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IX. BOTTOM POTENTIAL TEMPERATURE AND VERTICAL TEMPERATURE PROFILES OF NEAR-BOTTOM WATERS IN THE CENTRAL PACIFIC

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Introduction

Two earlier Hakurei-Maru cruises in the northern Central Basin collected the data of water temperature profiles down to the sea-bottom at some sites by a STD instrumentation (MARUYAMA and KINOSHITA, 1977; 1979). In our cruise, we tried to obtain the near-bottom water temperatures at piston coring sites along the two traverses, Lines A and B from the east of Wake to the west of Tahiti, utilizing the areas of the IC memory unused for the heat flow measurement by a thermogradmeter system within a piston corer head (MATSUBAYASHI, this cruise report). The purpose was to provide basic data of physical environmental conditions of pelagic sedimentation and manganese nodule formation.

Water temperatures were measured in two modes. Firstly, water temperature was recorded at the moment when the pilot corer of the piston corer reached the sea-bottom (Mode 1). The temperatures thus measured represent those at 7.5 m above the bottom. The results are considered to be reliable at all the piston coring sites except St. 1622. Secondly, measurements were made while the instrument was being hoisted at velocities of 70 to 100 meters/min after the piston corer left the bottom (Mode 2), so that the recorded temperatures have some lag behind a true water temperature. However, an error caused by the lag is insignificant since the vertical temperature gradient of water in the lowermost 1,000 m in this region is known to be very small (CRAIG *et al.*, 1972).

Results and discussion

The results of measurements of *in situ* water temperature (T *in situ*) at 7.5 m above the bottom as obtained by Mode 1 are shown in Table IX-1. The table also includes tentative values of their potential temperatures (Tp) calculated under the assumption of the mean salinity of 34.70 per-mil and use of the polynomials proposed by BRYDEN (1973).

Measurements by Mode 1 were conducted under a constant condition at every piston coring site, hence relative accuracy of the measurements are considered to be very high. T *in situ* values obtained are plotted against the water depth at the individual stations (Fig. IX-1). The figure shows a significant variation of Tp among the stations.

All the values of Tp seem to be higher by 0.03° to 0.04°C than the values by previous workers (LONSDALE and SMITH, 1980). The discrepancy may have resulted from the fact that the methods adopted by them to get potential temperatures were older ones, which give lower Tp by 0.01° to 0.03°C for the present results than those using BRYDEN's polynomial, or the systematic shift may have partly been caused by our calibration procedure;

Table IX-1 *In situ* temperature (°C) and potential temperature (°C) of waters measured at 7.5 m above the sea-bottom. Type classification shows the pattern of vertical temperature profile of near-bottom waters.

Type I					Type II					Type unknown				
St. no	Obs. no.	Water depth (m)	T *in situ*	Tp	St no.	Obs. no.	Water depth (m)	T *in situ*	Tp	St. no.	Obs. no.	Water depth (m)	T *in situ*	Tp
1603	(H15)	5479	1.331	0.845	1609	(H18)	4397	1.234	0.880	1644	(H35)	5027	1.332	0.901
1605	(H16)	5455	1.307	0.824	1612	(H19)	4808	1.410	1.003					
1607	(H17)	5698	1.226	0.715	1615	(H20)	3153	1.548	1.316					
1618A	(H21)	5530	1.308	0.816	1619	(H22)	5131	1.268	0.824					
1626	(H25)	4711	1.320	0.927	1624	(H24)	3908	1.400	1.094					
1630	(H27)	5537	1.272	0.780	1628	(H26)	4947	1.252	0.833					
1632	(H28)	5255	1.296	0.839										
1634	(H29)	5087	1.288	0.851										
1635A	(H30)	5350	1.324	0.854										
1636	(H31)	5747	1.384	0.860										
1638	(H32)	5791	1.392	0.863										
1640	(H33)	5915	1.416	0.870										
1642	(H34)	5441	1.352	0.869										

resistance values of thermistors were measured in a precisely controlled water bath with strirrer in the laboratory, whereas water temperatures at the ocean bottom were measured in a static condition. In this report, we do not regard the discrepancy as significant, because the absolute accuracy of thermometers which were used for the early-stage works of potential temperatures in the Central Pacific Basin is no better than $\pm 0.02°C$ (GORDON and GERARD, 1970).

Measurements by Mode 2 provided vertical temperature profiles of near-bottom waters. The measurements are considered very accurate only in six stations. In Fig. IX-2 only the reliable near-bottom temperature profiles are shown. When other data with less reliability are also taken into consideration, we can recognize two distinct types of vertical temperature profile through all the stations.

The first type (type I) is characterized by the presence of a minimum temperature at depths of 4,500 to 5,150 m. It is found at the stations mostly deeper than 5,200 m in the Central Pacific Basin (Table IX-1). This result is quite consistent with EDMOND *et al.* (1971)'s data regarding the common occurrences of nearly adiabatic temperature profiles in the Central Pacific bottom waters, which are the good evidence for the influx of cold bottom water, the Pacific Bottom Water (PBW) originating from the Antarctic Bottom Water (AABW).

The second type (type II) has no temperature minimum; the temperature increases monotonically from the sea-bottom upward. This type is distributed on and around the Manihiki Plateau, where an anomalous bottom-water of the first type also occurs. Type II

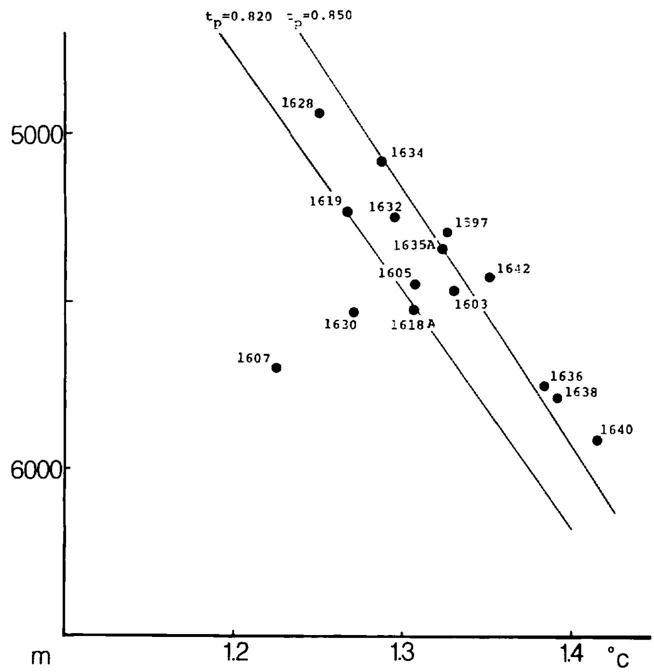

Fig. IX-1 Water temperatures *in situ* (plotted against water depth) measured at 7.5 m above the sea-bottom at the piston coring sites which have vertical water temperature profiles of Type I. Numbers attached stand for station numbers.

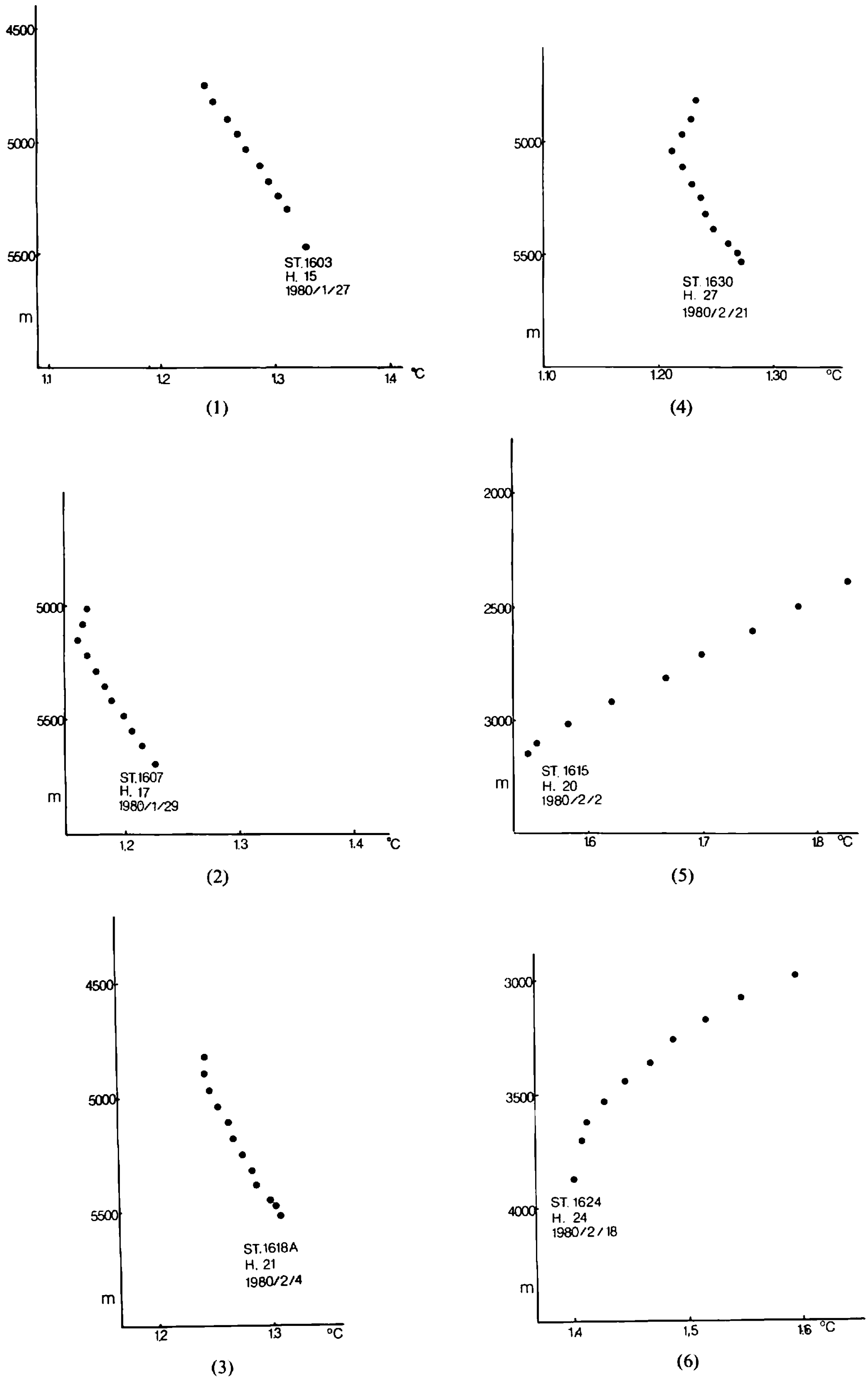

Fig. IX-2 Vertical temperature profiles (*in situ* temperature) of near-bottom water obtained in this work. Only the data which have high reliability are shown.

is found at Sts. 1609 (4,397 m at the foot of the "Western Plateaus"), 1612 (4,808 m at the Danger Islands Trough), 1615 (3,153 m at the "High Plateau"), 1624 (3,908 m at a topographic high in the "Eastern Plateaus", 1628 (4,974 m at the western margin of Central Pacific Basin), and 1619 (5,131 m at the Penrhyn Basin). Among these, Sts. 1615 and 1624 are situated within a depth range of the Pacific Deep Water (PDW) (CRAIG *et al.*, 1972), which has the profile slightly increasing water temperature with depth and has no temperature minimum near the bottom. Occurrences of type II at Sts. 1612, 1628, and 1619 in the deeper waters are very anomalous for either typical PDW or PBW. On the other hand we can find type I profile at St. 1626 in the "Eastern Plateaus", which seems to be anomalous for its shallow depth together with high Tp of bottom water. It seems curious that the both types are observed in the Penrhyn Basin: St. 1619 belongs to type II, whereas St. 1618A (5,530 m) about 200 km apart from St. 1619 southwesterly to type I. From the above observations on and around the Manihiki Plateau lateral dissipation of heat by water movement is more effectively taking place than the cases of type I may be inferred.

From the results of measurements by both modes, we notice a gradual northerly increase of temperature of bottom water deeper than 5,000 m in the Central Pacific Basin north to the Nova-Canton Trough. Starting with Tp value around 0.83°C on the immediate north of the trough, it gradually and constantly rises with a small gradient of about 0.02°C/1000 km in the meridional direction and finally reaches 0.87°C at the north of Magellan Trough (Fig. IX-3). The gradient is almost identical with that given in LONSDALE and SMITH (1980)'s map and may be interpreted to be due to very slow northward flow of bottom water (at a velocity of 13 km/yr according to an estimate by GORDON and GERARD (1970)) gradually warmed by the terrestrial heat flow through the sea floor.

It may be stated that the region of occurrence of the rough type manganese nodules (USUI, this cruise report) generally overlaps with the region of type I temperature profile, where very slow northward flow is observed. On the other hand, in the case of St. 1607 south of the Nova-Canton Trough, it is inferred from the Tp value that cold water inflow

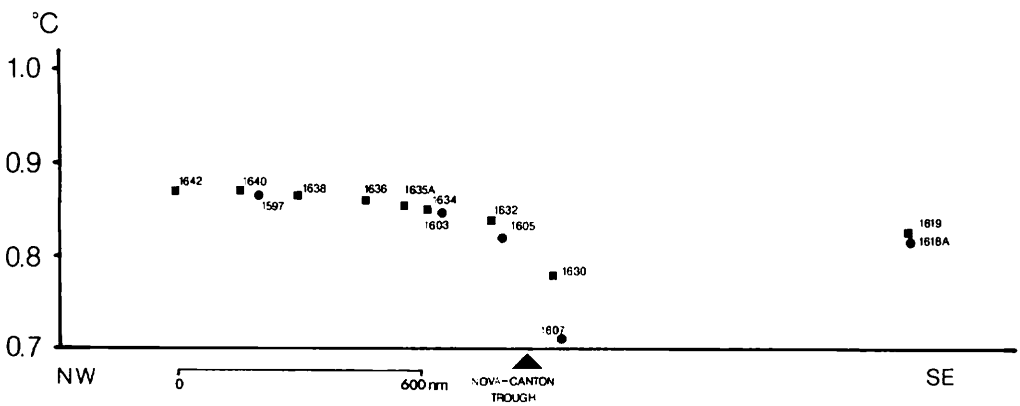

Fig. IX-3 Bottom potential temperature at each site along Line A (solid circles) and Line B (solid squares). Tp value at each site is plotted against distance from the position of Nova-Canton Trough.

may not be sufficiently slow, as discussed later, for producing a depositional environment favorable for the rough type manganese nodules to grow in the sediments. The possible genetic relationship proposed here between the nodule distribution and the very slow flow of bottom water seems to be consistent with MIZUNO and MORITANI (1981)'s model explaining the relation among manganese nodule distribution, sedimentation rate, and inferred bottom current velocity in a part of the northern Central Pacific Basin. However, the existing data being still insufficient for this problem, more data of bottom water hydrography in this region should be collected for further discussions on sedimentary processes connected with manganese nodule depositions.

A new finding is a great change of bottom water temperature between northern and southern sides of the Nova-Canton Trough. Tp values at Sts. 1607 and 1630 in the North Tokelau Basin immediately south of the trough are lower by 0.109°C (St. 1607) and 0.059°C (St. 1630) than those of the stations north of the trough, resulting in a very large gradient of Tp across the trough (see Fig. IX-3). The observed Tp values in the North Tokelau Basin are in good agreement with earlier results (REID and LONSDALE, 1974). We may suppose the east-northeast trending rapid flow of bottom water in the North Tokelau Basin nearly parallel to the trough. The low temperatures in the basin are indicative of the immediate northern extension of the cold bottom water passing through the Samoan Passage originating from the AABW. The low flanking ridge just south of the Nova-Canton Trough may prevent the northward outflow of the cold bottom water across the trough, and only its small part may enter into the north of the trough and be mixed with the relatively stagnant mass of bottom water to the north of the trough. This may cause a clockwise turning of bottom waters as figured by LONSDALE and SMITH (1980) around the north of the Manihiki Plateau.

The Tp values in the Penrhyn Basin are slightly lower than those in the area north to the Nova-Canton Trough and much higher than those in the North Tokelau Basin. GORDON and GERARD (1970) and WONG (1972) figured the flow of AABW into the Penrhyn Basin through the "Aitutaki Passage" (PAUTOT and MELGUEN, 1979) between the Manihiki Plateau and the Society Islands. The observed Tp values are much higher for an expected one if the cold bottom waters directly inflow through the passage into the Penrhyn Basin. The present data, together with REID and LONSDALE (1974)'s data around the Manihiki Plateau, seem to support their argument against the possibility that "a principal south-to-north passage for the Antarctic Bottom Water lies east of the Manihiki Plateau." The clockwise bottom water flows around the north of the plateau originating from the Samoan Passage may reach the part of the Penrhyn Basin with a gradual rise of Tp. However, the problem is still open for the future regional survey, because the relevant data around the Penrhyn Basin are still insufficient at the present time.

Conclusion

Our temperature data of near-bottom waters along the two traverses, Lines A and B from the east of Wake to the west of Tahiti contribute to better understanding of some aspects of present environmental conditions of pelagic sedimentation in the central Pacific. We can find a very slow northward flow of bottom water in the northern and central parts of the Central Pacific Basin to the north of Nova-Canton Trough. There is a possibility that the extensive distribution of r-type nodules is connected with the slow bottom current. The low flanking ridge on the south of the trough seems to contribute as a barrier to prevent a northerly outflow of a large mass of the AABW in the North Tokelau Basin beyond the trough and let it turn clockwise toward the northeast to east of the Manihiki Plateau, and in turn toward the Penrhyn Basin. Based on our temperature data of bottom waters, it seems difficult to postulate that the AABW from the south flows directly into the Penrhyn Basin through the "Aitutaki Passage". We can recognize lateral mixing which causes the absence of adiabatic temperature distribution of near-bottom waters on and around the Manihiki Plateau.

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