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VI. HEAT FLOW MEASUREMENT IN THE GH80-5 AREA

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Introduction

Heat flow measurement started from last cruise to study the relationship between hydrothermal spots and distribution of Mn-nodules. In last cruise rough investigation were carried out along the survey line that transects the Central Pacific Basin, Manihiki Plateau, and Penrhyn Basin. In this cruise measurements at close points in a narrow detail survey areas were done.

Method

Measurement of heat flow needs two value; thermal gradient of the sediment near the sea bottom and thermal conductivity of the sediment. The equation is as follows.

$$Hf = Tg \times Tc$$

Hf means heat flow value, Tg thermal gradient, and Tc thermal conductivity. To obtain the thermal gradient value in the right hand of the equation, three thermistor sensors were attached to piston corer which samples sediments vertically by penetrating to the sea bottom. Thermal gradient was calculated by the difference of temperature of three thermistors which were attached at different three depths. Thermal conductivity was measured on the sediments sampled by piston corer. The method using thermistors and piston corer is called the method of Lamont.

Thermal gradient

The recorder of temperature was IC (integrated circuit) memory and it obtained and stored three values every one minute for 31 minutes after the trigger of piston corer worked. and then its total memories were 3×32 values. When the piston corer was brought up on the board, the recorder in an anti-pressure case was taken off from the head part of piston corer, brought to laboratory of ship and, connected to CPU (control processing unit) after the cap of case was taken off. Then CPU read out the value stored in IC memory. The data are memorized on note book and are punched out on paper tape in 8 bit binary holes by paper tape puncher.

Three thermistors were kept for 3 minutes in a position of 30 m above the sea bottom before penetration. During the interval their temperature became to be same with that of environment and the value was used as a standard temperature for three thermistors together with the values which were obtained when the piston corer was pulled up and then kept for 3 minutes at 30 m above the bottom.

Thermal conductivity

Sediments were brought, after the core was cut in half on the deck, into the onboard laboratory where temperature is kept to be 20°C by air conditioner. The half was wrapped by thin vinyl sheet whose thickness was about 0.1 mm and kept on the side lack for three hours to wait that the temperature of sediment became to the room temperature and homogeneous in it. Showtherm QTM-D2 manufactured by Showa Denko Co. was used to measure the thermal conductivity. Measurement was done for every 33 cm; 3 points in 1 m core. The value of termal conductivity of a core was calculated as the average of their data between 3 m and 7 m where thermistors were attached.

DHF measurement

A test of DHF5 (digital heat flow meter) type heat flow meter which can record temperatures up to 8 thermistors for many adjacent sites was done at the two points near St. 2011 (P200). The anti-pressure case including temperature recorder and 3 thermistors were set on a spire of 4 m length. Another thermistor was set on the head part of the spire for checking whether the spire penetrated sediments and temperature of thermistor really changed. The two positions of DHF type heat flow meter test and that of P200 were on a line WWN-EES direction and 0.5 mile apart each other as shown in Fig. VI–1 represented on a track chart by NNSS. The temperature data converted into electric signals were changed to the time intervals of pair pulse of the attached 12 kHz pinger and were sent to the onboard PDR (precise depth recorder). The record of 12 kHz pinger was described on UGR recorder in a scanning rate of 0.5 second for one trace. Fig. VI–2 shows the record of the sound of the pinger. The differences in temperature were calculated from the distances between mark 0 and marks 1, 2, 3 written on the record of the figure. Only two sets of data were obtained for each site, owing to the noise of bowthruster which was obliged to operate to keep the ship at the same point during the measurement. Only thermal gradients were obtained from these record, because the spire can not get sediment

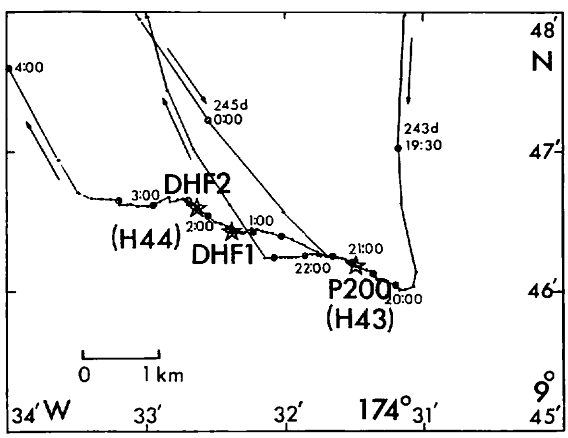

Fig. VI–1 Locality map of the test of DHF type heat flow meter.

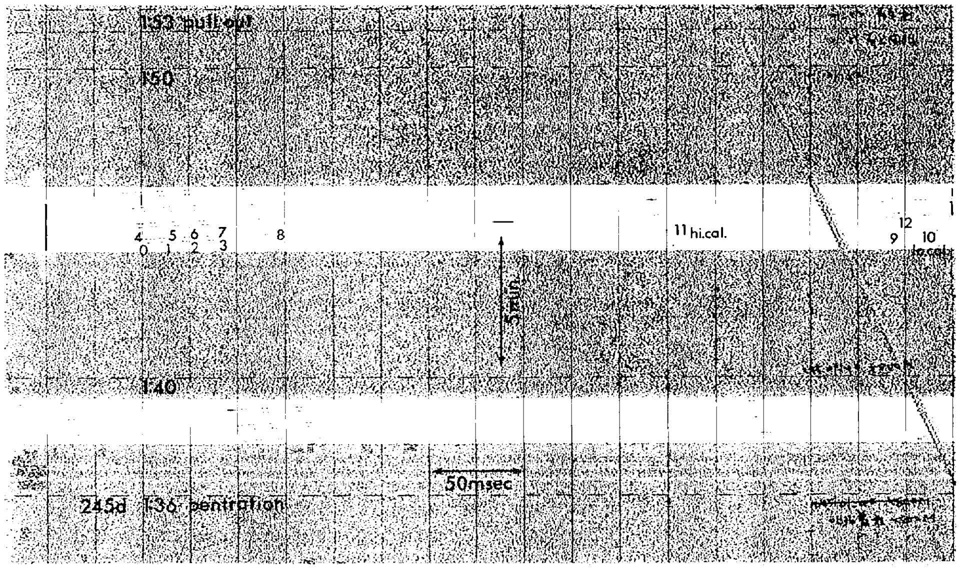

Fig. VI-2(1)

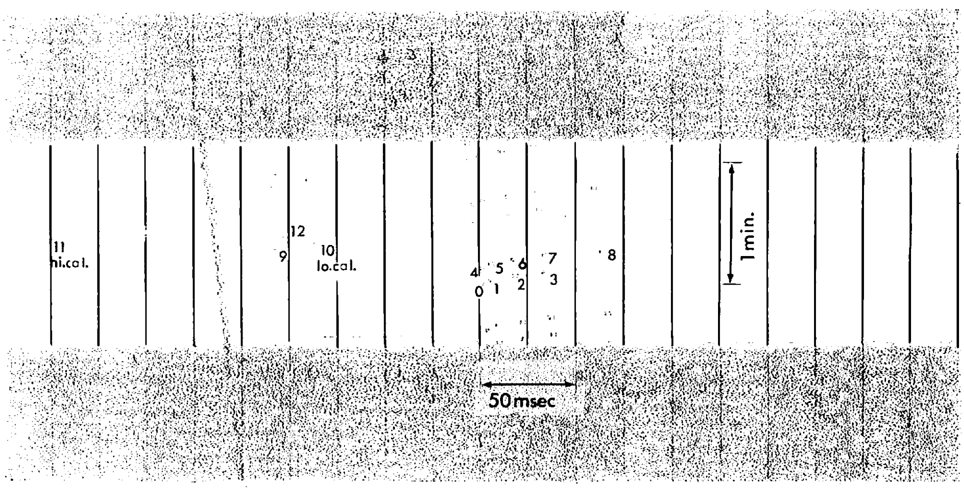

Fig. VI-2(2)

Fig. VI-2 Record of pinger attached to DHF type heat flow meter. Number 0 to 12 shows the recording channel and up to 8 thermistors are available. In this case 4 thermistors were set and repeated twice. so the data of 0, 1, 2 and 3 is the same as that of 4, 5, 6 and 7.

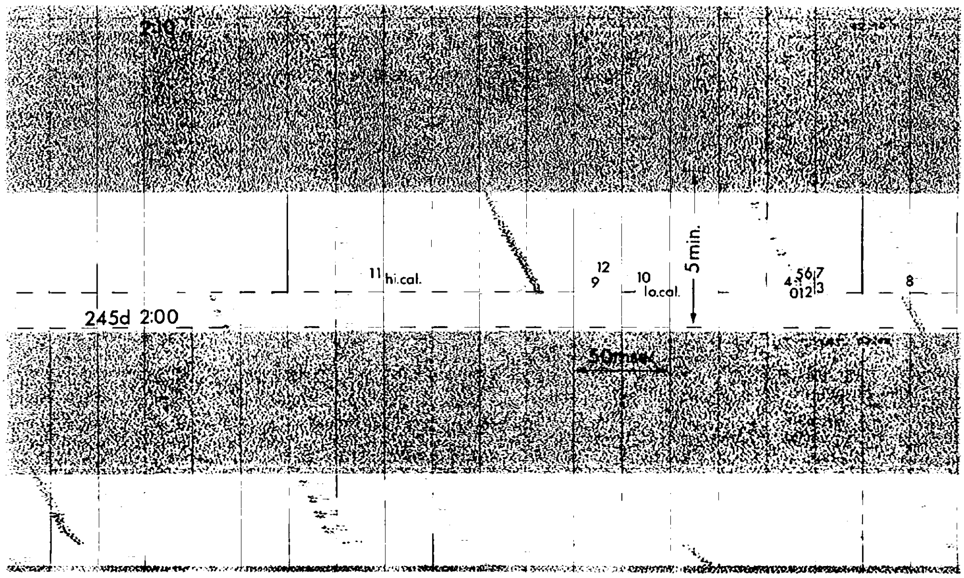

Fig. VI-2(3)

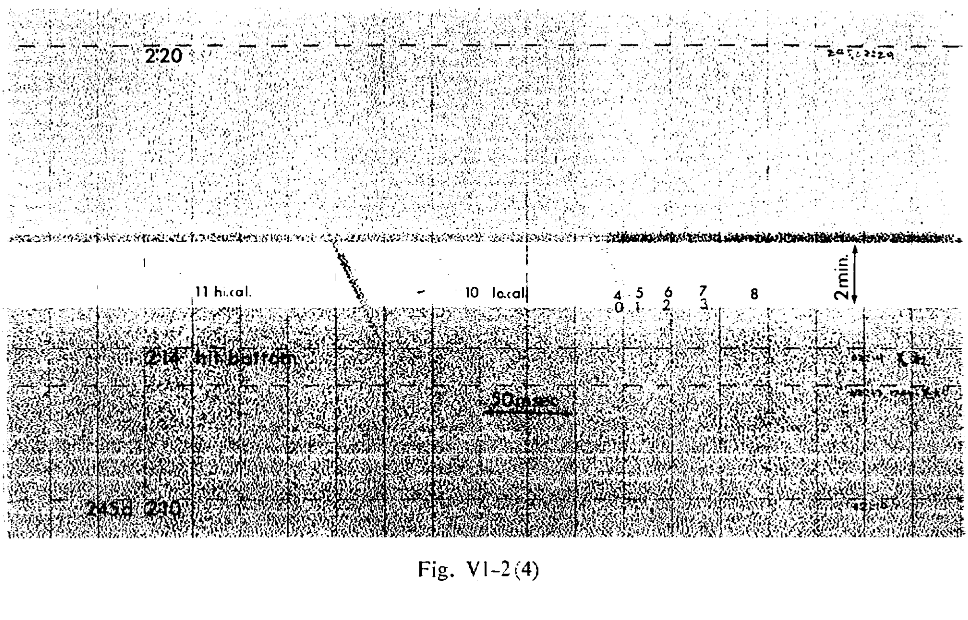

Fig. VI-2(4)

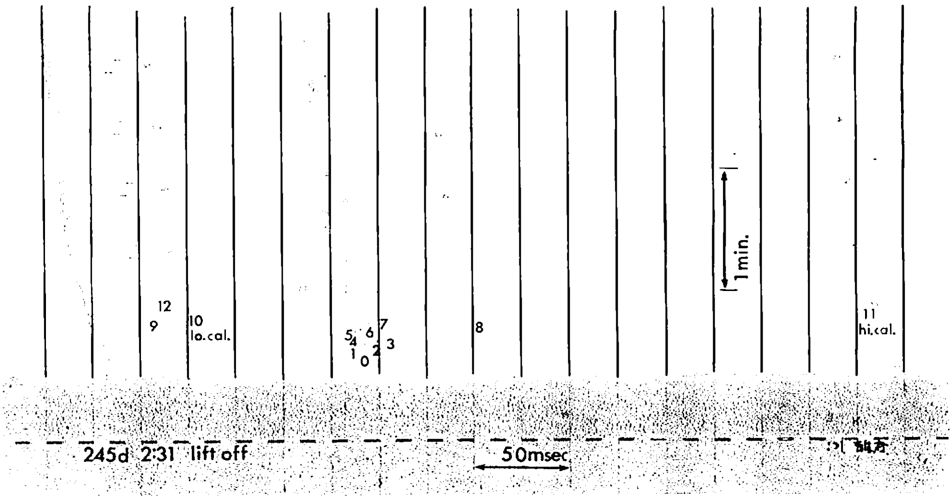

Fig. VI-2(5)

Table VI-1 Rank of the quality of data

Name	HF value	Rank of equilibrium*	Rank of topography**
P193(H36)	1.32±0.36	8	B
P194(H37)	1.18 0.13	7	B
P195(H38)	1.07 0.16	6	B
P196(H39)	1.40 0.37	7	B
P197(H40)	0.87	7	B
P198(H41)	1.38 0.05	10	C
P199(H42)	1.34 0.11	9	B
P200(H43)***	1.34 0.08	9	B
H44***	1.31 0.04	10	B
DHF***	1.40 0.13		B
DHF***	1.51 0.03		B
P201(H45)	1.24 0.16	9	B
P202(H46)	1.65 0.0	8	B
P203(H47)	1.17 0.11	10	B
P204(H48)	1.43 0.13	10	B
P205(H49)	1.47 0.15	10	C
P206(H50)	1.12 0.02	9	C
P207(H51)	1.29 0.15	9	B

* 10; Temperature reaches to good equilibrium inT2-T1 and T3-T1.
9; One of T2-T1 and T3-T1 is in good equilibrium.
8; Both have incline after 15 minutes.
7; Both data are not so good. 6; Both data are bad.

** A; Flat or rolled topography and sediment is thicker than 150 m around the site by 10 miles.
B; Flat or rolled topography and sediment is thicker than 20 m around the site by 10 miles.
C; Fluctuated topography or sediment is thinner than 20m.

*** These 4 data are obtained in almost same site and thermal conductivity value of P200 was used as ones to calculate heat flow in H44, DHF1, and DHF2.

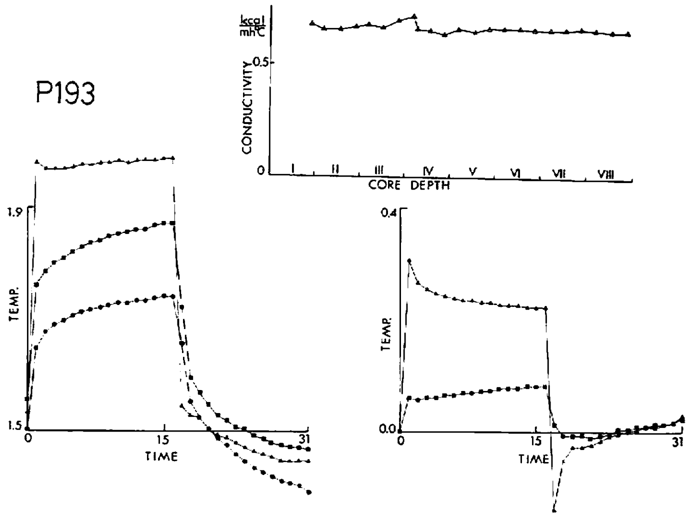

Fig. VI-3 (1)

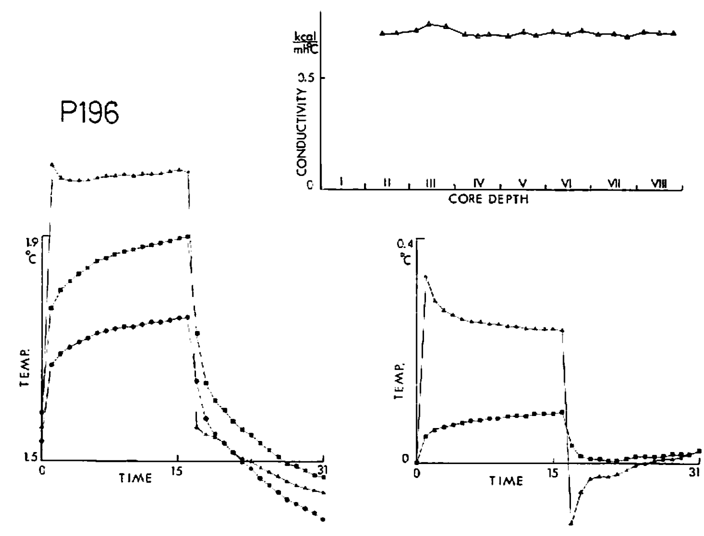

Fig. VI-3 (2)

Fig. VI-3 Typical six data of heat flow measurement. In each figure thermal gradient and thermal conductivity data are shown. Lower two figures are three thermistor data and two thermal gradient data which were calculated from the difference of two lower thermistors and uppermost thermistor are plotted against time in minute. Upper figure shows thermal conductivity data which are plotted against depth in sediment.

samples. For thermal conductivity data, that of P200 was used to calculate heat flow values in the Table VI–1, because other data of thermal conductivity in the detailed survey area I were nearly the same and these points were near each other.

Results

Figs. VI–3(1) ~ (6) show typical examples of the temperature vs. time and thermal conductivity vs. depth in the core. Table 1 shows the rank of quality of data and quality of environment, mainly topography. The criteria of topographical status around is shown by LANGSETH, *et al.* (1967) and SCLATER, *et al.* (1976), and it is same to the report of GH80–1 (MATSUBAYASHI, 1982).

All data are plotted on bathymetrical map and shown in Figs. VI–4(1) and (2). The values are expressed as the average of two heat flow value calculated from 3 thermistors and the range of difference is shown in the latter values attached to the average ones. P197 shows only one data which was caused by the short of lower

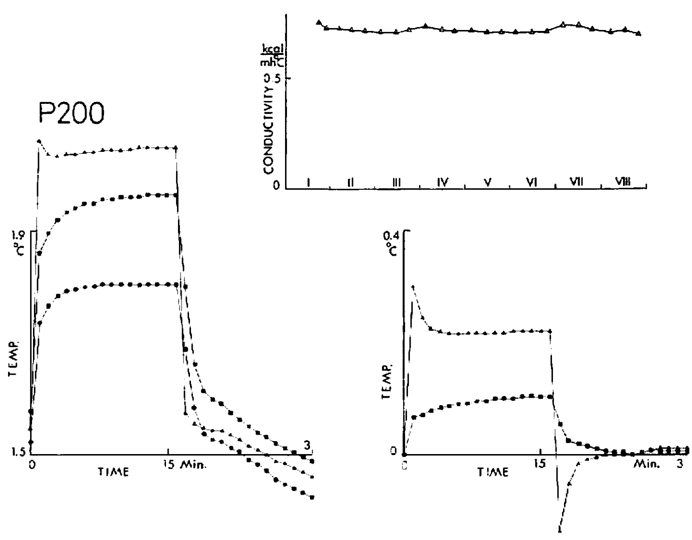

Fig. VI-3 (3)

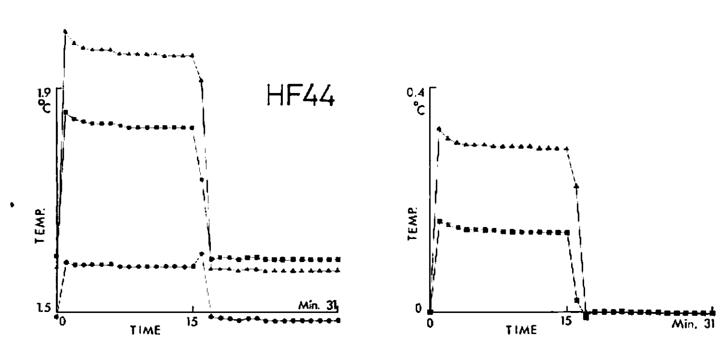

Fig. VI-3 (4)

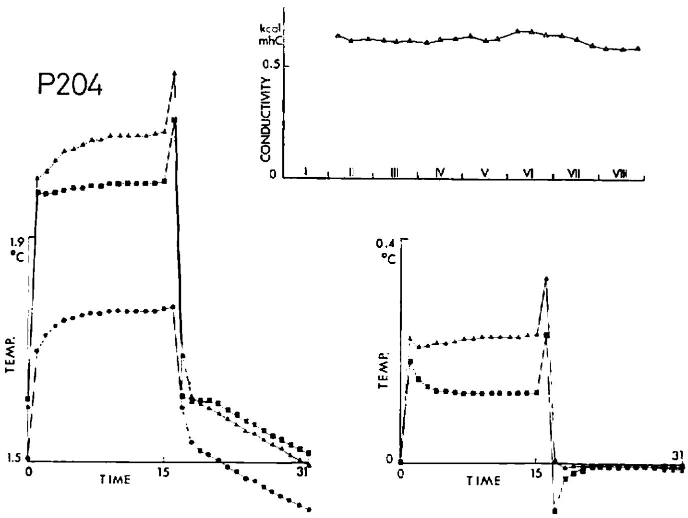

Fig. VI-3 (5)

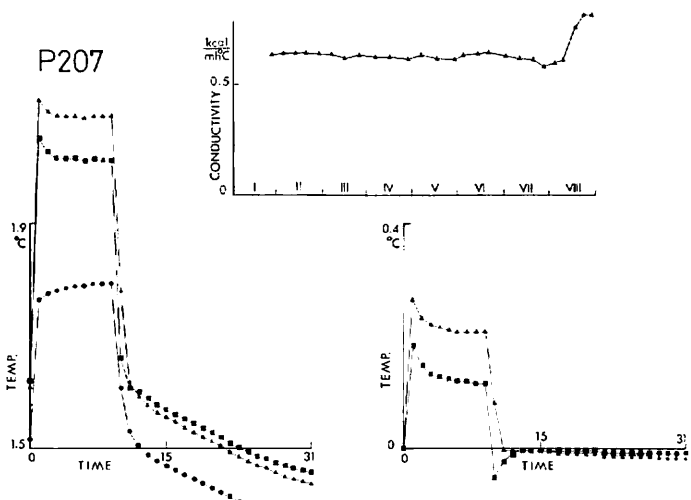

Fig. VI-3 (6)

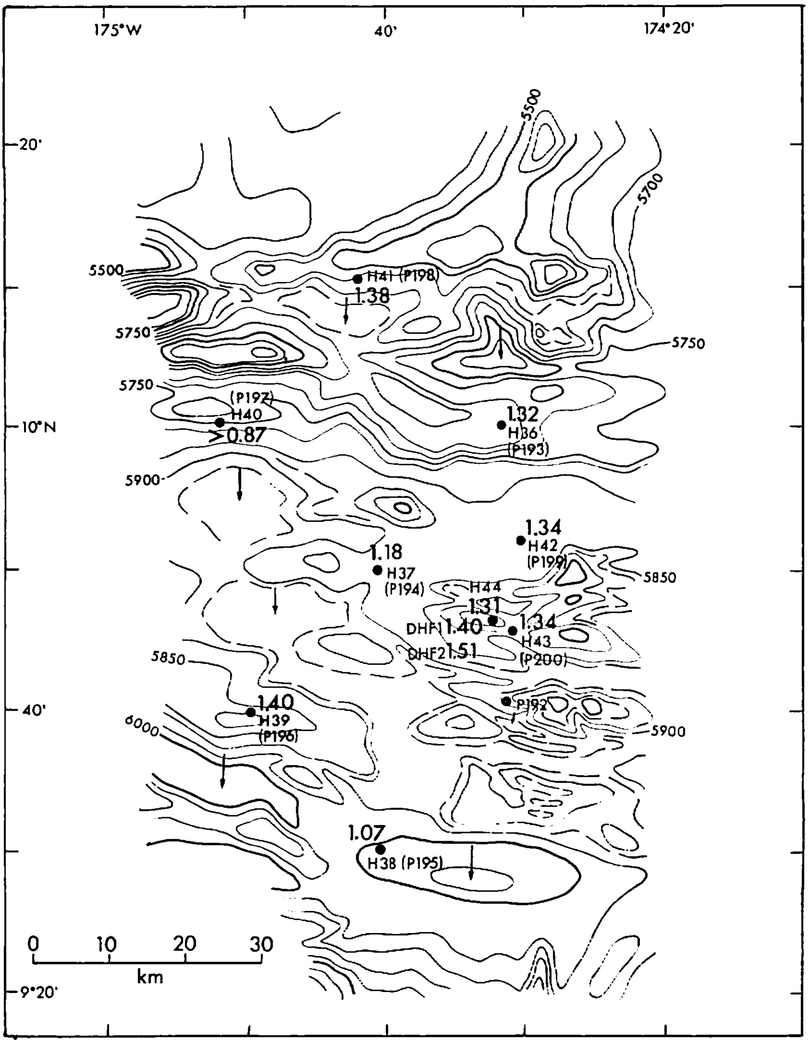

Fig. VI–4 (1)

Fig. VI–4 Heat flow values plotted on bathymetrical map.

thermistor during the piston corer penetration. The values around the Magellan Trough are plotted on the profile of topography and shown in Figs. VI–5(1)～(3).

The temperature of sea bottom water which affects to heat flow value is low and effect of it is thought to be small. The temperature of bottom water gives a good relation between itself and water depth and the relations are shown in Fig. VI–6. The value becomes higher as the water depth increases and it is the same as the data

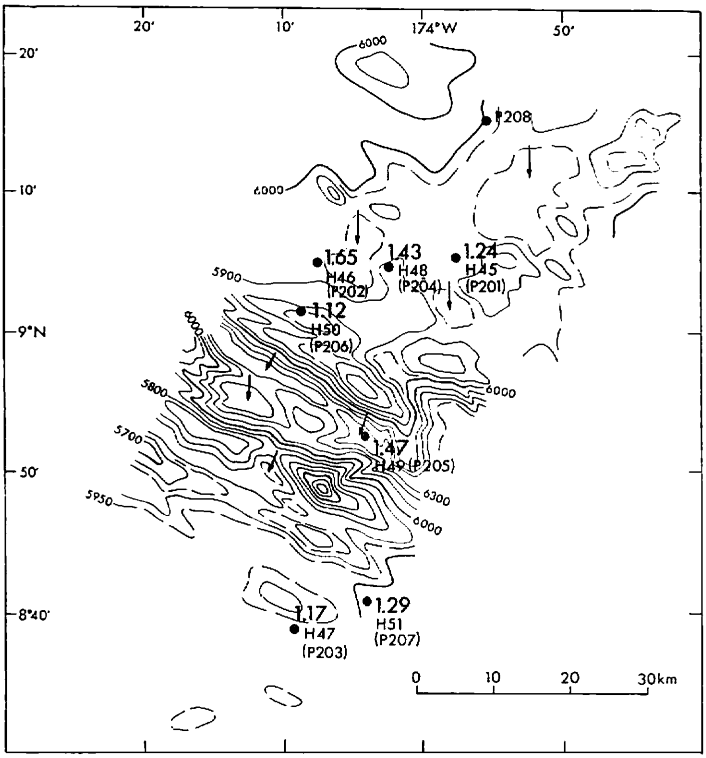

Fig. VI-4 (2)

obtained in the Central Pacific Basin in GH80-1 cruise. The relation is coincident with the change of temperature after piston corer was pulled up off the sea bottom. The temperature of thermistor after the departure from sea bottom is shown in Fig. VI-7. The vertical axis is shown in time in minute from the departure. In this area the longest record of P207 in sea water gives decreasing temperature even at its last record and it shows that the sensor worked out before it reached up to the temperature inversion layer at the water depth of approximately 4,300 m.

Discussion

The value of heat flow is at most 1.7 and at least 1.1, and the average value is 1.4 or 1.5. It is thought to be a little higher than the value presumed from the age of sea bottom which was estimated to be Mesozoic by TAMAKI *et al.* (1979). The variety of these heat flow is reasonable considering topographic effect and sedimentation effect and it is difficult to think that there is thermal resources near here. But if the higher value is fact, there might be a thermal resources in some old days. Then the age of ancient thermal resources can be calculated from the cooling equation of oceanic plate and it is estimated 80 Ma or so and it is not able to be after 50 Ma according to theoretical curve of SCLATER *et al.* (1970).

References

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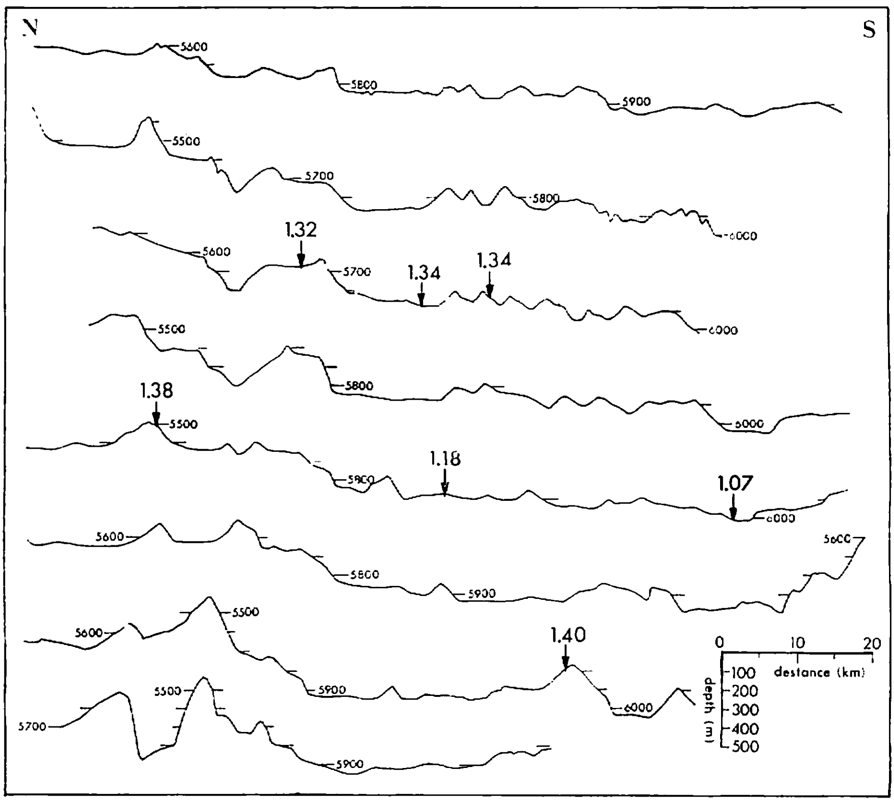

Fig. VI-5 (1)

Fig. VI-5 Heat flow values projected on profiles of the Magellan Trough. Lowest profile (3) is the result of simulation calculated from the topography by Matsubayashi.

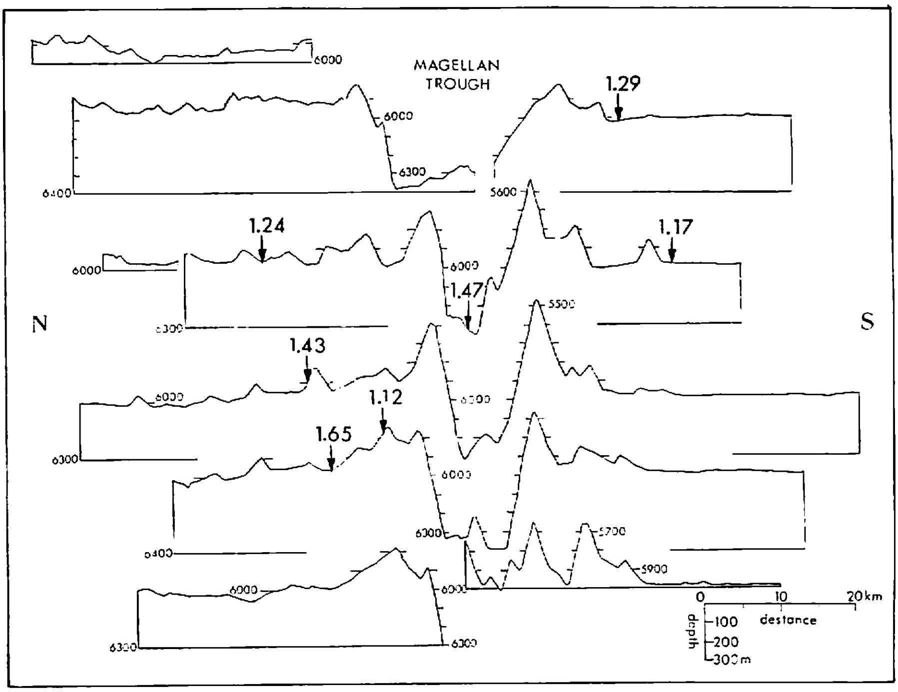

Fig VI-5 (2)

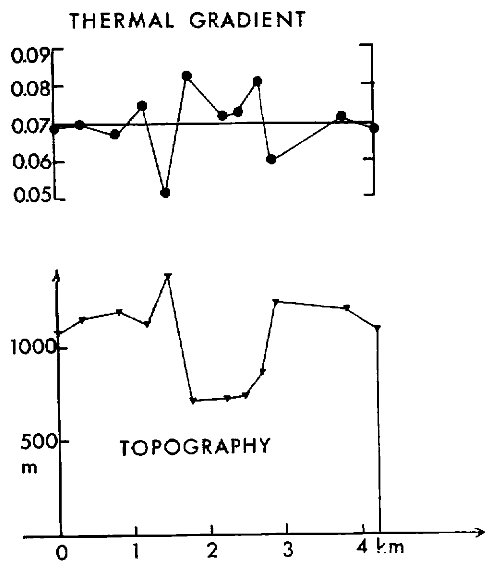

Fig. VI-5 (3)

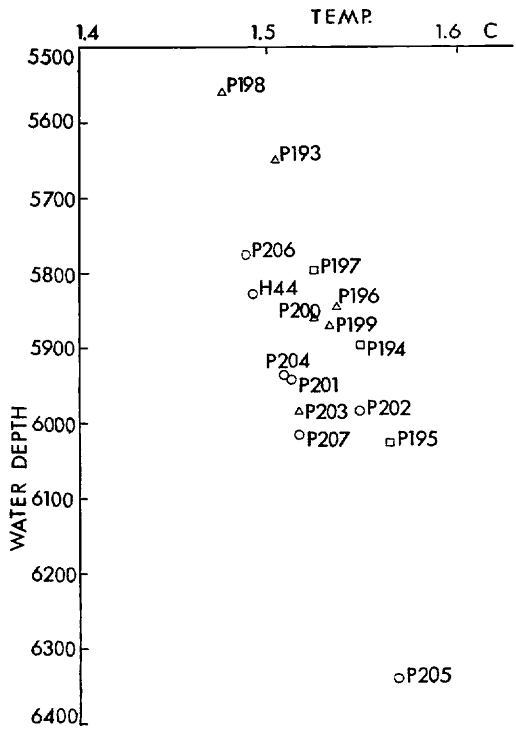

Fig. VI–6 Temperature near sea bottom (30 m above the sea bottom) plotted against water depth. Open circle is for the series of thermistor set No. 3, open square is for No. 4, and triangle is for No. 5. Vertical axis is water depth and horizontal axis is for temperature.

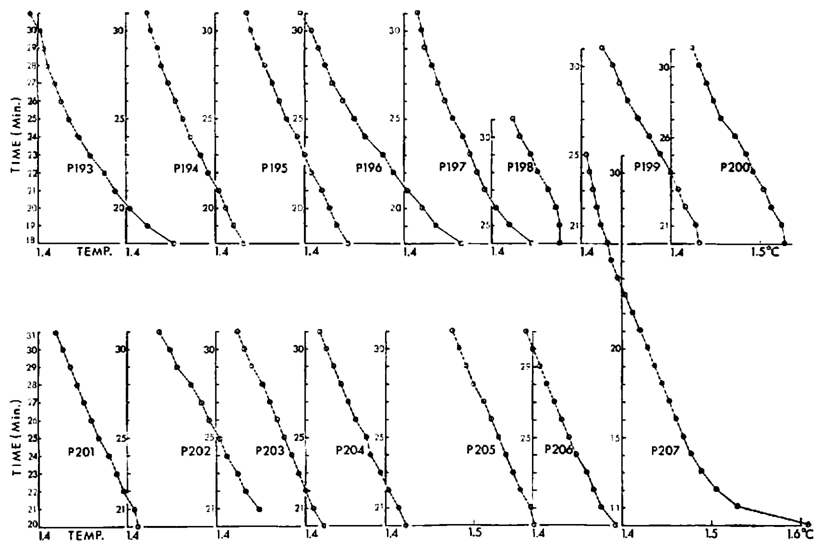

Fig. VI–7 Temperature change which appeared in uppermost thermistor after the piston corer had been pulled up from sea bottom. Vertical axis shows the time after the departure from sea bottom in minute and horizontal axis is temperature. Piston corer was pulled up at the speed of 60 m/min., so 31 minute shows 700 m from sea bottom in former half figures. Horizontal lines in each figure show the water depth in 500 m interval.