Geological Survey of Japan Cruise Report No. 18, p. 90–94, 1982

IV. RECONNAISSANCE MEASUREMENTS OF HEAT FLOW IN THE CENTRAL PACIFIC

Osamu Matsubayashi

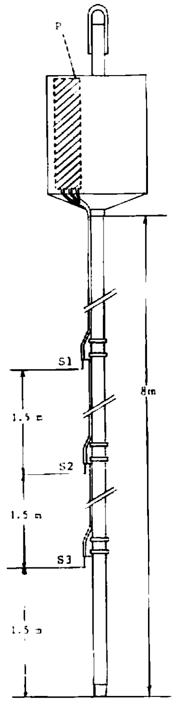
Measurements

The instrument to measure temperature gradient in sediments is named as GH80–1 type thermograd-meter which is electronically modified from the conventional type with outrigger probes strapped to a piston corer (GERARD *et al.*, 1962). For determining thermal conductivity of core samples a transient type heat wire method, usually called as Box Probe Method (MATSUBAYASHI and UYEDA, 1979), was employed. The specifications of the instruments are given in Table IV-1. A marked feature of the GH80–1 type thermograd-meter is a data recording system which uses C-MOS RAMs. Physical layout of the thermograd-meter is shown in Fig. IV-1 and the block diagram showing the electronic system including the onboard data retrieval system is given in Fig. IV-2.

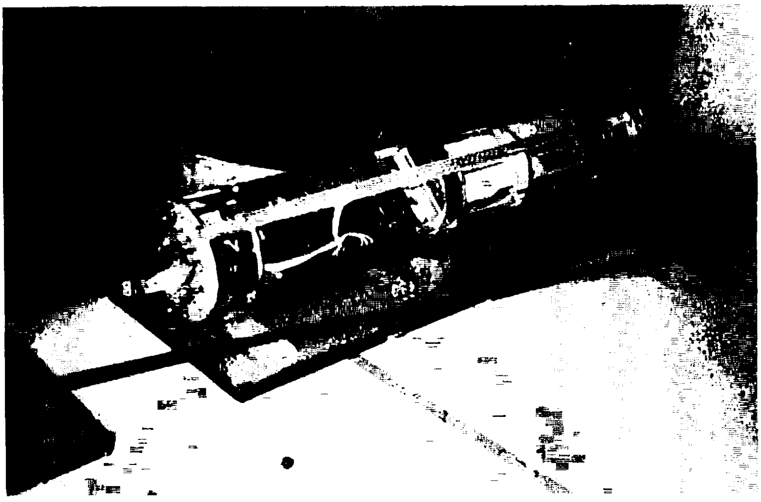
The idea of using a digital recording system with IC memory was initially introduced for heat flow measurements by YOKOTA *et al.* (1980). The difference between their system and ours is that we included bridges for linearizing temperature difference of very high resolution, whereas they only digitized the resistance of a thermistor in their apparatus. Performance of our recording system was found to be reliable even in deep-sea environment. Heat flow data of high quality were obtained at seven of the piston coring stations

Table IV-1 Instruments used in this work.

I. GH80–1 Type temperature gradient meter
Piston corer: Type GH80–1 (Fig. IV-1(a))
Pressure vessel: placed in corer head
length 800 mm, diameter 170 mm, weight 30 kg (in air)
depth usable 6000 m
material Al 7075
Thermometer: 3 thermistors with interval of 1500 mm
attached to the core barrel
range 0–6°C, resolution 0.002°C
Recorder: IC memory of 96 Words (12 bits each)
maximum recording time 31 min.
Battery: Li battery, 40 measurements without replacement
Data reader: LED display of temperature value
Manufacturer: Nihon Yushi Co.
II. Thermal conductivity meter
Type: Box probe method (transient method)
Accuracy: ±5% for 0.02–10 kcal/m h°C
Reference: fused quartz
Heating time: 20 sec. (standby time for repetition 4 min.)
Output: Digital display
Manufacturer: Showa Denko Co.



(a)



(b)

Fig. IV-1 (a) Piston corer used for temperature gradient measurements (P: pressure case for the electronic system, S1-S3: thermistor sensors).
(b) Physical layout of the measuring and recording system to be placed in a pressure case of a GH80–1 type thermograd-meter.

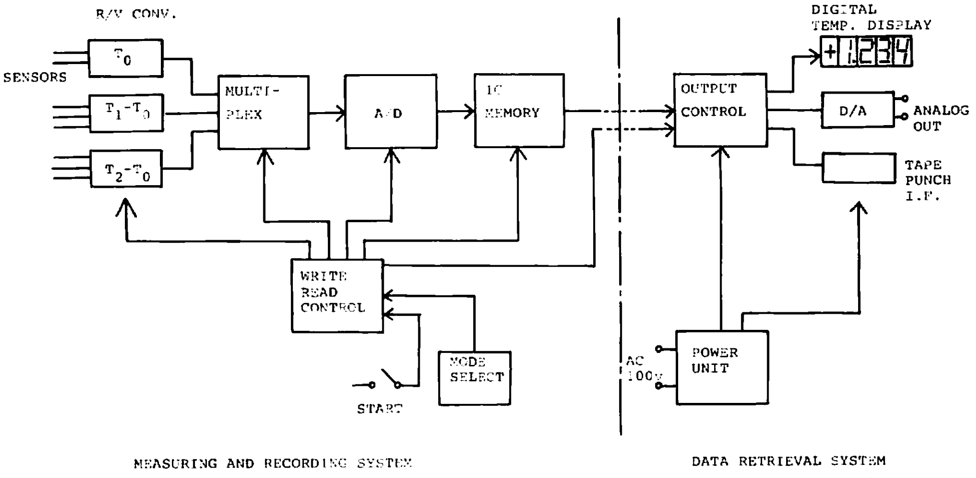


Fig. IV-2 Block diagram showing the electronic system of the GH80–1 type thermograd-meter. Data retrieval system used onboard is also included in the diagram.

in this cruise. Figures IV-3 and 4 show a typical time series of temperature at two of the three sensor probes and a vertical temperature distribution in and above sediments. Static water temperature at about 30 m above the bottom were used for the "zero adjustment" of the thermograd-meter after pulling out of the sediments. Thermal con-

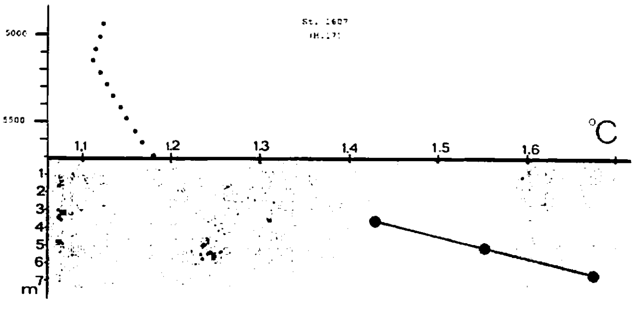
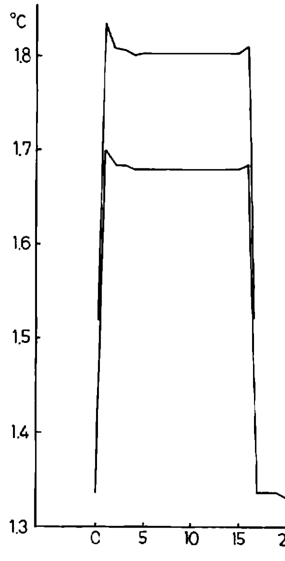


Fig. IV-4 Temperature at each level in and above sediments at station St. 1607. Linearity is very good for the three points in sediments, so that the Instrumental Performance Index at this station is 10.



← Fig. IV-3 Temperature data for the upper two sensors at station St. 1615. The plateau-like portions with temperature variation less than 0.004 °C are used for determining temperature gradient.

ductivity of half-split cores in water saturated state was measured at an interval of 20 cm after thermal steady state was attained at about 25°C.

Results and discussion

Data of temperature gradient measurements and thermal conductivity measurements are summarized in Table IV-2, where instrumental performance index used in LANGSETH and TAYLOR (1967) and Environmental Quality Factor (E.Q.F.) defined in SCLATER *et al.* (1976) are also included. Stations with E.Q.F. of B (outcropping basement within 18 km of the stations; see the caption of Table IV-2) seem to show lower heat flow due to water circulation than the true heat flow which can be predicted by plate cooling theoretical models. A low heat flow value at St. 1624 with E.Q.F. of C may be a more clear case showing this effect, although the temperature gradient is derived from only one pair of sensors (Instrumental Performance Index of 7) and internal check of temperature linearity was impossible.

Average of the seven heat flow data reported here is 53.9 ± 13.1 mW m^{-2}(1.29 ± 0.31 HFU). If only those ranked as A (E.Q.F.) are averaged, 65.7 mW m^{-2}(1.57 HFU) is obtained which is rather high but within one standard deviation from the mean for the age provinces of 80–95 m.y.B.P. (1.27 ± 0.85 HFU) and 95–100 m.y.B.P.(1.30 ± 0.41 HFU) in the South Pacific (SCLATER *et al.*, 1980).

It is concluded that observed heat flows in this survey are normal. Anomalously high or low heat flow was not found. There is a possibility that water circulation in areas with rough topography (B and C, E.Q.F.) may cause reduction of surface heat flow even in regions underlain by Mesozoic basement. Representative regional heat flow should be estimated from sites with good environment (ranked as A, E.Q.F.). Furthermore, closely spaced measurements are necessary to make this problem clearly settled.

Table IV-2 Summary of heat flow measurements.

Station	Position	Water depth	E.Q.F.*	Temperature gradient K m^{-1}	I.P.I.**	Thermal*** conductivity W m^{-1}K^{-1} (m cal/cm s °C)	Heat flow mW m^{-2} (HFU)
St. 1603							
P. 159	01°17.22′N	5479	A	0.0816	8	0.787±0.008	64.2
H. 15	170°42.28′W					(1.88 ±0.02)	(1.53)
St. 1605							
P. 160	00°57.91′S	5455	B	0.0711	7	0.812±0.008	57.8
H. 16	169°01.69′W					(1.94 ±0.02)	(1.38)
St. 1607							
P. 161	03°02.12′S	5698	A	0.0816	10	0.846±0.034	69.0
H. 17	167°29.91′W					(2.02 ±0.08)	(1.65)
St. 1615							
P. 164	11°36.55′S	3153	B	0.0353	9	1.20 ±0.063	42.3
H. 20	161°05.41′W					(2.86 ±0.15)	(1.01)
St. 1618A							
P. 165	14°28.86′S	5530	A	0.0785	10	0.821±0.017	64.4
H. 21	158°52.66′W					(1.96 ±0.04)	(1.54)
St. 1624							
P. 168	08°08.05′S	3908	C	0.0277	7	1.26 ±0.096	34.9
H. 24	161°12.37′W					(3.01 ±0.23)	(0.83)
St. 1630							
P. 171	01°30.45′S	5537	B	0.0547	8	0.821±0.034	44.9
H. 27	165°52.52′W					(1.96 ±0.08)	(1.07)
Average				0.0615±0.0226			53.9±13.1 (1.29±0.31)

*E.Q.F. (Environment Quality Factor proposed by SCLATER *et al.*, 1976) is assingned to each of the stations. Classification is as follows: A, flat or rolling hills with greater than 150 m of continuous sediment cover within 18 km of the station; B, flat or rolling hills with greater than 20 m of sediment but very thin or no sediment could be observed within 18 km of the station; C, rough topography with generally very thin sediment cover.

**I.P.I. stands for Instrumental Performance Index (LANGSETH and TAYLOR, 1967) in temperature gradient measurements. 10 and 9 show cases with two good geothermal gradient determinations; 8 and 7 are those with one accurate gradient measurement. Data with the index lower than 7 are not reported here.

***Mean thermal conductivity of each core is reported with correction for the actual difference of temperature and pressure between *in situ* and onboard laboratory conditions.

References

GERARD, R., LANGSETH, M., and EWING, M. (1962) Thermal gradient measurements in the water and bottom sediment of the western Atlantic. *Jour. Geophys. Res.*, vol. 67, p. 785–803.

LANGSETH, M. G., Jr. and TAYLOR, P. T. (1967) Recent heat flow measurements in the Indian Ocean. *Jour. Geophys. Res.*, vol. 72, p. 6249–6260.

MATSUBAYASHI, O. and UYEDA, S. (1979) Estimation of heat flow in certain exploration wells in offshore areas of Malaysia. *Bull. Earthquake Res. Inst.*, vol. 54, p. 31–44.

SCLATER, J. G., CROWE, J., and ANDERSON, R. N. (1976) On the reliability of oceanic heat flow averages. *Jour. Geophys. Res.*, vol. 81, p. 2997–3006.

SCLATER, J. G., JAUPART, C., and GALSON, D. (1980) The heat flow through oceanic and continental crust and the heat loss of the earth. *Jour. Geophys. Res.*, vol. 18, p. 269–311.

YOKOTA, T., KINOSHITA, H., and UYEDA, S. (1980) New DSDP (Deep Sea Drilling Project) downhole temperature probe utilizing IC RAM (Memory) elements. *Bull. Earthquake Res. Inst.*, vol. 55, p. 75–88.