 3 meters, a 25 meters stretch section, an active section of 25 meters, a dead section of 25 meters, and an approximate 30 m dummy rope. We used the No.6 winch which was installed in Hakuho-Maru for our towing operation (Fig.5-1-1). It was proved that the stretch section improved S/N ratio.

We obtained 10 lines of seismic reflection profiles (Fig.5-1-2). The S1, S2, S3 and S4 were combined 4 lines, from the Palau trench to the Yap trench (Fig.5-1-3). The S5, S6, S7 and S8 were the lines crossing the northern part of the Yap trench (Fig.5-1-4). The S9 was a long line along the latitude of 10°30'N from north of the Yap island to the Philippine trench (Fig.5-1-5). The S10 started at Philippine trench and ended at north of the Benham Rise (Fig.5-1-6).

5-2. Multichannel seismic reflection survey

Twelve-channel digital seismic reflection surveys were carried out with ship speed 5 knots. Five lines were obtained running across the north part of the Yap arc-trench system (Fig.5-2-1). Instantaneous interpretation of each line will be given below.

The profile M1

This profile shows that the Mariana arc is subducting beneath the northern extension of the Yap arc. the arrow in figure 7-2-2 indicats the trench axis related to the subduction.

The profiles M2 and M5

Trends of the profile M2 and M5 are perpendicular to the Yap trench axis.

The profile M5 is located approximate 20 km south of the Yap Island. Normal faults develop on the outer trench slope subducting beneath the Yap arc. The inner trench slope is devided into two escarpments by a terrace at the depth of 4100 m. In the central part of the Yap arc normal faults dipping to the east are identified.

The profile M2 is located north of the Yap Island. On the inner trench slope a small terrace exists at the depth of about 6700 meters. A crest in the western part of this profile morphologically corresponds to the terrace with a depth of 4100 meters seen in the profile M5.

The profile M3

This profile is western extension of the profile M2. Depthes gradually increase to the west on the western slope of the Yap arc. Graben structure remarkably develop on the slope.

The profile M4

The line M4 starts at the western end of the M3 and runs towards the south on the southern part of the Parece Vela Basin. This profile is characterized by the reflector with low frequency at the depth of 1 to 2 seconds in two-way travel time from the sea bottom. The reflector gently dips to the south.

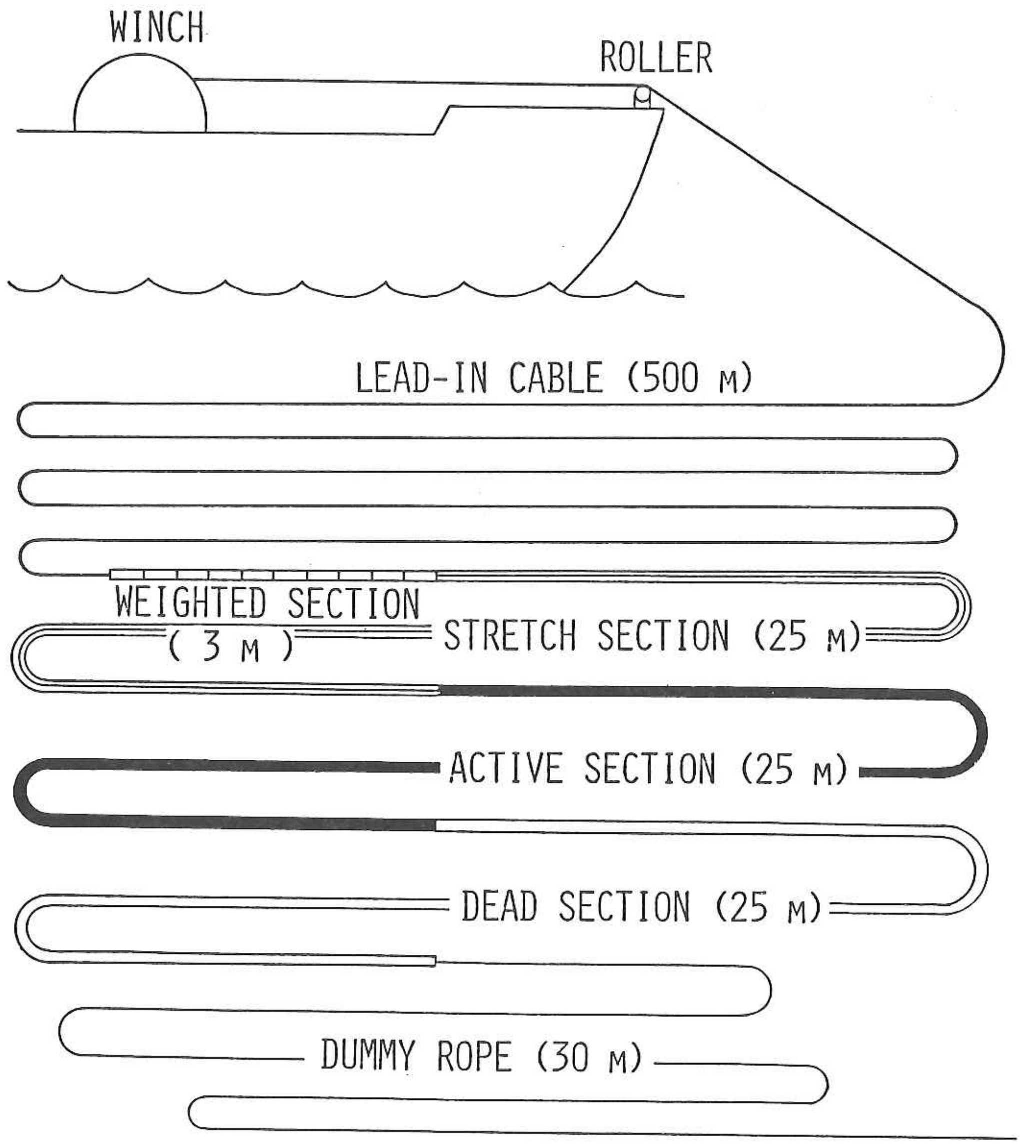


Fig. 5-1-1. Layout of the streamer cable towing system.

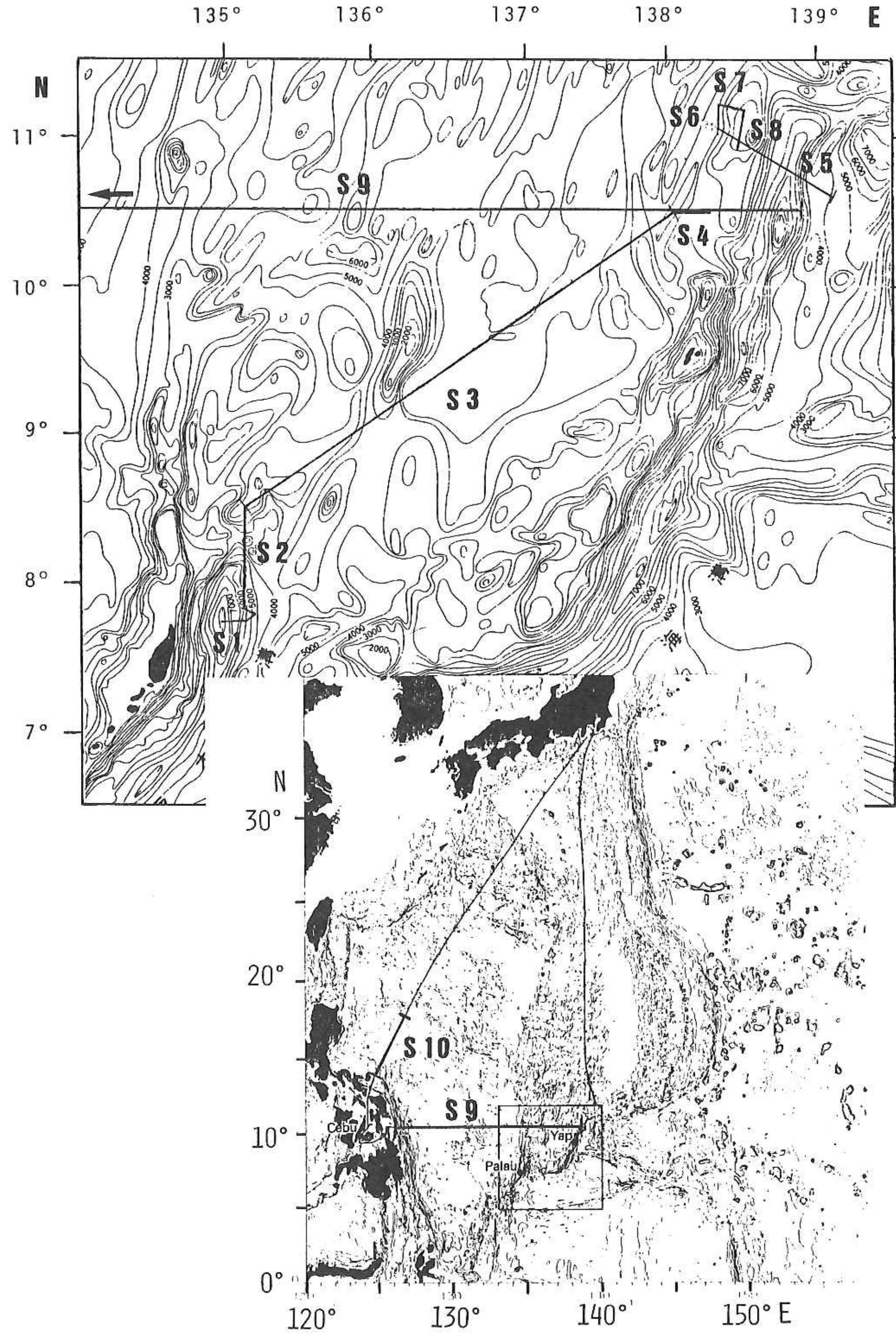


Fig. 5-1-2. Track lines of singlechannel seismic survey.

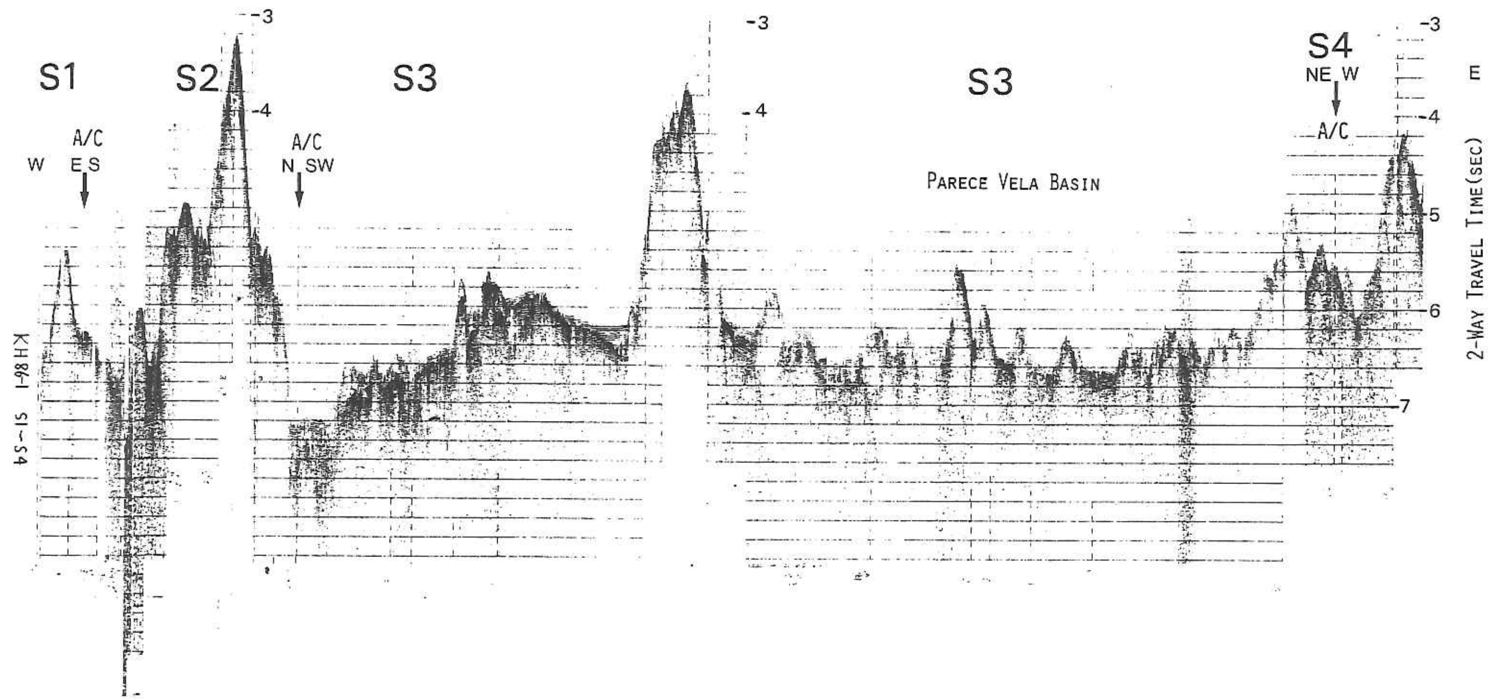


Fig. 5-1-3. Singlechannel seismic profiles of S1, S2, S3, and S4.

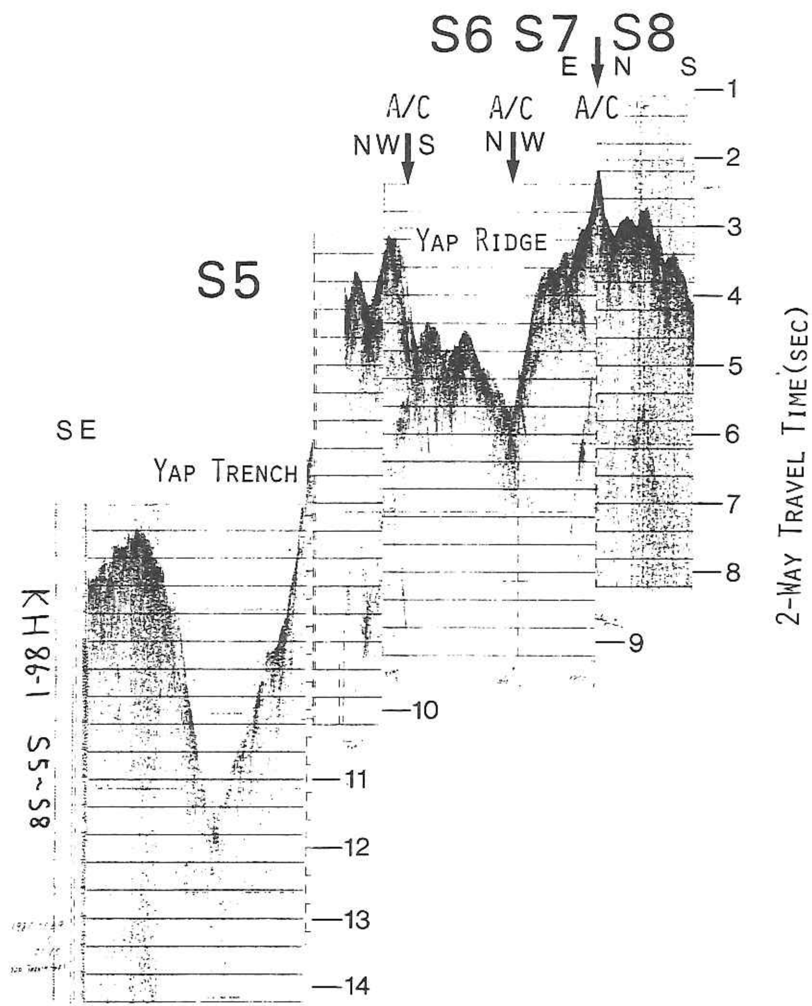
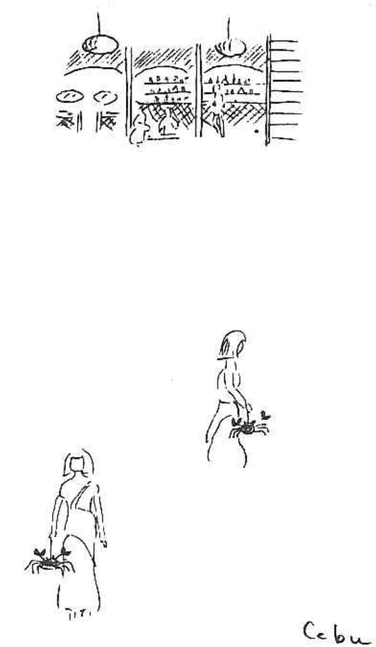


Fig. 5-1-4. Singlechannel seismic profiles of S5, S6, S7, and S8.



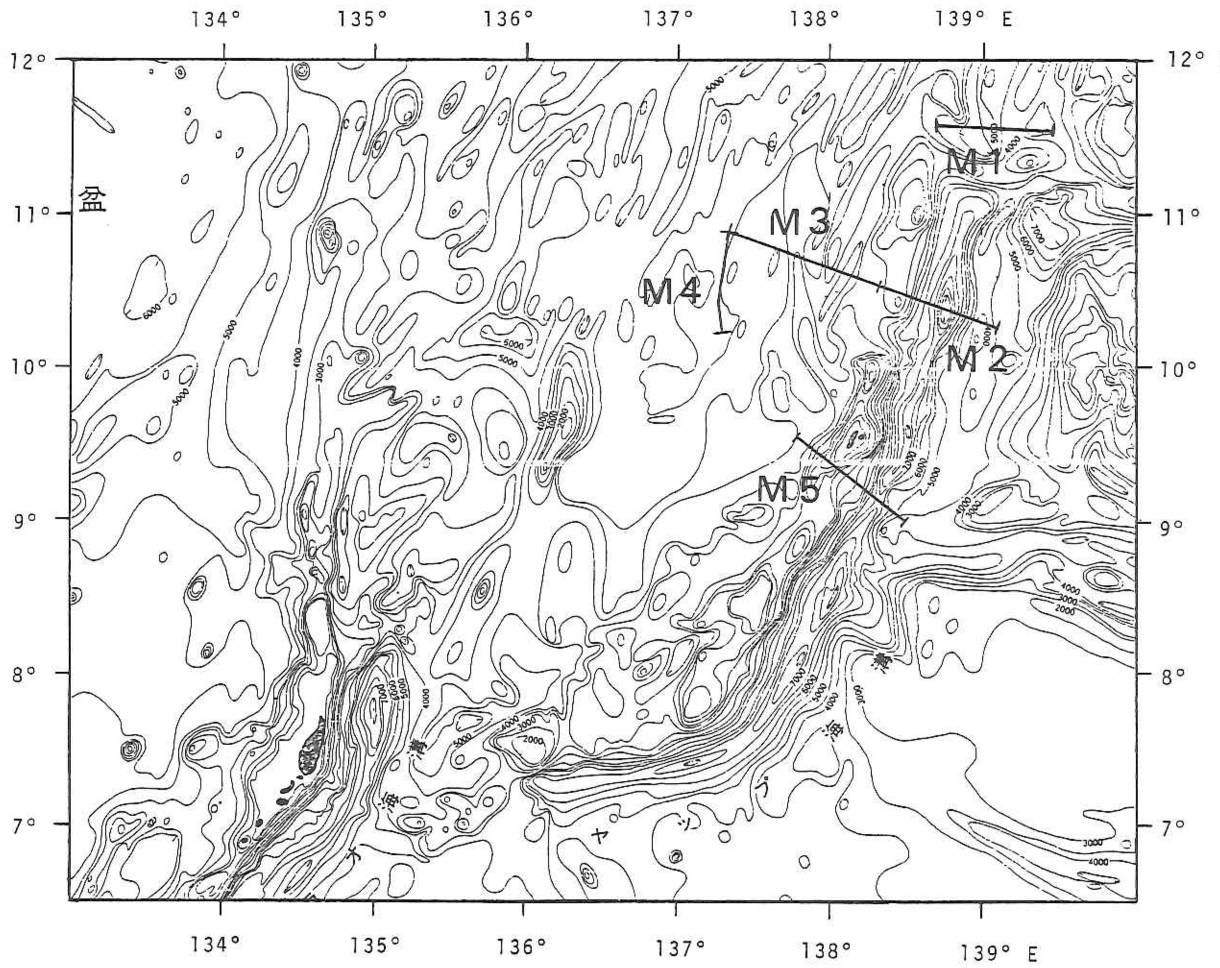


Fig. 5-2-1. Track lines of multichannel seismic survey.

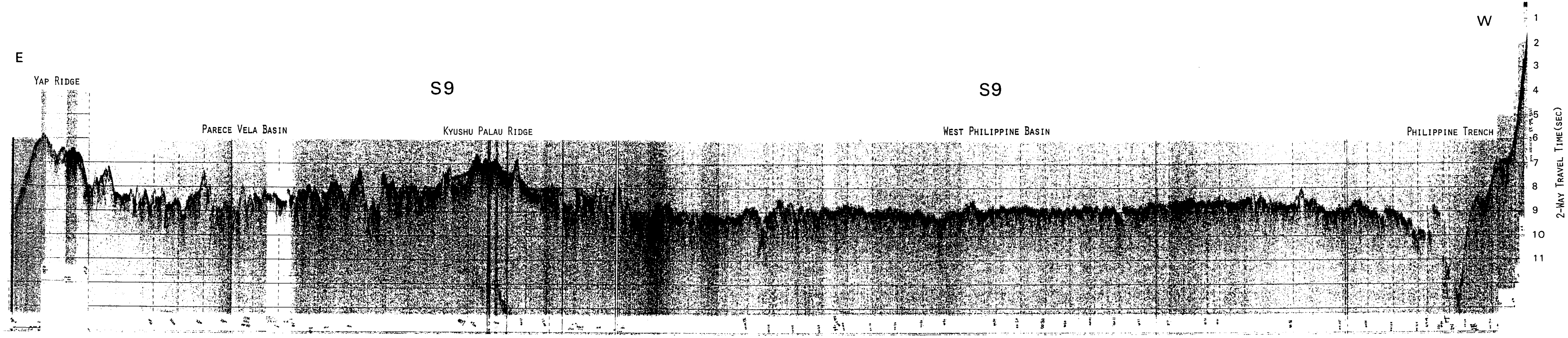


Fig. 5-1-5. Singlechannel seismic profile of S9.

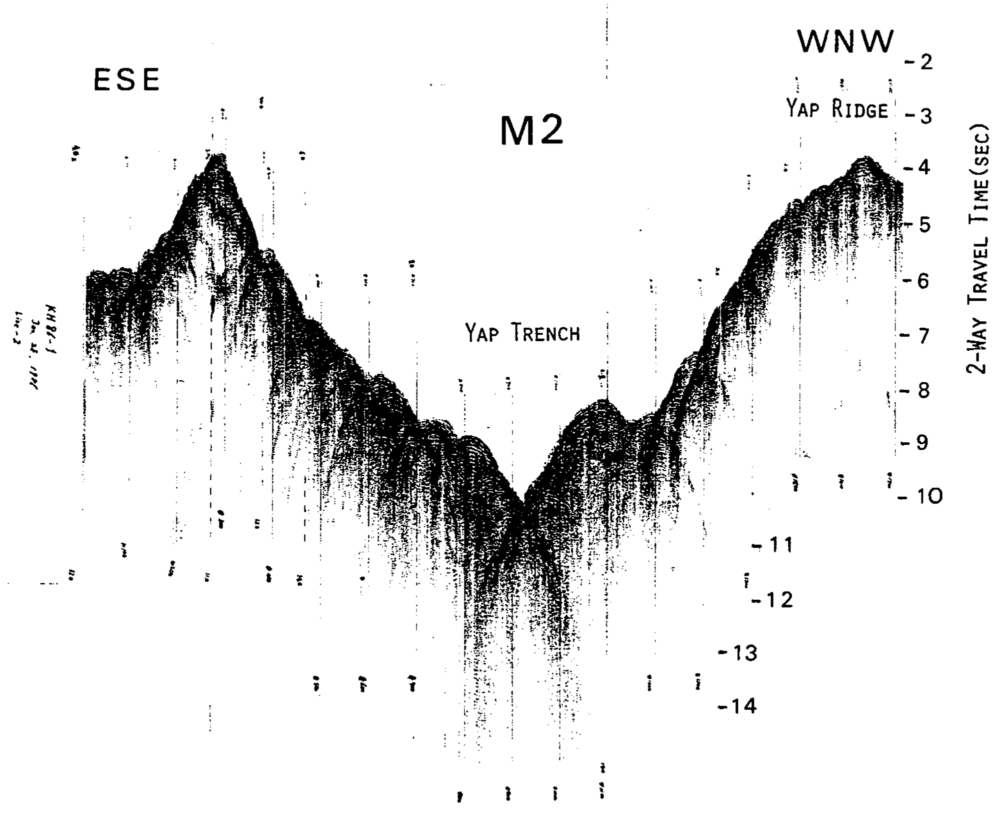


Fig. 5-2-3. Multichannel seismic profile of M2.

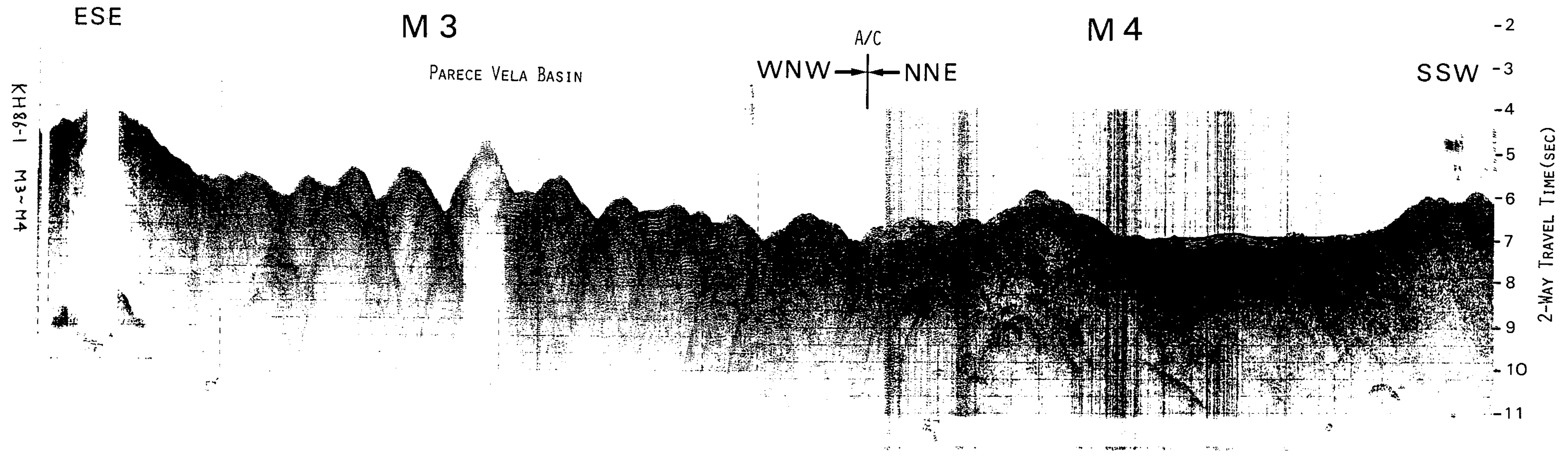


Fig. 5-2-4. Multichannel seismic profiles of M3 and M4.

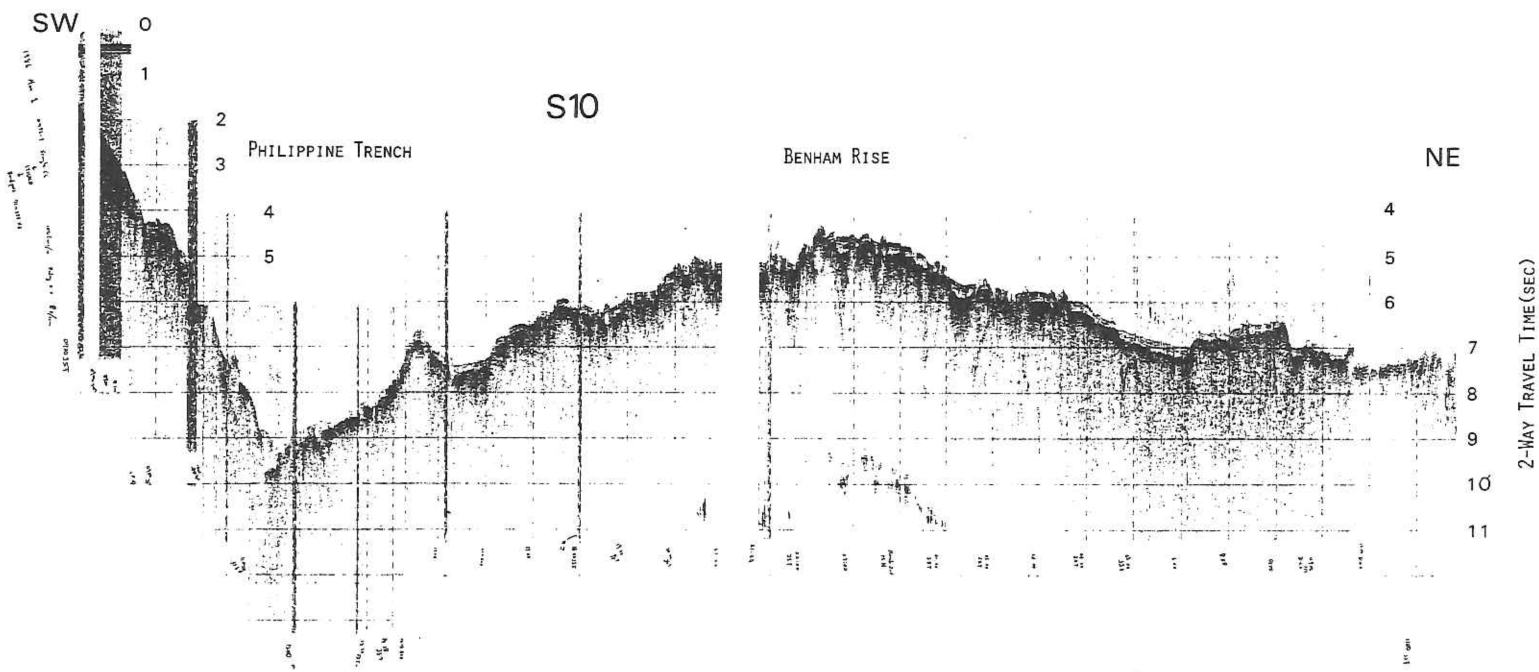


Fig. 5-1-6. Singlechannel seismic profile of S10.

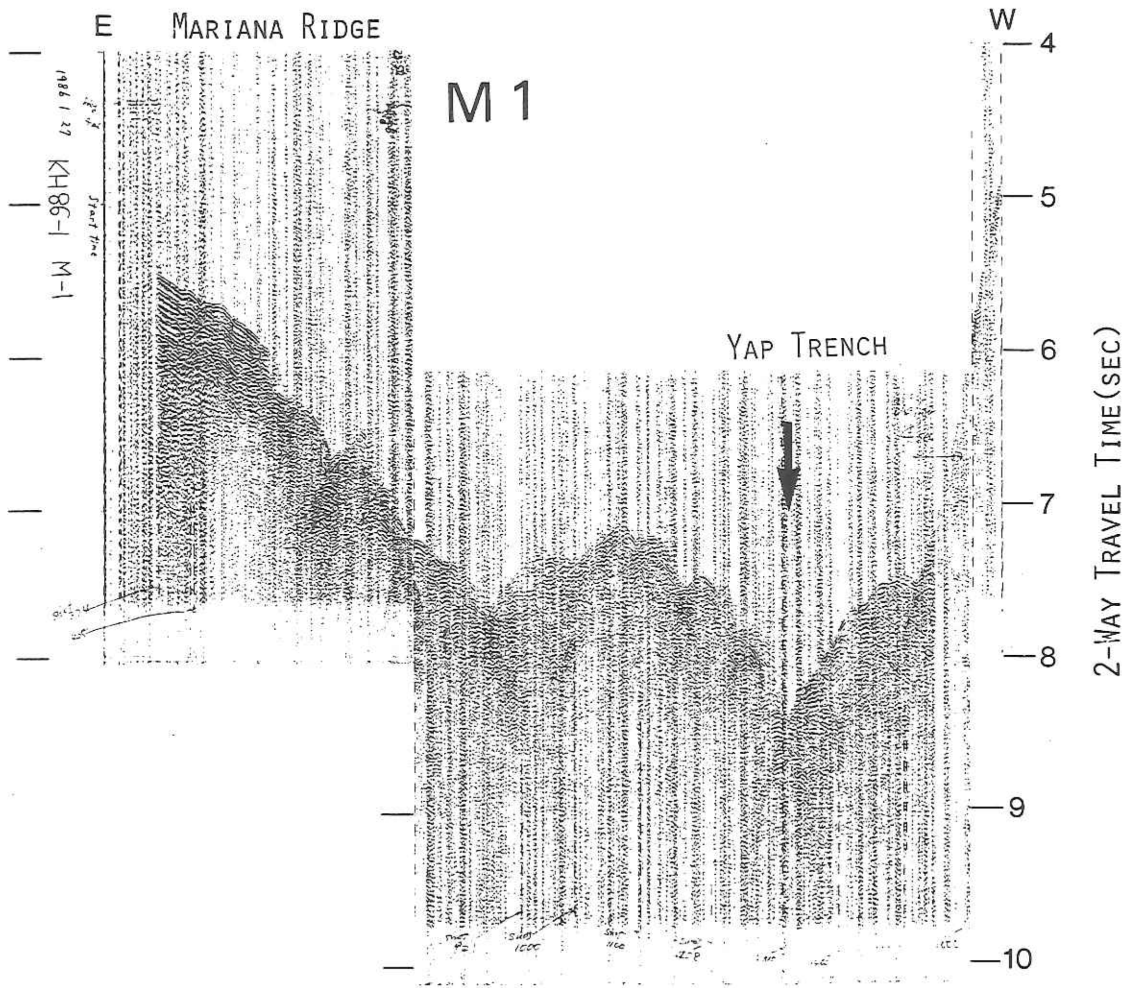


Fig. 5-2-2. Multichannel seismic profile of M1.

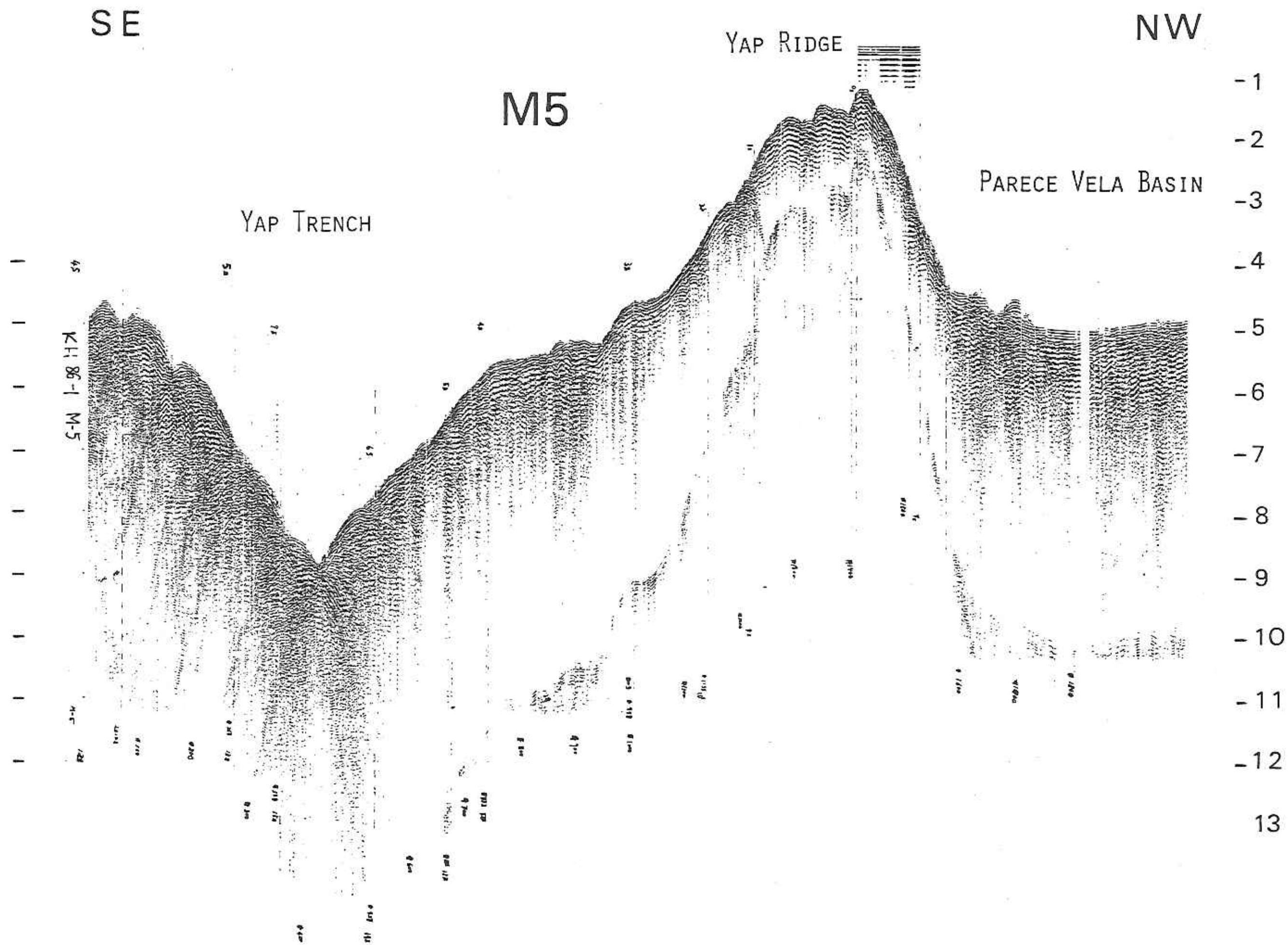


Fig. 5-2-5. Multichannel seismic profile of M5.

6. OBSH observation in the northern Yap Trench

H. KATAO, J. KASAHARA, H. TOKUYAMA, H. KINOSHITA and S. NAGUMO

Four pop-up type OBSH's (Ocean Bottom Seismometer and Hydrophone) equipped with acoustic release system were deployed in the northern Yap Trench region. Two OBSH's were deployed in back-arc side of the trench, and others were deployed in the other side of the trench, the Caroline Redge side. (Fig.6-1) Detailed position of the OBSH stations are listed in Table 6-1. All OBSH's were successfully retrieved after 8-11 days observation periods.

One of the purposes in this study is to determine the precise seismic wave velosity structure in this region by airgun-OBSH refraction study. As a seismic source, a 20-litter airgun, which was operated by the groupe of Chiba University, and 9-litter airgun, which belong to ORI, were used. Two refraction lines were shooted parallel to the trench axis. The shooting lines and positions of OBSH are shown in Fig.6-1. The data were generally good except some occasional disturbance due to bottom current. Determination of crustal structure will be done afterward.

Another purpose is to observe natural earthquakes around the Yap Trench. Numerous earthquakes and micro-earthquakes were observed by all station. Examples at the station YP-4 are shown in Fig.6-2. These events have very short S-P time showing their occurence near the station. This means that the Yap Trench region is seismically very active, and its seismicity appears to be comparable to that in the Japan Trench region.

Table 6-1. Data concerning to observation by OBSH

Stn.	Lat.	Long.	Depth	Deployment	Pop-up
YP-1	10 30.04'N	138 21.83'E	3080	Jan.30, 9:55	Feb. 7,23:20
YP-2	10 50.85'N	138 26.51'E	3080	Jan.30,13:47	Feb.10, 4:00
YP-3	10 15.68'N	139 05.27'E	4810	Jan.31,12:24	Feb. 9, 7:19
YP-4	10 34.82'N	139 11.64'E	4800	Jan.31,16:07	Feb. 9,16:18

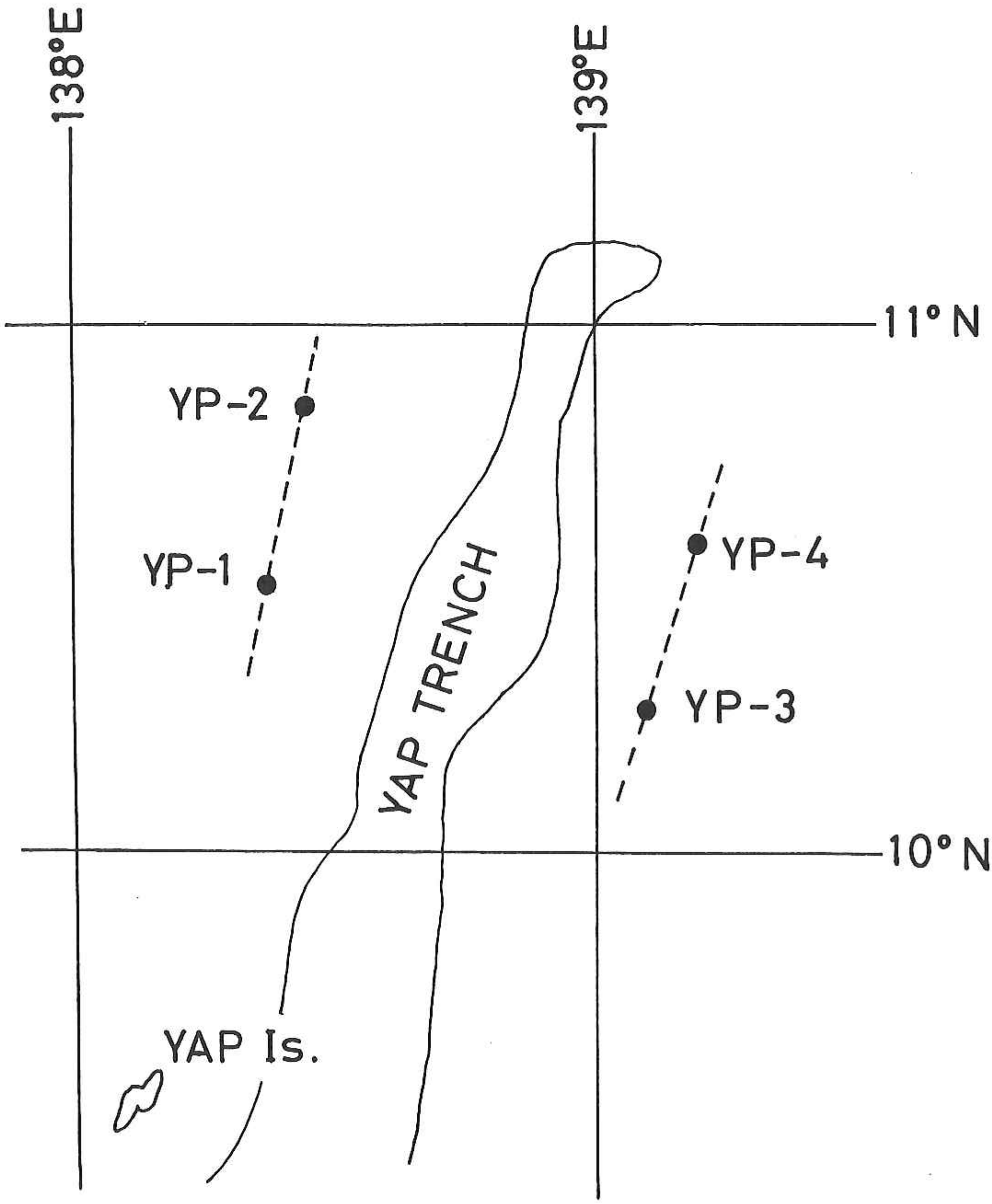


Fig. 6-1. Shooting pattern and OBSH's position.

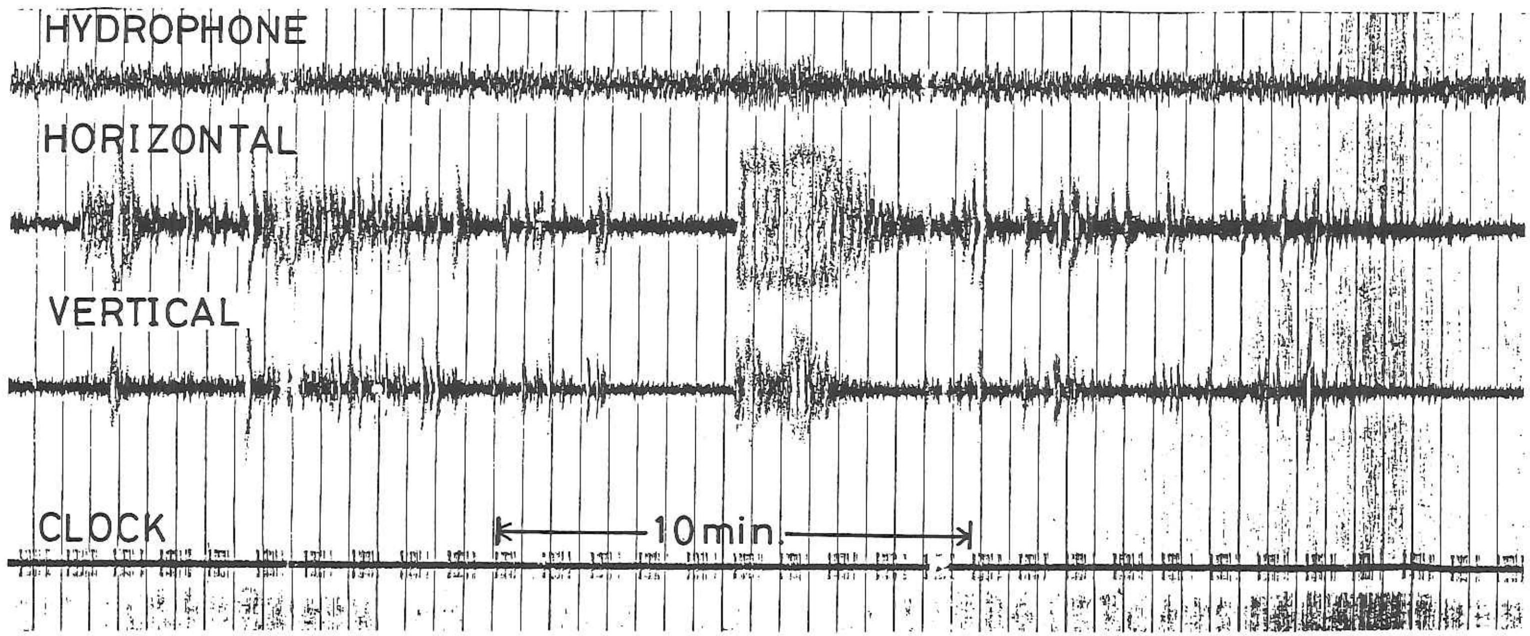


Fig. 6-2. Examples of earthquakes observed at station YP-4

7. Heat Flow Measurements

M. KINOSHITA, S. NAGIHARA, and H. KINOSHITA

During the KH86-1 cruise of ORI, heat flow measurements were made at seven stations (HF1-HF7) located in the northern region of the Yap Trench. Stations HF5 and HF6 were in the fore-arc region, and the other stations were in the back-arc region of the Yap Trench. Thermal conductivity was measured at four stations (PC1-PC3, GC1).

Method and instruments

Heat flow value is expressed as the product of temperature gradient and thermal conductivity.

Two sets of marine heat flow measuring system were used to measure the temperature gradients. They both have Ewing type probe, and permit multiple penetrations. One is a digital heat flow system (LDGO-DHFU) which belongs to ERI. It can be lowered with either heavy weight (about 400kg) and a long lance (4.5m) or light weight (about 150kg) and a short lance (3m). The six temperature data and instrument tilt are recorded on a cassette tape and simultaneously telemetered by 12kHz acoustic pulses. These data can be monitored by the echo sounding system of the ship and data loggings are made more effectively.

The other measuring system is the one newly developed at Chiba University. The probe (3.5m) measures both the temperature gradient and in-situ thermal conductivity, simultaneously. In this cruise, this system was put under a pressure bearability test (4000m depth) before actual heat flow measurement on HF4.

Thermal conductivity of the sediments were measured on samples taken by a gravity corer, and a piston coring , using the needle probe technique (Von Herzen and Maxwell, 1959).

Measurements

Temperature Gradient

HF1 (ERI LDGO-DHFU with light weight)

The station HF1,HF2,and HF3 are serially located toward the axis of the Yap Trench. The probe penetrated four times: At HF1A, four thermistors were in the mud, at HF1B and HF1C, it seemed like a full penetration, and at HF1D, four thermistors were in the mud.

HF2 (ERI LDGO-DHFU with heavy weight)

During the two penetrations of the probe, only two thermistors were in the mud because of hard sediments.

HF3 (ERI LDGO-DHFU with light weight)

This station was located on the western slope of the Yap Trench. Three penetrations were made fully, but three thermistors were damaged before the first penetration. This instrument had never experienced such a depth (6660m) !

HF4 (Chiba University type)

HF4 is the farthest station from the trench axis in the back-arc region. We tried two penetrations here. But the probe bent after the first penetration, which hampered the second. On the first penetration, two sensors were in the mud. In-situ conductivity measuring system did not work by some accidents.

HF5 (ERI LDGO-DHFU with light weight)

The station HF5 and HF6 were located at the eastern side of the Yap Trench. At HF5, two penetrations were made fully, but two thermistors were unstable.

HF6 (ERI LDGO-DHFU with light weight)

The station was located at the western end of the Caroline Basin. No penetrations were successful because of sandy sediments.

HF7 (ERI LDGO-DHFU with heavy weight)

HF7 was located in the western basin of the Yap Trench. The probe fully penetrated three times . The third thermistor from the top was unstable.

Thermal Conductivity

Thermal conductivities were measured on samples recovered at four stations (GC1, PC1-PC3). GC1 was close to HF1-HF3, and PC1-PC3 were far from HF1-HF7.

TABLE

Station	Location		W.D.	PEN
HF1-A	10° 32.4'N	138° 03.2'E	4300	4
B	32.2	03.2	4300	6
C	32.1	02.7	4300	6
D	32.0	02.7	4300	4
HF2-A	10 31.9'N	138 20.1'E	3520	2
B	31.8	20.0	3520	2
HF3-A	10 24.8'N	138 35.1'E	6660	6
B	24.8	35.0	6660	6
C	24.8	34.5	6660	6
HF4-A	10 16.3'N	137 16.2'E	4750	2
B	16.3	16.2	4750	0
HF5-A	9 19.2'N	138 47.5'E	4850	6
B	19.0	47.5	4850	6
HF6				0
HF7-A	9 29.8'N	137 48.2'E	3770	6
B	29.9	47.7	3770	6
C	29.9	47.7	3770	6

W.D. is the water depth (m); PEN is the number of thermistors in the mud.

8. Transponder navigation

T. FURUTA, H. FUJIMOTO, and H. MURAKAMI

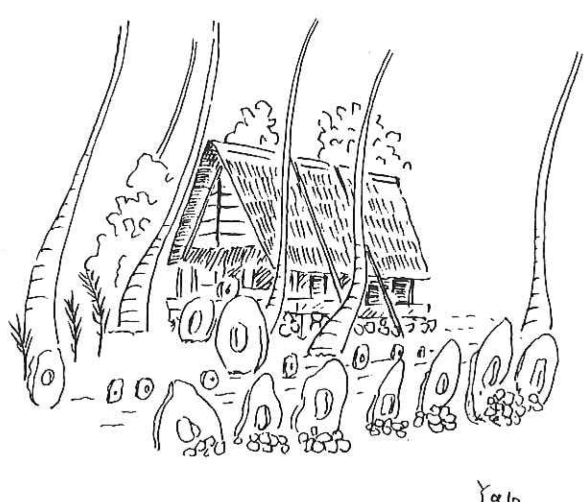
Acoustic transponder navigation system including subnavigation was carried out at the northern part of the Yap Trench with depth of approximately 4100 m for the precise positioning of the ship and deep-towed objects.

At the first step of operation, three transponders were deployed at the bottom with the distance of about 2 n.m. from each other. Ship's position is determined by the transponder system by measuring the acoustic travel time from the transducer towed from the ship to each transponder.

Secondly, a fourth transponder (D) specially designed for subnavigation was fixed at the end of a wire and towed from the stern of the ship to trace the three-dimensional position relative to the ship. This subnavigation system adopts the method of double transmissions. That is, at the first interrogation, the slant range between the ship and each of the four transponders is measured, and at the second, the total range of the loop (ship - transponder (D) - each of the three anchored transponders - ship) is measured. The position of the transponder (D) as well as of the ship is calculated by using these range data. In practice we cannot easily know the precise position of a dredger, deep-sea camera or other deep-towing instrument, because even if the ship stops and holds her position, the object towed by the wire may be carried away by an ocean current.

In order to monitor the position of an object towed by a wire, a trial measurement was carried out. After the transponder (D) at the end of the wire was vertically lowered to 3,000 m deep, the ship ran towing the wire for about half an hour at the speed of 3 knots. The result of subnavigation showed that the three dimensional positions of the towed object were obtained at unexpected location. It was observed that the end of the wire was still horizontally 1 km away from the ship even after the ship stopped and the wire seemed to be vertical.

The accuracy of the position obtained by the transponder navigation system is expected to be better than 10 m, if the sea condition is well. In the trial measurement in this cruise, however, the positions were not always obtained with this accuracy. The causes of this are thought to be the following; 1) interrogating transducer towed from the ship did not keep its stable altitude when ths ship was steaming, 2) the transponder net was not deployed on a flat bottom and the rough topography may sometimes disturb acoustic propagations, 3) hardware of the transponders was not adjusted to their best conditions.



9. Sediments and Rocks in and around the Palau and Yap Trenches

K.FUJIOKA, T.FURUTA, G.KIMURA, K.KODAMA, K.KOGA, S.KURAMOTO, H.MATSUGI, T.SENO, A.TAKEUCHI, M.WATANABE and S.YAMAMOTO

CONTENTS

9-1. Introduction

9-1-1. Introduction

The Mariana, Yap and Palau arc-trench systems fringe the eastern margin of the Pilippine Sea plate forming the complicated morphotectonic configuration. This region is quite interesting and important for the understanding the strike slip and normal subduction phenomena. The Yap Islands are located just in the junction between Mariana and Palau arc-trench systems, and high grade and young metamorphic rocks expose on these islands. Therefore, we intend to concentrate our efforts to understand how young and high-grade metamorphic rocks settle in this region under the modern plate-tectonics framework.

During the cruise KH 86-1, memorial cruise of Prof. Y. Tomoda, we tried to take sediments and rock samples from this region using piston corer, grab sampler, dredger and deep sea camera in order to know what kind of sediments and rocks distribute in this area. Table 9-1-1 shows the summary of the station survey and Fig. 9-1-1 shows the sampling location on the bathymetric map during the cruise. Six dredge hauls, three piston cores, two grab samples and seven deep sea camera photographs were successfully obtained from the Palau and Yap, trenches and their forearc region as well as the junction between Mariana and Yap trenches. In this report, we intend to describe the collected samples during the cruise for the convenience to the future studies of this region.

9-1-2. Acknowledgements

During the cruise KH 86-1, we would like to express our sincere thanks to those people who operate the ship and work on the various ship's instrumentations. Captain I. Tadama and all the other crew members and Prof. Y.Tomoda kindly allowed and helped us for taking invaluable samples from this area. Onboard scientific members including many students helped us for the preparation of piston coring, dredging and many other works at sea.

9-2. Topography

During the cruise 12 kHz echo sounder (PDR) measured the water depth along the ship's track (Fig.9-1-1,-2). Of these profiles, several cross sections are available to understand

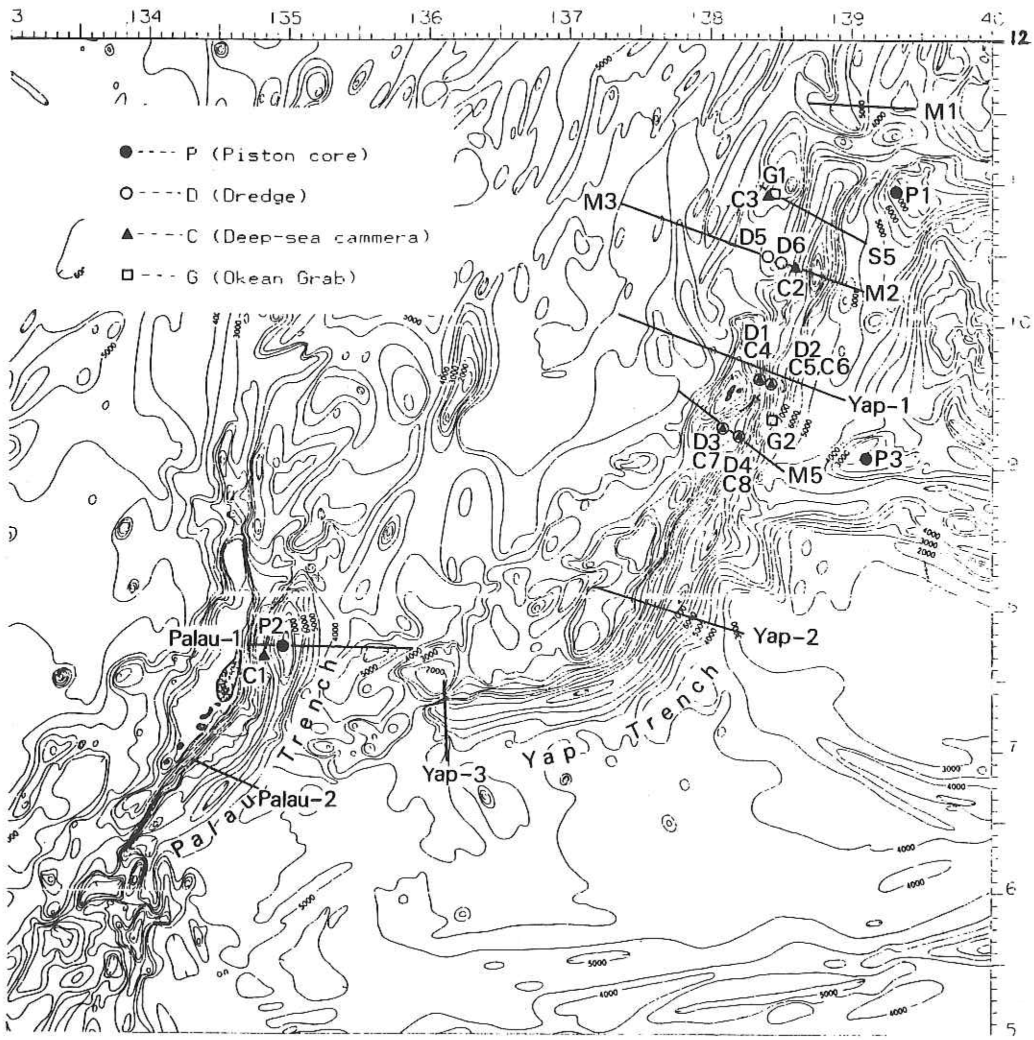


Fig. 9-1-1. Location map of the sampling sites for the cruise KH86-1

Table 9-1-1. Summary of the piston cores, dredge haules, grabs and deep sea cameras during the cruise KH86-1.

LIST OF RESEARCH STATIONS IN THE CRUISE KH 86-1

Site	Position		Investigation	Water Depth (corrected)	Date & Time		Remarks
P-1	10 57.0'	139 19.1'	Piston Core	7120(7223)	Jan.28	11:17	Start
	57.1	17.5		6970(7073)		13:45	Bottom Hit
	56.5	15.3		6600(6683)		15:48	On Deck
	(Location)Junction between Mariana and Yap Trench						
	(Recovery)Red clay with turbiditic mud						
P-2	7 44.8'	134 59.0'	Piston Core	7890(8053)	Feb. 6	08:29	Start
	44.1	58.7		7890(8053)		11:25	Bottom Hit
	44.4	57.4		7700(7838)		15:50	On Deck
	Palau Trench Floor						
	Red clay underlain by calcareous turbiditic beds						
P-3	9 04.5'	139 07.1'	Piston Core	2700(2687)	Feb.17	10:06	Start
	04.6	07.0		2730(2717)		11:15	Bottom Hit
	04.7	06.5		2730(2717)		12:10	On Deck
	Caroline Ridge						
	Calcareous ooze						
G-1	10 55.6'	138 25.8'	Grab	3050(3038)	Feb.10	10:01	Start
	55.4	25.7		3080(3068)		10:51	Bottom Hit
				3080(3068)		11:35	On Deck
	Yap Ridge, northern portion						
G-2	9 20.7'	138 25.0'	Grab	7250(7363)	Feb.19	13:12	Start
	20.8	24.9		7180(7293)		14:57	Bottom Hit
	20.0	25.2		7300(7413)		16:38	On Deck
	Yap Trench Floor						
	Red clay and dark sand						

D-1	9 38.6'	138 19.5'	Dredge Haul	2750(2736)	Feb.15	22:25	Start
	38.1	19.5		2580(2566)		23:13	Bottom Hit
	37.7	18.0		1900(1888)	Feb.16	00:45	Bottom Leave
	36.8	17.6		1750(1739)		01:04	On Deck

Yap Trench Forearc Central portion
Large amount of metamorphic rocks(amphibolite-greenschist)

D-2	9 37.2'	138 22.7'	Dredge Haul	4750(4763)	Feb.16	08:40	Start
	36.8	22.5		4380(4386)		10:23	Bottom Hit
	35.3	21.6		4080(4077)		13:08	Bottom Leave
	34.0	21.1		4250(4253)		14:16	On Deck

Yap Trench Forearc Central portion
Large amount of metamorphic rocks composing mostly pelitic and psammitic origin(amphibolite facies)

D-3	9 19.2'	138 03.4'	Dredge Haul	2370(2369)	Feb.18	21:25	Start
	19.2	03.3		2280(2268)		22:10	Bottom Hit
	18.4	00.8		2220(2208)		23:42	Bottom Leave
	17.8	00.3		2750(2737)	Feb.19	00:20	On Deck

Yap Trench Forearc Southern portion
Limestone and pumice

D-4	9 13.2'	138 12.1'	Dredge Haul	4050(4047)	Feb.19	05:56	Start
	13.0	10.1		4000(3997)		06:57	Bottom Hit
	12.9	06.9		3050(3038)		09:28	Bottom Leave
	12.7	06.1		2520(2506)		10:37	On Deck

Yap Trench Forearc Southern portion
Coralline limestone and hardground lithified chalk

D-5	10 29.8	138 29.8	Dredge Haul	3340(3329)	Feb.20	00:10	Start
	29.9	23.0		3220(3209)		01:08	Bottom Hit
	29.9	24.3		2810(2797)		02:14	Bottom Leave
	29.5	22.3		2890(2877)		03:25	On Deck

Yap Trench Forearc Northern portion
Various sizes and shapes of manganese crusted gravels

```
D-6  10 26.8   138 29.0 Dredge Haul    4550(4559)  Feb.20 04:38 Start
        27.2       28.5                4380(4386)         06:11 Bottom Hit
        27.1       27.8                4200(4203)               Bottom Leave
        27.5       29.6                4690(4699)         09:33 On Deck
     Yap Trench Forearc Northern portion
     Large amount of metamorphic rocks and hydrothermal deposits

C-1   7 40.7' 134 51.2'Deep Sea Camera 6300(6363)Feb. 5 23:18 Start
        40.4       51.8                          Feb. 6 01:14 Start Photo
        40.1       51.8                                 02:34 Finish Photo
        40.0       51.7                6250(6313)       04:11 On Deck
     Palau Trench

C-2  10 24.1' 138 38.0'Deep Sea Camera 7150(7263)Feb. 8 22:01
        23.7       38.1                                 23:55
        23.4       38.0                          Feb. 9 00:42
        23.0       38.2                6830(6923)       02:20
     Yap Trench Forearc

C-3  10 55.7' 138 26.3'Deep Sea Camera 3070(3058)Feb.10 06:50
        55.4       25.9                                 07:21
        55.0       25.7                2980(2968)       08:35
        54.7       25.5                2780(2767)       09:20
     Yap Ridge Nortern portion

C-4   9 38.7' 138 20.1'Deep Sea Camera 3070(3058)Feb.15 18:44 Start
        38.1       20.3                                 19:40 Start Photo
        37.6       20.2                2828(2807)       20:54 Finish Photo
        37.0       20.0                2580(2566)       21:46 On Deck
     Yap Trench Forearc Central portion

C-5   9 37.0' 138 24.1'Deep Sea Camera 5850(5898)Feb.16 03:43 Start
        37.6       24.0                                 05:25 Start Photo
        37.3       22.9                5550(5589)       06:39
        37.1       22.5                4800(4813)       07:51
     Yap Trench Forearc Central portion
```

C-6	9	42.1'	138	31.2'	Deep Sea Camera	7820(7969)	Feb.16	16:06
		41.0		30.8				18:20
		41.1		30.9		8150(8313)		19:35
		40.3		32.0		7750(7899)		22:08
	Yap Trench Forearc Central portion							
C-7	9	19.2'	138	03.6'	Deep Sea Camera	2410(2397)	Feb.18	18:21
		18.8		03.4				19:05
		17.7		03.5		2780(2767)		20:20
		19.2		03.4		2850(2837)		20:58
	Yap Trench Forearc Southern portion							
C-8	9	15.2'	138	10.0'	Deep Sea Camera	3950(3947)	Feb.19	01:46
		14.9		09.7				02:59
		14.6		09.4		3910(3907)		04:15
		14.4		09.1		3880(3873)		05:08

Yap

the morphology of the Yap and Palau arc-trench systems. The 1:1,000,000 scale bathymetric map of the northwestern Pacific (JODC, 1984) is also available to make a planview to the surveyed area.

Palau Arc-Trench system

Palau Islands are the southward extension of the Kyushu-Palau Ridge which comprises altered two pyroxene andesite and its equivalent. The Islands are topped by several steps of low-relief erosional surfaces and terraces and also by uplifted coral flats; there is no Quaternary volcanic front, because no Quaternary volcanic rocks are ever known. Such flat topography of Palau Islands is contrasting to the higher-reliefs in the other Arc-Trench systems in the western Pacific.

Palau trench runs easterly parallel to the Islands; the deepest (8050 m water depth) is located at its northernmost part and there develops a wide and flat sedimentary basin (10 km wide, 25 km long), which is filled not only by the pelagic sediments but also by the calcareous turbidites as reported in the piston coring section (KH 86-1, P-1).

The inner (landward, western) trench slope northeast off Babelthaob Island to the west of the 8000m trench floor is characterized by a lower slope break (inflection at 7200 m w.d.) with a few km wide depression or bench bounded by a basement high. The deep sea camera work (KH 86-1, C-1) operated at the steepest part (along an inflection of 6300 m w.d.) in the mid-slope.

Yap Island Arc-Trench system

Several cross sections of the Yap arc-trench system are shown in Fig. 9-2-1. Yap Arc is divided into five geomorphologic domains based on the JODC topographic map; They are the northern, north-central (Yap proper), and south-central parts, the northern junction area with the Mariana arc-trench system and the southwestern part. The survey of KH 86-1 cruise centered at the former two districts.

The forearc slope in the arc-trench gap from the ridge crest to the trench axis is not smooth nor simple but with five major inflection points are commonly observed in the PDR profiles. In more detail, most of these inflections look like fault notches in shape, indicating their origin of modern subvertical faulting with some trenchward stepping down. The forearc belt is morphologically divided into three units bounded by main slope-inflections. Configuration of each unit

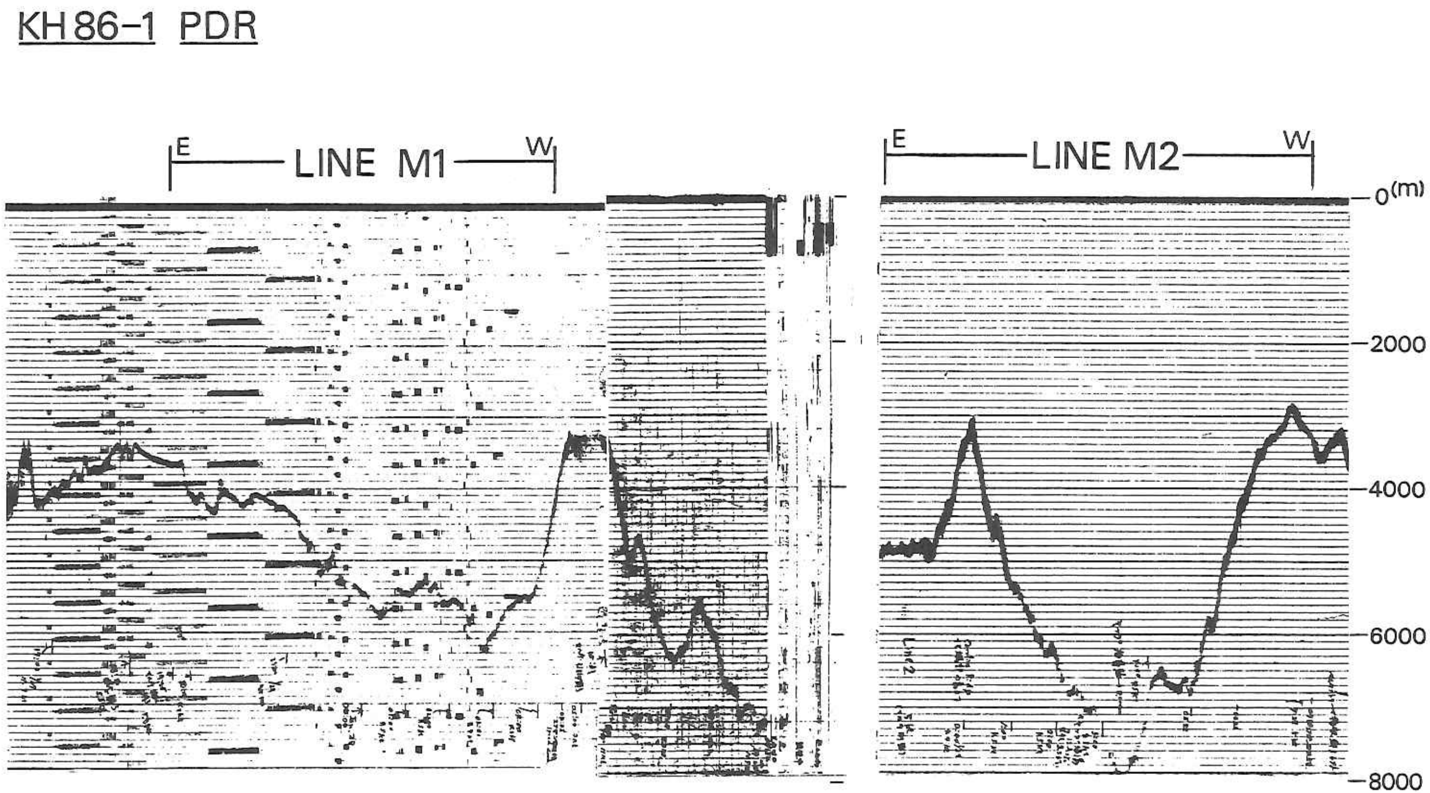
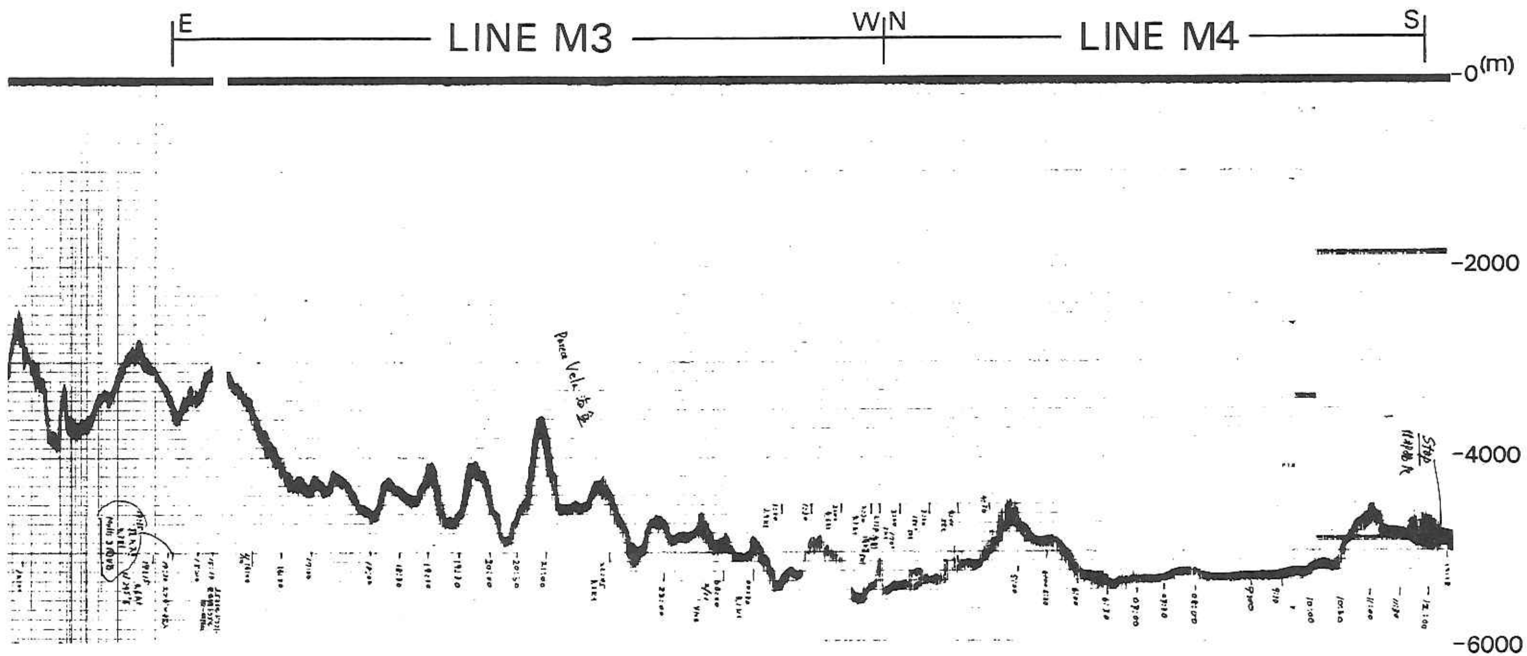
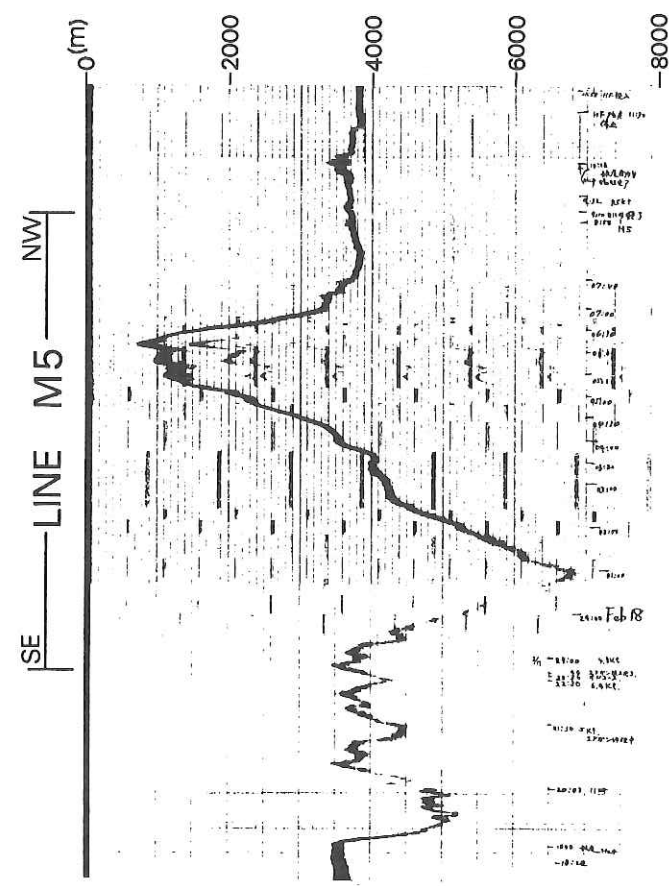


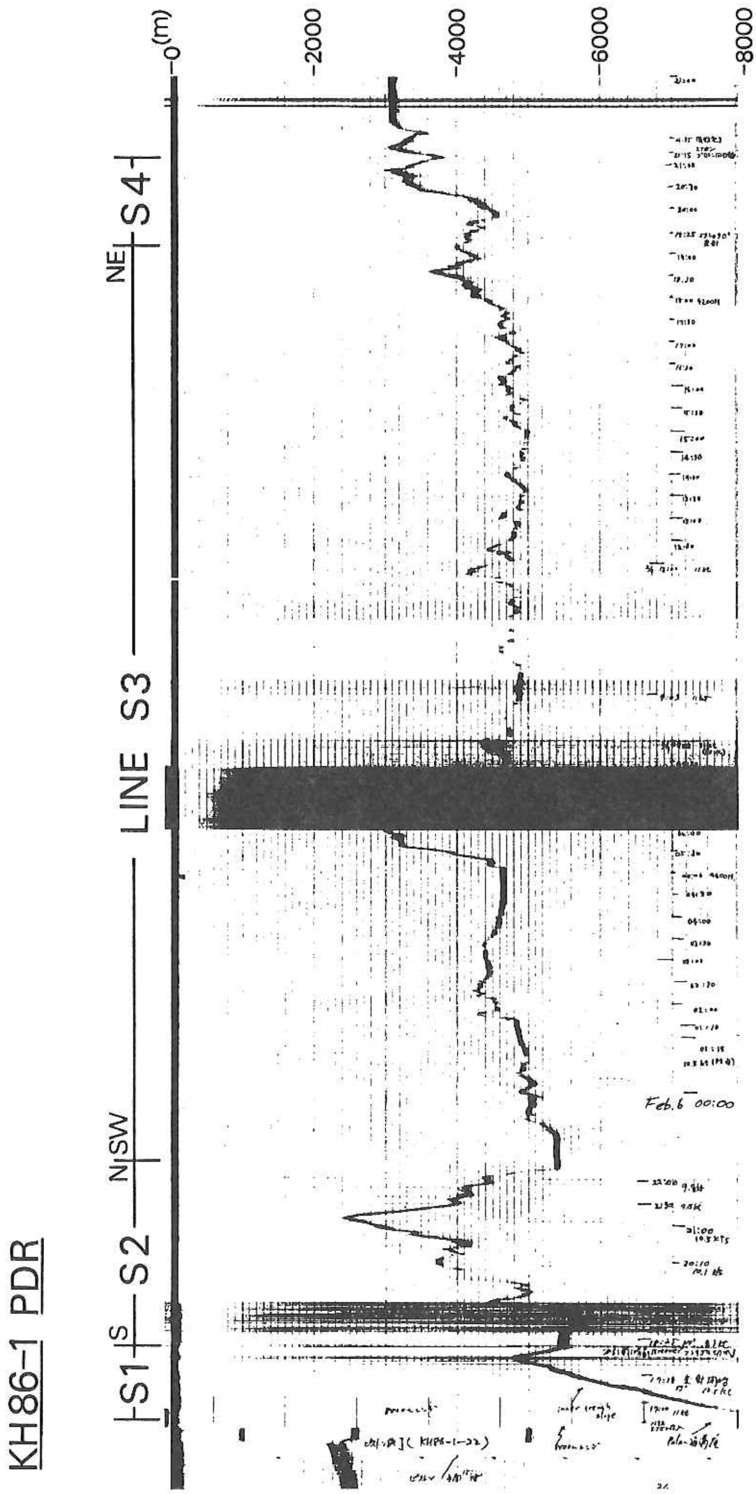
Fig. 9-2-1. Topographic cross sections obtained using PDR for the Palau and Yap Arc-Trench systems.

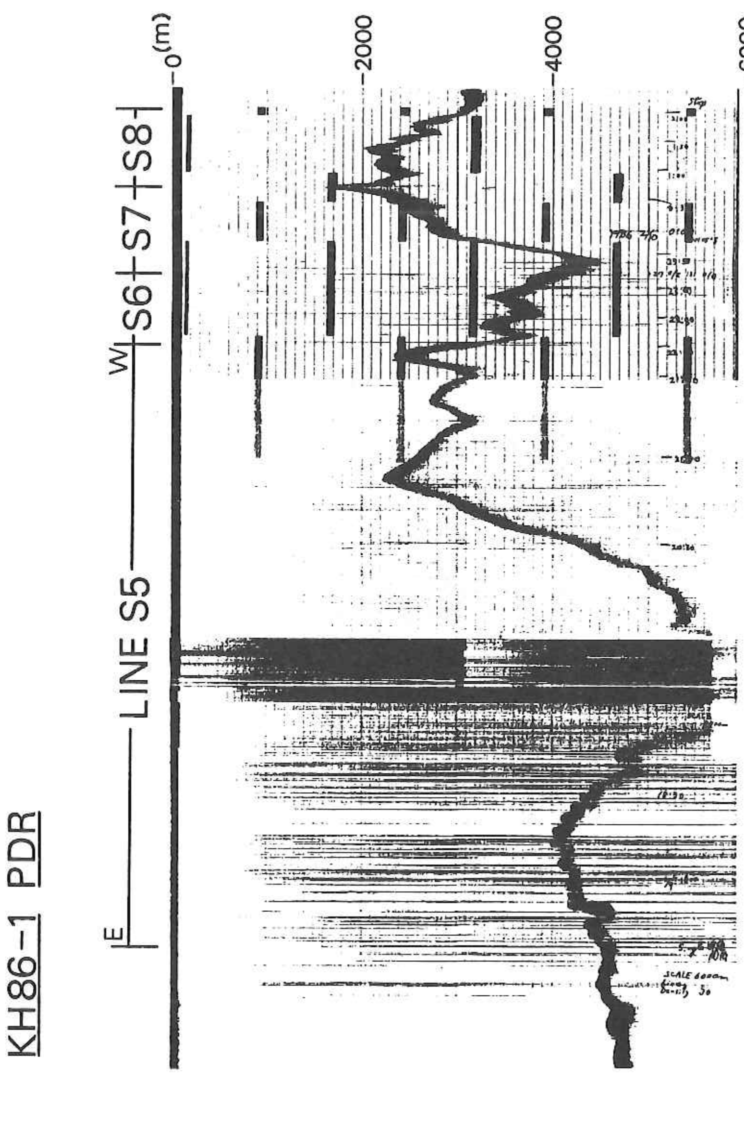
KH86-1 PDR



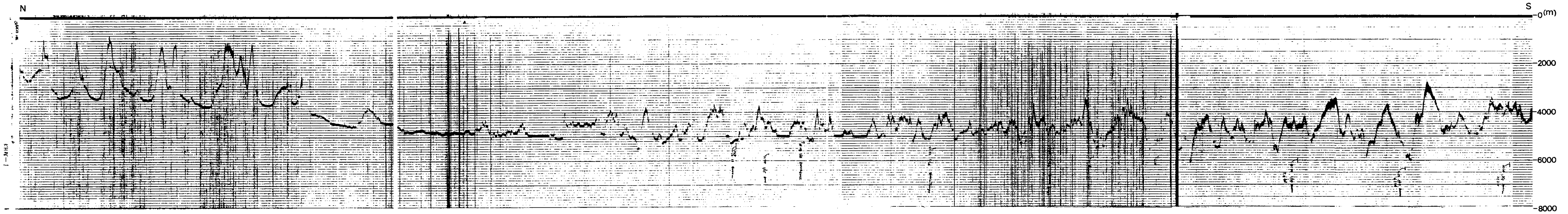


KH86-1 PDR


KH86-1 PDR
S1
S
S2
N
SW
LINE S3
NE
S4
0(m)
-2000
-4000
-6000
-8000
Feb.6 00:00


KH86-1 PDR
E
W
LINE S5
S6
S7
S8
0(m)
2000
4000
6000

KH 86-1 PDR (Tokyo→Yap)



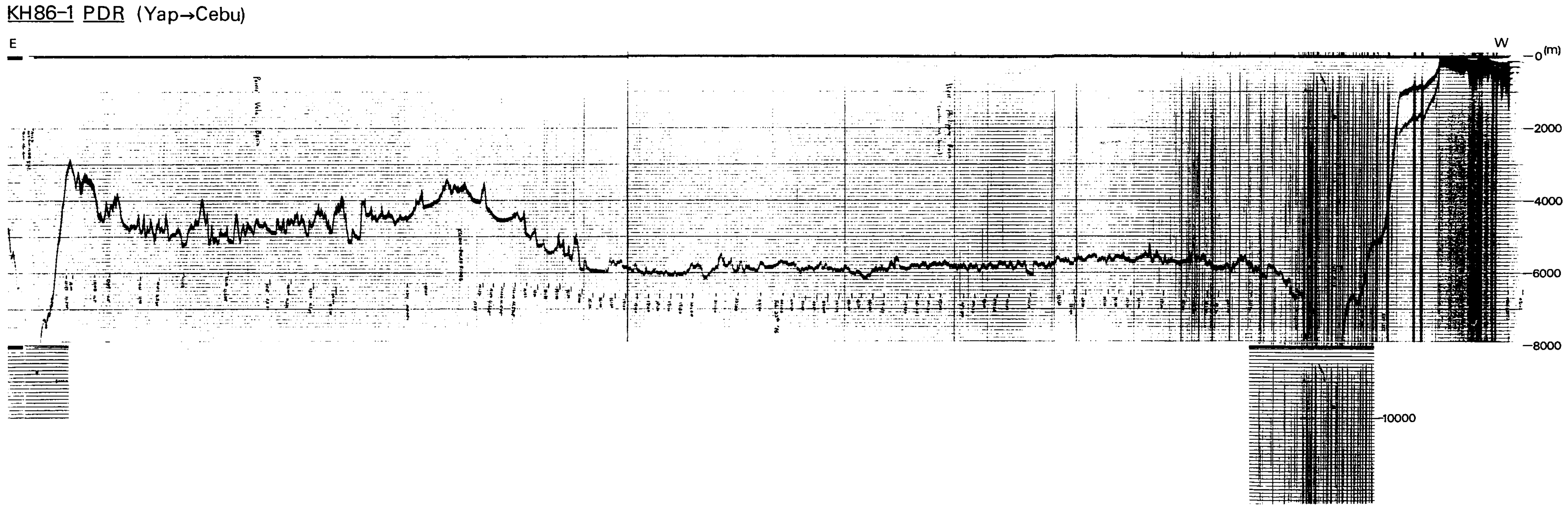


Fig. 9-2-1. Topographic cross sections obtained using PDR for the Palau and Yap Arc-Trench systems.

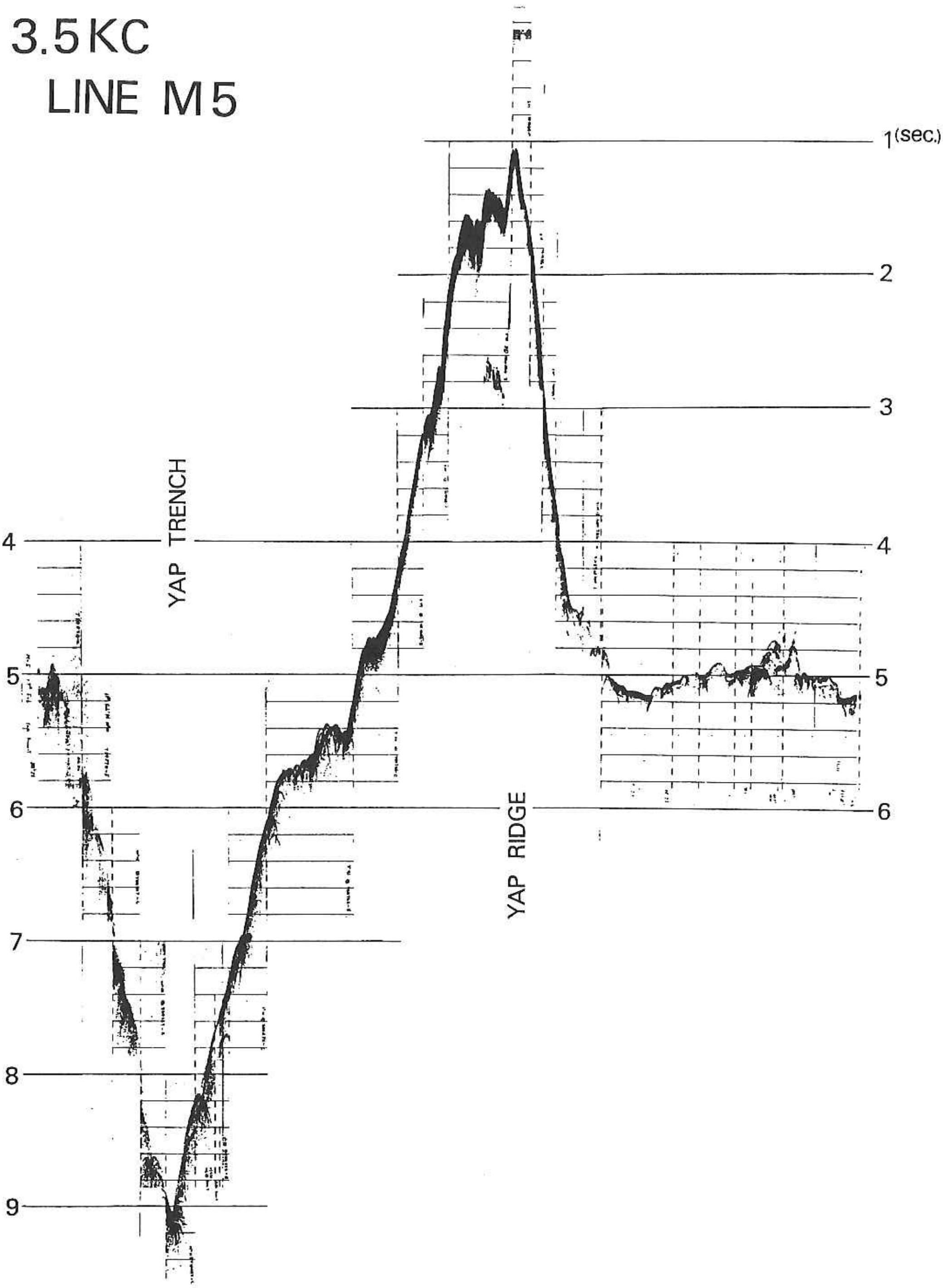


Fig. 9-2-2. 3.5 kHz echorgam across the Yap Arc-Trench system.

is more or less similar to the other.

Ridge crest zone; the shallow (peak) part above 2000-5000 m inflections; double or multiple ridges are common,

Upper trench slope; steep (more than 20°) escarpment above 5000-7000 m inflections; two or three large fault zones with 200-300 m high cliff are recognizable,

Lower trench slope including trench slope bench(es) bounded by a 2-3 km wide break (basement highs); making a toe toward the trench axis.

The northern portion of the arc is characterized by the westward tilting (1.1°) of its ridge crest, whose western flank (G-1: 3050 m w.d., D-5: 3220 m w.d.) is rather gentle than the eastern (D-6: 4380 m w.d.). It is adjacent to the southernmost part of Parece Vela Rift. The western flank of the northern ridge is gradually deepened westward and changes into the rift topography. This domain also includes deepest part of the Yap trench (8720 m w.d. or more). Major inflections in the forearc slope lie at around 5260 m w.d.(PDR-S5), 7450 m w.d.(S9), 6780 m w.d.(M2) from north to south.

The central portion is the highest among those divisions, including Yap Islands; The trench axis and major slope break (4030-4100 m w.d.) are also shallower than those of the northern portion. Both flanks of the Yap ridge is asymmetrical. Western slope is steeper than the eastern. Its crest also easterly inclined (3.2°). The backarc basin is rather flat in contrast to the northern part.

The northernmost part is located at the arc-arc junction, where the northern extension of Yap trench is intersected by an east-westerly barrier of basement high, ie. the western tip of Mariana arcs. The PDR profile M1 demonstrates an E-W cross section. The maximum depth in the profile is 6200 m w.d. This is not in the direct(northern) extension of Yap trench, but within the forearc belt. The eastern part (westward inclination 11° in average) of the profile shows graben-like depressions bounded by steep fault cliffs (around 200 m high) with inclination more than 20°.

9-3. Piston Core

9-3-1. General remarks

Sediments covering the trench floor has been little known because of the great water depth. We know a little about the

Table 9-3-1-1. Piston coring operation logs.

PISTON CORING OPERATION LOGS

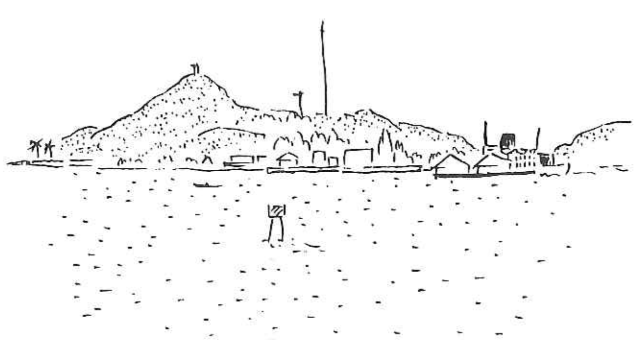
Date: Jan.28,1986 Ship: Hakuho Maru KH 86-1 Station: P-1
Lat.: 10°57.10'N Long.: 139°17.50'E
Location: Western end of Mariana Trench
Sea : calm Weather: fine
Bottom Topography: flat Profiler: flat and smooth
Length of Core Pipe: 12m Wall thickness: 7.5mm Material: Al
ID of Pipe: Core Head Wt.: 480kg Trigger Wt.: 60kg
Length Main Line: Length Trigger Line: 21m
Length Free Fall: 9m
Response at Hit : not clear Response at Pull-out: 7t/2min.
Time Lowered : 11h17m Uncorrected Water Depth: 7120m
Time Hit : 13h45m Uncorrected Water Depth: 6970m
Wire Angle at Hit: 0 Wire-out at Hit : 7200m
Cored Length : 800cm Trigger Cored Length : 45cm
Method of Storage: 2m container No. of Pipe Filled : 3
Length of Cores in Pipe 1. 139 2. 103 3. 136
No. of Cubic Samples for Paleomagnetism (No sampling)

Date: Feb.06,1986 Ship: Hakuho Maru KH 86-1 Station: P-2
Lat.: 07°44.10'N Long.: 134°58.70'E
Location: Palau Trench
Sea : very calm Weather: very fine
Bottom Topography: flat Profiler: soft sediment by 3.5kHz
Length of Core Pipe: 12m Wall thickness: 7.5mm Material: Al
ID of Pipe: 65mm Core Head Wt.: 480kg Trigger Wt.: 60kg
Length Main Line: Length Trigger Line: 20m
Length Free Fall: 8m
Response at Hit : very clear Response at Pull-out: not clear (7.5t)
Time Lowered : 08h29m Uncorrected Water Depth: 7890m
Time Hit : 11h25m Uncorrected Water Depth: 7890m
Wire Angle at Hit: 0° Wire-out at Hit : 8002m
Cored Length : ca.12m Trigger Cored Length : 109cm
Method of Storage: 2m container No. of Pipe Filled : 7
Length of Cores in Pipe 1. 180cm 2. 170cm 3. 173cm 4. 182cm
5. 184cm 6. 181cm 7. 25cm
No. of Cubic Samples for Paleomagnetism (No sampling)

Date: Feb.17,1986 Ship: Hakuho Maru KH 86-1 Station: P-3

Lat.: 9°04.60'N Long.: 139°07.00'E
Location: Caroline Ridge
Sea : calm Weather: fine
Bottom Topography: summit of an unnamed seamount
Profiler: thin soft sediment by 3.5kHz
Length of Core Pipe: 12m Wall thickness: 7.5mm Material: Al
ID of Pipe: 65mm Core Head Wt.: 450kg Trigger Wt.: 50kg
Length Main Line: Length Trigger Line: 20m
Length Free Fall: 8m
Response at Hit : Responce at Pull-out: ca.0.8t
Time Lowered :10h06m Uncorrected Water Depth: 2700m
Time Hit :11h15m Uncorrected Water Depth: 2730m
Wire Angle at Hit: 0 Wire-out at Hit : 2868m
Cored Length : 217cm Trigger Cored Length : 0m
Method of Storage: 2m container No. of Pipe Filled :
Length of Cores in Pipe 1. 130 2. 87
No. ofCubicSamples forPaleomagnetism (No sampling)

palau



lithology and sedimentary structure as well as the degree of mixing between pelagic and terrigenous sediments on the trench floor. The Palau and Yap trenches are the suitable place to study the nature of the trench-bottom sediments. During the cruise three piston cores were successfully recovered from the Palau Trench floor (P-1), the junction area between the Yap and Mariana trenches (P-2), and the summit of the Caroline Ridge seamounts. Precise piston core logs are listed in Table 9-3-1-1.

9-3-2. Piston core operation

A new model of piston corer was built for the cruise KH68-3 of 1968 and has ever since been used on board the Hakuho Maru. It uses a heat-treated alloy of Aluminum with Magnesium for pipe and head with accessories. Only the cutting edge and a part of head weight are made of steel.

A straight and unconnected pipe with a length of 12 meters has been used. It is sufficiently strong against bending force. It is expendable when it is bent by accidental hit at a hard bottom.

The outer diameter of the pipe is 80 mm, thickness of the wall is 7.5 mm. Head weight generally amounts to 450 kgs to 500 kgs considering easy handling for the shipboard work. The inner diameter of cutting edge is 5 mm smaller than the inner diameter of the main pipe, because of making the friction between the cored sediment and pipe wall minimum. Usually free-fall height is about 8 meters, since length of maim pipe plus weight head being 13 m and main wire from trigger to piston in pipe being 21 m.

No. 1 winch was used for the coring operation. The speed of wiring out was 60 mm/min before just 50 to 100 m above the bottom and the wiring was stopped for a while of a few minutes to end swinging. Then the wire was sent out at a quite low speed (dead slow) until the core hits the bottom. Immediately after checking the bottom hit by tension meter, the piston corer was wound up at 60 m/min or much faster.

9-3-3. Experimental treatise

Piston core samples were pushed out of the aluminum pipe using oil compressor cylinder and measured thermal conductivity of the sediments after 12 hours equilibriating with the room temperature. Columner sediments of the piston core were cut

KH 86-1 P 1

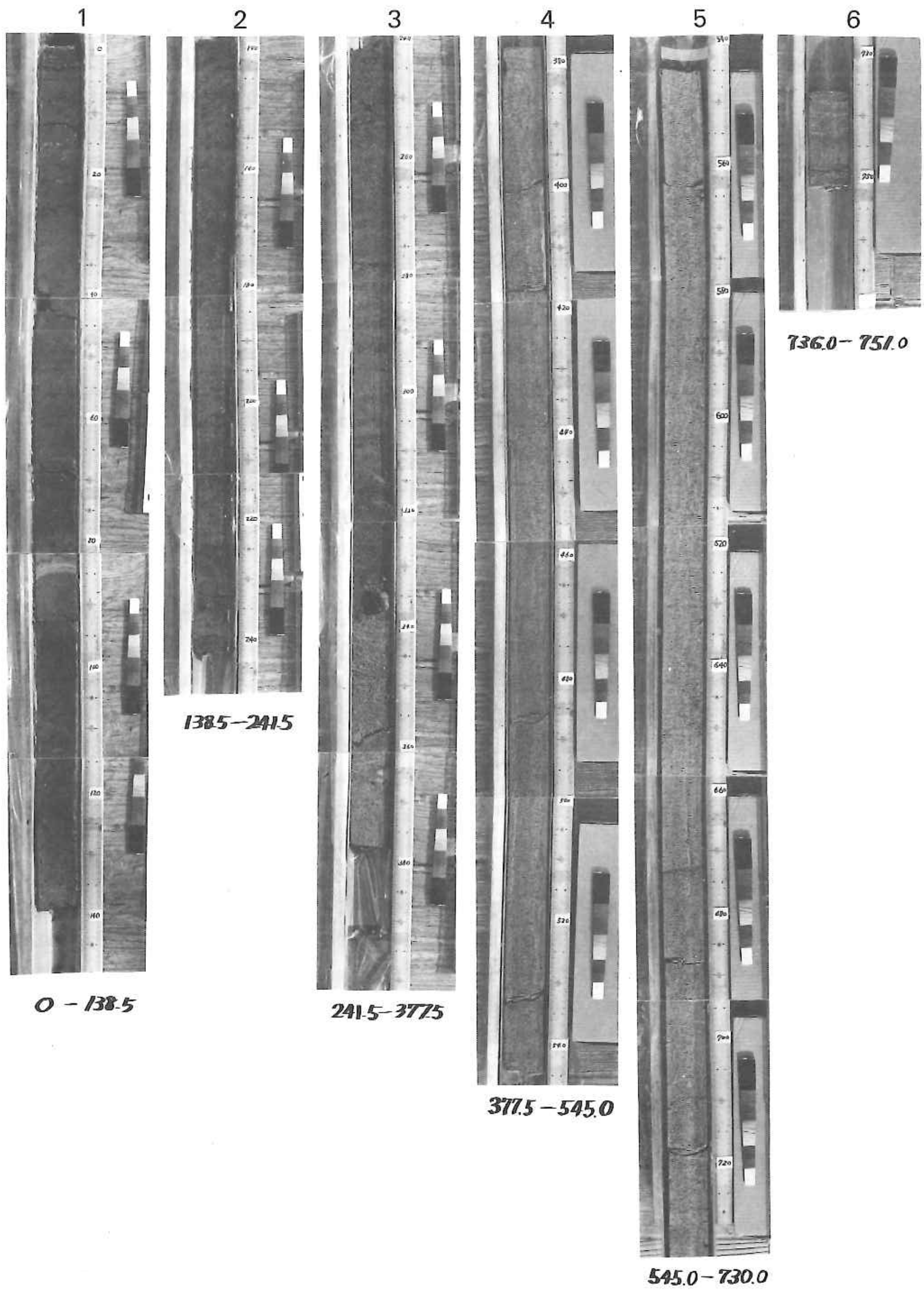
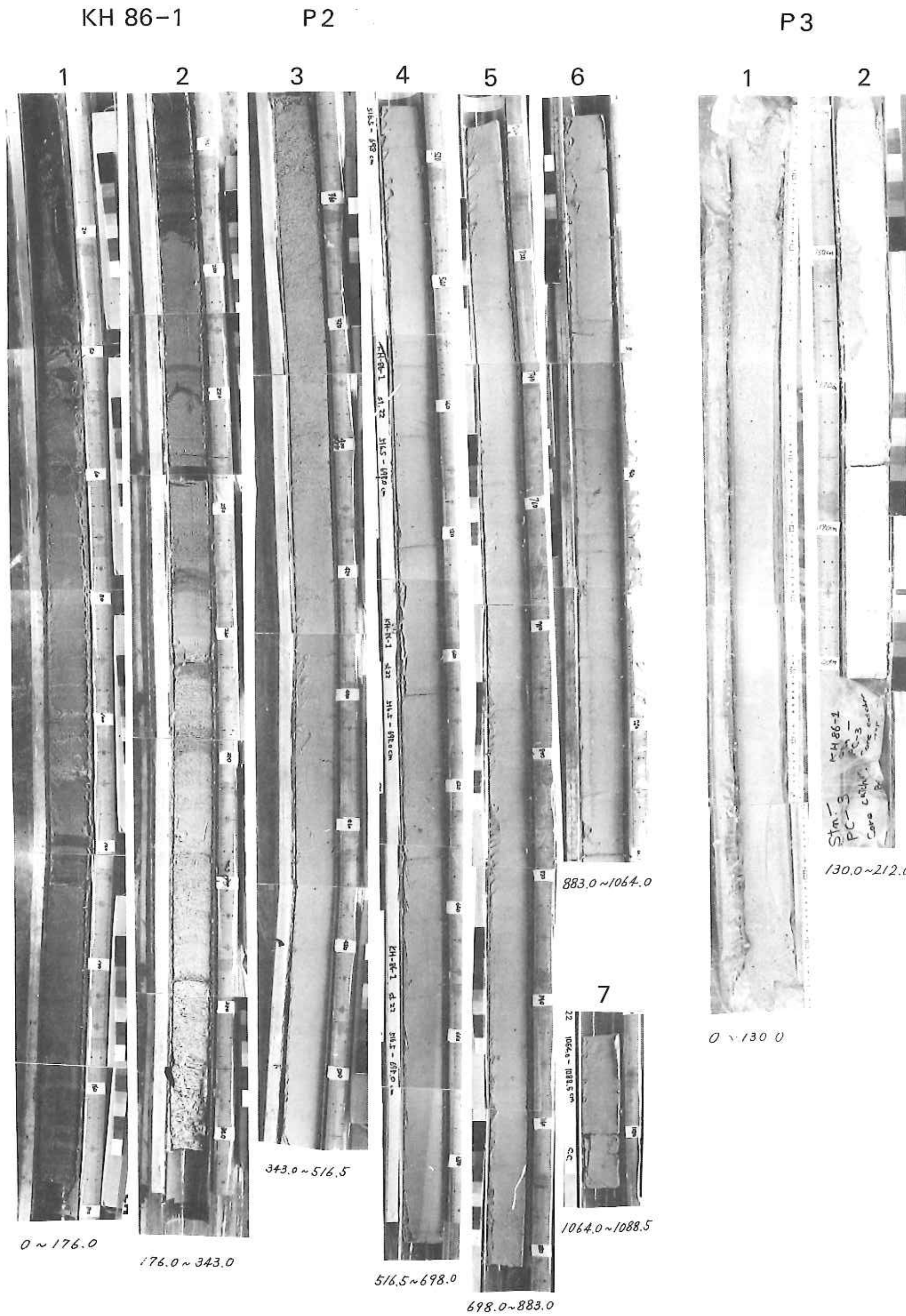


Fig. 9-3-3-1. Core photographs of the piston core samples from the Palau and Yap Trenches and Caroline Ridge.


KH 86-1
P2
P3
1
2
3
4
5
6
1
2
883.0~1064.0
130.0~212.0
7
0~130.0
0~176.0
176.0~343.0
343.0~516.5
516.5~698.0
698.0~883.0
1064.0~1088.5

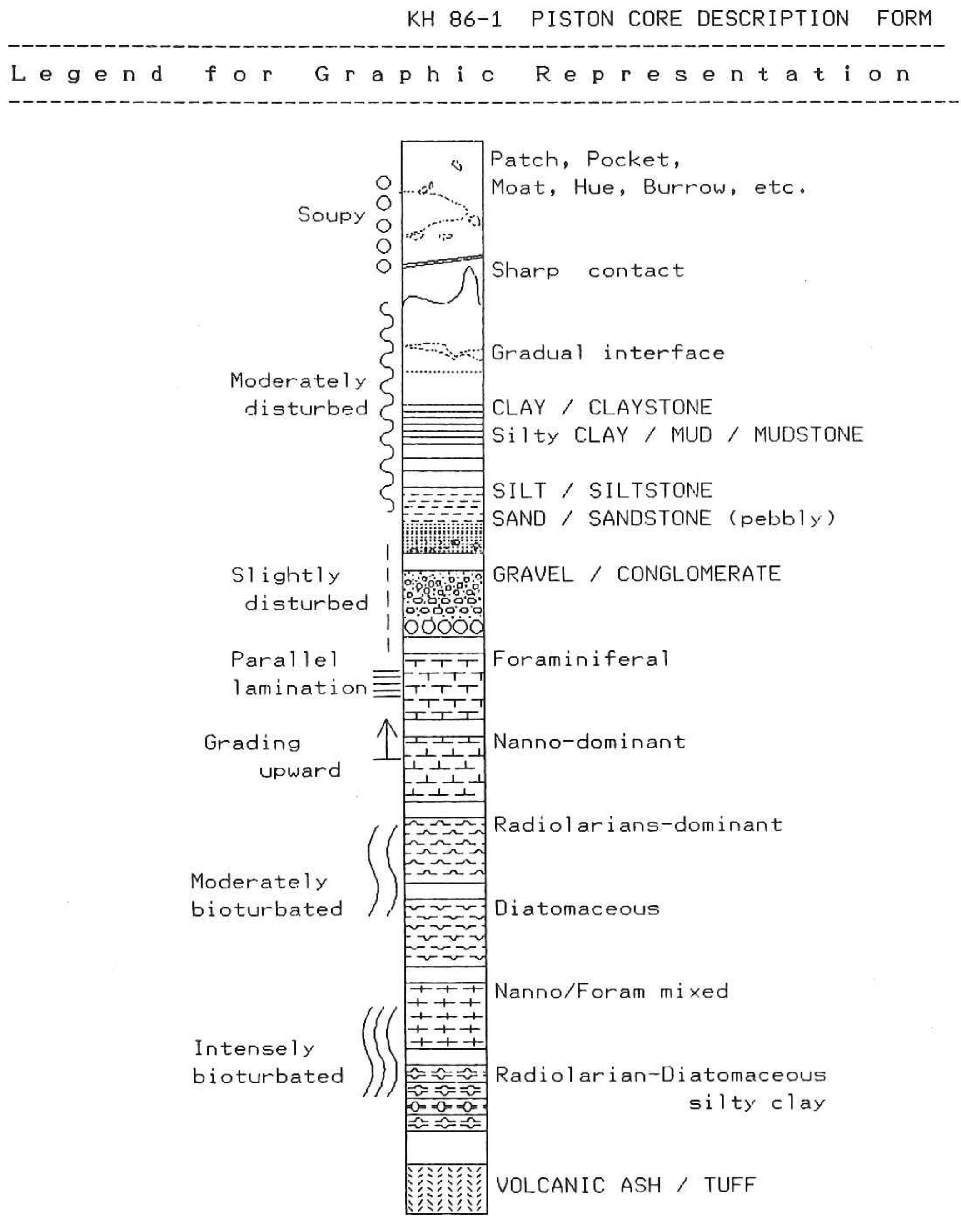
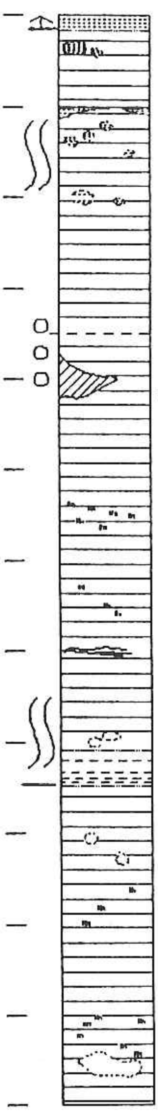


Fig. 9-3-3-2. Visual core description for lithology of the piston core sampls.

K H 8 6 - 1 Piston Core [Mariana Trench]

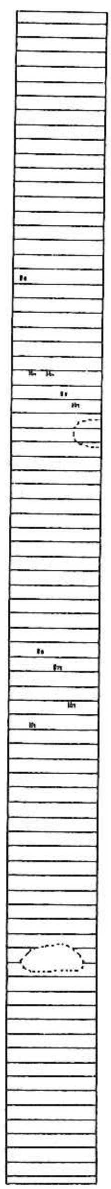
P C - 1 Core interval 0 - 120 cm



LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
0		Dull yellowish orange fine sand (10YR5/2) 0.5-1.5: Grayish brown fine sand (5YR3/2) 3-21: lumps of dark yellowish orange pumiceous sand (10YR6/2)
10	* 10	
	* 15	Pale olive clay (10Y6/2)
20	* 20	
30	* 30	
40	** 42	
50	* 50	Moderately yellowish brown clay (10YR5/4) 53-67:Moderately brown manganese spots (5YR3/4)
60		
	* 67	
	* 69.5	
70	** 70	Dark yellowish brown clay (10YR4/2)
	* 76	
80	** 82.5	82.5-84: Light olive brown clay (5Y 5/6) 84-85: Yellowish brown clay(10YR6/2)
	* 85	
	* 86	
90		
100		
110	* 111	111-115: Micro manganese nodules
	* 112.5	Dark yellowish brown clay(10YR4/2)
120		

(to be continued)

PC – 1 Core interval 120 - 250 cm.



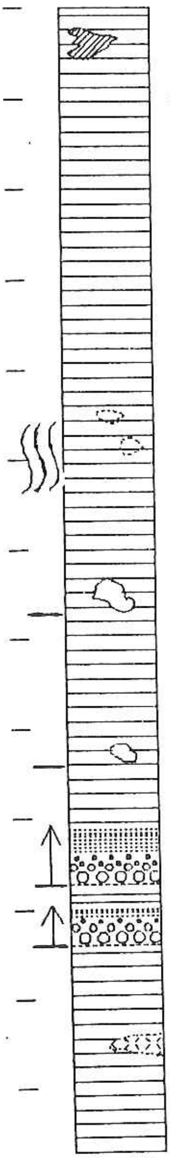
LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
120		
130		
	* 138	
140		
	* 144	Moderately brown clay (5YR5/4)
150		
160		
		165: Manganese micro-nodules
	* 168	Moderately yellowish brown clay (10YR5/4)
170		
		192-198: Manganese Micro-nodules
180		
190		
		192-197: Manganese micro-nodules
200		
210		
220		
		223: Dark yellowish brown clay (10YR4/2)
	* 229	
230		
240		
250		

(to be continued)

P C - 1 Core interval 250 - 378 cm

LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
250		
		253: Moderately brown clay (5YR3/4)
260	* 260	
270		
280		
290		
		293: Moderately yellowish brown clay (10YR5/4)
300		
310		
		315: Mn-crusted gravel (ϕ 3cm, 50g)
320		
	* 326	
330		
		333: Pumice gravel, partly Mn-crusted, 10g
340	* 342	
		342-347: Gravel layer grading upward
350		
		352-354: Gravel layer grading upward
360		
	*365	364-366: Grayish orange volcanic ash (10YR7/4)
370		
377.5 cm	End of core	377: Moderately yellowish brown clay (10YR5/4)

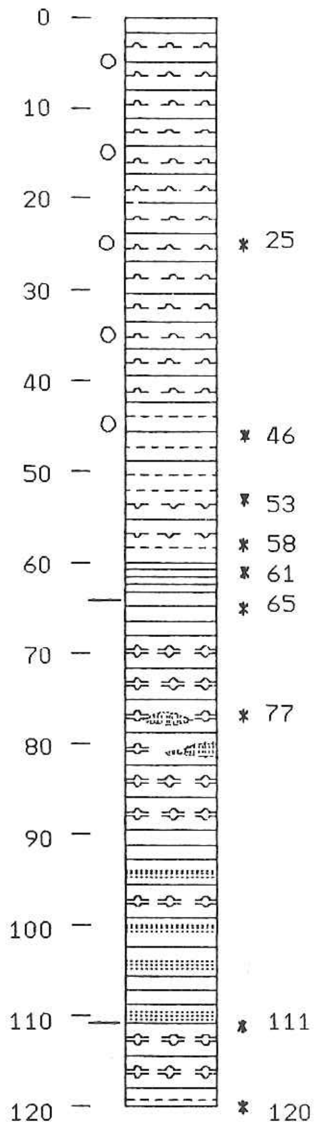
LITHOLOGY:



K H 8 6 - 1 Piston Core [Palau Trench]

P C - 2 Core interval 0 - 120 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION



Moderate brown radiolarian clay (5YR3/4)

Dark yellowish brown radiolarian clay (10YR4/2)

49: Gradual change in color

53-58: Moderate yellowish brown (10YR5/4) diatomaceous clay

58-60: Dark yellowish brown (10YR6/2) clay

80-81: Light olive gray calcareous silty sand (5Y 5/2)

Yellowish gray (5Y 7/2) calcareous clay

94-95: Light olive gray calcareous sand (5Y 5/2)

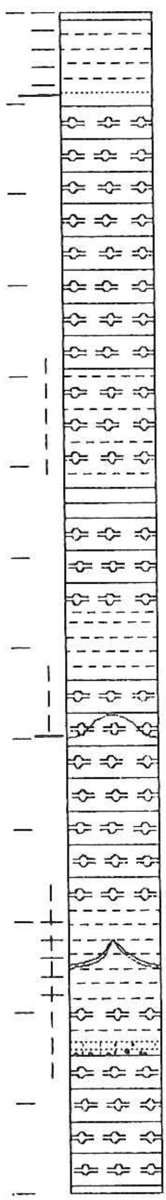
100-101: Light olive gray calcareous sand

104-105: ditto (5Y 5/2)

111-120: Dark yellowish brown clay(10YR4/2)

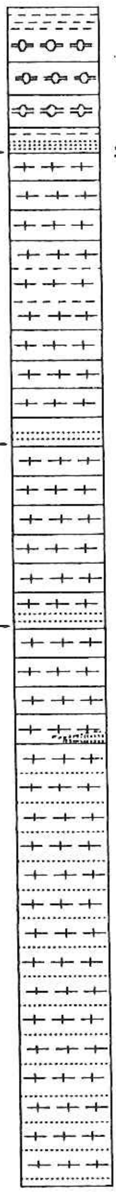
(to be continued)

P C − 2 Core interval 120 - 250 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION
120		* 120	120-128: Alternation of dusky yellowish brown clay (10YR2/2) and dark yellowish brown clay (10YR4/2)
		* 125	
130		* 130	
140			Dark yellowish brown siliceous clay(10YR4/2)
150			
160		* 160 * 162	Moderate brown clay (5YR 4/4)
170			170-176: Moderate yellowish brown clay (10YR5/4)
180			
		* 188	Moderate yellowish brown clay (10YR5/4)
190			
200		* 201	Light olive gray siliceous clay (5Y 5/2)
210			
220			
		* 225 * 228	Moderate yellowish brown clay (10YR5/4) Discordant thin layers of dusky yellowish brown clay (10YR2/2) 233-244: Thin layer of calcareous fine sand Light olive gray clay (5Y 5/2)
230			
240		* 240	
250			

(to be continued)

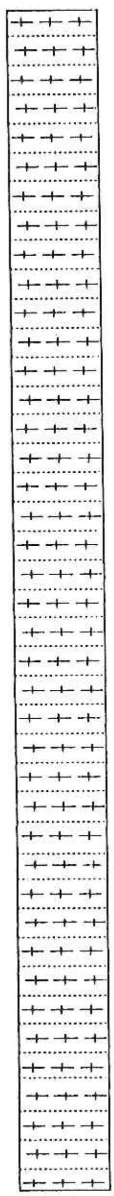
P C - 2 Core interval 250 - 380 cm



LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
250		Dark yellowish brown clay (10YR4/2)
260	* 260	
	* 265, 266	Grayish orange clay (10YR7/4) 265-266: Calcareous sandy silt, yellowish gray (5Y 7/2)
270		
280		278-283: Light olive brown Nanno-Foram clay (5Y 5/6)
290	* 294	: Yellowish gray Nanno-Foram clay (5Y 7/2) 296-297: Calcareous fine sand, light olive gray (5Y 5/2)
300		
310		316-317: Calcareous fine sand, light olive gray (5Y 5/2)
320		
330		330-331: Calcareous fine sand patch, light olive gray
340	* 345	Yellowish gray Nanno-Foram clay (5Y 7/2)
350		
360		
370		
380		

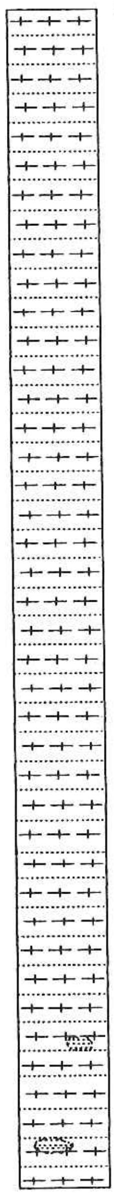
(to be continued)

P C - 2 Core interval 380 - 510 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION
380			Yellowish gray Nanno-Foram clay (5Y 7/2)
390			
400			
410			
420			
430			
440			
450			Yellowish gray Nanno-Foram clay
460			
470			
480			
490			
500			
510		* 510	Yellowish gray Nanno-Foram clay (5Y 7/2)

(to be continued)

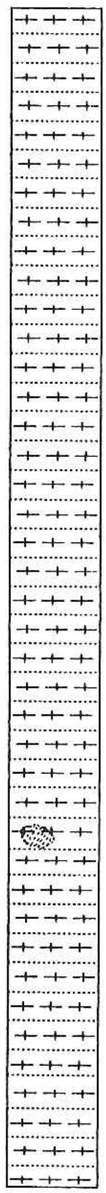
P C - 2 Core interval 510 - 640 cm



LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
510	* 510	Yellowish gray Nanno-Foram clay (5Y 7/2)
520		
530		
540		
550		Yellowish gray Nanno-Foram clay
560		
570		
580		
590		
600	* 600	
610		
620		624: Sandy spot
630		635: Sandy spot
640		

(to be continued)

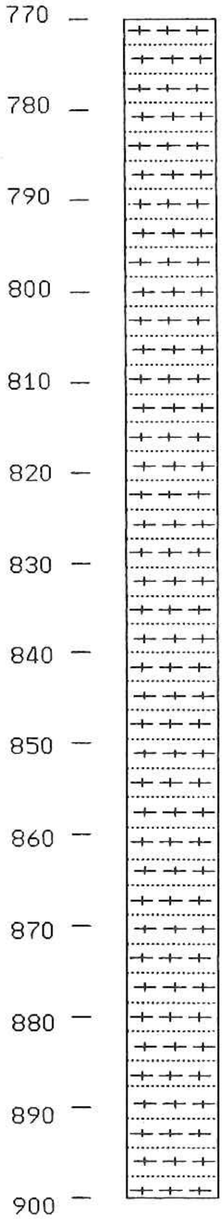
P C - 2 Core interval 640 - 770 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION
640			
650			
660			
			Yellowish gray Nanno-Foram clay (5Y 7/2)
670			
680			
690			
700			
710			
720			
730			Sandy spot
740			
750			
760			
770			

(to be continued)

P C - 2   Core interval 770 - 900 cm

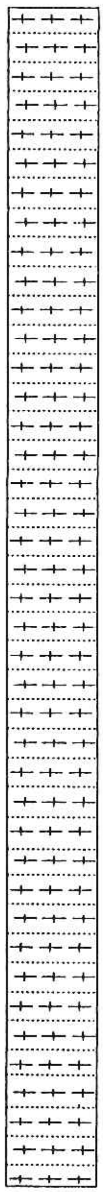
LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION



Yellowish gray Nanno-Foram clay (5Y 7/2)

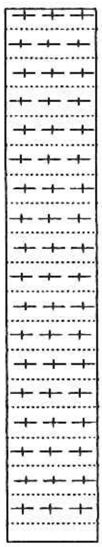
(to be continued)

P C - 2 Core interval 900 - 1030 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION
900			
910			
920			
930			
940			
950			Yellowish gray Nanno-Foram clay (5Y 7/2)
960			
970			
980			
990			
1000			
1010			
1020			
1030			

(to be continued)

P C - 2 Core interval 1030 - 1088.5 cm

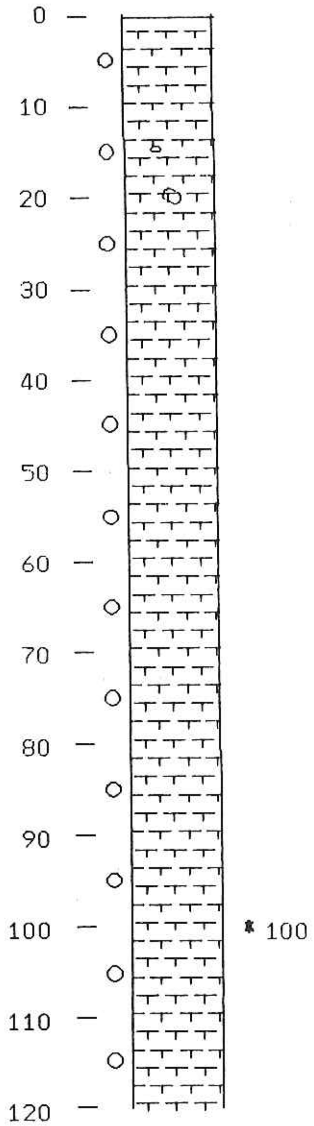
LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION
1030 – 1088.5			Yellowish gray Nanno-Foram clay (5Y 7/2)
1088.5			End of Core KH 86-1-P3

Length scale (cm): 1030, 1040, 1050, 1060, 1070, 1080, 1088.5

K H 8 6 - 1 Piston Core [Caroline Ridge]

P C - 3 Core interval 0 - 120 cm

LENGTH (cm)	LITHOLOGY	Smear slide	LITHOLOGIC DESCRIPTION



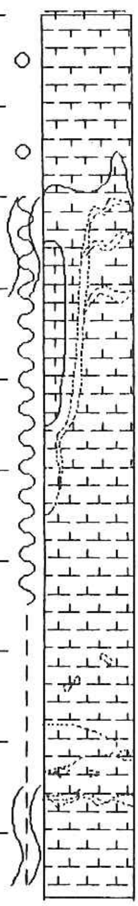
15: Well rounded pumiceous gravel (ϕ 4 mm)

20: Rounded limy gravel (ϕ 5 mm)

Foraminifer ooze, very soupy,
moderate orange pink (5YR8/4)

(to be continued)

P C - 3 Core interval 120 - 217 cm



LENGTH (cm)	Smear slide	LITHOLOGIC DESCRIPTION
120		
130		
140		140- : Pinkish gray Nanno ooze (5YR 8/1) 145-165: same as in 130 cm and above
150		
160		
170		Very pale orange Nanno ooze (10YR8/2)
180		
190	* 190	Burrows, pinkish gray Nanno ooze (5YR8/1)
200	* 200	205-207: remarkably bioturbated
210	* 214 * 216	Very pale orange Nanno ooze (10YR8/2)
217.0 cm		End of Core KH 86-1-P3

into two halves by thin wire;that is, archive and working. The archive half was used for the core photographs (Fig. 9-3-3-1) and then for the visual core descriptions (Fig. 9-3-3-2) before storage. Visual core descriptions and smear-slide observations were carried out onboard. Fig. 9-3-3-2 shows the results of the visual core description and Table 9-3-3-1 shows the results of smear slide observation.

The working half was first treated for the micro-sedimentary structural analysis using soft-X-ray apparatus. Sediment slices were cut into plastic box (20 cm x 8 cm x 0.8 cm) by thin wire. X-ray radiographs were taken under the condition of 40 kV, 12 mA, and 20-30 sec. for all the piston core samples obtained during the cruise. Precise core treatise is the same as described by Fujioka et al., 1985.

9-3-4. Lithostratigraphy of piston core sediments

P-1

The sediment recovered from the junction area between the Mariana and Yap arc-trench systems contains possibly pelagic origin reddish clay and other kinds of clays, and gravely beds and some gravels in the deeper part of the core. The sediments show several turbiditic sequences of clay and some interbedded thin sandy sediments. The topmost part of the core is covered by about 1 cm thick dull yellowish orange pumiceous sand with heavy minerals. A very few amount of terrigenous materials, such as quartz and feldspars, are contained in the sand bed. The thin sand in the surface is overlain by the brown clay but the contact between them is very gradual. The brown clay contains some interbeds and lumps of sand, and also some bioturbated clay. A very sharp contact is observed at the 55 cm core-depth and some interbedded clays are deposited above this contact. Among the interbedded clays, the bottom-most clay is different from other beds in terms of color; the yellowish brown clay just above the contact may represent some terrigenous clay which could be transported by turbiditic flow.

Although there can be some disturbance by bioturbation, the beds down to the 320 cm core-depth are quite monotonous by the deposition of brown clay. The contact at the 320 cm core-depth is sharp and a completely Mn crusted metabasalt (?) gravel was found above the sharp contact. Below the contact to the 377.5 cm core-depth in which the lower core was flowed in,

Table 9-3-3-1. Summary of the smear slides observation of the piston core samples.

SMEAR SLIDE DESCRIPTION

Device Interval	D/M	Sand	Silt	Clay	Qz	F	H.M.	Clay	V.G.	Mica	Carb.	Foram.	Nanno.	Diat.	Rads.	Spon.	Silico.	Sediment Name
P-1																		
10-11	M 0	10	90	5	20	5	50	5	2									Pale olive clay
16-17	M 0	30	70	10	40	2	30	2	3									Pale olive clay
20-21	M 0	30	70	10	20	10	50	5	5									Yellowish brown clay
30-31	D 0	15	80	10	20	5	45	5	5									Yellowish brown clay
42-43	D 0	10	90	20	30	5	30		2									Yellowish brown clay
42-43	M 0	15	85	20	30	3	40		3									Dark yellowish brown clay
50-51	D 0	15	85	20	25	3	40		5									Moderate yellowish brown clay
67-68	D 0	40	60	15	25	10	40		5									Yellowish brown clay
69-70	M 0	40	60	30	20	5	30	10	3									Dark yellowish brown clay
70-71	M 0	30	70	25	25	5	30	5	10									Brown clay
70-71	D 0	20	80	20	30	5	30		5									Brown clay
76-77	D 0	10	90	20	30	10	30		5									Dark yellowish brown clay
82-83	D 0	20	80	20	30	5	35		5									Dark yellowish brown clay
82-83	M 60	20	20	25	35	10	10		10									Grayish brown fine sand
85-86	D 0	10	90	20	30	5	30		5									Yellowish brown clay
86-87	M 0	30	70	20	30	10	30		5									Light olive brown clay
111-112	D 0	30	70	5	10	5	70	5										Brownish black clay
112-113	M 0	10	90	20	20	5	50											Pale yellowish brown clay
138-139	D 0	10	90	20	20	5	50	5										Yellowish brown clay
144-145	D 10	20	70	20	25	3	50		2									Brown clay
168-169	M 10	30	60	20	20	10	40		5									Yellowish brown clay
229-230	D 0	30	70	20	25		40	5	5									Brown clay
260-261	D 10	30	60	20	20		45	5	5									Brown clay
326-327	D 20	20	40	20	30	5	30	5	5									Dark yellowish brown clay
342-343	D 0	20	80	10	10	1	70		2									Yellowish brown clay
365-366	M 0	10	90	5	5	10	10	70										Grayish orange volcanic ash
P-2																		
25-26	D 0	10	90				50						10	20	10	1		Moderate brown radiolarian clay
46-47	D 0	10	90				40			5	10	5	5	15	10			Dark yellowish brown radiolarian clay
53-54	D 0	20	80			10	40			10		5	5	15	10			Moderate yellowish brown radiolarian clay
58-59	M 0	10	90				40			10		5	20	10	10	1		Dark yellowish brown diatomaceous clay
61-62	M 0	20	80				40			5		5	20	10	10	1		Pale yellowish brown diatomaceous clay
65-66	D 0	20	80				35				5	10	5	10	10			Yellowish gray clay
77-78	M 30	30	40				40			10	10	3	10	10	10			Light olive gray calcareous silty sand

111-112	M	0	10	90			50						5	15	10		Dark yellowish brown clay
120-121	M	0	60	40		30	30			5			5	5	10		Dusky yellowish brown silt
125-126	M	0	20	80						5			10	10	10		Dark yellowish brown clay
130-131	D	0	5	95	10		70			10			2	5	5		Dark yellowish brown clay
160-161	M	0	5	95			50			10			20	5	10		Moderate yellowish brown clay
162-163	D	0	10	90	10	10	40						20	15	10	1	Moderate brown clay
188-189	D	0	5	95	10		40						30	10	10		Moderate yellowish brown clay
201-202	D	0	30	70	10	10	40						20	10	10		Light olive gray clay
225-226	M	0	40	60		30	35	2		10		tr	10	5	5		Moderate yellowish brown clay
228-229	M	10	50	40			40			10	10	2	10	15	5		Dark yellowish brown silt
240-241	D	0	20	80	10	2	40						20	10	10		Light olive gray clay
260-261	M	0	20	80			40			10	10	10	10	15	2		Grayish orange clay
265-266	M	10	70	20	2	2	30	5	5	10	20	5		15			Yellowish gray silt
266-267	M	0	10	90			45			10			30	5	5		Light olive brown clay
294-295	D	10	30	60		2	35			10	10	20	10	5			Yellowish gray Nanno-Foram clay
345-346	D	10	30	60			35			10	10	20	10	10	5		Yellowish gray Nanno-Foram clay
510-511	D	0	30	70			10	2		40	2	20	5	2	1		Yellowish gray Nanno-Foram clay
600-601	D	0	30	70			30	2		10	10	20	2	10	2		Yellowish gray Nanno-Foram clay
P-3																	
100-101	D	20	10	70			tr				30	60					Nanno-Foram ooze
190-191	D	0	5	95			tr					90					Nanno-ooze
200-201	M	0	20	80							20	80					Nanno-ooze
214-215	D	0	15	85							15	85					Nanno-ooze
216-217	D	0	5	95							5	95					Nanno-ooze

D: Dominant Lithology M: Minor Lithology

Percent Texture

Sand Silt Clay

Percent Composition

Qz: Quartz
Clay: Clay Minerals
Carb: Carbonate Unspecified
Nanno: Calcareous Nannoplankton
Rad: Radiolarians
Silico: Silicoflagellate

F: Feldspar
V.G.: Vocanic Glass

H.M.: Heavy minerals
Mica: Mica Group
Foram: Foraminifera
Diat: Diatom
Spon: Sponge Spicule

the lithology is represented by gravely beds, pumice, some volcanic ash rich clay. Two gravely grading beds were recognized at the 347 cm and 354 cm core-depths. The pumice (?) gravel was also partially crusted by Mn and a portion of Mn crust (as vein) was cored also. There are numerous Mn rich dark spots throughout the core. The surface sand contains also Mn micronodules. These cores are barren of calcareous and siliceous microfossils.

Generally, the trench area is considered as hemipelagic environments in which terrigenous gray clay and pelagic red clay can be mixed together. Grayish clay, grayish clay overlain by thinly bedded red clay, and red clay were found in the trench and adjacent areas, but the characterization of trench sediments in terms of the color of sediment is usually difficult (Ikehara, 1984; Yamamoto,1984). The sediment recovered from the almost southwestern end of the Mariana Trench could be considered as being dominated by red clay with some very thinly bedded pumiceous and heavy mineral rich sand.

P-2

The Palau Trench floor is characterized by widely spaced flat floors (Kato et al., in press) and some cyclic sequences of transparent and opaque layers are evident by the seismic reflection study (Tokuyama et al., 1985). As far as the topographic and geological situations are concerned, the Palau Trench may be resembled to the Puerto Rico Trench (Ewing et al., 1955). The Puerto Rico Trench is famous area from which two piston cores containing carbonate turbidite sequences were recovered (Ewing et al., 1955).

Expectedly, about 50 cm thick brown clay underlain by various types of carbonate turbiditic sequences was recovered from the P-2 site at the flat floor of the Palau Trench. This brown clay unit (0 - 50 cm) is very soupy layer. The contact between the surface brown clay and its underlying clay with calcareous sand is very gradual. The topmost turbiditic calcareous sand in which coral sand is observed together with foraminifer and other calcareous organisms appears at the 77 cm core-depth and four thinly bedded calcareous sands succeed until the sharp contact at the 111 cm core-depth. The clays underlain by the surface brown clay are grayish and contain siliceous organic remains, but the interbedded clays with the turbiditic calcareous sands are slightly calcareous with the enrichment of nannofossils. Some alternation of brown and dark brown clay appears at the 120 cm to 130 cm core-depths and this may represent some redox cycles at the trench basin.

Another cyclic sequences of calcareous sand beds do not appear until the 233 cm core-depth. The calcareous sand at the 266 cm core-depth is about 2 cm thick and sharply contacts with the underlying calcareous mud. Below this horizon, the calcareous sand occurs as a very thin interbed in the nanno-foram clay. The nanno-foram clay may contain more than 60 % of calcitic organic remains, but the nanno-foram clay below the 345 cm core-depth is extremely thickly bedded and does not contain any calcareous sand bed except for some some sandy spots at 630 cm and 730 cm core-depths. No apparent sedimentary structure was observed in the very thick bed of calcareous mud by visual investigations, but soft X-ray photographs in Fig. 9-3-5-1 may show some very weakly bedded clay laminations in the thick calcareous mud. The origin of the about 7 m thick calcareous mud should be interpreted by more careful investigations in the onshore laboratory.

The carbonate turbiditic sequences in the Palau Trench floor are basically similar to those described by Ewing et al. (1955) at the Puerto Rico Trench floor. However, several different features in the turbidite sequences may be pointed out for the one at the Palau Trench. In other words, the longer core sequence in the Palau Trench shows more numerous numbers of calcareous sand beds in which shallow-water coralline sand is also contained. The brown mud indicates some redox cycles at some core-depths. The very thickly bedded calcareous mud may be some new types of carbonate turbidite in the trench basin.

P-3

About 200 cm long core of very soupy calcareous ooze was recovered from the almost summit of an unnamed seamount which may belong to the Caroline Ridge systems. The seamount is located about 100 km SSW of the Ulithi Atolls, and the cored summit is 2717 m in corrected water depth. Since the 200 cm long core was placed in the tip (core-catcher side) of the piston corer and recovered to the vessel, no flow-in structure was recognized. Instead, apparent flow-out structure during pressing out operations was observed because of very soupy nature of recovered sediment.

The upper half of the core is very soupy Foram ooze. Abundant planktonic foraminifers are contained in the soupy ooze. The ooze is also mixed with soup of nannofossil ooze. The lower half of the core is nannofossil rich ooze which is well compacted. No siliciclastic clays or grains are observed in the ooze and the term ooze is employed here as the very pure material composed of planktonic organisms (CaCO3 content should be more than 90 % to define as ooze). The contact between the upper foram ooze and lower nanno ooze was flowed out; however, some sharp contacts between them could be recognized on the. The lower nanno ooze is bioturbated at several horizons and contain many burrows.

The nannofossil ooze in the seamount can be different lithologically from the turbiditic mud of nanno-foram clay at the Palau Trench. Besides of difference in the CaCO3 content, sedimentary structures would be different between them. While the nanno ooze contains burrows, the nanno-foram clay may contain very weakly laminated beds and some winnowed sedimentary structures.

9-3-5. Sedimentary structure examined using soft-X-ray radiographs

P-1

Several types of the deformation structures are visually recognized in the core above 136.5cm. They are normal faults, dewatering veins, layer parallel shears, fold, narrow spacing cleavages, and kink bands. Their detail descriptions are presented in the following sections.

Normal Faults:

Normal Faults are developed in the uppermost part of the core above 42cm depth and between 82cm and 92cm. The sediments above 40cm are flowed along the normal faults, but the faults between 82cm and 92cm are rather brittle ones. These faults appear to have been originally one part of dewatering veins which will be mentioned later. Because all the faults converge to the wall of the core, they seem to have not been formed tectonically but in association with coring.

Dewatering veins:

Dewatering veins are found through the core. Most of the occurrences are anastomosing network. Between 26cm and 30cm, between 52cm and 57cm, S shaped veins are developed. From 70cm to 75cm, veins are arranged en echelon fashion. The veins are cut by layer parallel shearing at 71cm. Veins

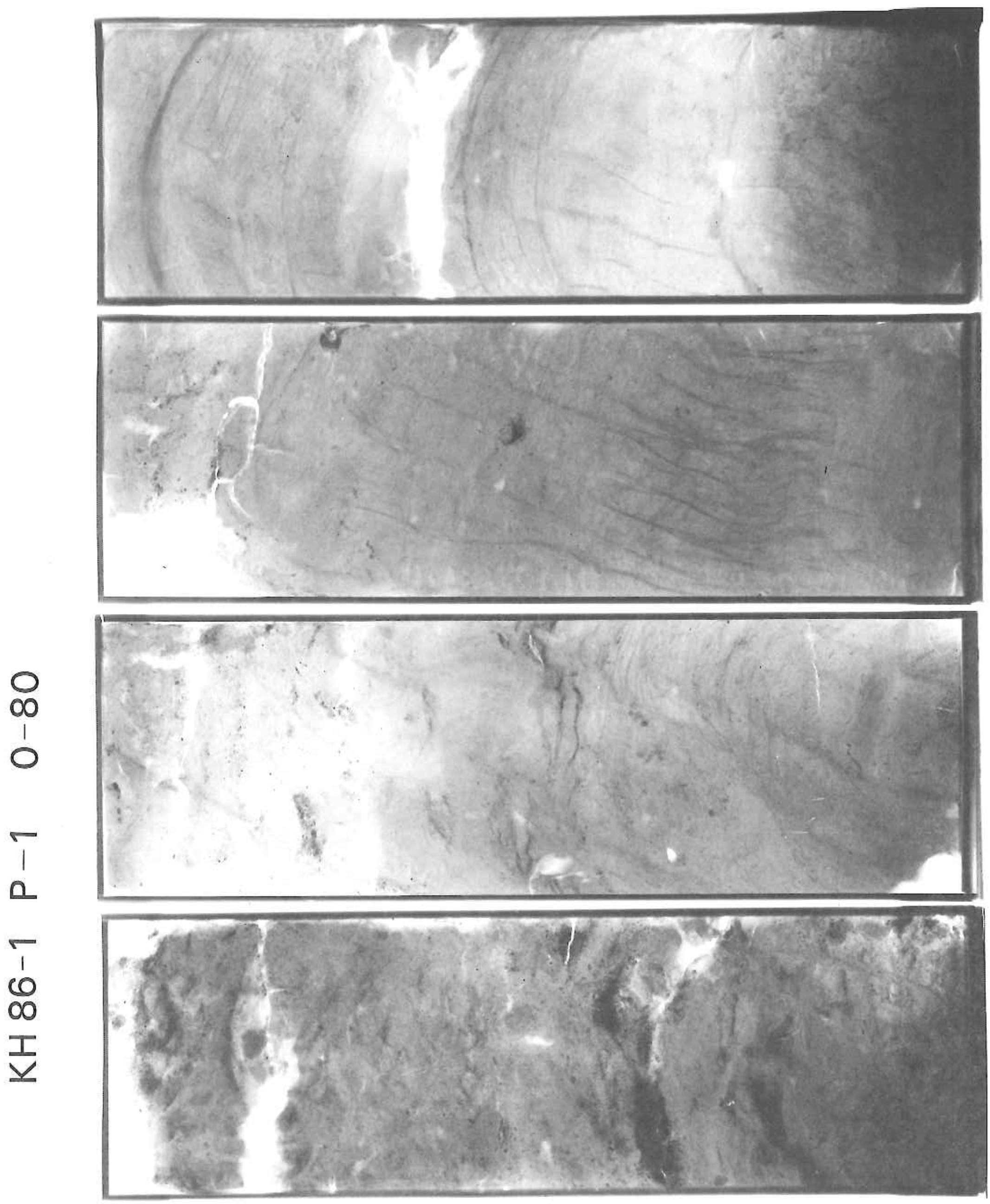
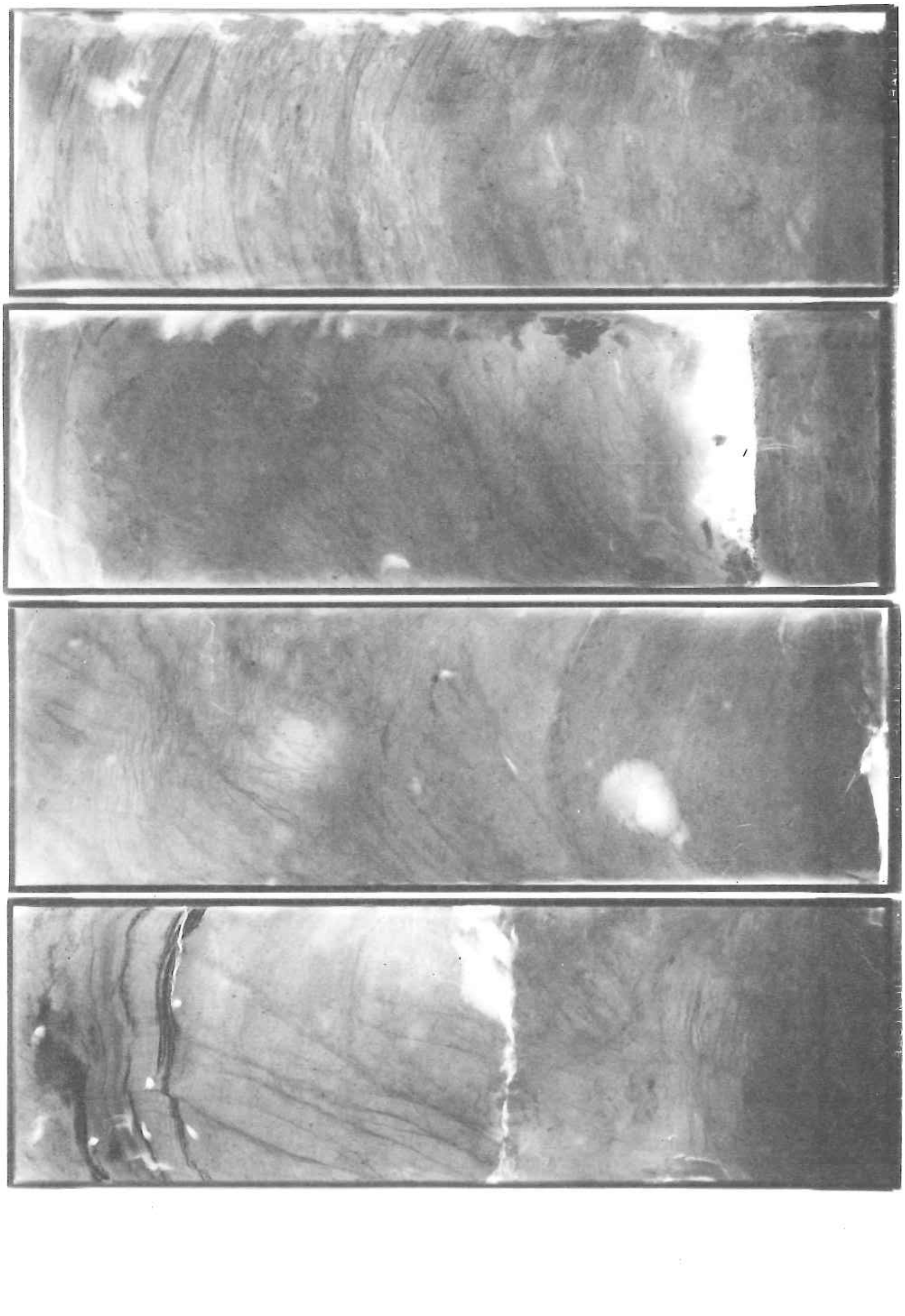
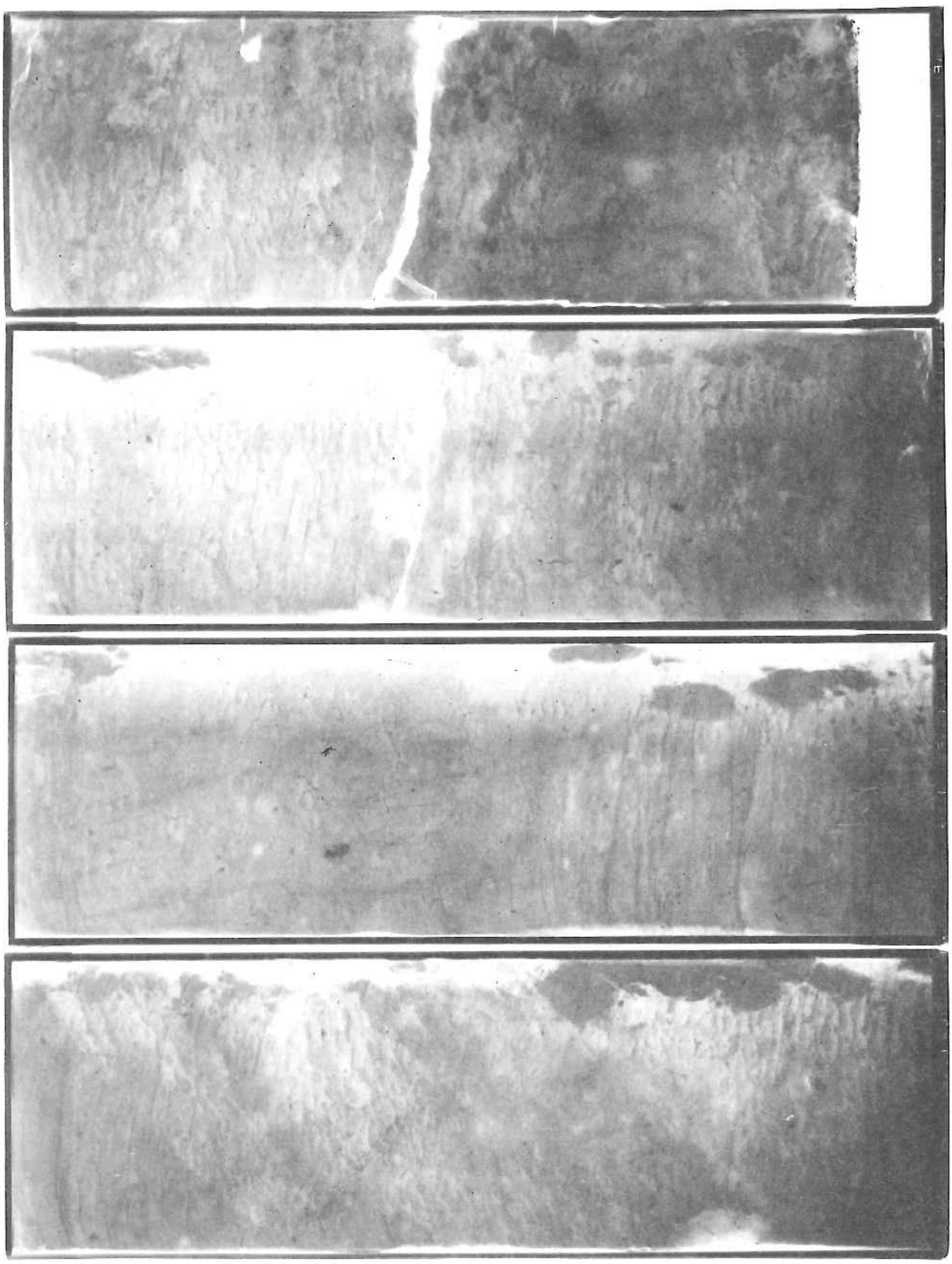


Fig. 9-3-5-1. Soft X-ray radiographs of the piston core samples.

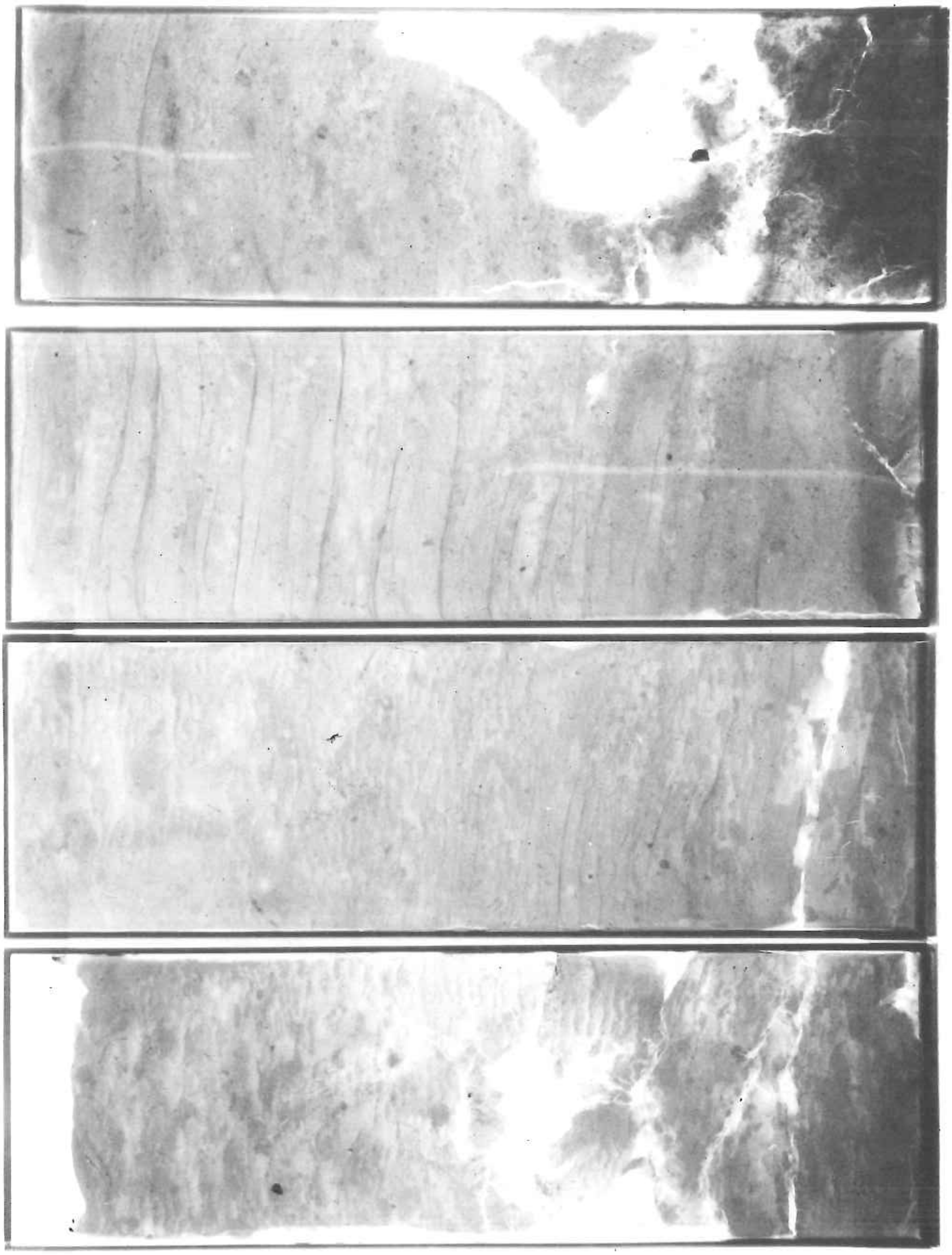


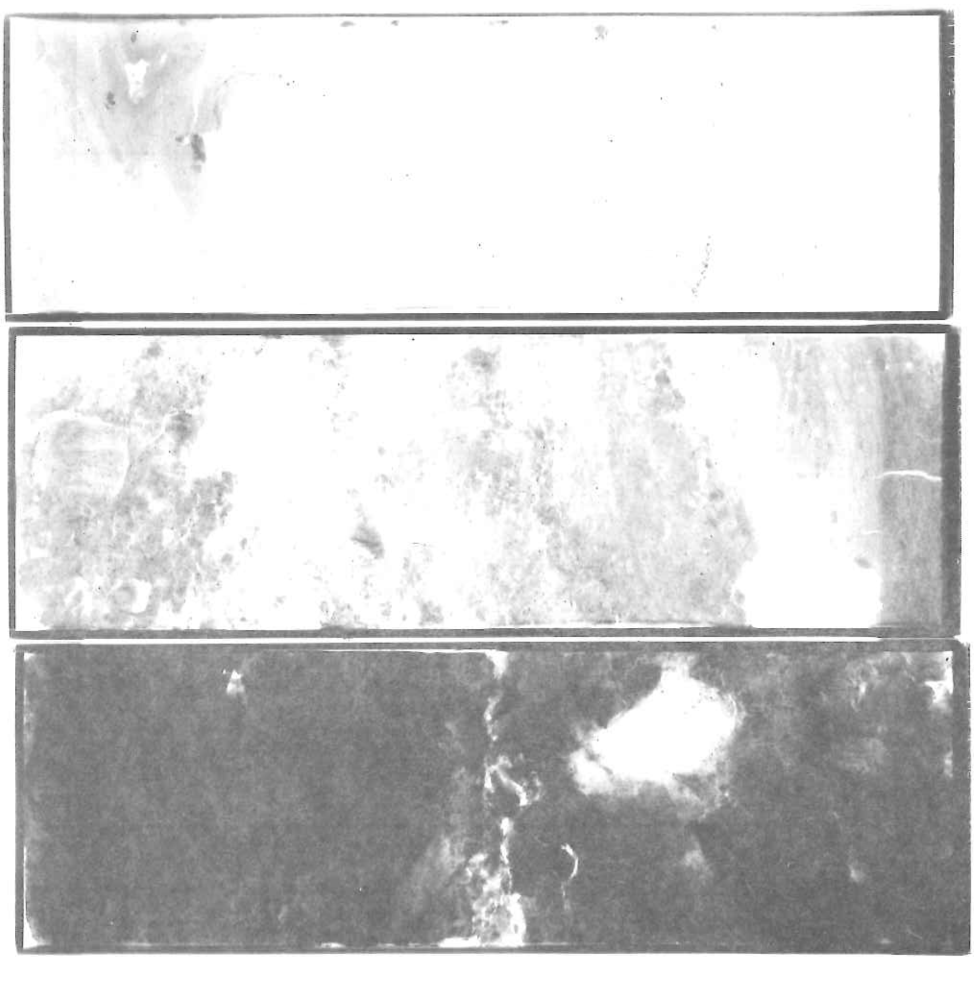
KH86-1 P-1 80-160



KH 86-1 P-1 160-240

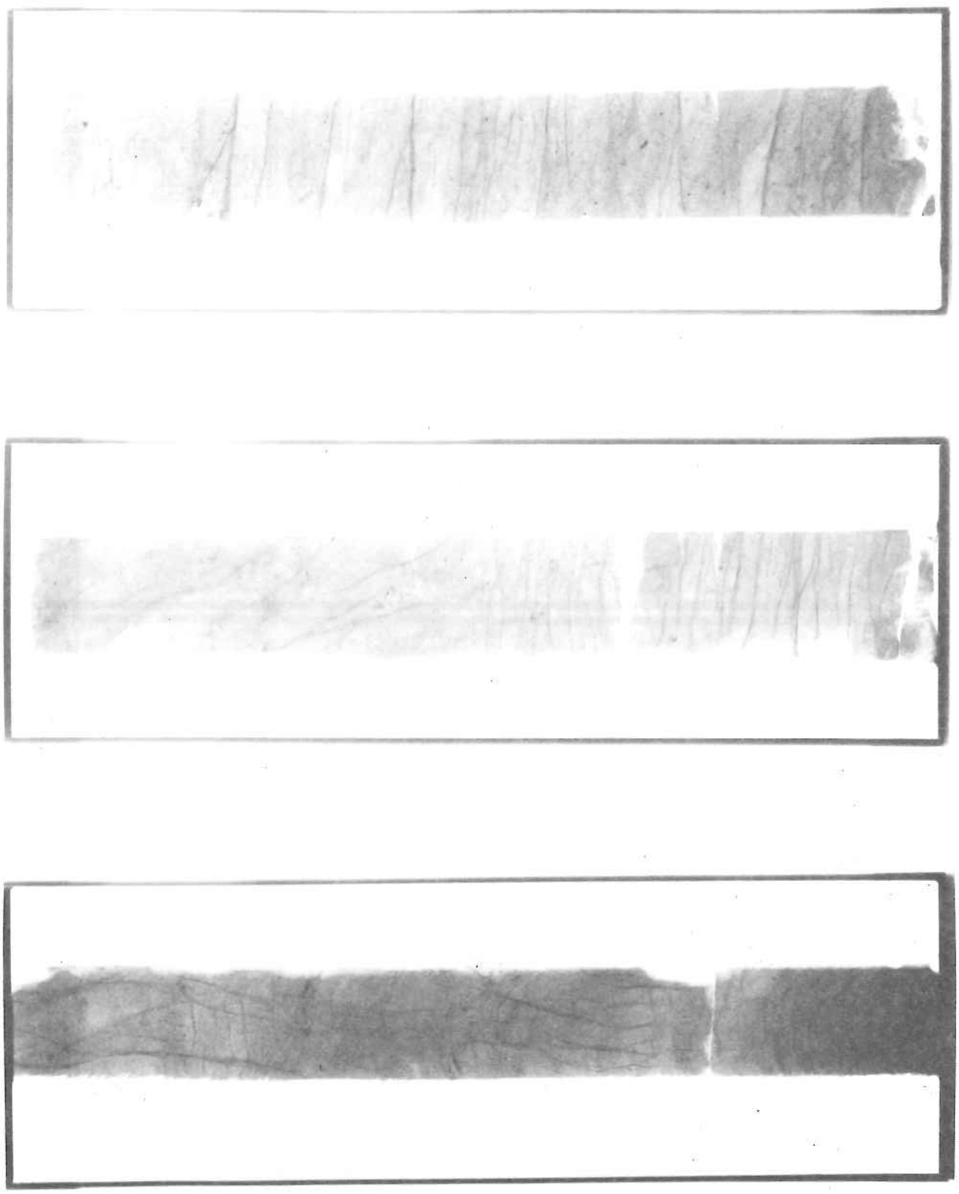
KH 86-1 P-1 240-320





KH-86-1 P-1 320-380

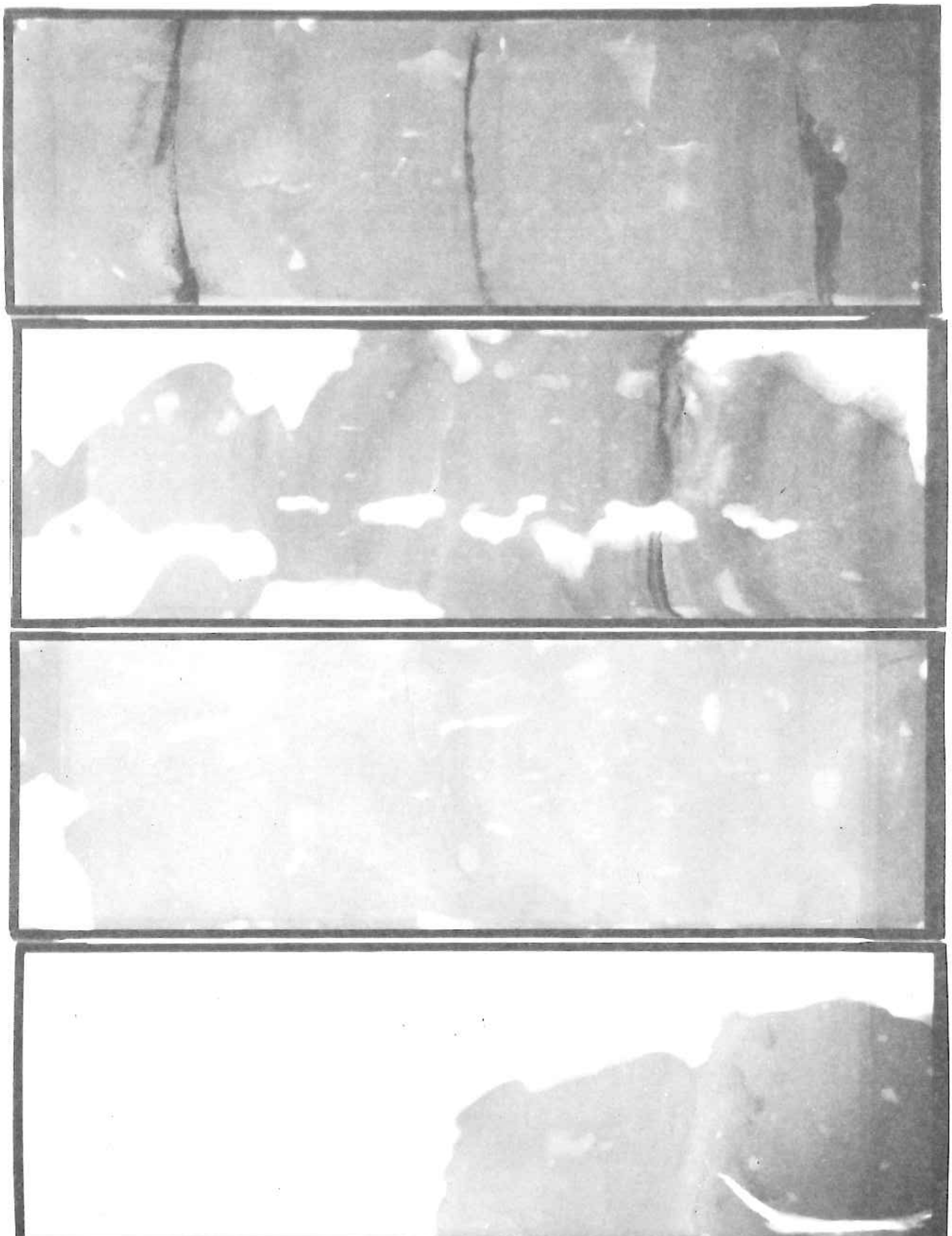
KH-86-1 P-1



280−300

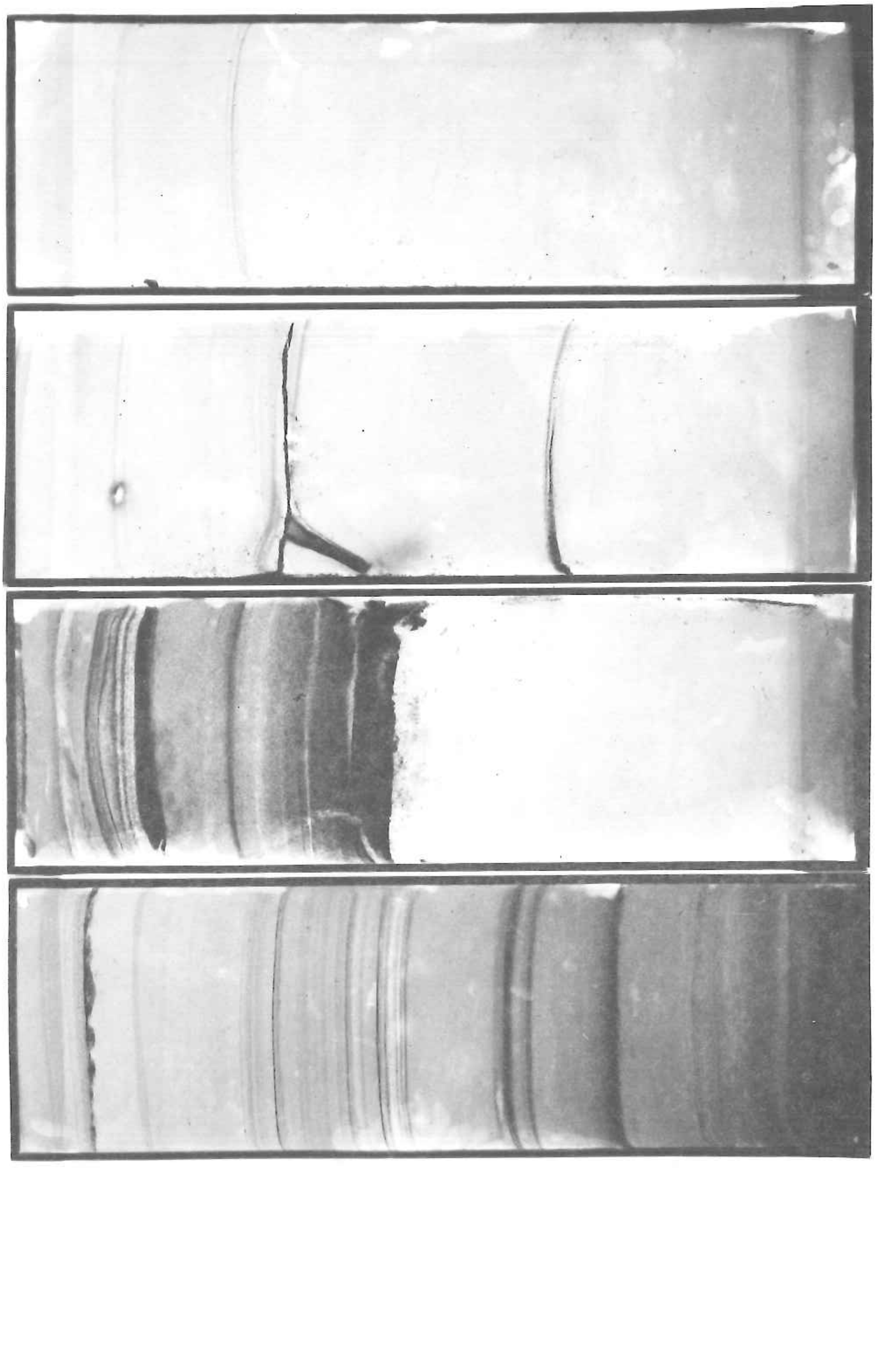
260−280

180−200

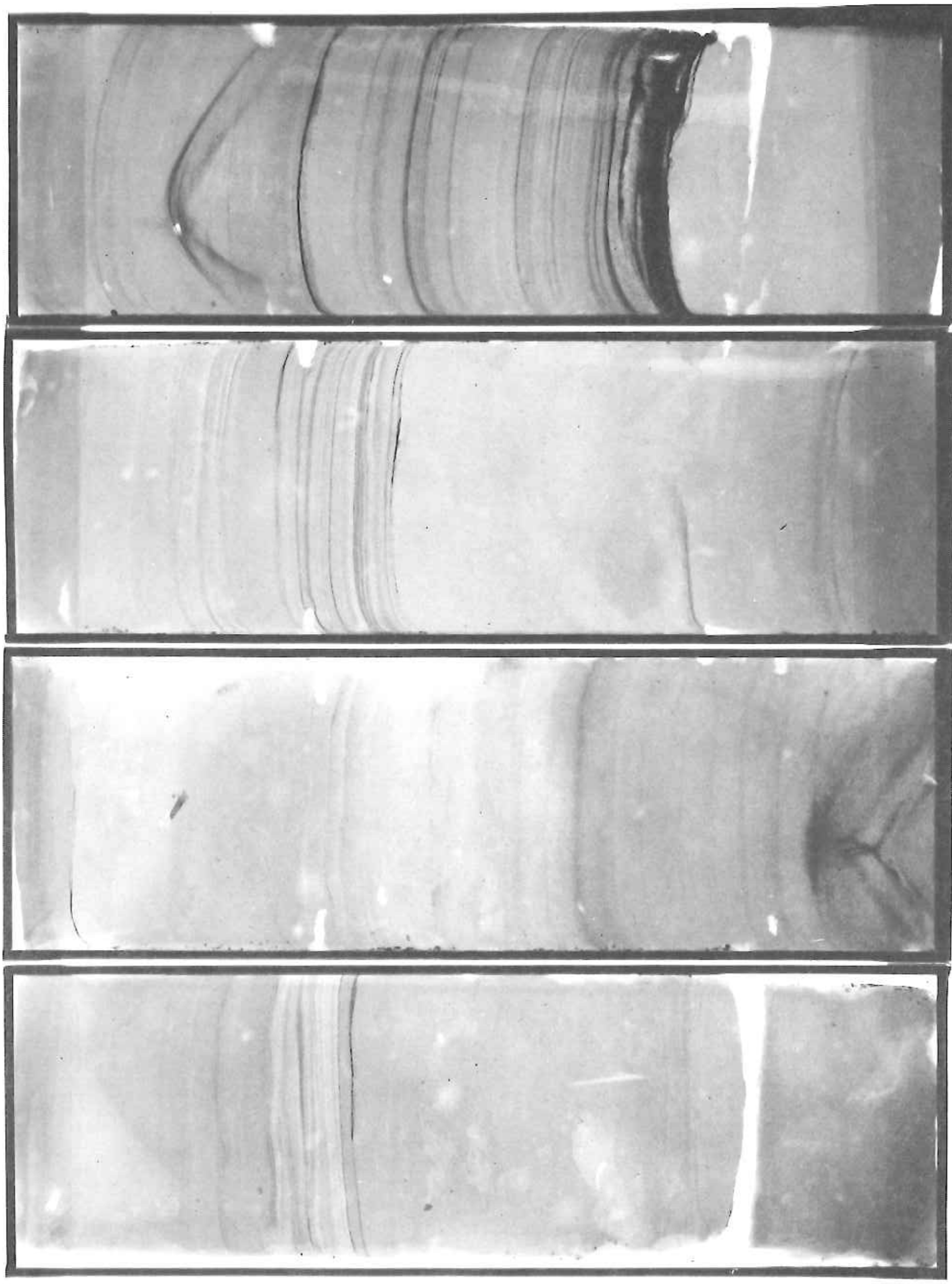


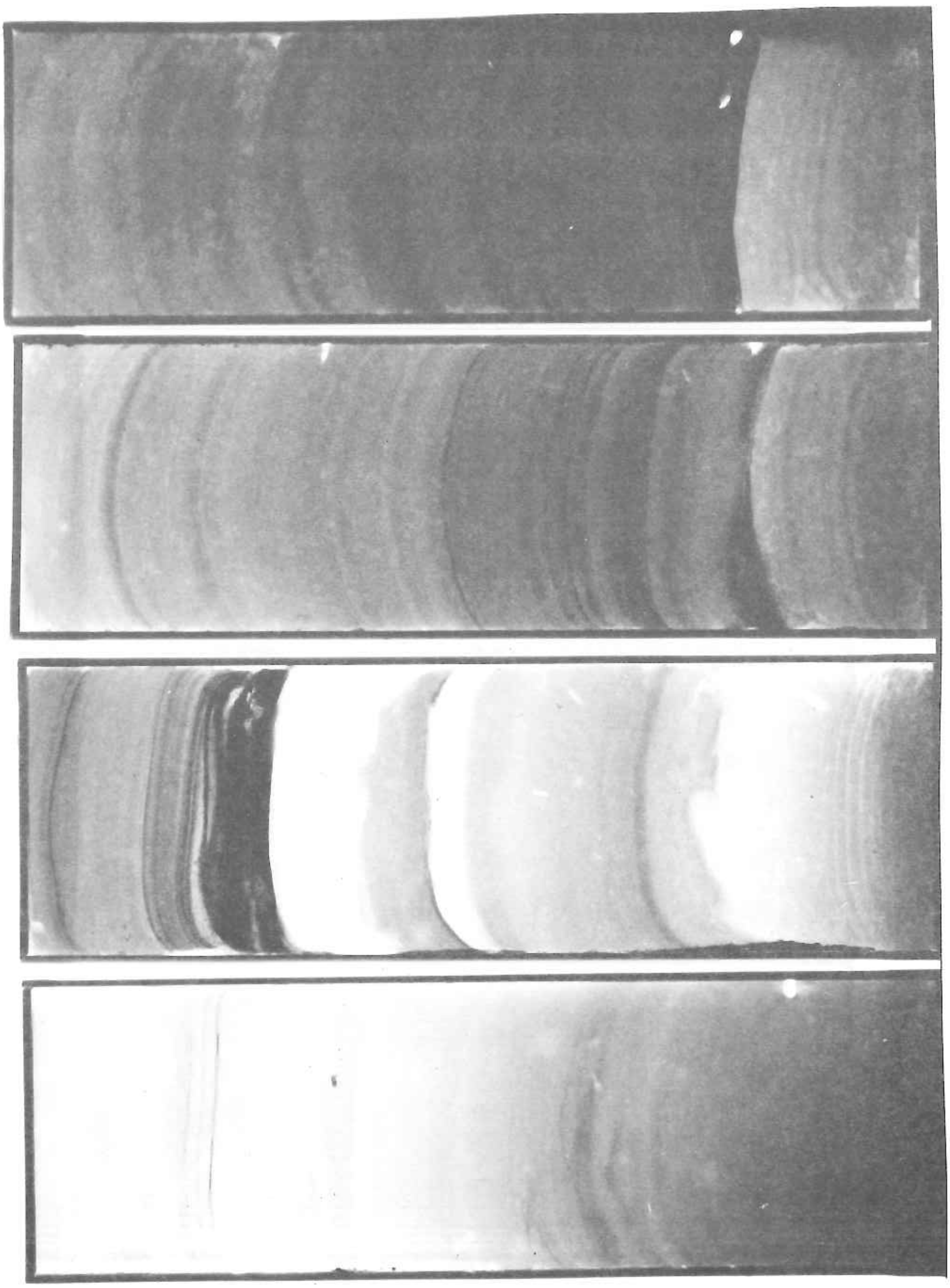
KH 86-1 P-2 0-80

KH 86-1 P-2 80-160

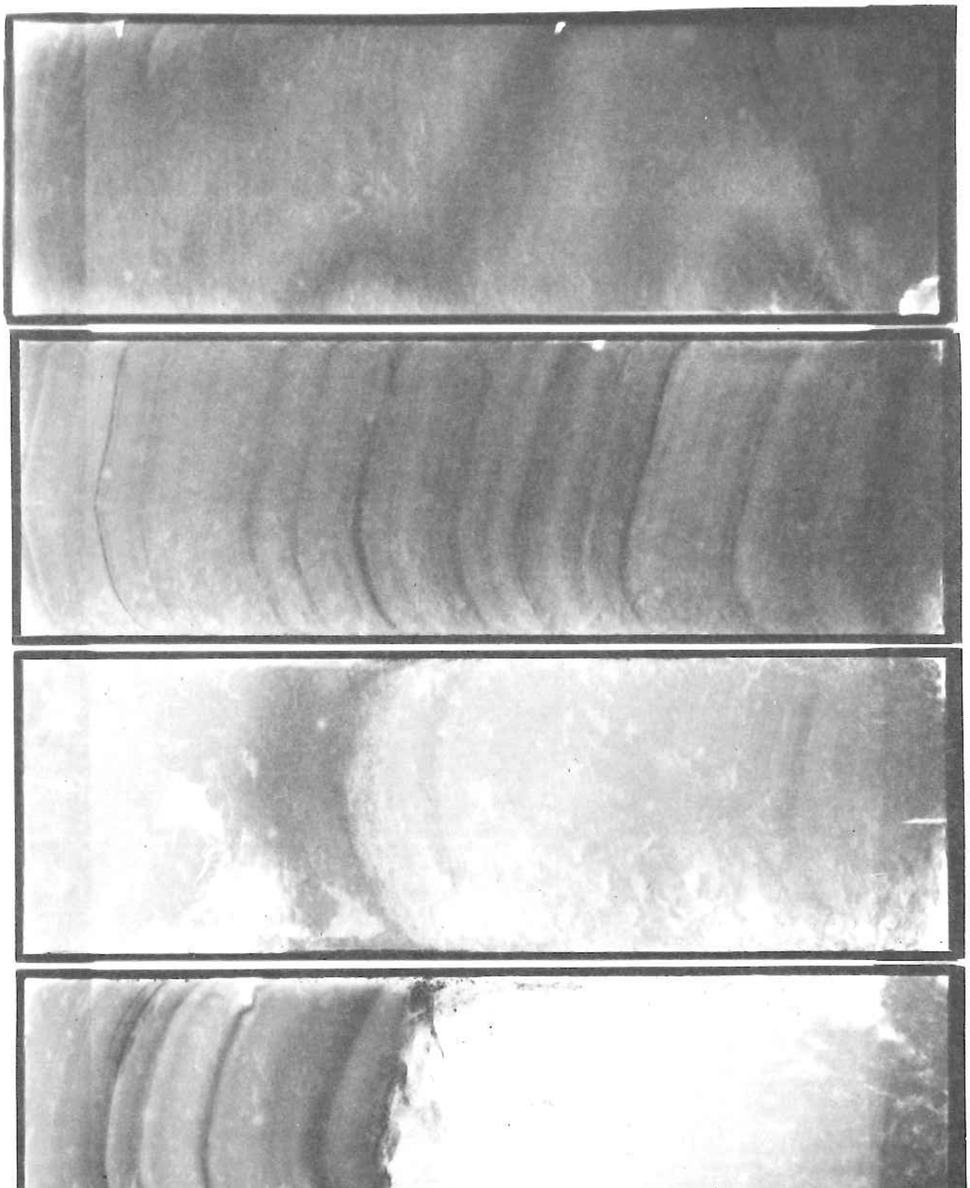


KH 86-1 P-2 160-240

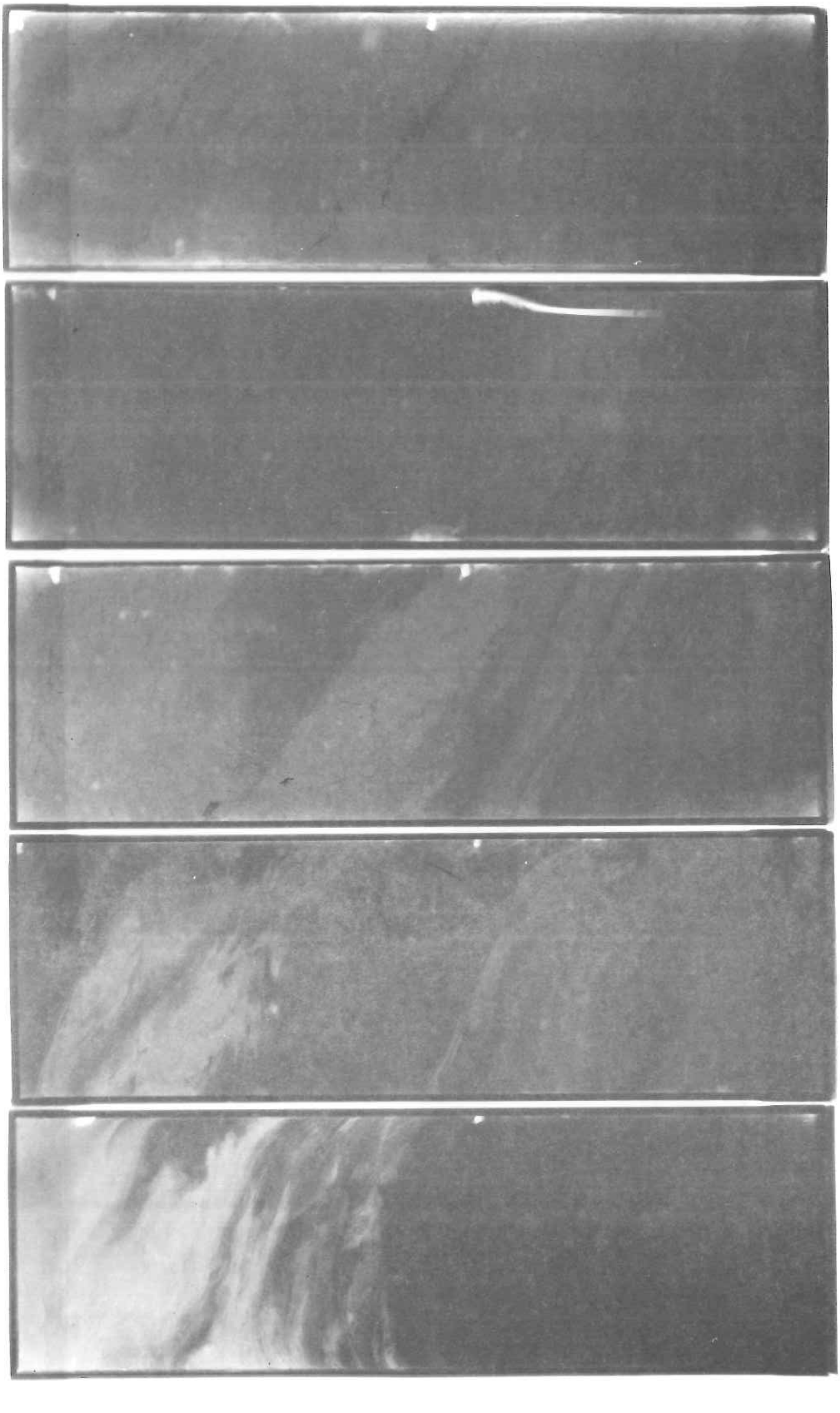




KH 86-1 P-2 240-320

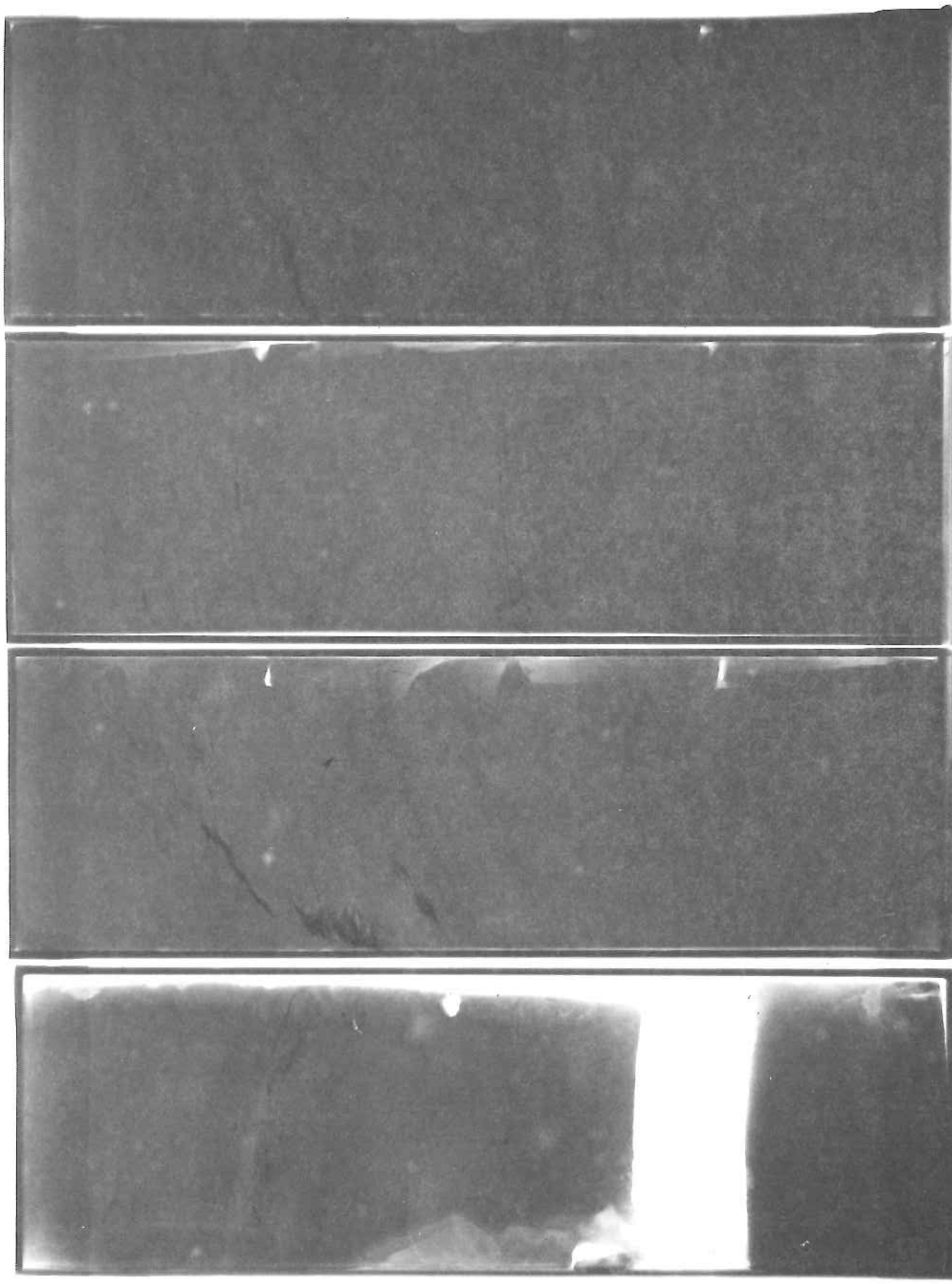


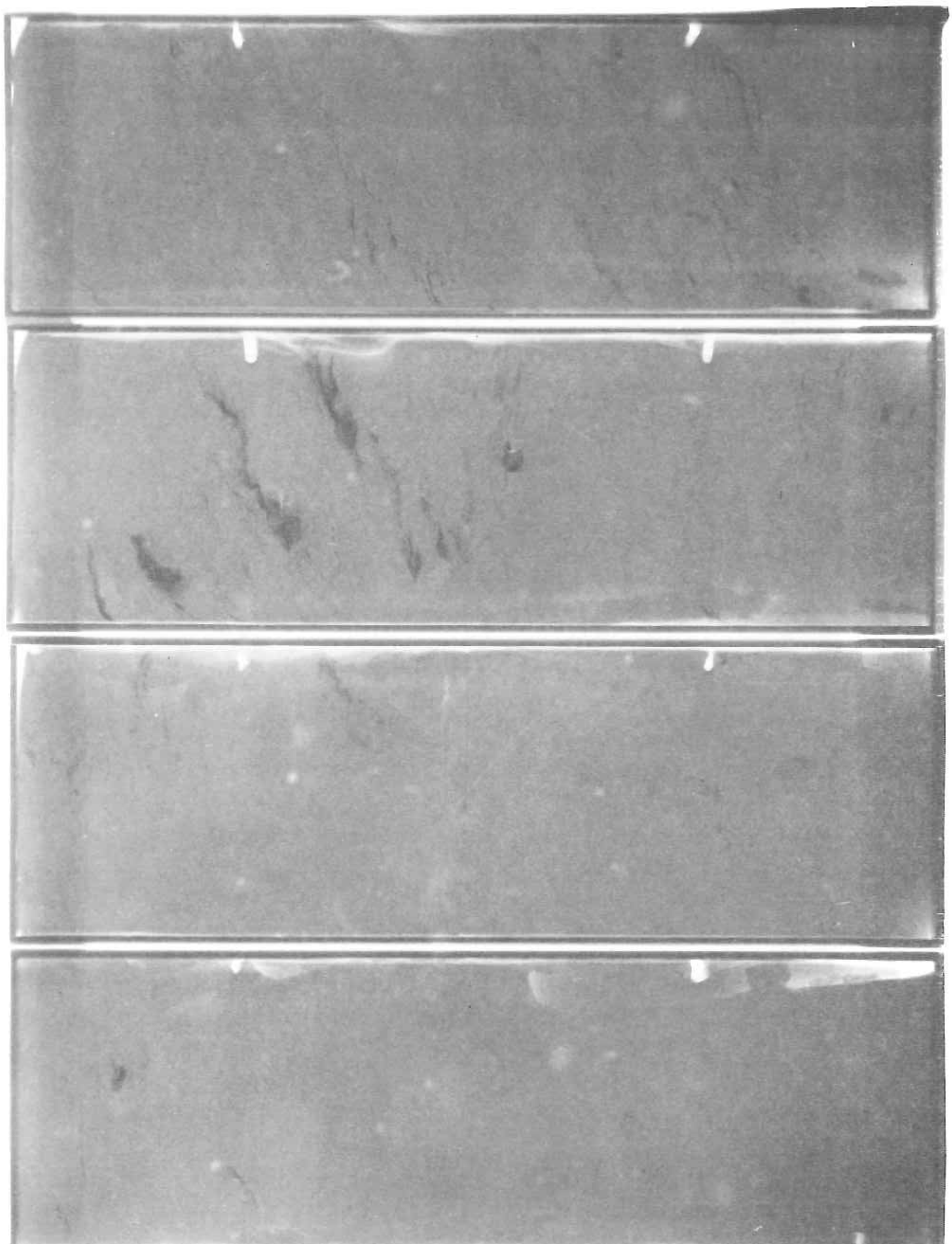
KH 86-1 P-2 320-400



KH 86-1 P-2 400-500

KH 86-1 P-2 500-580





KH 86-1 P-2 580-660

Table 9-3-5-1. Description of the upper turbidite unit in the P-2 piston core sediments.

Upper turbidite unit, PC-2 (Palau Trench)

No.	Base of Turbidite depth	Thickness of Bouma A-D	Thickness of Bouma E	Other Remarks
1	54.4	0.4	?	Uppermost part of the core in flowed
2	63.7	0.5	8.8	
3	70.3	0.2	6.4	Sole marking
4	78.8	1.2	7.3	ditto
5	82.1	1.4	1.9	1.0cm thick D
6	92.1	0.3	2.3	Contourite between No.5 and No.6
7	92.5	0.2	0.2	
8	94.5	0.8	1.3	
9	100.3	4.1	1.7	3.0cm thick D
10	103.4	2.4	0.7	Typical Bouma sequence
11	108.9	4.7	0.8	lacking of C
12	133.7	0.3	3.3	Parallel lamina (Contourite) between 108.9cm and 129.5cm
13	167.3	1.7	0.9	thin A, Contourite + pelagic clay between No.12 and No.13
14	167.6	0.1	0.2	C + E (lacking of A,B and D)
15	180.6	0.3	5.5(?)	
16	181.2	0.1	0.5	Contourite between 181.2cm and 204.8cm
17	208.5	2.6	1.1	B + C + D
18	226.0	1.7	2.3	Contourite + pelagic clay between 208.5cm and 221.0cm
19	234.4	6.9	1.1	A-D complete Bouma sequence, thick B
20	244.2	0.9	8.9	
21	247.1	1.3	1.3	
22	265.5	18.0	0.3	
23	269.3	2.0	1.8	
24	275.5	5.7	0.7	Sole marking
25	296.5	18.5	2.1	thick D, unclear C
26	316.4	19.4	0.5	
27	328.4	11.1	1.0	
28	347.2	3.7	15.1	Grading
29	378.5		8.8	laminae (sandy layer) on the slump unit(non turbidite)

developed from 85cm to 95cm are removed as normal faults which seems to have been formed by coring.

Layer parallel shear:

Layer parallel shears are dominantly developed through the core. These are resemble to laminae of sedimentary structure in their occurrence. Laminae are , however, composed of rather coarser grains as observed in the part above 40cm. Gouge of the layer parallel shears are composed of clay finer than surrounding mud/clay and indicate branch like occurrence in many case. The shears are recognized easily on some part because of clear displacement of dewatering veins such as 75cm.

Fold:

A fold of calcareous sand layer is found at 82cm core depth. Sand flows into the axial part of the fold and thins out into the limb. Asymmetric feature of the fold indicate that it was formed as drag fold in association with the layer parallel shearing.

Narrow spacing cleavage:

Narrow spacing cleavages vertical to layering are recognized from 60cm to 61cm, from 70cm to 80cm, and from 82cm to 85cm. The cleavages between 70cm and 80cm are difficult to discriminate from the dewatering veins but seem to be spaced narrower than the veins. The cleavages from 82cm to 85cm are developed in clay part of alternating layers of sand and clay. Some parts of the cleavages are displaced due to coring origin normal faults. These cleavages seems to primitive slaty cleavage caused by horizontal compressive stress.

Kink Band:

Kink bands are observed from 85cm to 105cm depth. Finally developed dewatering veins hide partly earlier deformation around there. Inbetween dewatering veins, kink bands deforming earlier layer parallel shears are observed. The sense of the kink band shows reverse fault like dislocation.

The profiles of the core below 136,5cm core-depth was taken in the vertical sense to the core above 136.5cm. As the result, the profiles indicate only parallel features to the strikes of dewatering veins and layer parallel shearing.

P-2

The column is divided largely into two units; upper turbidites (0-378.5cm) and lower slump units (378.5-1088.5cm).

In the upper unit, 28 turbidites are observed. the thickest turbidite has 19.4cm thick with complete Bouma sequence. In some part, contourites intercalated with pelagic clays are found. Description of each turbidite is shown in table 9-3-5-1. The lower unit of the core is composed of slump sediments. Just upon the slump sediments, parallel laminated sand and clay are accumulated. These layers are slightly inclined from the left to the right hand side on the radiograph. The uppermost part of the slump from 378.5cm to 440cm consists of folding clay. All axes of the folds are inclined as the same direction as the dip of the overlying laminated sand and clay layers. This asymmetric feature of the slump fold indicate that the slump was relatively slided from the left to the right hand side on the radiograph.

The internal structure of the slump below 440cm depth is characterized by flow structure with minor folds. the sense of the minor folds is similar to that of folds of uppermost part of the slump.

Below 515cm depth, the radiographs showed a mirror image in terms of sampling from the opposite side of half core. The sequence below 660cm depth was completely disturbed by slumping and sandy layers show boudinage or flow structures.

9-4. Grab sample

9-4-1. General remarks

Grab sampler is quite convenient to take a large amount of surface samples. We used stainless OKEAN type grab sampler for obtaining undisturbed surface sediments. Two sampling sites were chosen; the Yap Trench forearc ridge (G-1) and Yap Trench floor (G-2), respectively. Precise operation logs are listed in Table 9-4-1-1.

9-4-2. Lithology of grab samples

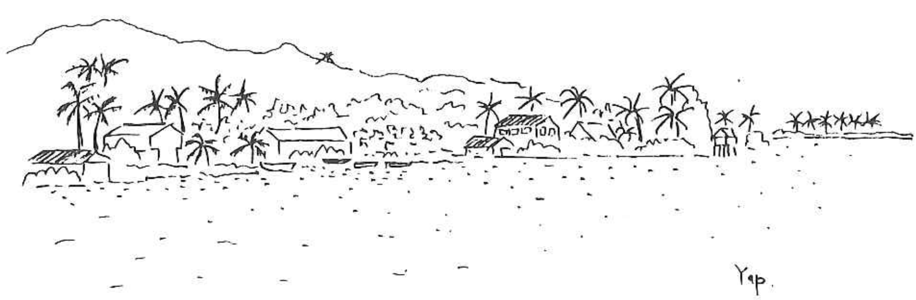
G-1

About 10 cm thick surface sediment was recovered by the operation. However, coring after recovery was not possible because of very loosened nature of foraminiferal ooze. Slightly pinkish colored foraminifer ooze was recovered. The ooze contains abundant planktonic foraminifers and extremely small amount of benthic foraminifers; however, no soupy ooze of

Table 9-4-1-1. Grab operation logs.

Date: Feb.10,1986   Ship: Hakuho Maru KH 86-1   Station: G-1
Lat.: 10 55.4'N   Long.: 138 25.7'E
Location: Yap Forearc Ridge
Weather: fine   Sea: calm
Bottom Topography: small depression on top of the ridge
Time Lowered : 10h01m   Uncorrected Water Depth: 3050m
Time on Bottom: 10h51m   Uncorrected Water Depth: 3080m
Wire Length : 3151m
Sample Recovered: Foraminiferal ooze

Date: Feb.19,1986   Ship: HakuhoMaru KH 86-1   Station: G-2
Lat.: 9 20.8'N   Long.: 138 24.9'E
Location: Yap Trench Floor
Weather: fine   Sea: calm
Bottom Topography: flat
Time Lowered : 13h12m   Uncorrected Water Depth: 7250m
Time on Bottom: 14h57m   Uncorrected Water Depth: 7180m
Wire Length : 7590m
Sample Recovered: Red clay with interbedded dark sand



nannofossil is contained in the ooze. Because of very loosened nature, no apparent sedimentary structure was recognized by visual investigation.

G-2

About 15 cm thick surface sediment was recovered by the grab sampling. The grab sampler was tilted during the operation. Considerable deformation on the sedimentary structure was made by tilting during sampling operations. However, surface red clay contains some interbedded sandy beds. The red clay contains some siliceous organic remains and siliceous spicules, but no nannofossil and foraminifer. Any grayish clay was not observed in any places of the sample. The sandy interbeds are dark colored and contain abundant heavy minerals and lithic fragments in addition to terrigenous grains of quartz and feldspars. The sandy grains also contain small amount of calcareous skeletons of benthic organisms. Some consolidated oxide bands (about 5 mm thick) were recognized as plane-like appearance.

9-5. Dredge Hauls

9-5-1. General Remarks

Rocks exposed on the Yap Islands are quite different with those of the Palau and Mariana; that is, high grade metamorphic rocks of the young age. Our purpose of this cruise is focused on the confirmation of the rock pieces distribute around the Yap Islands. Seismic profile lines are chosen in this respect just northwest of the Yap Islands as the landward reference site. Dredge hauls were also chosen on the multi-channel seismic profile line as the reference site of the land based geology of the Yap Islands. The other line is drawn just south of the Yap Islands to compare the rocks to those of the reference sites. The third line was chosen on the south block of the Yap system(see topographic chapter) in order to compare the rocks to those of the reference sites. Precise positions and operation logs are listed in Table 9-5-1-1.

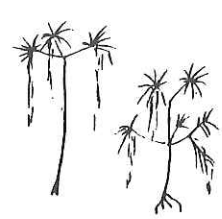
9-5-2. Operation

Dredge system we used in this cruise is shown in Fig. 9-5-2-1. Cylindrical chain type dredger was connected 10m chain

Table 9-5-1-1. Dredge operation logs.

Date: Feb.15,1986   Ship: Hakuho Maru KH 86-1   Station: D-1
Lat.: 9 38.1'N   Long.: 138 19.5'E
Location: Yap Trench Forearc Slope(off the Yap Island)
Weather: fine   Wind: 2m/s 80   Sea: calm
Bottom Topography: Steep slope
Type of Dredge : Cylindrical chain & two small cylindrical dredges
Additional Wt. : 3x50kg
Time Lowered : 22h25m   Uncorrected Water Depth: 2750m
Initial Time on Bottom: 23h13m   9 38.1'N 138 19.5'E
Uncorrected Water Depth: 2580m
Wire Length: 2855m   Wire Angle: 20
Direction of Haul: 260   Ship Speed: 1kt   Winch: No.5
Final Time on Bottom : 00h45m   9 37.7'N 138 18.0'E
Uncorrected Water Depth: 1900m
Wire Length: 3200m

Date: Feb.16,1986   Ship: Hakuho Maru KH 86-1   Station: D-2
Lat.: 9 36.8'N   Long.: 138 22.5'E
Location: Yap Trench Forearc Slope(off the Yap Island)
Weather: fine   Wind: Sea: calm
Bottom Topography: steep slope
Type of Dredge : Cylindrical chain & two cylindrical dredges
Additional Wt. : 4x50kg
Time Lowered : 08h40m   Uncorrected Water Depth: 4750m
Initial Time on Bottom: 10h23m   9 36.8'N 138 22.5'E
Uncorrected Water Depth: 4380m
Wire Length: 4957m   Wire Angle: 0
Directin of Haul : 270   Ship Speed: 1kt   Winch: No.1
Final Time on Bottom: 13h08m   9 35.3'N 138 21.6'E
Uncorrected Water Depth: 4080m
(minimum depthwas 3700m)
Wire Length: 4080m

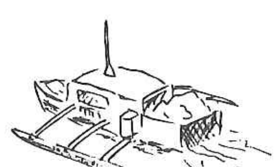


Date: Feb.18,1986 Ship: Hakuho Maru KH86-1 Station: D-3
Lat.: 9 19.2'N Long.: 138 03.3'E
Location: Yap Trench Forearc (southern portion)
Weather: fine Wind: 5m/s 80 Sea: calm
Bottom Topography: slope
Type of Dredge: Cylindrical chain & two cylindrical dredge
Additional Wt.:3x50kg
Time Lowered : 21h25m Uncorrected Water Depth: 2370m
Initial Time on Bottom: 22h10m 9 19.2'N 138 03.3'E
Uncorrected Water Depth: 2280m
Wire Length: 2377m Wire Angle: 0
Direction of Haul: 265 Ship Speed: Winch: No.5
Final Time on Bottom: 23h42m 9 18.4'N 138 00.8'E
Uncorrected Water Depth: 2220m
Wire Length: 2200m

Date: Feb.19,1986 Ship: Hakuho Maru KH 86-1 Station: D-4
Lat.: 9 13.0'N Long.: 138 10.1'E
Location: Yap Trench Forearc (southern portion)
Weather: fine Wind: 3-5m/s 90 Sea: calm
Bottom Topography: steep slope & small mound
Type of Dredge: Cylindrical chain & two cylindrical dredges
Additional Wt.: 4x50kg
Time Lowered : 05h56m Uncorrected Water Depth: 4050m
Initial Time on Bottom: 06h57m 9 13.0'N 138 10.1'E
Uncorrected Water Depth: 4000m
Wire Length: 4086m Wire Angle: 0
Direction of Haul: 270 Ship Speed:0.2-0.5kt Winch: No.1
Final Time on Bottom: 09h28m 9 12.9'N 138 06.9'E
Uncorrected Water Depth: 3050m
Wire Length: 4000m

Date: Feb.20,1986   Ship: Hakuho Maru KH 86-1   Station: D-5
Lat.: 10 29.9'N   Long.: 138 23.0'E
Location: Yap Forearc(northern portion)
Weather: rainy   Wind: 2m/s 230   Sea: calm
Bottom Topography: steep slope
Type of Dredge: Cylindrical chain & two cylindrical dredges
Time Lowered : 00h10m   Uncorrected Water Depth: 3340m
Initial Time on Bottom: 01h08m 10 29.9'N 138 23.0'E
Uncorrected Water Depth: 3220m
Wire Length: 3245m Wire Angle: 0
Direction of Haul: 270   Ship Speed:0.5-1kt Winch: No.5
Final Time on Bottom: 02h14m 10 29.9'N 138 24.3'E
Uncorrected Water Depth: 2810m
Wire Length: 3810m

Date: Feb.20,1986   Ship: Hakuho Maru KH86-1   Station: D-6
Lat.: 10 27.2'N   Long.: 138 28.5'E
Location: Yap Trench Forearc(northern portion)
Weather: rainy   Wind: 6-7m/s 90   Sea: calm
Bottom Topography:
Type of Dredge: Cylindrical chain & two cylindrical dredger
Time Lowered : 04h38m   Uncorrected Water Depth: 4550m
Initial Time on Bottom: 06h11m 10 27.2'N 138 28.5'E
Uncorrected Water Depth: 4380m
Wire Length: 4580m Wire Angle: 0
Direction of Haul: 270   Ship Speed: 1kt Winch: No.1
Final Time on Bottom: 08h28m 10 27.1'N 138 27.8'E
Uncorrected Water Depth: 4100m
Wire Length: 4520m



with three pillow type 50 kg weights. Chain bag wa connected by two small cylinder dredger to obtain much finer sediments as well. No. 1 and No. 5 winches were used depending on the water depth. First of all, topographic profile recovered by PDR was carefully examined to decide the dredge station. Wind speed and direction, current speed and direction is important to move the ship towards upslope. When the dredger reach the bottom, the ships head toward the direction which may orient upslope taking into account the wind and current. Extra 500 m wire takes out and then the tension meter is carefully observed whether dredger scream the surfaced rocks or not. Samples obtained during dredge hauls are described in Fig. 9-5-2-2.

9-5-3. Description of the dredged samples

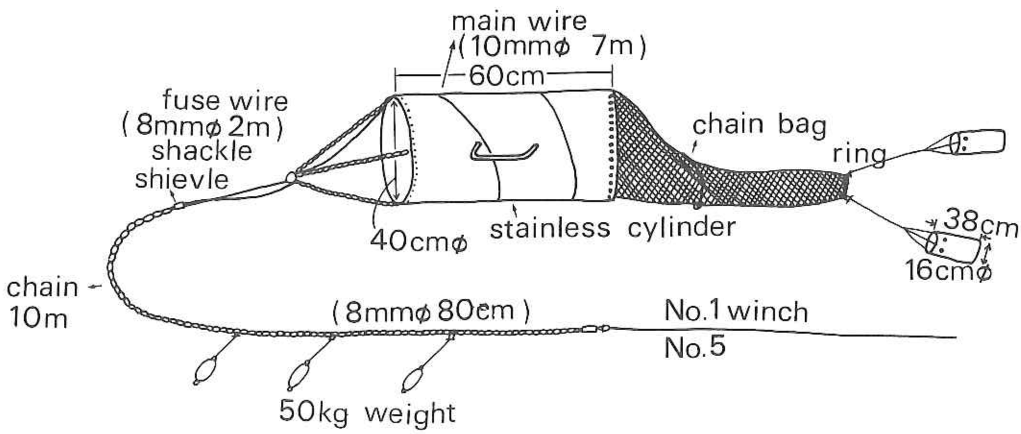
Photographs and the list of the obtained rocks are shown in Fig. 9-5-3-1 and Table 9-5-3-1.

KH 86-1 D-1:

This station is on the multi-channel Y-1 line which was surveyed during the cruise of KH84-1 , because of the being located nearest the Yap Island and so being as a reference site. Major rock type obtained at this station is amphibolite derived from basalt, basaltic tuff dolerite and gabbro. Most amphibolite has strong schistosity which was made by lineation of the green hornblende. Calcareous conglomerates,gneiss,and sandstones were obtained. Most rocks pieces show angular to subangular shape which represent the in situ cropping out. Breccia and serpentinite were also obtained. These rocks are quite similar to those exposed onshore Yap formation of the Yap Islands. Debris flow deposits exposed in the Yap formation. We obtained the matrix of the debris flow deposits as well at this station. This evidence support the station is a extension of the land geology of the Yap formation.

KH 86-1 D-2:

This dredge haul is fried on the Multichannel seismic line in the much deeper part of the D-1 station. More than 500 pieces of angular to subangular marble, Psammitic Gneiss, amphibolite, meta-gabbro, sandstones, meta-dolerite, meta-tuff. One olivine nodule was obtained from this station. Dolerite with contact of red shale was also recovered at the station.



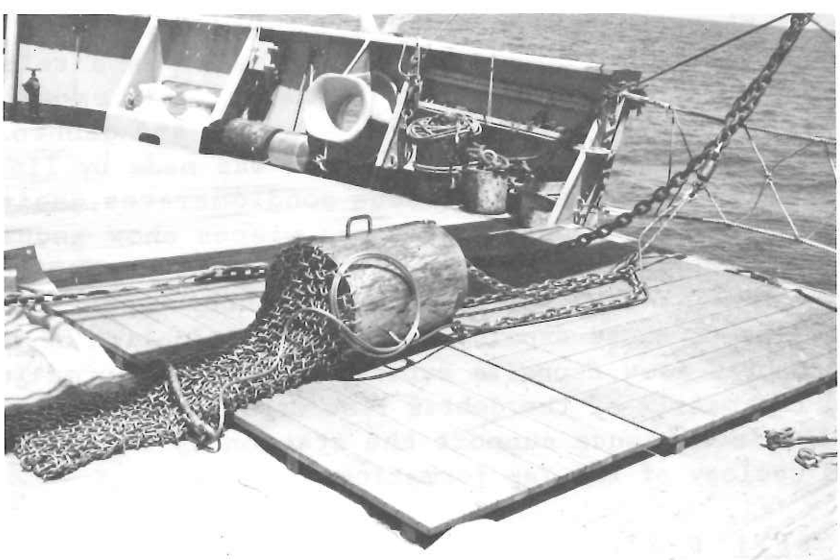
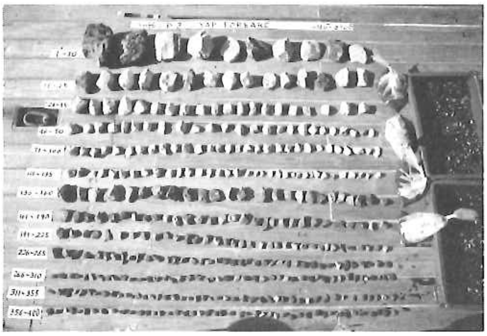


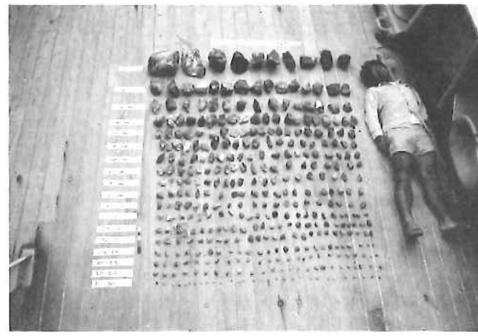
Fig. 9-5-2-1. Operation system for the cylindrical chain dredger used during the cruise KH86-1.

KH 86-1

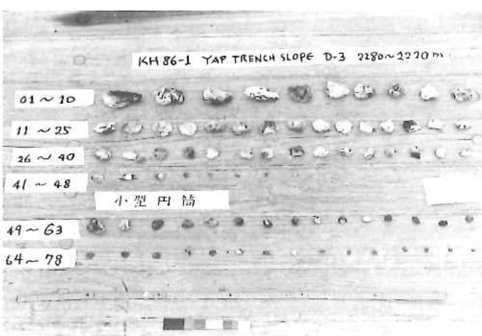
D1



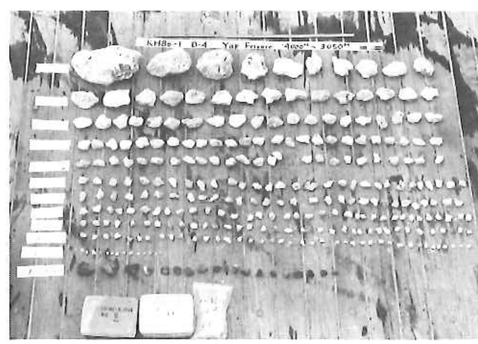
D2



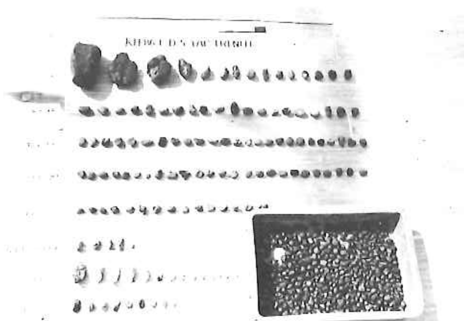
D3



D4



D5



D6

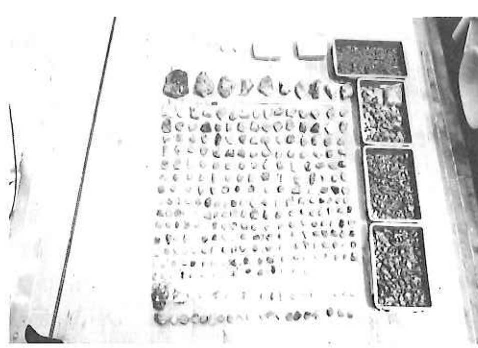


Fig. 9-5-2-2. Photographs of the rock samples recovered by dredge hauls during the cruise KH86-1.

Marbles were not found at D-1 stations. Some marble were quite pure, holocrystaline ones without Mn-coating. Gneisses expose on the Yap formation as the conglomerate. From the result of this dredge haul, gneiss exposed in situ in the deep sea. These rocks are quite similar to those of the Yap formation on land.

Results of D-1, D-2 support the stations are the seaward extension of the land geology of the Yap Islands. Taking in to account the general trend of the Yap formation being NE, tectonic block of the debris flows, high grade metamorphic rocks continue.

KH 86-1 D-3:

This station is located on the Multi-channel seismic line M-5 in which diagnostic topographic features were observed around 3000m and 4500m in water depth. D-3 was tried around water depth the former site. Topography is quite steep and cusp just around 3000m. Dredger landed at much shallower part of the slope. Major rocks obtained at this station is slightly Mn-coated grainstone-type lime stone. This rock type shows the fore reef sediments, just like the present fringing coral reef near the Yap Islands.

KH 86-1 D-4:

This dredge station was chosen at much deeper portion of M-5 seismic profile line. A large amount of various types of limestones were recovered. MOst of these limestones are coral reef origin. Limestone exposed onshore Yap Islands(Tayama,1935) belongs to the Quaternary Garim formation, of which crops out Garim Island east of Yap Main Island. It may be possibly analogous to the Garim limestone members or offshore coral reefs but it is necessary for further study onshore experiments.

KH 86-1 D-5:

This station was chosen on the seismic profile line M-2, because the site belongs to the northern portion of the Yap Arc-trench system so that the different rock types will be expected to recover. D-5 was tried at the shallower portion near the summit on the M-2 line. Various sizes and shapes of manganese crusted gravels and pumice fragments were recovered from the site. The more precise observation of the Mn-crust will be presented the following section. Tuff, breccia, tuffaceous sandstone, calcareous conglomerate, and serpentinites were also recovered from the site. These rocks may suggest the Quaternary volcanic activity around here.

KH 86-1 D-6:

This dredge haul was carried out at much deeper part of M-2 line. More than 1000 Pieces of rock fragments were obtained. They are serpentinite, Meta-tuff, Meta-basalt, Meta-dolerite, Meta-gabbro and hydrothermally altered rocks. Dacite, and rhyolite were also obtained at this site.

Hydrothermally altered rocks are light yellowish brown (nontronite) rocks which were not recognized original texture. This and also another evidence suggests the in situ or nearly hydrothermal activity relating to the volcanic activity of the northern part of the Yap arc-trench system.

9-5-4. Limestone samples recovered by dredge haul

Several types of limestones were unexpectedly recovered by dredge hauls. They are chalk, lithified chalk hardground, grainstone-type limestone, and coral reefal limestones including coral fragments. These different types of limestones were recovered from the different locations of the dredge hauls. A brief summary on the lithologic description of these limestones is given in this section.

Chalk from D-1 site: Several pieces of boulder-sized chalk were dredged together with metamorphic and igneous rocks. The chalk boulders are suspected to be derived from some undersea exposures of chalk beds, judging from the hardness and shape of the boulders. However, the exposures of the beds should be proved by the seismic or drilling investigations. The chalk contains nannofossils and foraminifers. The paleontological age determination of the chalk is required to confirm the possible exposures of the ancient chalk beds in the ocean floor.

Grainstone-type limestone from D-3 site: Some of the grainstone-limestone samples are stratified with the approximately 1 cm thick bed, but most of them do not show the bedding planes. The one in which the stratification is evident was termed as Biostrom grainstone. The boulders or the gravels of the limestone are crusted by manganese oxides, but the apparent thickness of the manganese crust was not determined.

Some of them are partially crusted by manganese oxides. They are also boreholed by organisms. Several coral fragments (biolithite) were also dredged from the D-3 site. The biolithites are rather loose and porous but some of them show well lithified texture of corals.

The grainstone limestone is composed of, foraminifer chambers which are cemented by sparry calcite cement. Tuffaceous material or siliciclastic material was not observed in the limestone. The limestone may be different from from types of the samples recovered from the KH-84-1 St. 5 of the Ogasawara Plateau, which are termed as grainstone to (tuffaceous) calcareous sandstone by Konishi (1985) and Ishii et al. (1985). The genesis of the grainstone limestone is speculative but the limestone may belong to the similar types of "Awaishi Limestone" in the Okinawa Island, which is foraminiferous biosparite limestone as the terrace deposit. Although more detail petrographic and other investigations are required to clarify the genesis of the grainstone/"Awaishi" limestones, the grainstone limestone is suspected to be shallow lagoonal or back-reef environmental deposit. in other words, the once shallow water sequences may be exposed in the under sea cliff to deposit their fragments as tallus. Judging from the manganese crustal conditions, the tallus may be deposited in the ocean floor at the very recent period.

Several coral fragments (biolithite) were also dredged from the D-3 site. The biolithites are rather loose and porous but some of them show well lithified texture of corals.

<u>Coralline limestones and lithified hardground chalk from D-4 site:</u>

A large amount of coral fragments and coralline limestones was recovered from the D-4 site dredge hauls. They are not crusts by manganese oxide but moderately rounded, or some of them show erosional surface. One large boulder (weighed 10 kg) is moderately chalky limestone in which erosional surfaces and crinoid stems are represented. No nannofossil was observed in the limestone, except for recrystallized minute calcite crystals. The lithified chalky limestone is considered as chalk hardground in which some replacements and lithification may take place on the semiconsolidated chalk beds (Mullins et al., 1984; Kennedy and Garrison, 1975).

The coral fragments and coralline limestones are categorized into coralline biomicrudite, coralline biomiclulite, and biolithite as shown in Table 9-5-3-1. the coralline biomicrudite or biomiclutite is the reefal limestone as products of reefal growth, and the texture differences, such as gravely or mudstone textures, may classified them into two types. The biolithite is a part of corals skeletons. Some biolithites are very micritic but they cannot be recognized as the lithified chalk hardground. When th size of the gravel becomes small, it may be difficult to differentiate the fragments of dead corals from the loosened gravels of the biomicrudite.

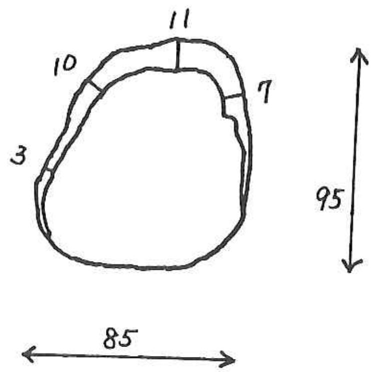
The coralline limestone boulders and gravels may be derived from some subsided coral reefs in the water depth of about 4000 m at the Yap forearc. Hawkins and Batiza (1977) reported very shortly on the dredge haul of coral fragments off the arc ridges in the dredging depths between 4028 m and 1492 m. Therefore, the submerged coral reefs would be common at around 3000 m or 4000 m water depths off the Yap arc ridges. The gravel-sized corals could be also considered as debris flow from shallow floors along the slope; However, the size of boulder gravel would be too large to be considered as debris flow or other long-distance transported deposits (Mullins et al., 1984).

The age of coralline limestone and the lithified chalk hardground is very speculative and more detailed onshore studies would be required. Judging from the lithified conditions of the hardground chalk and the lithologic situations of the coral fragments and coralline limestones, the hardground chalk could be older and bedded at the lower places than the coralline limestones.

9-5-5. Manganese crust recovered by dredge hauls

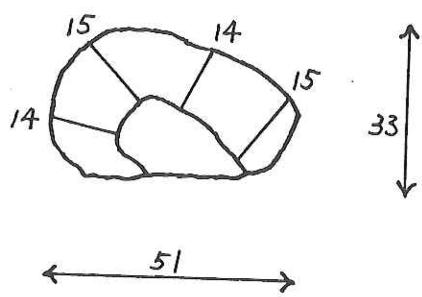
The thickness and crustal situations of the manganese crusted gravels and boulders were briefly investigated on the larger selected samples. The tables and sketch figures show the results of the investigation. Since the manganese crusted gravels were dredged from the wide depth ranged (between 3220 and 2810 m) along the slope, the depth variations on the crust thickness and chemical compositions of the crust are very speculative. Among of the investigated gravels, the thickest crust was about 20 mm but the thinnest one is as thin as 1 mm. No relationship between the thickness and the size of the gravels was recognized. Some irregularity on crusting and conjugating crust of more than the gravels or the manganese intrusion along the fracture of the inside gravels were also

#001



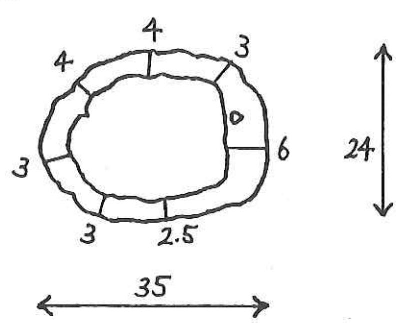
Core Rock: Conglomerate
(sandstone matrix)

#004



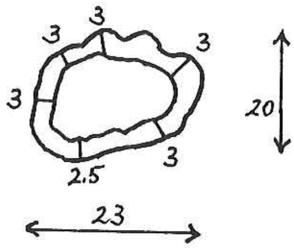
Core Rock: Conglomerate
(sandstone matrix)

#008



Core Rock: Conglomerate
(sandstone matrix)

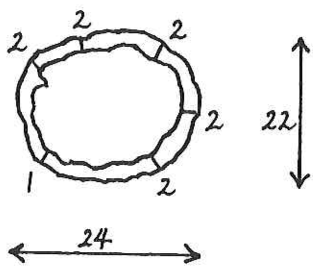
#009



Core Rock:

Yellowish green siltstone

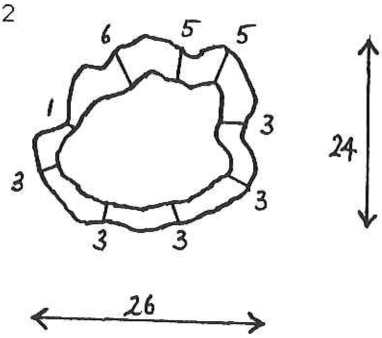
#010



Core Rock:

Yellowish green fine sandstone

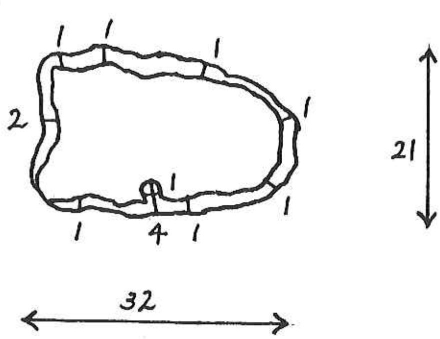
#012



Core Rock:

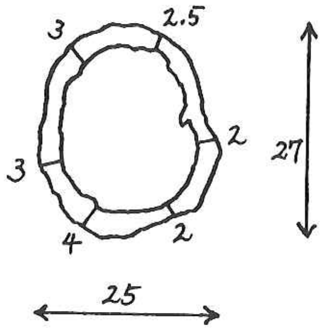
Yellowish brown mudstone

#014



Core Rock: Conglomerate
(Fine sandstone matrix)

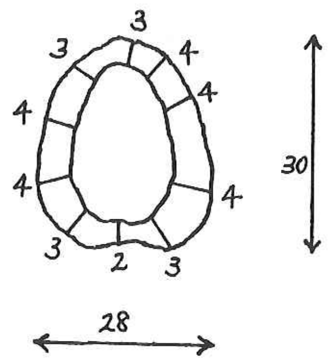
#016



Core Rock:

Yellowish siltstone
(Fractured)

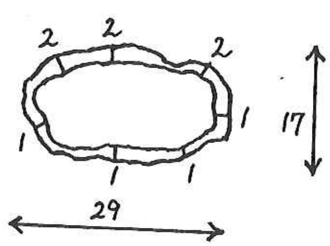
#024



Core Rock:

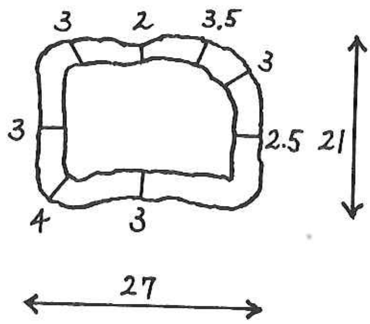
Brownish mudstone

#037



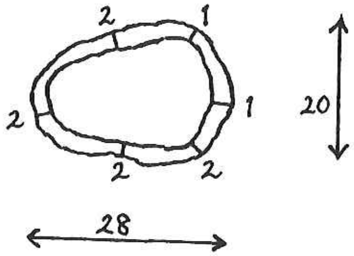
Core Rock: Laminated mudstone
with some gravels

#038



Core Rock: Conglomerate
(mudstone matrix)

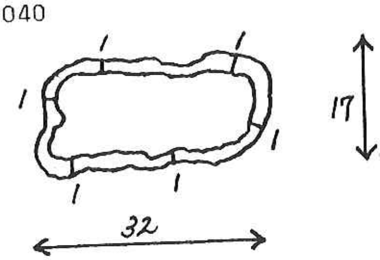
#039



Core Rock:

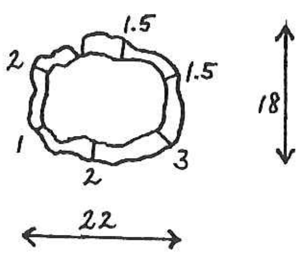
Yellowish medium sandstone

#040



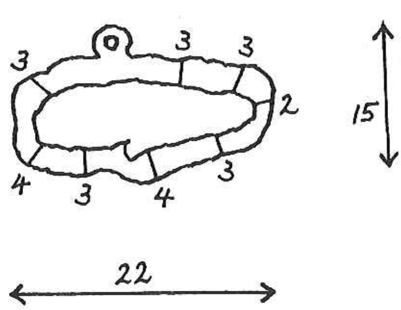
Core Rock: Conglomerate
(siltstone matrix)

#041



Core Rock: Conglomerate
(Silica cemented sandstone)

#042



Core Rock: Laminated mudstone
(bedding plane is folded)

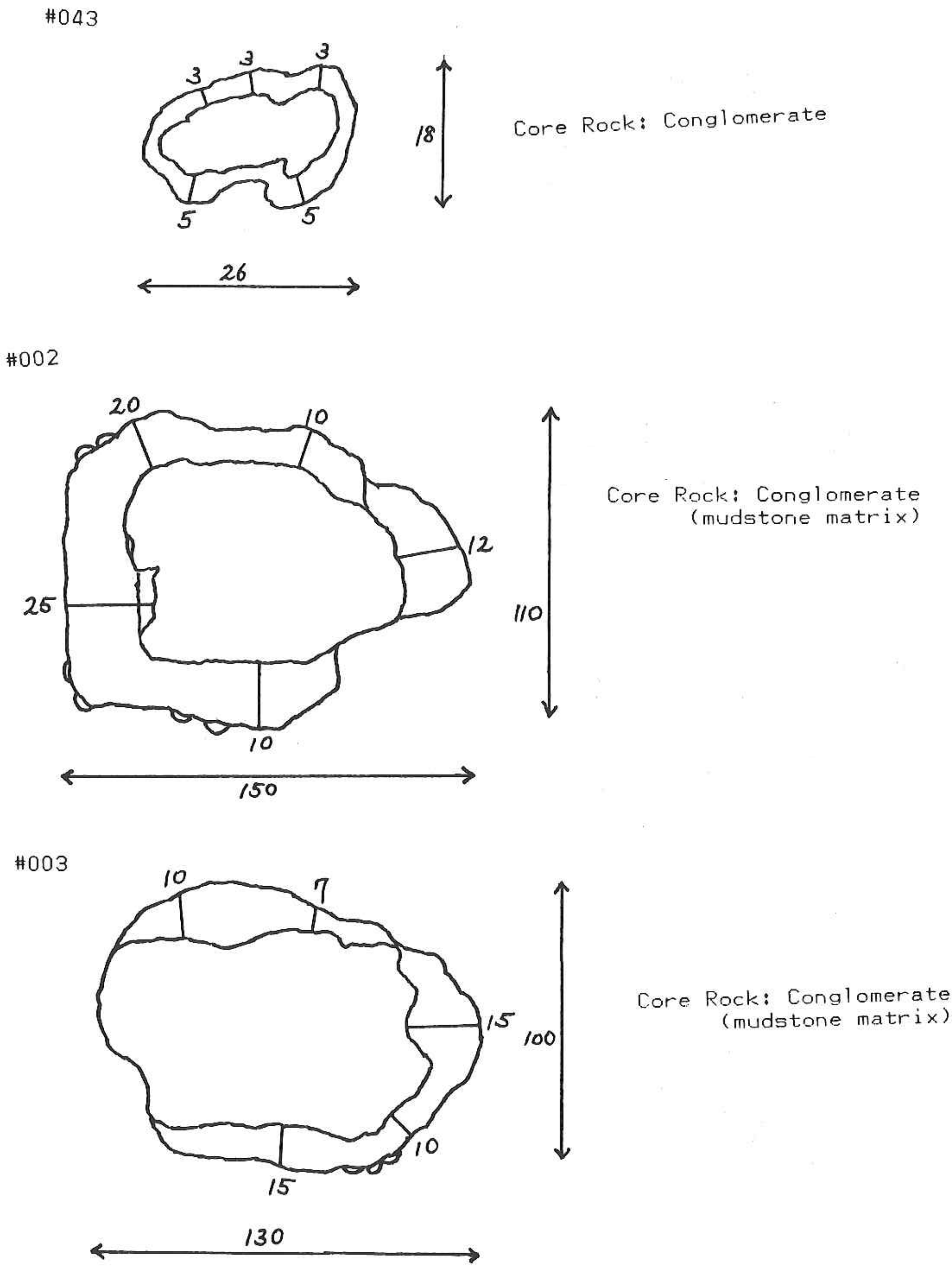


Fig. 9-5-5-1. Sketches of the selected Mn nodules recovered by dredge haul (D-5).

recognized. The inside gravels are mostly yellowish clastic rocks. Conglomerate, sandstone, silt stone, and mudstone were recognized as inside gravels. some of them are bedded or fractured and the deformation on the bedding plane was observed on a very few sample. The heavy metal compositions of the crust, particularly on Mn, Fe, Co, and Ni will be studied at the onshore laboratories and the growth rate of the crust would be also attempted at the laboratory.

9-6. Deep sea cameras

Eight-operations of deep sea photography were attempted by wired stereoscopic deep sea camera system during the cruise. The precise camera operations are listed in Table 9-6-2. The camera system was the same as that of during KH 84-1 cruise. But in this cruise, one new payload, Digital Memoryed Compass, added in this system (Fig. 9-6-1).

This compass was function that the potential difference between flash direction and N pole was measured and then synchronize with flash trigger and write into RAM with time and gradient data as for the inclination of the outcrops. These data were moved into the computer onboard after the recovery of the Camera Unit. This compass was tested at seven operations of the Camera sites except one operation because the Rated Depth of the compass's pressure resistant aluminum cylinder might be exceeded.

Specifications of Bentos type 372 camera and type 382 electron-flash also were already shown in Table 8-1 in the Preliminary Cruise Report of KH 84-1.(Watanabe & Ishii, 1985).

Specifications of Digital Memoryed Compass made by KAIYODENSHI Co. Ltd. are shown in Table 9-6-1 and the graphic pattern of the compass records by computed onboard is also shown in Fig. 9-6-2.

9-7. Geologic outline of the Yap islands

9-7-1. Introduction

The Yap islands are situated at the southern margin of the Philippine sea Plate. the Yap trench is geomorphologically clear, however, no recent volcanism is observed in the Yap islands. The island are composed mainly of metamorphic rocks

Table 9-6-1. Specification of Digital Memoryed Compass

Rated depth	6000m	
Cases	Diameter 80mm x 400mm aluminium sylinder	
Data of record	(1) compass	: o - 359 , 1° step
	(2) sensor of gradient	: max direction 15°
	(3) time	: hour,minite,second
Capacity of data	999 data	
Trigger of measuring	(1) inner trigger	: 4,6,10,20,40,60sec
	(2) external trigger	: TTL/CMOS level positive pulse
Interface	RS-232C serial interface	
Battery	DC 9 volt (UM-2 dry sell battery 1.5 volt x 6)	

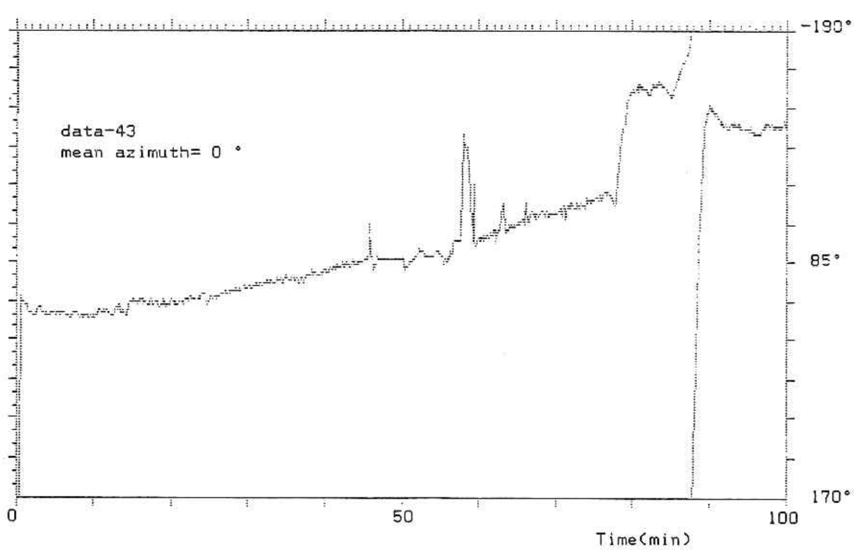


Fig. 9-6-2 Example:graphic patern of compass record ,station KH86-1-43
It seems that camera unit was hit on the bottom ,a few times.
(Programed by TAKEUCHI and UCHIYAMA)

Table 9-6-2. Operation logs of deep sea camera.

Date	February 5,1986	February 8,1986
Station No.	KH86-1-21 (C-1)	KH86-1-27 (C-2)
Location	Palau Trench	Yap Trench Forearc
Wether	Fine	Fine
Wind	300° 5m/sec	180° 10m/sec
Sea	Good	Good
Bottom topography	Slope	Slope
Water depth(start)	6350m	6850m
(finish)	6300m	7050m
Film & Film length	Kodak 5294(100ft)	Kodak 5294(100ft)
Battery No.	No.86-01	No.81-01
Lens focussed(camera A)	1.2m	1.2m
(camera B)	1.2m	1.2m
Iris(camera A)	11	11
(camera B)	11	11
Shot interval	6sec	6sec
Compass	Int trigger(10sec)	Int trigger(10sec)
Time lowed	23:20	22:01
& location	7°40.6N 134°51.4E	10°24.1N 138°38.0E
Shot start time	01:14	23:55
& location	7°40.4N 134°51.8E	10°23.7N 138°38.1E
Shot finish time	02:34	00:42
& location	7°40.1N 134°51.8E	10°23.4N 138°38.0E
Time surfaced	04:11	02:20
& location	7°40.0N 134°51.7E	10°23.4N 138°38.0E
Result	Fig 9-6-3,9-6-4	Nothing
Remarks	Combined with Piston core P-2	withdraw camera navigation

February 10,1986	February 15,1986	February 16,1986
KH86-1-30 (C-3)	KH86-1-32 (C-4)	KH86-1-34 (C-5)
Yap Ridge Northern Portion	Yap Trench Forearc Central Portion	Yap Trench Forearc Central Portion
Rain	Fine	Fine
180° 15m/sec	110° 5m/sec	110° 5m/sec
Moderate	Good	Smell
Slope	Slope	Flat
3080m	3100m	6000m
2950m	2850m	5500m
Kodak 5294(100ft)	Kodak 5294(100ft)	Kodak 5294(100ft)
No.86-01	No.86-01	No.81-03
1.2m	1.2m	1.2m
1.2m	1.2m	1.2m
11	11	11
11	11	11
6sec	6sec	6sec
Ext trigger(6sec)	Ext trigger(6sec)	Ext trigger(6sec)
06:49	18:40	03:45
10°55.7N 138°26.3E	9°38.7N 138°20.1E	9°37.0N 138°24.1E
07:20	19:39	05:24
10°55.4N 138°25.9E	9°38.1N 138°20.3E	9°37.6N 138°24.0E
08:35	20:54	06:39
10°55.0N 138°25.7E	9°37.6N 138°20.2E	9°37.3N 138°22.9E
09:20	21:46	07:51
10°54.7N 138°25.5E	9°37.0N 138°20.0E	9°37.1N 138°22.5E
Fig.9-6-5,9-6-6	Fig.9-6-7,9-6-8	Fig.9-6-9,9-6-10
Combined with Grab G-1	Combined with Dredge haul D-1	Combined with Dredge haul D-2

February 16,1986	February 18,1986	February 19,1986
KH86-1-36 (C-6)	KH86-1-43 (C-7)	KH86-1-45 (C-8)
Yap Trench Forearc Central Portion	Yap Trench Forearc Southern Portion	Yap Trench Forearc Northern Portion
Fine	Fine	Fine
30° 5m/sec	50° 8m/sec	100° 5m/sec
Good	Swell	Good
Flat	Slope	Flat
7985m	2550m	3910m
7850m	2780m	3905m
Kodak 5294(100ft)	Kodak 5294(100ft)	Kodak 5294(100ft)
No.86-01	No.86-01	No.81-03
1.2m	1.2m	1.2m
1.2m	1.2m	1.2m
11	11	11
11	11	11
6sec	6sec	6sec
Ext trigger(6sec)	Ext trigger(6sec)	Ext trigger(6sec)
16:06	18:20	01:45
9°42.1N 138°31.2E	9°19.2N 138°03.6E	9°15.2N 138°10.0E
18:20	19:05	03:00
9°41.1N 138°30.8E	9°18.8N 138°03.4	9°14.9N 138°09.7E
19:35	20:20	04:15
9°41.0N 138°30.9E	9°17.7N 138°03.5E	9°14.6N 138°09.4E
22:08	20:58	05:08
9°40.3N 138°32.0E	9°17.6N 138°03.6E	9°14.4N 138°09.1E
Fig.9-6-11,9-6-12	Fig.9-6-13,9-6-14	Fig.9-6-15,9-6-16
	Combine with Dredge houl D-3	Combine with Dredge houl D-4

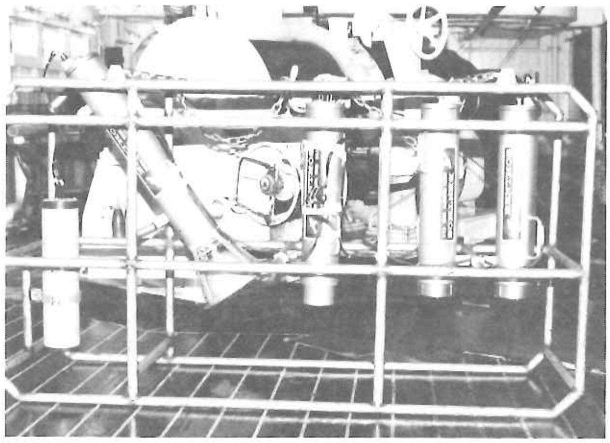


Fig.9-6-1 Photograph of Deep Sea Camera System Note:CA;camera A,CB;camera B, EF;electro-flash,SP;sonar pinger,DC;digital memoryed compass

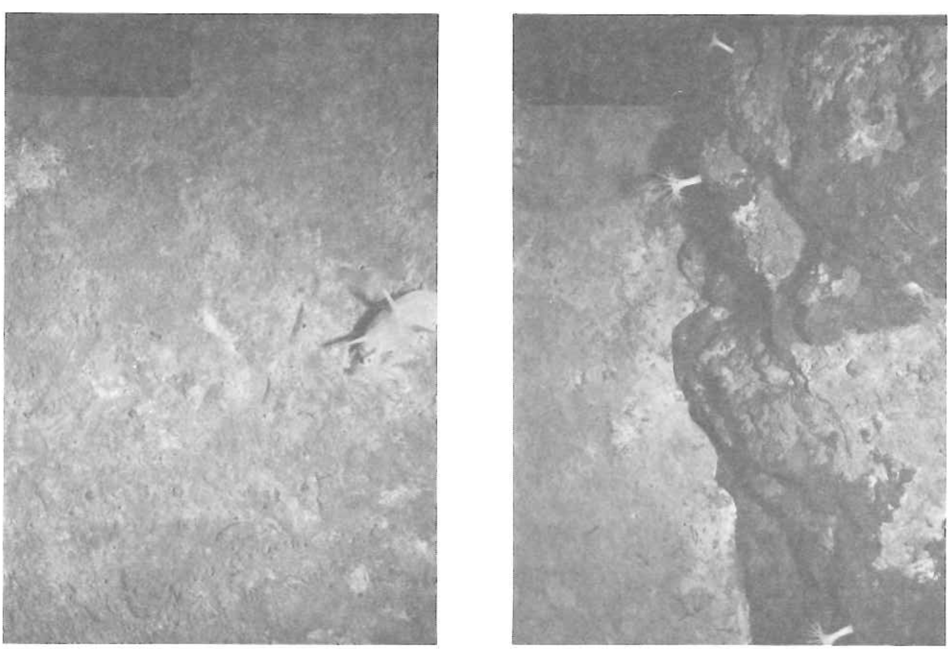


Fig.9-6-3,9-6-4 Topography of the bottom,KH86-1-21(Palau Trench, Depth 6300m)

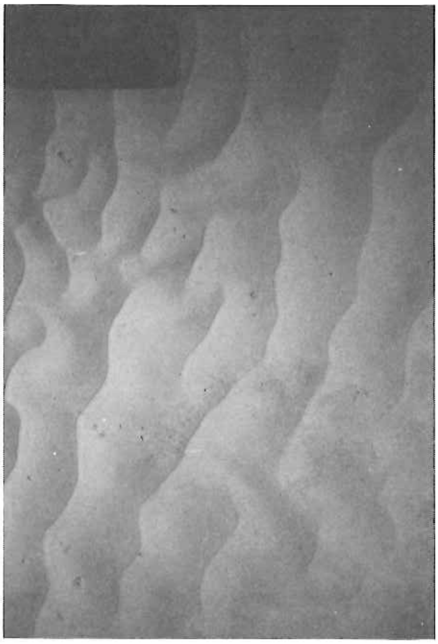
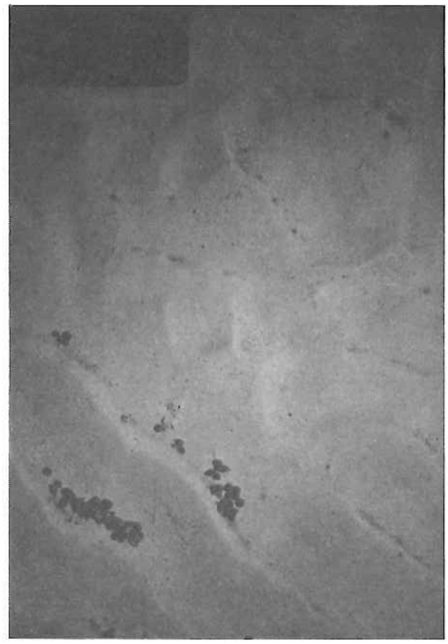



Fig.9-6-5,9-6-6 Topography of the bottom,KH86-1-30(Yap Ridge, Depth 2950m)

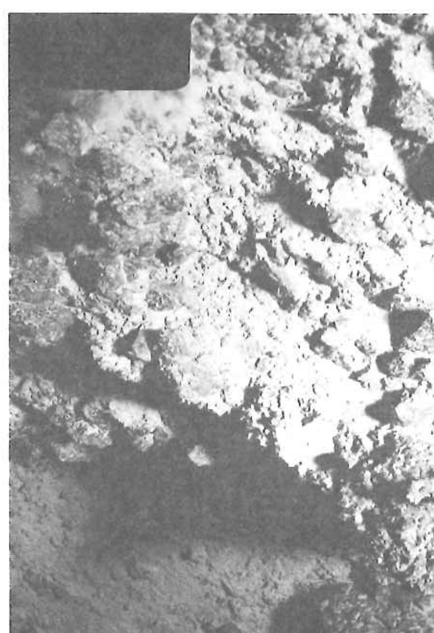



Fig.9-6-7,9-6-8 Topography of the bottom,KH86-1-32(Yap Trench, Depth 2850m)

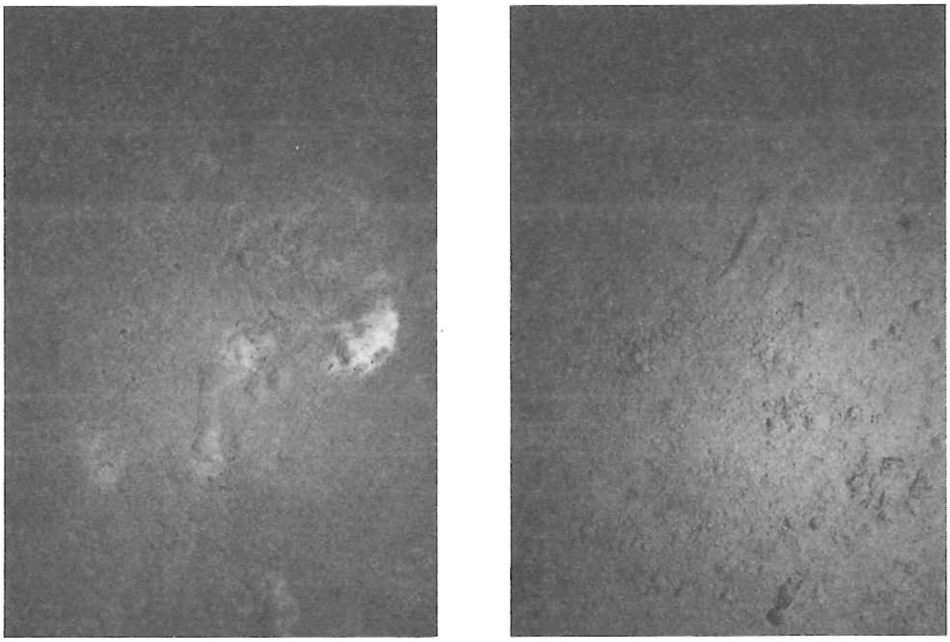


Fig.9-6-9,9-6-10 Topography of the bottom,KH86-1-34(Yap Trench, Depth 5500m)

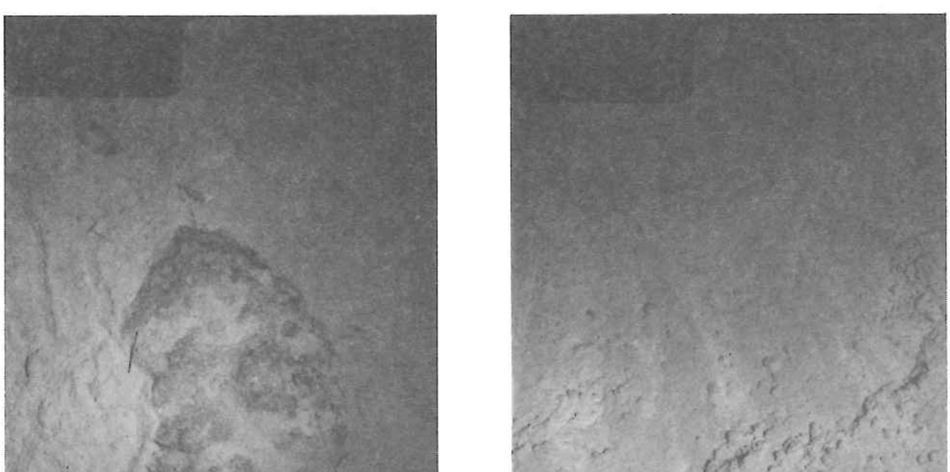


Fig.9-6-11,9-6-12 Topography of the bottom,KH86-1-36(Yap Trench, Depth 7850m)


Fig.9-6-13,9-6-14 Topography of the bottom,KH86-1-43(Yap Trench, Depth 2780m)


Fig.9-6-15,9-6-16 Topography of the bottom,KH86-1-45(Yap Trench, Depth 3905m)

and a few of old volcanics (Tayama, 1935 etc.). This fact of the Yap islands is an outstanding enigma in the island arcs situated along the western margin of the Philippine Sea plate; Mariana, Yap and Palau trench arc systems. Because same tectonic model of the Yap trench arc system showed a continuous subduction along the Yap Trench (e.g. McCabe and Uyeda, 1983). Hawkins and Batiza (1977) interpreted a tectonic setting of the Yap trench arc system as a incipient zone or just after the ceasing from subduction.

We made two day field trip to approach this enigmatic problem of the Yap islands.

9-7-2. Geologic outline of the Yap islands

Before world war II, (Tayama (1935) investigated the geology of the Yap islands and divided the geologic constituents into four units. The following is summary of Tayama's description and our observations.

Yap Formation:

Basement of the islands consists of the Yap Formation which is metamorphic rocks of greenschist, amphibolites, metagabbro etc. with minor deformed acidic to medium pultonic rocks. The metamorphic are cropped out dominantly in the islands. The strike of foliation of the schists and their mineral lineations show NNE direction which is the same as elongation of the islands. Ultramafic rocks are distributed mainly in northeastern Maap island.

Maap Formation (Map Formation by Tayama,1935):

The Maap formation covers the Yap Formation unconformably and composed of debris flow deposites and intercalates alternating beds of sandstones and mudstones.

Many kind of breccias are recognized within the debris flow deposites; amphibolites, metagabbros, greenschists, and ultramafic rocks, which appear to have been derived from the Yap Formation, and gneissose granites, andesitic rocks and other rocks, which are not observed as original outcrops in the islands. The Miocene leading fossil, Miogypsina is found from the Maap Formation (Tayama, 1935). The alternation bed of sandstones and mudstones with calcareous beds are intercalated within the debris flow deposites.

<u>Tomir volcanics (Tomir agglomerate by Tayama,1935):</u>

The Tomir volcanics are distributed mainly in the northeastern part of the islands and cover the basement rocks . Although the volcanics are completely weathered into reddish soil or shaley red beds, internal texture of the volcanic rocks and original occurrence of the rocks are remained. We observed at some localities that the NNE trending vents of the volcanics are remained.

Hawkins and Batiza (1977) implicated that these volcanic breccias are almost the same as weathered debris flow deposites of the Maap Formation. The occurrence and composition, however, support that they are volcanics after the Maap Formation (Tayama, 1935; Johonson et al., 1960).

<u>Garime Limestone:</u>

Tayama (1935) reported the Garime limestone from Garime island. Its age and detail occurrence have not been reported yet.

9-7-3. Points of the observation in our field trip.

As the results of our field trip, the following possibilities are pointed out.

1. It is possible to divide the Yap formation into several segments. The boundaries among them are NNE trending faults which are observed as fault breccia or gouge zones at some localities. Shiraki (1980) suggested that metamorphic grade of the Yap Formation becomes higher from west to east gradually. Alternatively, it is possible that eastern segments are different from the western segments in their composition and metamorphic grade.

2. The Maap Formation seems to be distributed along the NNE trendign faults. The depositional depth of the formation appears to have not been under shallow water but deep one because no molluscan or mega fossils indicating shallow marine facies are observed in the formation.

9-8. Summary

During the cruise we obtained rocks and sediments, and deep sea photography around the Palau and Yap trenches. Our major results of onboard observations are as follows:

1) Yap arc-trench system is divided into five domains, northern, north-central, south-central, northern junctional and southwestern parts which represent the different geologic history affected by the surrounding Philippine Sea, Pacific and Caroline plates.

2) Fresh volcanic rock fragments and hydrothermally affected rocks may suggest the in-situ or nearby hydrothermal activity in relation to the Quaternary volcanic activity.

3) Trench floor sediments are affected strong deformation which may relate the subduction of the Caroline plate under Philippine Sea plate.

4) PDR and topographic map suggest the strike-slip movements in between northern, southern Yap and Central Yap Islands.

5) The discovery of carbonate turbidite in the approximately 8000m deep Palau Trench would be very significant at the western Pacific region.

6) Some evidences of submerged coral reefs can be recognized at the deeper ocean bottoms as deep as 4000 m.

7) Chalky limestone beds are suspected to be exposed at some places of the Yap forearc regions. Among them, the discovery of hardground chalk from the Yap forearc would be very significant.

Finally, we should say "Karrimegar" and "A la kafel" to all the native people of the Yap Islands who were willingly to support and help us for the field trip on the Yap Islands.

References

Ewing, M., and Heezen, B.C., 1955, Puerto Rico trench topographic and geophysical data: Geol. Soc. Amer., Sp. Paper, No. 62, p. 255-268.

Fujioka,K., Furuta, T., Kitazato, H., Ikehara, K. and Fuyuan Z., 1985, Preliminary study of piston cores from KH 84-1 cruise: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 34-60.

Hawkins, J., and Batiza, R., 1977, Metamorphic rocks of the Yap arc-trench system: Earth and Planet. Sci. Lett., v. 37, p. 216-229.

Ikehara, K., 1984, Surface sediments of the Izu-Mariana region,dredged and cored during cruise KH84-1: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 191-195.

Ishii, T., Kobayashi, K., Shibata, T., Naka, J., Johnson, K., Ikehara, K., Iguchi, M., Konishi, K., Wakita, H., Zhang, F., Nakamura, Y., and Kayane, H., 1984, Description of samples from Ogasawara Fore-arc, Ogasawara Plateau and Mariana Trough, during KH84-1 cruise: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 89-168.

Johnson, C., Alvis, R., Hetzler, R., and Blumestock, D., 1960, Military geology of Yap Islands, Caroline Islands: Intelligence Div., Office of the Engineer, H.Q., U.S. Army Pacific, APO 958, 168 pp.

Kato, S., Kato, G., and Asada, A., in press, Detailed bathymetry of the northern Palau Trench by multi-beam sonar: Submitted to UJNR/SBSP 14 th Joint Meeting, October 1985 (Tokyo), 9 pp. with 6 figures.

Kennedy, W.J., and Garrison, R.E., 1975, Morphology and genesis of nodular chalks and hardgrounds in the Upper Cretaceous of southern England: Sedimentology, v. 22, p. 311-386.

Konishi, K., 1984, Cretaceous reefal fossils dredged from two seamounts of the Ogasawara Plateau: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 169-180.

McCave, R., and Uyeda, S., 1983, Hypothetical model for the bending of the Mariana Arc: in The tectonic and geologic evolution of southeast Asian seas and islands: part 2. Ed. D.E. Hayes;p. 281-293. Amer. Geophys. Union Washington D.C.

Mullins, H.T., Heath, K.C., Van Buren, M., and Newton, C.R., 1984, Anatomy of a modern open-ocean carbonate slope: northern Little Bahama Bank: Sedimentology, v. 31, p. 141-168.

Shiraki, K., 1971, Metamorphosed basement rocks of Yap Islands, western Pacific: possible ocean crust beneath an island arc: Earth and Planet. Sci. Lett., v. 13, p. 167-174.

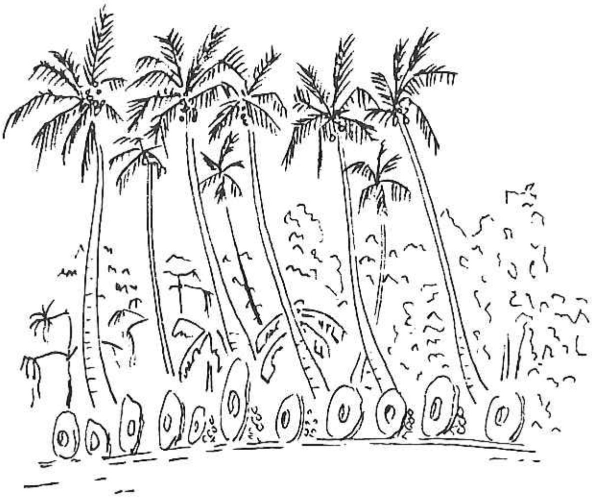
Tayama, R., 1935, Topography, geology and coral reefs of the Yap Islands: Inst. Geol. Paleont., Fac. Sci., Tohoku Imp. Univ., Contri. 19, p. 1-43. (in Japanese)

Tokuyama, H., Asanuma, T., Nishiyama, E., Hatori, H., Chiba, H., Ueno, S., and Tomita, N., 1984, Multichannel seismic reflection survey: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 282-291.

Watanabe, M. and Ishii, T., 1985, Wired stereoscopic deep sea camera during KH 84-1 cruise: Prelim. Rept. of the Hakuho Maru Cruise KH84-1, p. 253-264.

Yamamoto, S., 1984, Correlation of Fe and Mg in noncalcareous clay of deep-sea sediment from the Japan Trench and adjacent Pacific floor: Bull. Coll. Sci., Univ. Ryukyus, No. 37, p. 43-55.

Yap.



Yap

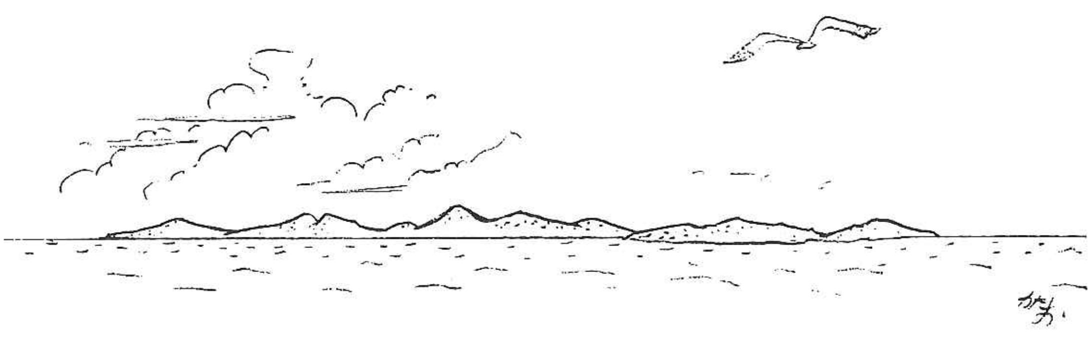


Table 9-5-2-1. Summary of the major rocks recovered by dredge haules during the cruise KH86-1.

KH86-1 D-1

No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock name	Remarks
001	33.0	20.0	13.0	10000	SA	Gneiss	Flow folds, calcareous(?)
002	25.0	16.0	13.0	5400	A	Meta-gabbro	Layering or metamorphic seg.
003	22.0	16.0	11.0	6500	SA	Amphibolite	Original rock is basalt or tuff
004	20.0	16.5	11.0	3600	SA	Meta-basalt	Amphibolite facies
005	20.0	11.5	10.0	3300	SA	Meta-sandst	Thin grn tuff'lens, tect origin
006	25.0	12.0	11.5	4500	A	Amphibolite	Original Rk is gab. or dol.
007	24.0	10.0	8.5	2900	SA	Meta-gabbro	Non schistose
008	16.5	12.0	6.5	3000	A	Meta-gabbro	Amp. facies, wkly schistose
009	19.5	10.0	8.5	3300	SA	Meta-breccia	Calc.veins&frags
010	16.0	12.0	9.0	2500	SR	Meta-gabbro	Grnschist fac.(nonschistose)
011	16.0	11.5	5.5	1600	A	Meta-gabbro	Weakly schistose
012	21.0	10.0	9.0	2000	SA	Meta-gabbro	Non-schistose
013	15.0	9.5	6.0	1400	SA	Amphibolite	Original Rk may be basalt
014	15.0	12.0	8.5	1800	SA	Amphibolite	Original Rk may be bas. or tuff
015	15.0	9.0	7.0	1400	SA	Meta-gabbro	Amphibolite facies
016	15.0	9.5	8.0	1700	SA	Meta-basalt	Tiny rutile
017	18.0	15.0	8.0	1800	A	Meta-basalt	Weakly schistose
018	16.0	15.0	8.0	1600	SA	Meta-gabbro	Non-schistose
019	16.0	10.0	6.0	1100	SA	Meta-gabbro	Amphibolite facies
020	13.5	11.0	5.0	1000	SA	Meta-tuff	Thin vein
021	12.0	10.0	7.0	1000	SA	Meta-basalt	Weakly schistose
022	14.0	9.0	6.0	1000	SA	Qtz-gneiss	Sedimentary(?)
023	15.0	10.0	8.0	1300	SR	Meta-Sandst.	
024	17.0	10.0	4.5	1100	SA	Meta-gabbro	
025	13.0	8.0	4.0	900	A	Amphibolite	Weakly schistose, rutile
026	16.0	9.0	5.5	700	SA	Amphibolite	Rutile
027	12.0	10.0	5.5	800	SA	Meta-basalt	Amphibolite facies
028	15.0	6.5	4.5	600	SA	Amphibolite	Weakly schistose
029	13.0	8.0	4.5	600	SA	Meta-basalt	Amphibolite facies
030	13.5	8.0	5.0	750	SR	Amphibolite	Original Rk may be lapilli tuff
031	13.0	6.5	5.0	650	SA	Amphibolite	Basalt or tuff
032	12.0	10.0	5.5	700	SA	Meata-gabbro	Amphibolite facies
033	14.0	9.0	6.5	950	SA	Amphibolite	Dolerite origin(?)
034	13.0	8.0	6.5	1000	SR	Breccia	Basaltic frag. and round qt.pod
035	12.0	7.5	5.0	700	SA	Meta-basalt	Weakly schistose, amph.facies
036	10.0	9.0	5.5	500	SR	Amphibolite	Massive
037	12.0	8.0	6.5	900	SA	Amphibolite	Gabbro origin
038	13.5	11.0	6.5	1000	SA	Amphibolite	Non-schistose
039	11.0	8.5	5.0	700	SA	Meta-basalt	Tiny rutile spot
040	12.0	8.5	5.0	500	SR	Meta-basalt	
041	12.0	9.5	5.5	750	SA	Meta-basalt	Hematite pods (spots)
042	14.0	7.0	3.0	400	SA	Meta-basalt	
043	10.0	7.5	6.0	700	SA	Meta-basalt	Fine grained rutile
044	10.0	8.5	6.0	600	SR	Amphibolite	Gabbro origin
045	10.5	6.5	5.0	500	SA	Amphibolite	Including segregation pods(white)
046	12.0	9.0	5.0	800	SA	Meta-basalt	or Gabbro (Amphibolite facies)
047	10.5	6.0	4.0	450	A	Meta-basalt	Fine grained rutile(amphibolite)
048	11.0	8.5	2.0	400	SA	Meta-basalt	ditto
049	10.5	7.5	2.5	400	A	Meta-basalt	Fine grained rutile
050	10.0	9.5	4.0	500	SA	Breccia	Matrix is ch. & epi.(bas.frag.)
051	10.0	6.5	5.0	500	SR	Breccia	Monlth.&mtrx.&frag.are same,deb.f.
052	9.0	7.0	3.5	450	SA	Meta-tuff	Round lith.flag.irregular vains
053	11.5	7.0	5.0	750	SA	Qtz.gneiss	Irregular mafic layer
054	9.0	8.0	5.5	450	SR	Breccia	Matrix is epidote
055	14.0	9.5	6.0	800	SA	Amphibolite	Non schistose
056	11.5	8.0	3.5	450	SA	Amphibolite	Massive
057	12.5	6.5	3.0	500	A	Amphibolite	Meta-basalt(?),weakly schistose
058	9.5	6.5	4.5	350	SR	Quarts vain	or Chart
059	9.0	6.0	5.0	450	SR	Meta-tuff	Medium-coarse
060	12.0	8.0	3.5	400	SA	Amphibolite	Quarts gash

061	9.0	5.0	2.5	300	A	Meta-basalt	Rutile
062	10.5	6.5	4.0	350	SA	Meta-basalt	
063	9.0	5.5	3.0	250	SA	Amphibolite	
064	10.0	7.5	3.5	500	SA	Meta-basalt	Tiny hematite spots
065	7.5	6.0	4.5	300	SR	Gneiss	
066	7.5	5.5	3.5	250	SR	Qtz.gneiss	
067	11.0	8.0	3.5	250	A	Meta-breccia	Basaltic frag. mat.qt.& epi.
068	9.0	7.0	1.0	150	A	Meta-basalt	Rutile
069	10.5	8.0	4.0	350	A	Meta-basalt	or Tuff massive non schistose
070	9.0	7.0	3.5	300	SA	Meta-basalt	
071	9.0	5.5	4.0	350	SA	Amphibolite	Weakly schistose, rutile
072	7.0	4.5	3.0	200	A	Meta-basalt	Tiny rutile
073	8.0	6.0	2.0	200	SR	Meta-basalt	
074	8.5	5.0	2.0	200	SA	Meta-basalt	
075	7.5	6.0	4.0	250	SA	Meta-tuff	Banding & lithic fragment
076	8.0	7.0	4.0	400	SR	Amphibolite	
077	9.0	6.0	3.5	400	SA	Meta-basalt	Rutile spots
078	10.5	5.0	3.5	250	A	Amphibolite	
079	9.0	7.0	4.0	250	SA	Amphibolite	Rather coarse (gabbro origin?)
080	11.5	6.0	4.0	300	A	Meta-gabbro	
081	10.0	4.0	3.0	300	A	Meta-tuff	Amphibolite facies, rutile
082	9.0	4.0	2.5	200	A	Meta-basalt	
083	10.5	8.0	3.5	350	SA	Meta-basalt	Amphibolite
084	14.0	6.0	1.5	200	A	Meta-basalt	ditto
085	9.5	6.0	3.5	350	A	Meta-basalt	Rutile (amphibolite facies)
086	9.0	5.0	2.5	200	A	Meta-basalt	Rutile (amphibolite facies)
087	12.0	6.0	5.5	600	SA	Meta-tuff	Irregular dk-green spots
088	9.0	7.0	4.0	350	SA	Meta-basalt	Weakly schistose
089	8.0	5.5	4.0	350	A	Meta-basalt	White segregation or pod(quarts)
090	9.0	5.0	4.0	350	A	Meta-basalt	
091	11.0	7.0	3.0	300	A	Amphibolite	
092	11.0	4.5	3.5	250	A	Meta-dolerite	
093	7.0	5.0	2.5	150	SA	Meta-tuffbre.	White vein
094	7.0	5.0	3.0	200	SR	Amphibolite	
095	7.5	5.0	3.0	200	SA	Amphibolite	(Tuff?)
096	7.0	4.0	3.0	120	SR	Breccia	Volcanic or tuff breccia,lt-green
097	6.5	5.5	3.0	100	SA	Amphibolite	Fine graind
098	7.0	5.0	4.0	250	SR	Meta-tuff	Lithic frag. are lt-gray-green
099	7.5	5.0	3.5	200	SA	Breccia	White fragments
100	8.5	5.0	2.0	180	SA	Meta-basalt	Light-grayish-green
101	10.5	6.0	2.5	250	SA	Meta-tuff	
102	10.5	5.0	3.0	350	A	Amphibolite	Meta-tuff(lithic fragments)
103	9.0	6.5	4.0	300	SA	Meta-tuffbre.	Light-bluish-gray
104	10.0	4.5	4.0	250	SA	Amphibolite	Schistose fine vein
105	9.0	6.0	1.5	100	A	Amphibolite	
106	8.5	6.0	4.0	200	A	Meta-gabbro	
107	8.5	6.0	3.0	250	SA	Meta-tuff	Lithic fragment
108	8.0	5.5	4.0	250	SA	Meta-gabbro	
109	8.0	5.5	3.5	200	A	Amphibolite	
110	6.0	3.5	2.5	100	A	Amphibolite	
111	10.0	4.0	3.0	200	A	Amphibolite	
112	7.5	5.5	3.5	220	SA	Meta-gabbro	
113	8.0	5.0	3.0	150	SA	Meta-gabbro	
114	6.5	5.0	4.0	150	SR	Marble	
115	8.5	5.5	2.5	150	A	Met.volc.bre.	Bas.frag.now into amph.facies
116	6.5	6.0	3.0	150	SR	Meta-tuffbre.	
117	6.5	4.5	2.5	200	A	Meta-gabbro	
118	7.0	4.5	2.5	200	SA	Amphibolite	White vein
119	8.5	4.0	2.5	200	SA	Amphibolite	Rutile spots
120	7.0	5.5	4.0	200	SA	Amphibolite	Rutile
121	8.0	5.0	1.5	150	SA	Amphibolite	
122	10.0	5.0	3.0	300	SA	Meta-tuff	Fine grained, amphibolite facies
123	9.0	6.0	5.0	250	A	Amphibolite	Meta-tuff
124	9.0	4.0	3.0	130	A	Amphibolite	

125	8.5	4.0	2.5	100	A	Amphibolite	
126	6.5	4.0	3.0	200	A	Amphibolite	Rutile
127	7.0	5.0	2.0	150	SA	Amphibolite	
128	7.0	3.0	2.0	150	SA	Amphibolite	Lithic fragments
129	7.0	5.0	3.0	200	SA	Amphibolite	
130	9.0	6.0	4.0	150	SA	Calc.conglo.	Cg. amphibolite(large rk piece)
131	9.0	4.5	3.0	200	SA	Meta-tuff	Qt.rich segregation pods
132	8.0	4.0	3.0	150	SA	Amphibolite	Mn-coat
133	8.0	4.0	6.0	200	SA	Amphibolite	Mn-coat
134	8.0	4.0	5.5	200	SA	Amphibolite	Mn-coat
135	6.5	5.0	2.5	120	SA	Amphibolite	Mn-coat
136	7.5	5.0	3.0	150	SA	Meta-basalt	Mn-coat
137	6.0	5.5	4.0	150	SA	Meta-conglo.	Mafic rocks are now epidote
138	7.0	6.0	4.0	200	SA	Meta-dolerite	Amphibolite facies
139	7.0	4.5	3.5	150	SA	Amphibolite	Tiny rutile
140	6.0	5.5	5.0	150	SA	Meta-dolerite	Mn-coat
141	7.0	5.5	1.0	50	A	Amphibolite	Schistose
142	7.0	4.0	1.5	60	A	Amphibolite	
143	6.5	2.0	3.5	100	SA	Amphibolite	
144	6.0	5.0	1.5	100	SA	Meta-basalt	Mn-coat
145	7.0	3.5	1.5	100	A	Amphibolite	Mn-coat
146	6.0	5.5	2.0	150	SA	Meta-basalt	Cavity is filled by meta.minerals
147	8.5	4.0	3.0	150	SA	Meta-dolerite	White vein Mn-coat
148	7.0	4.0	2.5	100	SA	Meta-basalt	Mn-coat
149	7.0	4.0	3.0	150	SA	Meta-dolerite	Mn-coat
150	7.0	4.0	2.0	150	SA	Meta-gabbro	Qt.rich pods Mn-coat
151	6.0	4.5	3.0	100	SA	Meta-basalt	Amphibolite ptly Mn-coat
152	8.0	4.5	2.5	150	SA	Amphibolite	Schistose rutile
153	7.5	4.0	1.0	100	A	Amphibolite	Rutile
154	5.5	5.0	3.0	150	SR	Meta-tuff	Medium grained ptly Mn-coat
155	7.0	4.0	3.0	150	SA	Meta-basalt	
156	7.5	6.5	3.0	150	SA	Meta-basalt	Dk. grn. vein (Amphibolite)
157	7.0	4.0	2.5	150	SA	Meta-basalt	Xenolith (olivine nodule)
158	6.0	4.5	4.0	150	SR	Marble	Holocrystalline pure
159	8.0	4.0	2.0	100	SA	Meta-basalt	Mn-coat
160	6.0	4.0	2.5	100	SA	Amphibolite	Meta-tuff Mn-coat
161	6.0	5.0	2.5	120	SA	Meta-basalt	Amphibolite (pyrite?) rutile
162	7.0	5.0	3.0	100	SA	Serpentinite	Mn-coat
163	6.0	4.0	3.0	100	A	Meta-basalt	Quartz-amphibolite vein
164	6.0	4.0	2.0	100	SA	Amphibolite	Mn-coat
165	8.0	3.5	2.0	100	A	Amphibolite	Mn-coat
166	6.5	4.0	3.0	100	SA	Meta-dolerite	
167	7.0	3.5	3.0	150	SA	Amphibolite	Mn-coat
168	6.5	4.0	3.0	100	SA	Serpentinite	Mn-coat, amphibolite facies
169	5.0	4.0	3.0	100	SR	Met.calc.cg.	Basaltic fragment
170	7.0	4.5	3.0	200	SA	Serpentinite	Mn-coat
171	5.5	4.0	2.0	100	SA	Meta-basalt	Mn-coat
172	7.0	4.0	2.0	100	SA	Amphibolite	
173	6.0	4.0	3.5	100	SR	Qtz.gneiss	Flow folds p.
174	5.5	3.5	3.0	100	SA	Meta-dolerite	Mn-coat
175	6.0	4.5	1.5	100	SA	Amphibolite	Mn-coat
176	6.0	4.5	2.0	100	SA	Amphibolite	Mn-coat
177	6.0	4.0	3.0	100	SA	Amphibolite	Mn-coat
178	7.0	4.0	3.5	200	SA	Meta-conglo.	Mtrx.is epi.,Bas.frag.(tuff bre.?)
179	7.0	4.5	1.5	100	SA	Amphibolite	Mn-coat
180	8.5	4.5	3.5	150	SA	Amphibolite	Schistose
181	7.0	3.5	2.5	120	A	Amphibolite	
182	6.0	3.0	2.5	100	SA	Amphibolite	Partly Mn-coat
183	6.5	5.0	3.0	150	A	Meta-basalt	Amphibolite facies Mn-coat
184	7.0	4.0	3.0	100	A	Amphibolite	Partly Mn-coat
185	7.5	3.5	2.5	100	A	Amphibolite	
186	6.0	4.5	1.5	100	SA	Meta-gabbro	Mn-coat
187	7.5	4.0	2.5	100	A	Amphibolite	Wht. vein(epidote qtz.)

188	4.0	3.0	2.0	50	SR	Amphibolite	Mn-coat
189	5.0	3.5	1.5	100	SA	Mt.dolerite	Mn-coat
190	5.0	4.0	3.0	50	SA	Meta-basalt	Mn-coat
191	5.5	3.0	2.5	100	SA	Mt dolerite	Mn-coat
192	5.5	4.0	2.0	90	SA	Meta-basalt	Mn-coat
193	6.5	3.5	2.0	100	SA	Epidosite	Originally conglomerate
194	5.0	3.5	2.0	100	A	Mt.andesite	Not so much metamorphosed Mn-coat
195	5.0	4.5	2.0	100	SA	Meta-basalt	Mn-coat
196	4.0	3.0	2.0	50	A	Mt.dolerite	Mn-coat
197	6.5	4.0	2.0	100	SA	mt.dolerite	Mn-coat
198	5.5	3.5	2.5	100	A	Meta-basalt	Mn-coat
199	5.0	3.0	1.5	50	SA	Meta-basalt	Mn-coat
200	6.0	5.0	3.0	100	SA	Amphibolite	Tiny rutile schistose Mn-coat
201	5.0	4.0	2.5	100	SA	Amphibolite	Partly Mn-coat
202	5.0	4.0	2.0	50	SA	mt.dolerite	Rather schistose Mn-coat
1001	12.0	9.0	7.5	570	SA	Chalk	Semiconsolidated,edge is rounded
1002	8.5	6.5	5.5	260	SA	Chalk	ditto
1003	8.5	6.5	5.5	230	R	Chalk	One side of erosion.surf.,fract.
1004	6.0	6.0	4.0	100	SA	Chalk	Semiconsolidated
1005	Broken two pieces			120	R	Chalk	ditto
1006	5.5	4.5	3.5	90	SA	Chalk	ditto
1007	Broken two pieces			60	SA	Chalk	ditto
1008	5.5	4.0	3.2	30	R	Chalk	ditto
1009	Br.several pieces			160	--	Cholk	Loosely consolidated,erosion.surf.

KH 86-1 D-2

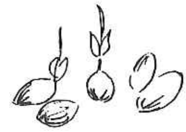
No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock name	Remarks
001	26.0	20.5	23.5	6700	SA	Meta-sandst.	White spot
002	24.0	19.5	3.0	3500	A	Calc.conglo.	Dk brown irregular vein
003	17.0	16.0	10.0	3000	A	Meta-sandst.	Irregular white vein
004	17.0	14.0	12.5	3300	SA	Quartzite	Quartzose gneiss with druse
005	15.0	11.0	3.5	950	A	Psami.gneiss	Flow folds, white calc. vein
006	14.0	12.0	7.5	1500	A	Amphibolite	Massive accicular crystal(?)
007	12.0	12.0	6.5	1500	SA	Psami.gneiss	Calc. flow folds
008	12.5	12.5	5.0	1000	A	Augen gneiss	
009	15.0	9.0	6.0	1250	A	Meta-gabbro	Amphibolite facies
010	11.5	9.0	4.5	1000	A	Gneiss(augen)	Psamitic origin
011	13.0	9.0	6.0	1000	SR	Meta-igne.rk.	Comatiite(?),large block oakleaf
012	10.5	8.5	7.0	1150	SR	Meta-sandst.	like crystals
013	10.0	9.0	8.0	1000	R	Marble	
014	12.0	7.0	6.0	850	SA	Psami.gneiss	Flow folds
015	12.5	8.5	5.0	700	SA	Gneiss	Psamitic &calcareous
016	12.0	8.0	7.0	700	A	Amphibolite	Thin band (schistose)
017	8.5	8.0	5.0	600	SA	Meta-sandst.	Same as No.001
018	10.0	7.5	4.5	550	SR	Psami.gneiss	
019	7.5	7.5	6.0	550	R	Psami.gneiss	Irregul.dk brown spots(hematite)
020	11.0	7.5	2.5	300	SA	Amphibolite	Meta-tuff
021	9.5	6.5	4.0	400	SA	Psami.gneiss	Flow folds
022	12.0	6.0	3.5	250	A	Meta-gabbro	
023	11.5	17.0	2.5	400	A	Meta-gabbro	
024	12.0	7.0	5.0	500	SA	Gneiss	Psamitic flow folds
025	11.5	6.5	4.5	400	SA	Psami.gneiss	White spots(porphiroblast)
026	9.0	7.0	3.5	400	SR	Psami.gneiss	
027	8.0	6.0	4.5	300	SR	Calc.gneiss	Partly psamitic
028	9.0	5.0	4.0	350	SA	Psami.gneiss	
029	10.0	7.0	5.5	450	SR	Psami.gneiss	

030	8.0	6.0	4.0	300	SR	Psami.gneiss	
031	7.0	5.5	3.0	200	R	Meta-sandst.	
032	6.0	5.0	4.5	200	A	Marble	
033	7.0	5.0	4.5	200	SA	Psami.gneiss	
034	7.0	5.0	3.5	150	SA	Marble	
035	6.5	4.0	4.0	200	SA	Psami.gneiss	
036	5.5	4.9	4.0	220	SA	Meta-sandst.	
037	7.0	4.0	4.0	180	SA	Meta-sandst.	
038	7.5	4.0	3.0	150	SA	Meta-sandst.	
039	6.0	4.0	3.2	140	SA	Meta-sandst.	
040	6.8	4.0	3.3	160	SR	Meta-sandst.	
041	5.5	4.4	2.7	100	SA	Meta-sandst.	
042	5.5	4.0	2.0	70	SA	Meta-tuffbre.	Large calc.fragments
043	6.0	5.0	3.5	150	SA	Meta-sandst.	
044	7.5	5.0	4.0	300	SR	Meta-sandst.	Partly calcareous
045	5.3	4.8	4.5	200	SA	Marble	
046	7.3	5.0	4.7	150	SR	Meta-sandst.	
047	6.0	5.0	2.0	90	SR	Meta-sandst.	
048	6.5	4.5	4.0	150	SR	Marble	Partry psamitic layer
049	5.0	4.3	2.4	100	SR	Meta-sandst.	Thin layer
050	6.3	3.5	2.3	90	SR	Meta-sandst.	
051	6.3	5.0	4.0	120	SR	Marble	
052	5.3	4.7	3.2	90	SR	Marble	Sandy brown thin vein
053	7.0	4.2	2.5	100	SA	Marble	Red brown oxide on surface
054	7.2	6.0	3.3	140	SA	Marble	Highly impurity sandy
055	5.5	4.0	2.5	90	SR	Marble	
056	5.0	4.7	3.8	140	SR	Marble	Impure pods(dk gray sandy)
057	4.2	2.5	2.5	90	SA	Meta-tuff	Medium-coarse grained
058	6.7	5.0	3.3	100	SR	Sandy marble	Thin lamina(sandy & calc.bond)
059	4.7	3.3	3.3	100	SR	Sandy marble	
060	5.7	4.5	3.7	100	SR	Sandy marble	Lamina(sandy & calc.)

061	4.5	3.7	2.6	70	SR	Sandy marble	Sandy & calcareous
062	5.0	3.5	3.0	60	R	Marble	Pure
063	7.2	5.7	3.8	150	R	Gneiss	Sandy flow folds
064	4.0	3.8	3.0	100	R	Marble	
065	4.7	3.5	2.5	70	SR	Marble	
066	4.0	3.5	2.5	50	SR	Marble	
067	4.7	4.5	2.7	90	SR	Gneiss	Sandy flow folds
068	4.0	4.0	2.5	40	R	Sandstone	White vein
069	3.8	3.5	2.7	50	R	Meta-tuff	Medium grained
070	4.5	3.3	3.0	50	SR	Marble	
071	5.5	5.5	3.7	110	SR	Marble	Schistose(Original sed. strct)
072	5.5	4.5	3.7	90	SR	Sandy marble	
073	6.5	3.8	3.5	60	SA	Marble	
074	4.7	4.7	2.8	50	R	Meta-sandst.	
075	5.2	4.5	2.2	60	R	Meta-sandst.	
076	5.5	4.5	2.0	40	R	Sandy marble	
077	5.0	4.5	3.8	100	R	Sandy marble	
078	5.5	4.0	3.0	90	SR	Marble	
079	6.8	3.5	2.5	80	R	Marble	
080	5.0	3.3	3.0	60	R	Marble	
081	6.4	4.5	2.5	90	SR	Meta-sandst.	Lamina(thin band?)
082	5.5	4.3	1.7	50	SR	Meta-sandst.	Lamina medium graind
083	8.5	2.3	2.0	50	SA	Marble	Medium grained
084	4.5	3.0	2.5	50	SR	Meta-sandst.	Calcareous
085	4.5	3.5	3.5	70	R	Meta-sandst.	
086	4.0	3.5	2.0	50	A	Meta-sandst.	Massive medium grained
087	4.3	4.3	2.9	60	R	Marble	Brown thin vein
088	4.7	3.0	2.5	50	R	Meta-sandst.	Brown oxide patch
089	5.0	4.0	3.0	100	SR	Marble	Pure fine grained
090	4.5	3.3	2.8	80	SA	Marble	Sandy coarse grained
091	3.3	2.9	2.7	60	A	Marble	Medium grained
092	4.5	3.5	2.3	50	A	Maeble	Impure

093	5.0	3.5	2.5	100	SA	marble	
094	3.3	2.5	1.5	40	SR	Sandy marble	
095	4.5	3.0	1.5	40	R	Marble	Sandy laysr
096	4.5	3.4	2.0	50	SR	Marble	Pure
097	5.5	4.3	2.3	60	SA	Marble	
098	5.6	3.0	2.7	80	SA	Meta-sandst.	Vein
099	4.0	3.5	2.7	50	SA	Meta-sandst.	Lamina
100	5.6	4.0	1.5	50	R	Marble	
101	4.5	3.5	2.0	60	SR	Meta-sandst.	
102	5.0	4.5	2.7	70	SA	Meta-sandst.	Lamina thin gash
103	4.0	3.0	2.2	40	SR	Meta-sandst.	Medium grained
104	5.0	3.5	2.0	60	R	Sandy marble	Coarse grained
105	4.3	3.8	2.5	60	SA	Meta-sandst.	Calcareous
106	5.0	3.5	2.5	60	SR	Meta-sandst.	
107	4.7	4.0	3.5	80	SA	Meta-sandst.	Thin calcareous patch
108	4.0	3.0	2.2	60	SR	Meta-sandst.	
109	5.5	3.5	3.0	90	SA	Meta-sandst.	Calcareous
110	4.2	3.2	2.5	60	SA	Meta-sandst.	
111	5.0	3.2	2.0	70	SR	Sandy marble	Lamina
112	4.5	3.7	2.5	50	SR	Meta-sandst.	Lamina calcareous
113	4.5	4.3	1.7	50	SA	Meta-sandst.	Irregular brown vein
114	4.0	3.0	1.8	40	SA	Meta-sandst.	
115	4.5	3.5	2.5	50	SA	Meta-sandst.	Calcareous granule
116	3.5	3.0	1.7	50	SR	Meta-sandst.	Calcareous granule
117	4.5	3.5	2.8	50	SA	Marble	
118	3.0	2.2	1.4	20	SR	Meta-sandst.	
119	4.0	2.5	1.8	20	SR	Meta-sandst.	Calcareous
120	3.2	2.5	1.8	40	SA	Marble	
121	3.0	3.0	2.1	60	SR	Marble	
122	3.0	2.2	1.0	10	SR	Meta-sandst.	
123	3.3	2.7	1.5	10	SA	Meta-sandst.	
124	3.4	2.0	1.2	10	A	Marble	
125	2.7	2.0	1.2	20	SA	Meta-sandst.	
126	3.0	1.8	1.7	20	R	Marble	Partly red brown oide coat
127	3.0	2.0	1.4	20	SA	Meta-sandst.	
128	4.0	2.7	2.0	40	R	Meta-sandst.	
129	3.7	3.2	1.7	40	SR	Meta-sandst.	
130	3.0	3.0	2.7	20	SA	Sandy marble	
131	3.7	3.5	1.5	40	SA	Sandy marble	
132	4.0	3.0	2.5	40	SR	Meta-sandst.	Thin brown patch
133	4.5	2.8	2.0	50	SA	Meta-sandst.	
134	3.0	2.2	1.2	20	R	Meta-sandst.	Calcareous granule
135	3.0	2.5	2.0	30	R	Marble	
136	9.5	7.0	4.0	300	A	Meta-gabbro	Mn-coat
137	7.0	6.3	3.0	160	A	Meta-gabbro	Holocrystalline
138	7.5	7.5	3.5	260	SR	Meta-tuff	
139	9.0	7.0	3.0	250	SA	Meta basalt	Schistose
140	8.0	4.5	3.5	120	SA	Sandy gneiss	Flow fold partly brown oxide coat
141	6.0	4.8	3.8	130	SA	Meta-sandst.	Lamina and flow fold
142	8.0	7.0	5.0	260	A	Meta-conglo.	Round qtz crystals
143	7.5	7.0	3.5	290	A	Meta-gabbro	Fine grained
144	6.5	6.0	4.4	160	A	Meta-gabbro	Holocrystalline Mn-coat
145	7.5	4.0	1.0	80	A	Meta-doler.	Surf.is the bound.betwn.red shale
146	6.0	5.0	1.8	100	SA	Amphibolite	Pyrite epidote spots
147	7.0	4.0	2.0	110	SA	Met.Ol.Nodu.	
148	7.5	4.3	2.6	120	A	Meta-tuff	Medium grained Mn-coat
149	8.0	6.0	3.0	190	A	Meta-conglo.	
150	6.5	4.0	3.0	110	SR	Meta-tuff	
151	5.0	3.5	3.3	110	A	Meta-tuff	Frag.are calc.rk.,brn.spots c.grn.
152	6.5	4.0	3.0	130	SA	Meta-basalt	Schistose (Amphibolite facies)
153	6.5	4.5	2.5	150	SA	Meta-tuff	Massive fine grained
154	5.0	4.0	2.2	60	A	Meta-basalt	Mn-coat
155	5.8	3.7	2.5	80	SR	Meta-basalt	
156	5.4	2.7	2.4	80	A	Meta-tuff	Fine grained

157	5.2	4.4	2.0	90	A	Meta-conglo.	Calcareous rock fragments
158	7.0	3.3	2.3	110	A	Meta-gabbro	Partly Mn-coat
159	5.0	4.2	2.0	90	SA	Meta-doler.	
160	4.5	3.8	2.8	70	SA	Meta-gabbro	Banding?
161	6.0	6.0	1.5	110	A	Amphibolite	Partly Mn-coat
162	5.5	3.4	2.0	80	SR	Meta-breccia	Fragments are epidosites
163	4.0	3.5	2.0	50	SA	Meta-gabbro	Partly Mn-coat
164	5.7	3.5	2.3	60	A	Meta-breccia	Matrix is dark green
165	4.5	2.5	2.0	50	A	Meta-basalt	Micro-phenocryst
166	4.0	3.0	2.6	70	A	Meta-gabbro	Mn-coat
167	3.5	2.8	2.5	50	SA	Meta-tuff	Medium grained
168	3.4	3.0	1.5	20	SR	Meta-sandst.	
169	4.2	3.7	2.0	40	SR	Meta-doler.	Amphibolite facies
170	3.7	3.0	2.0	40	R	Meta-tuff	Very fine grained
171	5.2	2.7	1.5	50	SA	Amphibolite	
172	5.5	4.0	2.0	80	A	Meta-gabbro	Holocrystalline
173	5.0	3.5	2.3	60	A	Meta-basalt	Porphyritic
174	4.3	3.5	2.5	50	SA	Meta-basalt	Cavity filled by quartz & epidote
175	5.0	4.3	2.2	60	A	Meta-dolerite	
176	4.5	3.7	2.0	70	SR	Meta-basalt	Amphibolite facies
177	5.3	4.4	3.0	70	SA	Amphibolite	
178	3.6	3.5	2.8	60	SR	Meta-sandst.	Medium grained
179	7.0	2.5	1.5	50	A	Meta-basalt	
180	4.0	3.0	2.0	30	A	Meta-tuff	Chalcopyrite on surface
181	5.0	3.6	3.0	50	A	Meta-basalt	Mn-coat
182	4.0	2.5	2.5	50	SA	Meta-basalt	Amphibolite facies
183	5.5	3.0	2.0	60	A	Meta-tuff	Medium grained
184	4.5	3.0	2.0	40	SA	Amphibolite	
185	4.3	4.0	1.5	40	A	Meta-gabbro	Mn-coat
186	5.4	3.8	1.5	50	A	Meata-gabbro	Gabbro pegmatite, Mn-coat
187	4.0	3.7	0.7	30	A	Meta-tuff	Mn-coat
188	4.5	3.0	1.5	30	A	Meta-dolerite	Mn-coat
189	4.0	2.7	2.0	40	SA	Meta-gabbro	Rather acidic(Dioritic)
190	3.5	3.5	2.5	40	A	Meta-breccia	Mn-coat
191	5.0	3.0	2.2	80	SA	Meta-basalt	
192	4.5	4.0	2.0	40	SA	Meta-tuff	Very-coarse grained
193	4.0	2.7	2.6	70	SR	Meta-tuff	Coarse well sorted
194	4.0	3.7	1.0	40	SA	Meta-breccia	Round fragments
195	6.0	3.7	0.7	30	A	Meta-tuff	Chalcopyrite on surface
196	3.5	2.5	2.0	40	A	Meta-sandst.	
197	4.0	3.7	1.7	30	SR	Meta-tuff	Rather acidic medium grained
198	4.5	2.0	1.4	30	SA	Meta-tuff	Coarse grained
199	4.0	3.0	2.0	40	SA	Meta-tuff	Pyrite,chalcopyrite on surface



KH 86-1 D-3

No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock name	Remarks
001	10.0	5.0	2.0	110	SA	Bist.Grainst.	Mn crust,boreholes,mud supt.,loose
002	7.5	4.5	3.0	140	SA	Biomiclutite	Mn c.,brhol.,slight.lse.,fract.
003	7.5	5.0	2.0	90	SA	Bist.Grainst.	Slightly Mn crusted,boreholes,lse.
004	8.7	3.5	2.5	100	SA	Bist.Grainst.	Mn c.,brhol.,lse.,m.supt.,fract.
005	7.0	4.8	3.0	80	R	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
006	6.0	4.8	3.0	70	R	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
007	5.5	3.5	2.0	60	R	Biolithite	Very slightly Mn c., some brhol.
008	5.5	3.8	2.5	50	SA	Biolithite	Very slightly Mn c.,boreholes
009	5.0	4.0	2.0	40	SA	Grainstone	Mn c.,brhole.,lse.,m.supt.,fract.
010	5.5	4.0	2.0	10	SA	Grainstone	ditto
011	5.5	3.5	3.0	10	SA	Grainstone	ditto
012	5.5	3.5	3.2	40	R	Grainstone	Slightly Mn c.,brhol.,lse.,g.supt.
013	5.5	4.0	2.0	30	SA	Grainstone	ditto
014	4.2	4.0	2.0	10	SA	Grainstone	Not Mn c.,brhol.,lse.,g.supt.
015	6.0	3.8	2.5	20	R	Grainstone	Slight.Mn c.,brhol.,loose,g.supt.
016	5.0	3.2	2.5	10	R	Grainstone	ditto
017	5.0	3.0	2.0	10	SA	Grainstone	Hf.Mn c.,brhol,lse.,g.supt.,fract.
018	5.0	3.8	2.5	20	R	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
019	4.2	3.5	2.3	10	R	Grainstone	ditto
02Q	4.2	3.4	2.2	20	R	Grainstone	ditto
021	3.8	3.0	2.0	10	R	Grainstone	V.slight.Mn c.,brhol.,lse.,g.supt.
022	4.0	3.5	2.8	20	SA	Grainstone	Slight.Mn c.,brhol.,lse,g.supt.
023	4.7	3.3	2.0	15	SA	Bist.Grainst.	Mn c.,brhol.,lse.,g.supt.,fract.
024	4.5	2.5	2.5	10	SA	Grainstone	Slightly Mn c.,brhol.,lse.,g.supt.
025	4.3	2.2	2.0	10	SA	Grainstone	V.slight.Mn c.,brhol.,lse.,g.supt.
026	5.0	3.2	2.2	10	R	Grainstone	ditto
027	4.0	3.0	1.8	5	SA	Grainstone	ditto
028	4.0	3.0	2.0	10	R	Grainstone	ditto
029	3.5	2.8	1.8	5	R	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
030	3.5	3.0	2.0	10	R	Grainstone	V.slight.Mn c.,brhol,lse.,g.supt.
031	4.0	3.0	2.0	5	SA	Grainstone	V.slight.Mn c.,brhol.,lse.,g.supt.
032	3.2	3.0	2.2	10	SA	Grainstone	Sl.Mn c.,brhol.,lse.,g.supt,spar.
033	3.5	2.5	1.7	10	SA	Grainstone	Hf.Mn c.,some brhol.,lse.,g.supt.
034	4.0	3.0	2.5	7	SA	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
035	3.8	2.3	2.0	5	SA	Grainstone	ditto
036	3.5	2.5	1.5	5	SA	Grainstone	ditto
037	2.5	2.0	1.5	5	R	Grainstone	V.slight.Mn c.,brhol.,lse.,g.supt.
038	3.2	2.5	1.2	5	SA	Bist.Grainst.	H.Mn c.,brhol.,lse.,g.supt.,fract.
039	3.2	2.2	1.9	-	SA	Grainstone	V.slight.Mn c.,brhol.,lse.,g.supt.
040	3.3	2.2	1.5	-	SA	Grainstone	ditto
041	3.0	2.0	1.0	-	SA	Bist.Grainst.	ditto
042	2.1	1.7	0.8	-	SA	Biolithite	Not Mn crusted,loose
043	2.2	1.9	1.0	-	SA	Bist.Grainst.	Slight.Mn c.,lse.,g.supt,fract.
044	1.5	0.8	0.6	-	SA	Grainstone	ditto
045	1.0	1.0	0.8	-	SA	Grainstone	Hf.Mn c.,lse.,g.supt.,fresh fract.
046	1.0	0.8	0.5	-	SA	Grainstone	Half Mn crusted,loose.,g.suported
047	1.5	0.5	0.5	-	SA	Grainstone	ditto
048	1.1	0.8	0.8	-	SA	Grainstone	Hf.Mn c.,brhol.,lse.,g.supported
049	4.5	3.5	2.0	10	SA	Grainstone	ditto
050	3.0	3.0	1.5	-	SA	Grainstone	ditto
051	3.0	2.4	0.9	-	SA	Grainstone	Heavily Mn c.,brhol.,lse.,g.supt.
052	3.0	2.2	1.0	-	SA	Grainstone	Hf.Mn c.,brhol.,lse.,g.supported
053	2.5	2.2	1.2	-	SA	Grainstone	Slight.Mn c.,brhol.,lse.,g.supt.
054	2.3	2.2	0.8	-	A	Bist.Grainst.	Hf.Mn c.,brhol.,lse.,g.supported
055	2.2	1.8	0.9	-	SA	Grainstone	Heavily Mn c.,brhol.,lse.,g.supt.
056	2.0	1.7	1.2	-	SA	Grainstone	Heavily Mn c.,lse.,g.supported
057	2.0	1.8	1.5	-	SA	Grainstone	Slightly Mn c., brhol.,lse,g.supt.
058	2.0	2.0	0.8	-	SA	Grainstone	ditto
059	2.2	1.5	1.3	-	SA	Grainstone	ditto
060	2.3	1.9	1.3	-	SA	Grainstone	Heavily Mn c.,brhol.,lse.,g.supt.

061	-	-	-	-	-	Hard rock(?)	
062	2.2	1.6	1.2	-	SA	Grainstone	Heavily Mn crust,lse.,g.supt.
063	-	-	-	-	-	Hard rock(?)	
064							
065	2.0	1.6	0.9	-	SA	Grainstone	Heavily Mn crusted,lse.,g.supt.
066	2.0	1.6	0.9	-	SA	Mollus.frag.	ditto
067	2.0	1.2	1.0	-	SA	Grainstone	Slightly Mn crusted,lse.,g.supt.
068	1.8	1.7	0.8	-	SA	Grainstone	Half Mn crusted,loose,g.supt.
069	2.0	0.7	0.5	-	SA	Grainstone	Slight.Mn c.,lse.,g.supt.,fract.
070	1.4	1.2	1.1	-	SA	Grainstone	Not Mn crusted,lse.,g.supt.
071	1.3	0.9	0.6	-	SA	Grainstone	Hf.Mn crusted,lse.,grain supported

KH 86-1 D-4

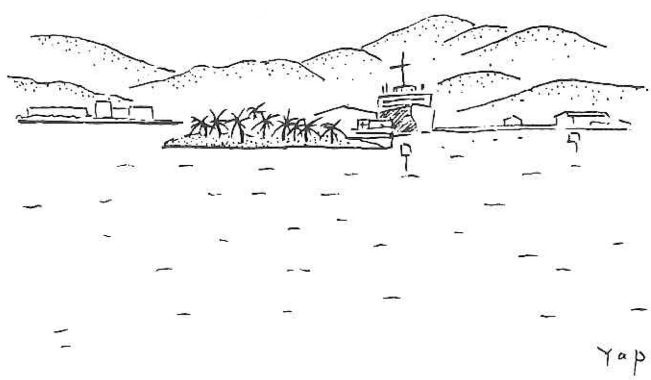
No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock Name	Remarks
001	34.0	20.0	16.0	10000	R	Micritc Ls.	Crinoid stem
002	23.0	14.0	13.5	3600	R	C.Biomicrud.	C.fag.mic. sement reefal binding
003	18.0	13.5	10.0	2700	SA	C.Biomicrud.	Coral & organism allochem, micr.
004	14.0	12.0	8.5	1100	R	C.Biomiclut.	Coral reefal Ls, smooth surface
005	15.0	10.0	5.0	600	R	Biolithite	C.frag.,one crnod.stem,smth.surf.
006	13.5	8.0	6.0	500	R	C.Biomicrud.	C.,mic.cemt.,rcryst.v.,smth.surf.
007	14.0	7.0	6.0	480	R	Biolithite	C.frag.,erosional smooth.surface
008	11.0	9.0	6.5	520	R	ditto	ditto
009	11.5	7.5	6.0	400	SA	C.Biomicrud.	C.,algal ball,reefal binding(?)
010	10.5	8.0	6.0	510	R	C.Biomicrud.	Corals,boreholes,smooth surface
011	13.0	9.0	6.5	550	SA	C.Biomicrud.	Corals,sparry,small Mn crust
012	13.5	10.0	5.0	690	SA	C.Biomicrud.	Corals and other fossiles
013	10.5	10.0	4.0	310	SA	C.Biomicrud.	Corals, boreholes
014	12.0	8.0	4.5	400	SA	C.Biomicrud.	Corals & other fossiles,sparry
015	10.0	7.0	4.5	320	R	C.Biomicrud.	Corals, crinoids, small Mn crust
016	10.5	7.0	4.5	380	SA	Biolithite	C.frag. *cavit.,er.surf.
017	10.0	7.5	6.0	340	SA	Biolithite	C.frg.atch.with.c.stem.& othr.*
018	11.0	6.0	5.0	340	SA	Biolithite	Micritic,C.frag.with cracks
019	11.0	6.0	4.0	290	SA	Biolithite	Coral
020	9.5	5.5	5.0	280	SA	Biolithite	C.,one side of erosion.surf.,spar.
021	10.5	7.0	3.0	140	SA	Biolithite	ditto,some Mn crust
022	8.0	5.0	4.0	250	SA	Biolithite	Coral,sperry surface
023	9.5	6.5	4.5	220	SA	Biolithite	Coral
024	8.5	7.0	3.0	160	SA	Biolithite	C.,smooth surf.with borehol.,Mn c.
025	9.5	6.5	4.0	160	SA	C.Biomicrud.	C.,spar.& secd.calc.cryst.in cavt.
026	8.5	5.5	4.0	180	SA	Biolithite	Coral
027	7.5	7.0	4.0	210	SA	C.Biomicrud.	Corals, sparry
028	8.0	8.0	4.5	150	SA	Biolithite	Coral, sparry surface
029	7.5	4.5	4.0	150	SA	Biolithite	Coral

030	8.0	5.5	3.5	110	R	Biolithite	Coral,thin Mn crust in boreholes
031	8.0	7.0	3.5	150	SA	Biolithite	Coral
032	10.5	4.3	2.5	100	SA	C.Biomicrud.	Corals, Sparry
033	8.9	6.0	2.5	105	SA	Biolithite	Coral,one side of erosional surf.
034	8.5	6.5	2.5	135	R	Biolithite	Coral
035	7.0	5.3	3.5	150	SA	Biolithite	Coral, sparry
036	8.0	6.5	3.5	160	R	Biolithite	Coral
037	6.5	5.5	4.0	125	R	C.Biomicrud.	Coralline blocks cemented by mic.
038	7.0	4.8	4.0	130	SA	Biolithite	Coral
039	7.0	6.0	3.8	180	SA	Biolithite	Coral
040	6.5	5.3	2.7	80	SA	Biolithite	Coral, sparry
041	8.0	5.0	2.0	80	SA	Biolithite	Coral
042	7.8	4.3	4.3	100	R	C.Biomicrud.	Corals
043	6.5	5.5	4.8	125	SA	Biolithite	Coral
044	7.0	5.2	3.0	95	SA	C.Biomicrud.	Corals,spar.sement,stained yellow
045	8.3	4.0	3.8	90	SA	Biolithite	Coral,some erosional surface
046	6.5	5.7	2.0	55	SA	Biolithite	C.,spar.smnt.,stain.yllw.,er.surf.
047	6.2	4.8	3.3	90	SA	C.Biomicrud.	corals
048	5.7	4.4	2.3	80	SA	Biolithite	Coral,sparry surface
049	6.0	5.3	3.5	95	SA	Biolithite	Coral,some erosional surface
050	6.0	5.3	3.8	110	SA	Biolithite	Coral,sparry
051	7.3	4.5	2.7	60	SA	C.Biomicrud.	Corals,Sparry
052	5.8	4.2	3.8	75	SA	Biolithite	Coral
053	6.3	4.5	2.2	60	SA	Biolithite	Coral,some erosional surface
054	5.8	4.5	2.8	55	R	Biolithite	C.frag.attach.with mollusca,brhol.
055	6.4	3.4	2.7	60	SA	Biolithite	Coral,sparry surface
056	6.3	4.2	3.1	55	SA	Biolithite	Coral,small Mn crust
057	6.0	4.5	4.0	100	SA	Biolithite	Coral,sparry
058	6.2	4.2	2.7	60	R	Biolithite	ditto
059	6.5	4.5	3.2	90	SA	Biolithite	ditto
060	5.5	3.5	2.5	55	SA	Biolithite	ditto
061	6.9	4.8	2.0	45	SA	Biolithite	Coral,sparry,one side of er.surf.
062	6.0	4.8	3.7	80	R	Biolithite	Coral
063	6.3	4.1	3.8	80	SA	C.Biomicrud.	C.,sement.by yllw.stain.sparite
064	6.1	4.2	3.1	90	SA	Biolithite	Coral,sparry surface
065	6.0	5.0	4.1	100	SA	Biolithite	Coral,boreholes
066	5.0	4.0	3.0	50	SA	Biolithite	Coral,sparry
067	5.5	4.2	3.0	60	SA	lith./micrud.	Coral fragment
068	4.5	4.5	2.2	55	SA	Biolithite	Coral sparry surface
069	6.2	3.2	1.3	40	SA	Biolithite	Coral
070	6.1	3.8	2.3	20	SA	Biolithite	Coral,sparry
071	7.0	4.0	2.8	60	SA	Biolithite	Coral
072	5.5	3.5	3.0	60	SA	Biolithite	Coral,sparry
073	5.2	4.5	2.5	40	SA	C.Biomicrud.	ditto
074	5.2	4.5	2.8	30	SA	Biolithite	Coral,boreholes
075	5.5	3.5	3.0	40	SA	Biolithite	Coral,sparry
076	6.3	3.3	2.8	60	SA	Biolithite	C.attch.echinoid(sea urchin)stems
077	5.0	3.9	1.5	40	SA	Biolithite	Coral
078	6.4	3.0	2.9	50	SA	Biolithite	Micritic,coral
079	5.5	3.5	2.5	40	SA	Biolithite	Coral
080	5.3	4.2	3.3	40	R	Biolithite	Coral
081	5.0	4.7	3.2	30	SA	Biolithite	Coral,sparry
082	7.2	3.8	2.3	40	SA	Biolithite	Coral
083	5.8	4.0	3.6	70	SA	Biolithite	Coral
084	5.7	4.7	2.1	60	SA	Biolithite	Coral,sparry
085	5.7	3.4	2.8	25	SA	Biolithite	Coral
086	5.2	4.2	2.6	55	SA	Biolithite	Coral
087	4.7	4.0	3.1	50	SA	Biolithite	Coral
088	4.8	3.5	2.8	30	SA	Biolithite	Coral,boreholes
089	4.5	3.8	3.0	30	SA	Biolithite	Coral
090	5.3	3.9	2.7	55	SA	Biolithite	Coral
091	5.9	3.2	2.8	50	SA	Biolithite	Coral
092	5.0	4.7	3.1	55	SA	Biolithite	C.,spar.,one side of smth.surface

093	4.7	4.1	2.8	25	R	Biolithite	Coral
094	5.2	4.0	2.9	30	SA	Biolithite	Coral,some Mn stain
095	5.0	3.3	3.1	40	A	Biolithite	Micritic, coral
096	4.8	4.2	1.9	20	SA	Biolithite	Coral, sparry
097	4.2	3.5	2.4	30	R	Biolithite	Coral
098	4.7	3.8	1.9	30	SA	Biolithite	C.,spar.,smth.er.surf.on one side
099	4.8	3.9	2.0	40	SA	Biolithite	Coral,sparry surface
100	5.2	3.8	2.0	30	SA	Biolithite	Coral
101	4.9	4.2	1.5	20	R	C.Biomicrud.	Coral
102	5.5	3.3	3.0	25	SA	Biolithite	Coral (Micritic)
103	5.4	3.7	2.3	30	SA	Biolithite	Coral
104	6.3	3.5	2.4	40	SA	Biolithite	Coral
105	4.5	3.3	2.9	25	SA	Biolithite	Coral,sparry
106	5.0	3.3	2.8	25	SA	Biolithite	Coral
107	4.5	3.8	2.5	25	SA	Biolithite	Coral
108	4.5	4.0	1.8	25	SA	Biolithite	Corals,bore holes,biomicrudite
109	4.2	3.8	2.6	30	SA	Biolithite	Coral
110	5.0	3.2	2.2	25	SA	Biolithite	Coral
111	4.3	3.8	2.8	20	SA	Biolithite	Coral
112				20	SA	Biolithite	C.,micritic cement but very lse.
113	5.3	2.8	1.5	10	SA	Biolithite	Coral
114	4.4	3.5	2.9	20	SA	Biolithite	Coral,sparry
115	6.0	2.7	2.0	20	SA	Biolithite	Coral,sparry
116	5.1	3.3	1.8	20	R	Biolithite	Coral,erosional surface on side
117	4.3	3.5	2.2	15	R	Biolithite	Coral
118	5.0	2.7	3.3	10	SA	Biolithite	Coral,sparry
119	5.5	3.5	0.9	10	SA	Biolithite	Coral(fresh fract.)
120	5.0	3.5	3.4	50	SA	Biolithite	Coral,micritic cement in fracture
121	4.0	2.8	1.8	10	A	Biolithite	Coral(micritic)
122	4.8	3.2	2.2	15	SA	Biolithite	Coral(micritic)
123	4.0	3.3	2.5	20	SA	Biolithite	Coral,sparry
124	4.0	3.3	2.9	30	SA	Biolithite	Coral
125	4.0	2.9	1.5	15	SA	Biolithite	Coral,bore holes
126	5.5	3.3	2.2	20	SA	Biolithite	Coral,micritic cement in fracture
127	4.9	3.2	2.3	20	SA	Biolithite	Coral
128	5.0	2.8	2.3	25	SA	Biolithite	Coral
129	4.0	3.6	2.1	20	SA	Biolithite	Coral
130	4.3	3.3	2.6	20	SA	Biolithite	Coral
131	4.4	3.0	2.2	20	SA	C.Biomrd.	Corals
132	5.0	3.0	2.0	15	SA	Biolithite	Coral with algal balls
133	4.5	3.2	2.1	15	SA	Biolithite	Coral
134	4.0	2.5	2.1	20	SA	Biolithite	Coral
135	5.0	2.4	2.1	15	SA	Biolithite	Coral
136	4.4	3.2	2.5	20	SA	C.Biomrd.	Corals
137	4.5	3.0	2.2	15	SA	Biolithite	Coral
138	4.3	2.7	2.2	10	SA	C.Biomrb.	Corals
139	4.0	3.4	2.2	10	R	Biolithite	Coral
140	3.7	3.2	1.8	8	SA	Biolithite	Coral
141	3.5	3.2	1.8		SA	Biolithite	Coral attached nwith forams
142	4.2	2.7	2.3	20	SA	Biolithite	Coral,sparry surface
143	4.3	2.9	2.7	10	SA	Biolithite	Coral
144	4.8	3.2	1.7	10	SA	Biolithite	Coral,(fresh fract.)
145	5.0	3.3	2.2	10	SA	C.Biomrd.	C.,yellowish stain.sparry cement
146	5.0	3.0	1.7	15	SA	Biolithite	Coral
147	4.3	3.1	2.0	10	SA	Biolithite	Coral
148	4.2	4.0	1.7	10	SA	Biolithite	Coral,oxidized surface,
149	3.8	3.2	1.8	10	SA	Biolithite	Coral
150	4.9	3.3	1.8	10	SA	Biolithite	Coral
151	4.0	3.2	2.6	5	SA	Biomrd.	Coral,crinod stem(?)
152	4.0	3.3	1.8	5	SA	Biolithite	Coral,sparry surface
153	3.2	2.9	2.0	5	SA	Biolithite	Coral
154	4.6	4.0	2.7	10	SA	Biolithite	Coral,erosional surface
155	4.6	3.3	2.1	5	SA	Biolithite	Coral

156	4.0	3.8	1.7		SA	Biolithite	Coral
157	4.2	3.6	2.2	5	SA	Biolithite	Coral
158	3.3	33.3	2.0	5	SA	Biolithite	Coral
159	3.2	2.9	2.2	5	SA	Biolithite	Coral
160	4.0	3.0	1.8	5	SA	Biolithite	Coral
161	4.3	3.3	3.2	5	SA	Biolithite	Coral
162	5.0	3.5	2.2	5	SA	Biolithite	Coral(micritic)
163	4.0	2.9	1.8		R	Biolithite	Coral
164	3.8	3.1	2.2	5	SA	Biolithite	Coral
165	3.9	2.9	2.0		SA	Biolihtite	Coral,sparry surface
166	3.8	2.6	2.1		SA	Biolithite	Coral
167	3.7	3.4	1.7		SA	Biolithite	Coral,erosional surface
168	3.9	2.5	1.8		SA	Biolithite	Coral,sparry sdurface
169	3.2	3.0	2.0		SA	Biolithite	Coral
170	3.6	2.9	1.8		SA	Biolithite	Coral
171	3.8	2.8	2.4		SA	Biolithite	Coral
172							
173	3.5	3.2	2.1		SA	Biolithite	Coral
174	4.2	2.5	2.1		SA	Biolithite	Coral
175	3.4	2.2	2.0		R	Biolithite	Coral
176	3.3	2.8	2.3		SA	Biolihtite	Coral
177	4.2	3.4	2.5		SA	Biolithite	Coral
178	3.4	2.4	2.2		SA	Biolithite	Coral
179	2.9	2.4	1.9		SA	Biolithite	Coral
180	3.3	2.4	1.9		SA	Biolithite	Coral
181	3.6	2.5	2.0		R	Biolithite	Coral
182	3.5	2.5	1.5		SA	Biolithite	Coral
183	3.5	2.4	1.4		SA	Biolithite	Coral
184	3.5	2.4	1.7		SA	Biolithite	Coral
185	3.2	2.2	1.7		SA	Biolihtite	Coral
186	3.2	3.0	2.2		R	Biolithite	Coral
187	3.3	2.3	2.1		SA	Biolihtite	Coral
188	3.5	3.0	1.5		SA	Biolithite	Coral
189	3.2	2.9	2.7		SA	Biolithite	Coral
190	3.3	2.8	2.1		SA	Biolithite	Coral
191	3.2	3.1	2.5		R	Biolithite	Coral
192	3.8	2.6	2.4		SA	Biolithite	Coral
193	3.5	2.8	2.3		SA	Biolithite	Coral
194	4.0	2.5	1.5		SA	Biolithite	Coral
195	2.8	2.8	2.0		SA	Biolithite	Coral
196	3.3	2.4	2.1		SA	Biolithite	Coral
197	3.2	3.0	1.3		SA	Biolithite	Coral
198	4.0	2.0	1.7		SA	Biolithite	Coral,iron stained
199	3.5	2.5	1.3		SA	Biolithite	Coral,some Mn cotas
200							
201	3.6	2.0	1.4		SA	Biolithite	Coral
202	3.5	2.4	1.8		SA	Biolithite	Coral
203	3.8	1.8	1.7		SA	Biolithite	Coral
204	3.3	2.9	1.8		SA	Biolithite	Coral
205	3.2	2.7	1.5		SA	Biolithite	Coral
206	2.8	2.6	2.2		R	Biolithite	Coral
207							
208	4.2	2.2	1.7		SA	Biolithite	Coral
209	3.0	2.2	1.9		SA	Biolithite	Coral
210							
211							
212	4.0	2.5	1.9		SA	Biliothite	Coral
501	8.0	6.0	3.0		R	Pumice	Well vesiculated
502	6.7	6.1	3.5		SA	Pumice	Well vesiculated without Mn-coat
503	6.5	4.5	4.0		A	Meta-basalt	White vein,partry Mn-coat
504	5.0	4.5	2.4		A	Calc.conglo.	Mtrx.is calcareous,basaltic frag.
505	4.3	3.6	2.4		SR	Serpentinite	Fresh,partly pyrophyllitic vein

506	4.4	3.4	2.3	SA Meta-tuff	Mn-coat
507	4.5	3.5	2.3	SR Serpentinite	Highly altered(diallage)
508	5.0	3.8	2.4	SR Meta-basalt	Mn-coat
509	3.8	3.0	1.8	SR Tuff breccia	Vari.kind of accident.frag.,Mn-c.
510	3.8	2.7	1.7	SA Pumice	
511	4.0	2.6	2.2	SA Calc.conglo.	
512	4.0	2.6	1.8	A Meta-basalt	Very fine grained, aphitic
513	4.0	3.2	2.0	SA Qtz.diorite	Altered,partry Mn-coat,or qt.vein
514	3.2	2.5	1.6	SR Tuf.sandst.?	Mn-coat
515	3.5	3.0	2.5	SR Tuf.sandst.	
516	3.5	3.0	2.1	SR Sandstone	
517	3.7	3.2	2.5	SR Tuff breccia	Mn-coat,altered pumice,calc.mud
518	2.8	2.7	1.5	SR Meta-tuff	Medium grained,Mn-coat
519	3.0	2.5	2.1	SR Sandstone	



KH 86-1 D-5 (All the pieces are Mn nodule)

No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock Name	Remarks
001	21.0	11.0	10.5	2050	R	Conglomerate	Rod-ellip R 100% S 0% 7mm crust
002	15.0	11.0	5.0	650	SR	Conglomerate	Fractured R 90% S 10% 15mm crust
003	13.0	10.0	7.0	450	SR	Conglomerate	Fractured R 75% S25% 10mm crust
004	8.5	5.0	4.0	150	R	Conglomerate	Ellip.fract.R 60% S 40% 15mm crust
005	6.5	4.7	4.0		SR		
006	4.8	4.5	2.7		SR		
007	5.8	2.5	2.1		SA		
008	5.0	4.0	2.8	15	R	Conglomerate	Ellip. R 100% 4mm crust
009	5.5	3.0	2.5	10	R	Siltstone	Rod R 100% 3mm crust
010	5.2	2.8	2.5	10	R	Sandstone	Rod R 20% S 80% 2mm crust
011	3.8	3.1	2.7		R		
012	4.0	3.0	2.5	10	R	Mudstone	Ellip. R 50% S 50% 3mm crust
013	3.9	3.3	2.3		R		
014	4.5	3.5	2.2	10	R	Conglomerate	Ellip. R 30% S 70% 1mm crust
015	4.1	3.0	2.7		SR		
016	5.0	2.8	2.8	10	R	Siltstone	Rod R 30% S 70% 3mm crust
017	3.9	2.8	2.0		R	Calc.mud	
018	3.9	2.2	2.1		R		
019	3.5	2.9	2.5		R		
020	4.3	3.3	2.3		R		
021	4.2	3.0	2.5		R		
022	4.3	3.1	2.7		R		
023	4.2	2.7	2.6		R		
024	3.5	3.2	2.8	10	R	Mudstone	Spher. R 40% S 60% 4mm crust
025	4.6	3.1	2.2		R		
026	5.2	3.2	1.9		SR		
027	4.0	2.7	2.1		R		
028	4.0	2.8	2.2		R		
029	3.3	2.7	1.9		R		

030	3.8	3.2	2.4		R		Three heads
031	5.0	3.5	2.2		SR		
032	4.2	3.4	2.1		R		
033	4.2	3.4	2.1		R		
034	4.7	2.4	2.1		R		Rod
035	4.5	3.1	2.4		SR		Maltiple heads
036	3.8	2.8	1.5		R		
037	3.5	3.0	2.0	5	R	Mudstone	Ellip. S 100% 2mm crust
038	3.5	3.0	2.9	10	R	Conglomerate	Ellip. R 80% S 20% 3mm crust
039	3.8	3.2	2.7	10	R	M.sandstone	Ellip. R 50% S 50% 2mm crust
040	4.0	3.5	2.0	7	R	Conglomerate	Ellip. R 20% S 80% 1mm crust
041	5.0	2.7	2.2	10	R	Conglomerate	Rod R 60% S 40% 2mm crust
042	4.2	3.0	2.0	5	R	Mudstone	Disc. R 85% S 15% 3mm crust
043	3.7	3.0	2.2	5	R	Conglomerate	Ellip. R 15% S 85% 3mm crust
044	3.3	2.7	2.3		R		
045	4.4	2.5	1.8		SR		Two heads
046	4.6	2.6	2.2		SR	Calc.mudstone	Three heads
047	4.0	2.8	2.5		R		
048	3.5	2.8	2.0		R		Irregular shape
049	3.3	3.0	1.7		SR		Irregular shape
050	3.2	2.8	1.8		R		
051	3.9	2.6	2.1		R		Two heads
052	3.5	3.1	2.3		R		Three heads
053	3.8	2.8	2.7		R		
054	3.8	3.4	1.9		SR		
055	3.1	2.9	1.6		R		
056	3.2	3.0	2.1		SR	Calc.sandst.	
057	3.1	2.4	2.2		R		
058	4.6	2.7	2.1		SR		
059	3.6	3.1	1.6		SR		Irregular shape
060	3.2	2.6	2.5		R		Three heads
061	3.4	2.7	1.9		R		
062	3.4	2.9	2.0		R		
063	3.6	2.7	1.9		R		
064	3.6	2.7	1.9		SR		Irregular shape
065	3.3	2.8	2.2		R		
066	2.8	2.3	1.7		SR	Calc.mudst.	
067	2.2	1.9	1.6		SR	Sandstone	
068	3.6	2.9	2.5		R		Two heads
069	4.4	2.6	2.0		SR		Three heads
070	4.3	3.6	1.9		SR		Multiple heads
071	3.6	2.6	1.9		SR		
072	3.1	2.7	2.5		R		
073	3.3	2.7	2.6		R		
074	3.4	3.0	1.6		R		
075	3.4	2.7	1.9		R		
076	3.5	2.5	2.0		SR		
077	4.0	2.7	1.9		SR		
078	3.8	2.2	1.9		R		
079	3.2	2.6	2.5		R		
080	3.6	3.0	1.7		SR		
081	3.0	2.7	1.6		R		
082	3.3	2.8	1.9		R		
083	3.4	2.6	2.1		R		
084	3.3	2.4	2.1		R		
085	3.1	2.6	1.9		R		
086	2.9	2.0	1.7		SR	Calc.mudst.	Two heads
087	3.0	2.2	1.9		R		
088	2.9	2.1	2.0		R	Calc.mudst.	
089	3.8	2.7	2.1		R		Maltiple heads
090	4.0	2.7	1.5		SA		
091	3.9	2.9	2.3		SR		Three heads
092	3.6	3.0	2.0		R		Two heads

093	3.6	2.4	2.1	R		
094	3.1	2.7	1.4	SR	Calc.mudst.	
095	3.3	2.3	2.0	R		
096	3.0	2.4	1.5	R		
097	3.4	2.3	1.6	SR		
098	3.1	2.3	2.0	R		Two heads
099	3.7	2.2	1.9	R		
100	4.1	2.4	2.0	SR		Two heads
1001	4.1	2.3	2.9	R	Pumice	
1002	4.2	3.3	2.2	SR	Pumice	
1003	3.8	2.8	2.0	R	Pumice	
1004	4.7	2.5	1.7	SR	Pumice	
1005	1.6	1.5	1.2	SR	Pumice	
2001	8.6	4.3	2.6	SA	Tuff	Coase grained,altered pumice
2002	7.0	3.9	2.8	SA	Tuff	Accidental fragments
2003	7.5	3.1	2.0	SA	Tuff	
2004	6.0	3.3	2.5	SA	Tf.granl.s.s.	
2005	4.5	3.0	2.1	SA	Tuff	Large pumice fragment
2006	4.1	2.8	1.7	SA	Tuff	Partly Mn-coat
2007	3.7	2.6	1.5	A	Tuff	
2008	3.0	2.0	1.6	SA	Tuff	
2009	3.1	2.1	1.6	SA	Tuff	
2010	3.0	1.3	1.1	SA	Tuff	
2011	2.8	1.7	1.3	A	Tuff	
2012	2.6	1.3	1.0	SA	Tuff	
2013	1.7	1.3	0.8	A	Tuff	
2014	1.7	1.3	0.9	SA	Tuff	Partly Mn-coat
2015	1.6	1.2	0.6	SA	Tuff	
2016	4.9	2.9	1.7	SA	Tuff	Partly Mn-coat
2017	3.7	3.1	1.8	SA	Calc.mudst.	Chalk
2018	3.5	2.5	2.2	SR	Calc.mudst.	
2019	4.5	2.3	1.1	SA	Tuf.sandst.	V.coase grained
2020	3.5	2.7	1.3	SA	Calc.mudst.	
2021	3.3	2.0	1.4	SA	Tuff	Altered,partly Mn-coated
2022	3.4	2.2	1.1	SA	Tuff	ditto
2023	3.3	1.9	1.4	SA	Tuff	ditto
2024	2.8	1.4	1.0	SA	Tuff	
2025	1.1	1.0	0.4	SA	Tuff	

KH 86-1 D-6

No.	X(cm)	Y(cm)	Z(cm)	W(g)	R	Rock name	Remarks
001	25.5	19.5	9.0	4700	R	Serpentinite	Metamorphic ultramafics
002	21.0	04.5	9.5	2150	SA	Calc.conglo.	Conglo.having calc.matrix
003	18.5	12.0	8.0	2100	SR	Serpentinite	Relict Cpx, highly altered
004	16.0	11.5	10.8	1950	A	Meta-gabbro	Irregular vein
005	15.0	10.8	9.0	1700	SR	Serpentinite	Highly altered & metamorphosed
006	15.8	7.5	5.7	550	SR	Meta-tuff	Includ.pseudomorphs of microfossil
007	15.5	10.5	7.0	1100	A	Serpentinite	
008	15.0	9.0	9.0	800	A	Calc.conglo.	Conglo.having calc.matrix
009	13.5	10.5	7.5	950	SR	Serpentinite	Highly altered, relict Cpx
010	14.0	9.5	7.0	1100	A	Calc.conglo.	
011	10.5	8.6	6.0	650	A	Serpentinite	Highly altered (hydrothermally?)
012	11.0	7.0	5.0	700	SR	Meta-gabbro	Altered
013	9.0	7.0	6.0	650	A	Hydthm.alt.rk.	
014	9.5	6.0	5.5	370	SA	Serpentinite	Altered
015	12.0	8.0	5.5	450	SA	Calc.conglo.	Fragments are fresh basaltic rk.
016	11.0	7.0	4.5	250	A	Serpentinite	
017	8.5	8.0	4.5	400	A	Serpentinite	Altered
018	9.0	6.0	5.0	250	A	Serpentinite	ALtered
019	10.0	5.8	5.5	400	A	Serpentinite	
020	10.0	7.5	4.5	350	A	Meta-gabbro	
021	8.0	6.0	3.0	250	A	Serpentinite	
022	7.0	6.5	4.0	300	A	Meta-tuff	Basaltic (vein)
023	8.0	6.0	6.0	350	A	Meta-tuff	Incld.larg.micfoss.are recrystlzd.
024	8.5	5.0	3.8	230	A	Serpentinite	Highly altered (hydorothermally)
025	7.0	6.0	4.0	220	SA	Serpentinite	Altered
026	11.0	6.0	5.0	480	A	Serpentinite	Antigorite(?)
027	8.0	6.0	3.0	260	SA	Rhyolite(?)	Hydrothermally alt., quartz druse
028	8.0	6.5	3.0	250	SA	Meta-tuff	Medium grained, lithic (angular)
029	9.0	8.0	3.0	220	A	Meta-tuff	Medium grained
030	7.0	4.5	4.5	150	R	Sandstone	Medium grain.,crust.by Mn-Fe oxide
031	9.0	4.0	3.5	240	A	Hydthm.alt.rk.	
032	9.5	6.0	4.3	180	SR	Tuff	Pumice fragments & rk fragments
033	11.0	7.0	6.0	450	A	Serpentinite	Highly hydrothermally altered
034	8.5	6.5	2.0	200	A	Meta-tuff	Rouned fragments
035	6.5	6.5	3.5	320	A	Metamorph.rk.	Garnet porphylobl.(orig.acid.tf.)
036	9.0	6.5	4.0	260	A	Meta-basalt	Meta-tuff or propyrite
037	9.5	5.6	5.0	340	A	Hydthm.alt.rk.	(Origin is igneous)
038	9.0	6.5	5.5	380	A	Hydthm.alt.rk.	ditto
039	11.0	7.0	4.0	250	A	Serpentinite	Altered into hydrotherm.materials
040	9.0	7.0	5.0	350	A	Serpentinite	
041	6.0	5.5	4.5	150	A	Tuff	Basalt.xenolith(frag.)coarse grain
042	6.0	5.3	4.0	200	A	Meta-basalt	propyrite or meta-tuff
043	6.0	4.0	2.5	110	A	Meta-tuff	or Meta-basalt
044	7.0	4.5	3.0	150	A	Meta-basalt	Greenschist facies
045	10.5	6.0	3.0	200	A	Serpentinite	Altered
046	7.0	6.3	2.5	200	A	Serpentinite	Spinel lherzolites(?)
047	8.0	5.0	2.5	170	A	Alt.volc.rk.	Pale greenish gray
048	8.0	6.0	5.0	230	A	Swrpentinite	Originally layered ultramafic rk.
049	7.5	5.0	4.0	250	A	Sandstone	Grading
050	9.5	5.5	3.5	160	A	Serpentinite	Highly altered (hydrothermally)
051	8.5	6.0	5.0	270	SR	Dacite	Included by altered hallo
052	7.0	5.0	4.0	160	SA	Serpentinite	Altered
053	6.0	6.0	3.0	150	A	Serpentinite	Altered
054	6.5	4.5	4.0	180	SA	Serpentinite	Altered
055	7.0	4.5	4.5	180	SA	Serpentinite	Altered
056	9.5	5.0	2.5	160	A	Serpentinite	Highly serpentiniozed
057	8.0	5.0	2.4	120	A	Hydthm.alt.rk.	
058	6.0	4.5	3.0	170	SA	Meta-tuff	
059	7.7	5.5	3.2	160	A	Meta-basalt	
060	7.0	5.2	4.5	230	A	Serpentinite	Altered

061	7.0	5.4	4.1		A	Hydthm.alt.rk.	Mn-coat
062	7.0	5.2	4.2	250	A	Rhyolite	Alt.cavity was fill.by qt.Mn-coat
063	5.7	4.6	2.7		SA	Meta-tuff	Medium garained, Mn-coat.
064	5.0	4.9	4.6		SR	Serpentinite	Altered thin Mn crust
065	6.0	5.2	4.1		SA	Meta-tuff	Acidic alter.hallo,part.Mn-coat
066	6.0	5.3	3.8		SR	Meta-tuff	Mn crust
067	5.7	5.2	3.5		SA	Hydthm.alt.rk.	
068	6.3	5.5	3.2		SA	Meta-tuff	Mn-coat,irregular white vein
069	6.9	5.0	3.0		SR	Hydthm.alt.rk.	
070	6.5	4.8	3.7	200	SA	Meta-tuff	Altered, Mn-coat
071	8.2	4.9	3.6		SA	Serpentinite	Altered, thin Mn-coat
072	7.5	6.7	3.8		SA	Hydthm.alt.rk.	Partly Mn-coat
073	7.2	3.1	3.1		SA	Hydthm.alt.rk.	
074	6.8	5.5	3.2		SA	Meta-tuff	Hydthm.alt.,lt.gray.grn.,Mn-coat
075	4.7	4.0	3.8		SR	Serpentinite	Veinlet, Mn-coat
076	6.2	5.0	3.1		SA	Meta-basalt	Thin Mn crust
077	6.4	4.1	3.5		A	Meta-tuff	Altered, Mn-coat
078	4.2	3.8	3.8		SR	Alt.serpent.	Hydrothermally
079	7.0	4.9	3.8		SA	Pillow bre.	Altered, partly Mn-coat
080	8.0	5.5	3.5		SA	Hydthm.alt.rk.	Light yellowish brown, Mn-coat
081	8.5	6.1	3.0		A	Serpentinite	Schistose, altered, Mn-coat
082	7.9	4.5	4.0		A	Hydthm.alt.rk.	Mn-coat
083	7.0	4.3	4.0		SA	Meta-tuff	Medium grained, Mn-coat
084	6.2	5.5	4.5		SA	Altered tuff	Basaltic frag., pumice, Mn-coat
085	5.8	5.1	4.3		SA	Serpentinite	Altered, Mn-coat
086	5.6	4.5	3.5		SR	Quartzite(?)	A possible vein, joint rich
087	5.0	4.7	4.0		A	Meta-basalt	Hydrotherm.alt., Mn-coat
088	5.0	4.0	3.2		SR	Serpentinite	Altered, antigorite, Mn-coat
089	5.5	3.3	2.7		SA	Meta-tuff	Medium grained, Mn-coat
090	7.5	4.0	3.8		SA	Serpentinite	Highly altered, Mn-coat
091	4.6	4.0	2.9		SR	Hydthm.alt.rk.	
092	7.0	3.5	2.8		SA	Meta-tuff	Mn-coat
093	7.0	4.2	3.5		SR	Meta-tuff	Altered, soft, lt.grayish green
094	6.6	6.2	3.3		SA	Meta-tuff	Fine grained, Mn-coat
095	6.7	4.5	2.5		SA	Meta-tuff	Med.grain.,partly serpentinized
096	6.9	4.5	3.9		SA	Hydthm.alt.rk.	
097	9.2	3.9	3.0		A	Meta-tuff	Medium grained
098	6.8	4.4	3.0		A	Hydthm.alt.rk.	Partly Mn-coat
099	7.2	5.2	2.5		A	Hydthm.alt.rk.	
100	7.4	3.9	2.8		A	Meta-tuff	Hydrotherm.altered,partly Mn-coat
101	6.6	4.9	3.8		SR	Meta-tuff	or Meta-dacite, Mn-coat
102	5.5	4.1	3.8		SA	Serpentinite	Altered
103	4.9	3.6	1.9		SA	Serpentinite	Altered
104	7.0	4.3	3.2		SA	Serpentinite	Altered (meta-tuff?)
105	6.6	3.8	3.5		SA	Meta-tuff	Grading, Mn-coat
106	6.5	4.2	3.8		SA	Hydthm.alt.rk.	Mn-coat,(original serpentinite?)
107	4.4	3.5	2.3		SA	Serpentinite	Mn-coat
108	5.7	3.7	2.9		A	Hydthm.alt.rk.	Partly Mn-coat
109	4.9	3.2	2.9		SR	Serpentinite	Altered
110	4.5	4.1	2.6		SA	Hydthm.alt.rk.	Mn-coat
111	9.3	6.2	3.3		A	Hydthm.alt.rk.	Mn-coat
112	4.8	3.7	3.0		A	Serpentinite	Altered
113	6.1	4.0	3.2		A	Serpentinite	Brown spots, Mn-coat
114	6.4	5.0	3.7		SA	Conglomerate	Scoriaceous, many rock fragments
115	6.3	5.4	2.0		A	Hydthm.alt.rk.	
116	4.5	3.9	1.6		A	Meta-tuff	Mn-coat
117	5.5	4.0	2.2		SA	Meta-tuff	Medium grained, Mn-coat
118	6.0	4.7	2.4		A	Hydthm.alt.rk.	
119	4.6	3.7	3.0		SR	Meta-gabbro	Altered & Metamorphosed, Mn-coat
120	5.6	4.4	2.5		A	Serpentinite	Partly Mn-coat
121	7.2	4.5	4.2		SA	Serpentinite	Highly alt.(hydrotherm.),Mn-coat
122	5.3	4.0	3.2		A	Serpentinite	Mn-coat
123	6.3	3.7	3.2		SA	Hydthm.alt.rk.	
124	5.6	4.3	2.7		SA	Calc.conglo.	Fragments are alt.pumice,Mn-coat

125	4.7	3.9	2.8		A	Meta-basalt	Dk green phenocryst?, Mn-coat
126	7.1	6.4	3.2		SR	Hydthm.alt.rk.	Mn-coat
127	4.5	4.2	3.8		SR	ditto	ditto
128	5.3	3.7	2.5		A	ditto	Altered hallo
129	8.3	4.8	3.0		A	ditto	ditto
130	4.5	4.3	2.4		SA	Serpentinite	Highly altered, Mn-coat
131	3.5	3.1	2.5		SR	Serpentinite	ditto
132	4.3	3.7	3.2		SR	Hydthm.alt.rk.	Mn-coat
133	5.3	3.3	1.8		A	ditto	
134	6.3	3.0	2.0		SA	Pumice	Altered, Mn-coat
135	6.30	3.7	2.0		SA	Meta-tuff	Fine grained, Mn-coat
136	5.0	4.5	3.2		SA	Hydthm.alt.rk.	Partly Mn-coat
137	5.9	4.2	2.7		SA	Serpentinite	Altered
138	5.6	4.6	2.2	100	SA	Hydthm.alt.rk.	Partly Mn-coat
139	5.2	4.5	2.7	80	SA	Serpentinite	Highly altered
140	5.7	3.2	2.5	80	A	Meta-tuff	Medium grained
141	6.0	4.2	3.0	100	A	Hydthm.alt.rk.	Mn-coat
142	5.5	3.7	2.4	80	A	Meta-basalt	Cavity was fill.by Qt.,Mn-coat
143	4.9	4.6	2.8	100	SA	Serpentinite	Altered, Mn-coat
144	5.5	5.2	3.5	130	SA	Meta-tuff	Medium grained
145	5.1	3.8	2.8	60	SA	Meta-tuff	Mn-coat
146	7.4	4.4	4.0	180	A	Meta-tuff	Cavity, Mn-coat
147	7.1	4.4	4.0	80	A	Serpentinite	Highly altered, Mn-coat
148	5.5	4.3	3.8	90	R	Dacite	Pumice.porous pl-phenocry.,Mn-coat
149	5.5	4.0	2.7	70	SA	Meta-tuff	Highly altered pumice, Mn-coat
150	4.3	3.8	2.9	70	SR	Sandstone	Medium grained, Mn-coat
151	6.5	4.7	4.5	70	SR	Breccia	Altered pumice, mudstone fragment
152	7.5	3.58	2.7	50	A	Hydthm.alt.rk.	
153	6.2	5.0	2.8	60	A	ditto	Mn-coat
154	4.6	3.6	1.6	50	A	Meta-tuff	Medium grained, Mn-coat
155	5.0	4.2	3.5	50	SR	Serpentinite	Altered, Mn-coat
156	5.0	5.0	3.2	60	R	Dacite	High.vesicl.includ.by calc.m.s.,Mn
157	4.8	3.8	3.2	60	SR	Meta-tuff	White vein
158	4.3	3.0	2.8	60	SA	Serperntinite	Mn-coat
159	6.5	5.3	3.3	60	SR	Mudstone	Mn-coat
160	4.2	4.0	3.0	40	A	Hydthm.alt.rk.	(Original rock sandstone)
161	6.0	4.3	2.5	40	A	Meta-tuff	
162	6.3	3.5	2.7	50	SR	Serpentinite	Mn-coat
163	5.0	4.7	2.8	60	SR	Serpentinite	
164	6.5	5.0	3.3	70	R	Meta-tuff	Pumiceous, thick Mn crust (3.8mm)
165	4.8	3.5	3.3	50	R	Basalt	Fresh well vesiculated, alt.hallo
166	4.5	3.7	3.0	70	A	Meta-tuff	Coase grained
167	4.8	4.3	3.0	50	A	Serpentinite	Mn-coat
168	5.3	4.8	3.0	75	SA	Meta-tuff	Granule size(epidosite)Mn-coat
169	5.2	4.7	3.5	90	A	Meta-tuff	Mn-coat
170	5.5	5.3	2.7	60	SR	Dacite	Flow struct.,quite fresh,Mn-coat
171	4.5	3.7	3.5	60	R	Meta-dacite	Mn-crust(max 1.5mm), vesicular
172	4.0	4.0	2.5	50	SA	Meta-tuff	Medium grained
173	5.8	4.0	2.5	50	SA	Tuff	Altered, Mn-coat
174	6.0	4.0	3.2	40	SR	Calc.sandst.	Coarse grained,Mn-crust(max 4.0mm)
175	5.5	3.9	3.3	60	A	Meta-tuff	Mn-coat
176	5.8	4.2	2.7	70	A	Hydthm.alt.rk.	Mn-coat
177	7.8	4.5	2.0	110	SA	Serpentinite	Mn-coat
178	5.0	4.3	3.8	80	A	Meta-tuff	Reddish spots
179	6.3	3.5	2.0	60	SA	Meta-tuff	Fine grained
180	5.3	4.2	2.3	50	SA	Meta-tuff	Coarse grained
181	5.2	4.2	3.2	70	A	Serpentinite	Mn-coat
182	4.8	3.8	2.3	40	SA	Serpentinite	Mn-coat
183	5.5	4.7	1.8	60	SA	Serpentinite	
184	5.7	4.0	1.5	60	SA	Meta-tuff	Mn-coat
185	3.5	3.0	2.3	70	A	Hydthm.alt.rk.	
186	5.5	4.0	2.8	50	SA	Meta-tuff	Coarse grained, Mn-coat
187	5.3	3.7	3.5	60	SA	Meta-tuff	Hydrothermally altered, Mn-coat

188	4.0	3.0	2.8	50	SA	Serpentinite	Altered, schistose(?), Mn-coat
189	4.7	3.6	2.7	50	A	Meta-tuff	Mn-coat
190	6.5	4.0	2.2	70	A	Serpentinite	
191	5.7	4.0	3.7	90	SR	Meta-tuff	Coarse grained, Mn-coat
192	6.2	4.5	2.8	70	SA	Meta-tuff	Granule size, Mn crust (thick)
193	6.5	3.2	3.2	60	A	Serpentinite	Dk green vein, Mn-coat
194	5.8	4.0	3.7	80	SA	Serpentinite	
195	4.2	3.7	3.0	40	A	Breccia	Mn-coat
196	4.0	3.0	2.8	60	SA	Hydthm.alt.rk.	
197	5.8	4.3	3.8	90	A	Meta-tuff	Hydrothermally altered, Mn-coat
198	6.0	4.8	2.5	60	A	Meta-tuff	Mn-coat
199	4.7	3.5	2.8	50	R	Serpentinite	Mn-coat
200	5.2	3.0	2.5	50	A	Serpentinite	Altered