Geological Survey of Japan Cruise Report No. 24, p. 81-86, 1999

VIII. HEAT FLOW MEASUREMENTS IN THE OFF TOKAI AREA

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Introduction

Six heat flow data were obtained using violin-bow type heat flow sensors after 8 trials in the off Tokai area during GH97 cruise of R/V "Hakurei-maru" .

Equipment

A modified NTS12 model (NTS12-m), made by Nichiyu-giken-kougyou Co., was used to record temperatures in the sediment. It can memorize 12 x 7500 times in its digital memory and can repeat measurement every 40 second, in the case of 12 channel recording. Six thermistors were set in a stainless steel pipe and connected to the NTS 12-m using an anti-pressure cable (Fig. VIII-1). Two sensor pipes of 3 m length were newly built and several steps of length from 2 to 6m were prepared together with a sensor pipe of 2m length. During last year's cruise it appeared that pipes of 4m length were very uncomfortable to treat on board. For keeping the sensor wire at 5 cm from the core barrel, we put 2 plinths (stands) near the top and near the bottom end of the

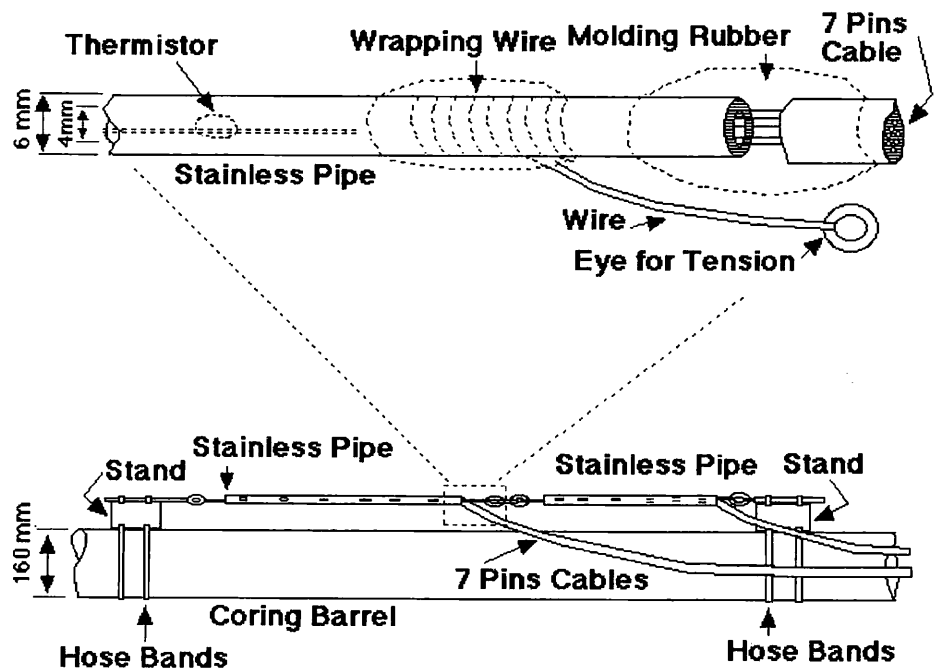

Fig. VIII-1 Conceptual figure of temperature-measuring tube with 6 sensors.

Keywords: heat flow, Enshu-nada, thermal gradient, thermal conductivity

core barrel to keep the sensor wire straight between them. A violin-bow type sensor system was used for the convenience of treatment on board, and several 2 and 3 m length sensor pipes were prepared for 7m or 5m core barrels.

A quick thermal conductivity meter (QTM), made by Showa Denko C.O., was used for the on-board thermal conductivity measurement of sediments. The sediment core was cut in half and the half was wrapped with thin vinyl sheet to prevent drying. Then it was kept for half a day in an air-conditioned room to achieve a stable temperature condition in the sediment. Measurements were done on the sediment sample and a correction for the difference of temperature and pressure between room and sea bottom was applied to get true value of thermal conductivity on the sea floor. Heat flow values were calculated as the multiplication of thermal gradient values and thermal conductivity.

Results

An example of temperature change during the penetration at station 310 is shown in Fig. VIII-2. The differences of temperature among the sensors were recalculated on the assumption that the temperature of each thermistor was the same just before the penetration in case of deep sea. Each sensor's position is calculated as the distance from the top of core catcher as follows:

1: 80 cm, 2: 134 cm, 3: 188 cm, 4: 242 cm, 5: 296 cm, 6: 350 cm, 7: 352.5 cm, 8: 404.5 cm, 9: 456.5 cm, 10: 508.5 cm, 11: 560.5 cm, 12: 612.5 cm

Sediment on the outside wall of corer was recognized 37.5 cm above the 7th sensor

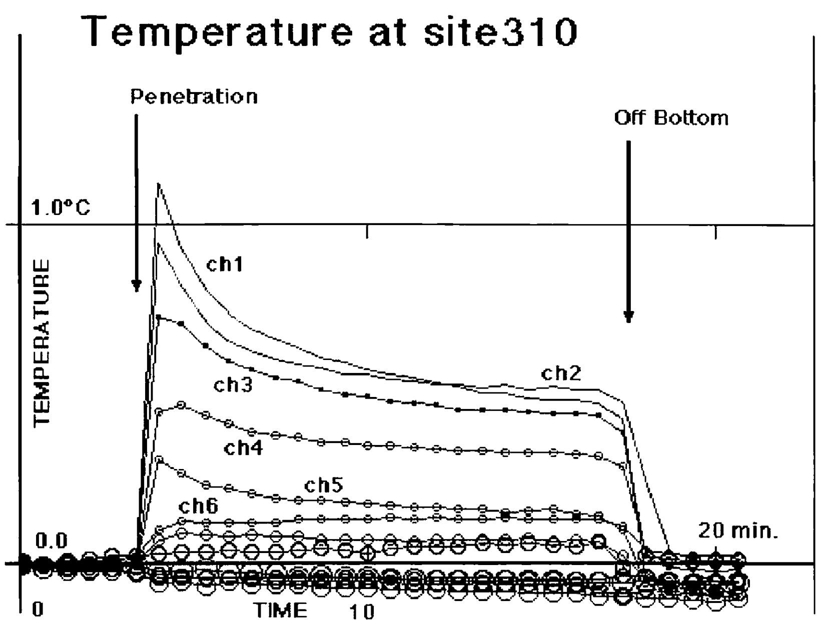

Fig. VIII-2 Example of temperature recording by modified NTS12 before and after the penetration and measurement at the station 310. Temperature change of every channel was recalculated using standard temperature of that just before the penetration.

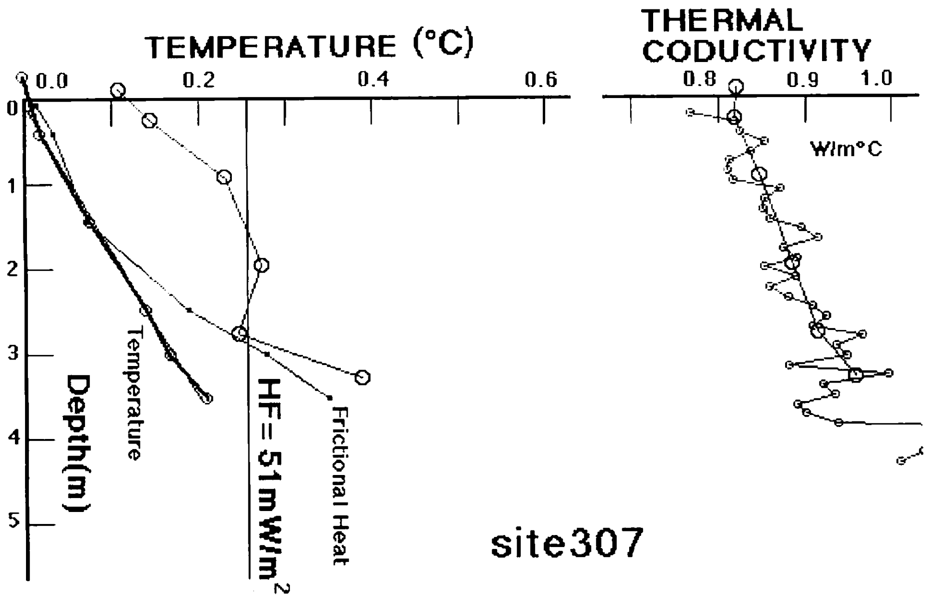

Fig. VIII-3 Example of the variation of data with depth in sediment at st.307. Thermal gradient, frictional heat and thermal conductivity measured using QTM type thermal conductivity meter on board are shown.

after the recovery on board, so the corer had penetrated at least 390 cm into the sediment.

An example of temperature, thermal conductivity and condition of frictional heat with depth from the sea floor at station 307 is given in Fig. VIII-3. The temperature in Fig. VIII-3 was corrected for the effects of frictional heating, that results from the penetration of the sediment. (Bullard correction). The depth from the sea floor was estimated from the position of the highest attached sediment on the core barrel after the recovery on board. Thermal conductivity values are usually low near the surface, approximately 0.8 W/°C , and gradually increase to 0.9 or more. However the depth of increase changes from core to core. Thermal conductivity values were measured on each core sample and temperature data were measured outside of core barrel. There are important discrepancies between the points of the core where the temperature and thermal conductivity are measured due to the shortening of core during the sampling. To avoid this difference, the positions of thermal conductivity measurement were recalculated as the core sample is extended to the penetration length.

Heat flow values were calculated using average values of the thermal conductivity. Thermal conductivity values vary from 0.8 to 0.9 or more, and sometimes even to 1.2, where sandy layer occurs. For the calculation of the average thermal conductivity, weighted values, that were proportional to the thickness of sedimentary layers, were used. Frictional heat curve of Fig. VIII-3 depicts the value obtained from the difference between the highest temperature after the penetration and the fully stabilized temperature.

Measurements were carried out at 5 stations on the continental shelf of Enshu-nada,

Table VIII-1 Heat flow stations in GH97

Area	Latitude Longitude	Water Depth	Topography	St. No.
Enshu-nada	34°02.53'N 138°15.12'E	2,665m	flat slope	306
	34°15.06'N 137°25.08'E	1,025m	flat slope	308
	34°14.19'N 137°29.07'E	1,290m	flat slope	309
	33°50.95'N 137°47.20'E	2,560m	flat slope	310
	34°05.03'N 138°08.03'E	2,420m	flat slope	311
Kumano Basin	33°48.96'N 137°05.87'E	1,990m	northeast end	307

and 1 station at the northeastern end of the Kumano Trough (Table. VIII-1, Fig. VIII-4). Measurements at two other stations -in the Nankai Trough and the Enshu Ridge- failed, because the corer could not penetrate into the sediment. All temperature data are summarized in Fig. VIII-5 to show the variety of thermal gradients.

Thermal gradient values of each station are calculated from the temperature change with depth using the least square method. Generally speaking the penetration depth is not enough for all stations. This might influence the reliability of heat flow values in water shallower than 1000m. Fig. VIII-6 shows all the heat flow data in the sample area compiled together with old data (Yamano *et al.*, 1997).

Future study

Sensor pipes of 3 m long were prepared for the present study using the technique of putting 6 thermistor sensors into a 6 mm diameter stainless steel pipe. For making eyes to pull from both side, soldering between stainless steel wire and pipe was useful and enough strength was obtained. Sensor pipes of 3 m long were much more useful than the 4m long pipes used last year. It is important to undertake new efforts to accurately measure the temperature at more station in the offshore area around Japan.

References

Joshima, M. and Kuramoto, S.(1997) Heat flow measurements in and around Ishikari Bay, Shakotan Peninsula area. In Scientific report of the general study on the environmental change in the sea west of the Hokkaido district -off the southwest of Hokkaido- (1996). Geological Survey of Japan, 33-40. (in Japanese).

Yamano, M., Yamagata, T. and Kinoshita, M.(1997) Compilation of heat flow data in Northwestern Pacific area. Proceedings of the 1997 Japan Earth and Planetary Science Joint Meeting, p. 245, (in Japanese).

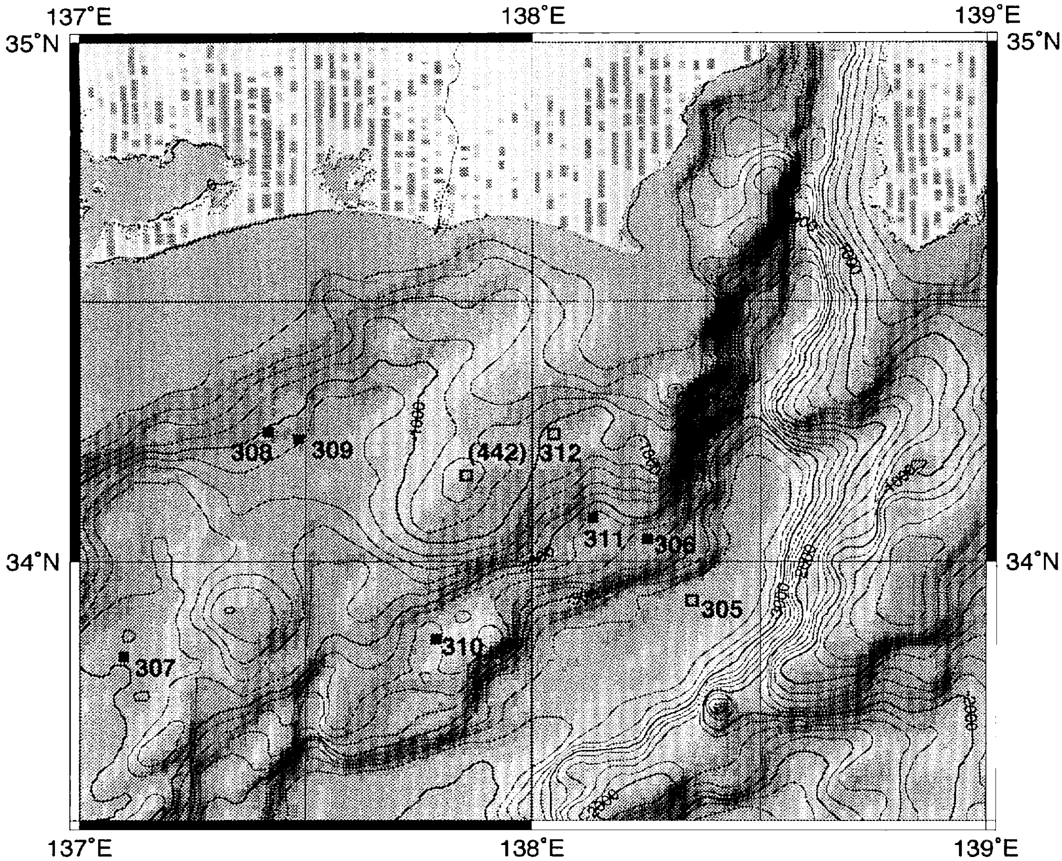

Fig. VIII-4 Measurement stations during the GH97 cruise (442 is just the reference no measurement was done).

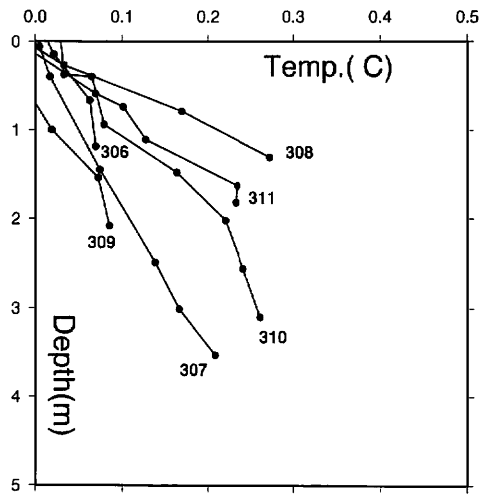

Fig. VIII-5 Thermal gradients of all stations. All 6 temperature curves were plotted in one diagram. The number near the curve shows each site.

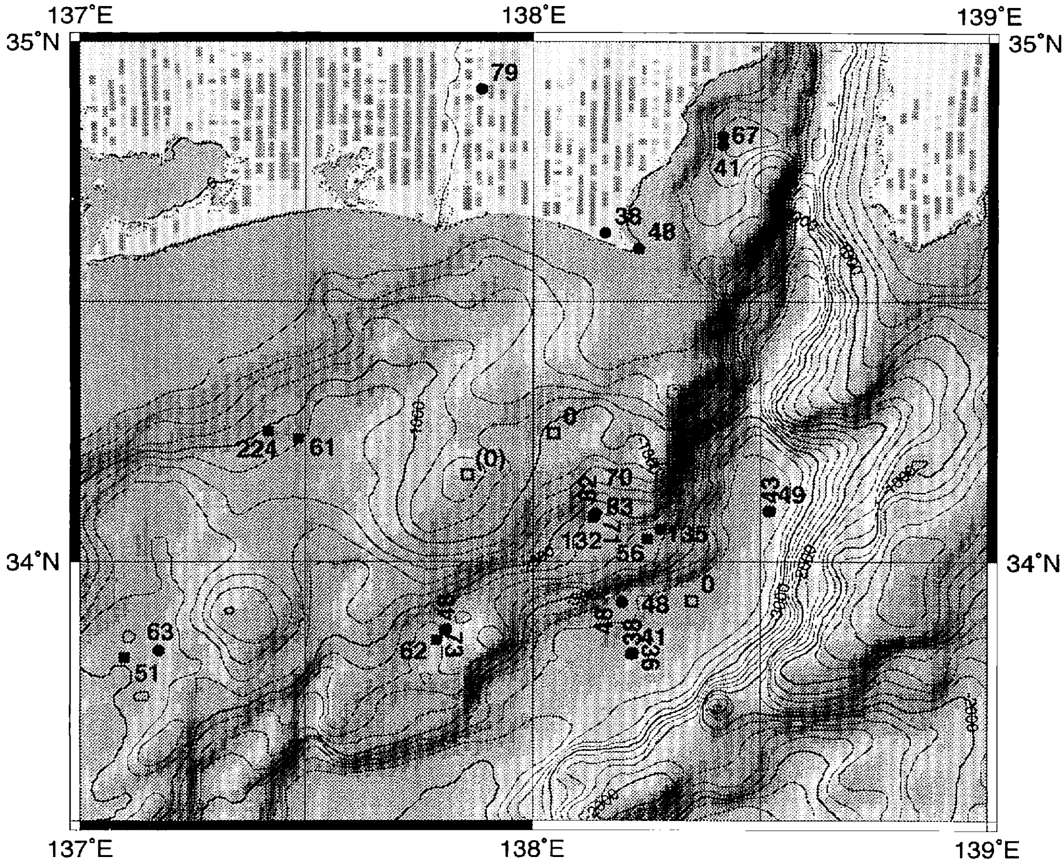

Fig. VIII-6 Distribution of heat flow values in GH97 area. Solid circles indicate old data compiled by Yamano *et al.* (1997), Solid squares show the data in this cruise. Numbers near the mark indicate the heat flow values in mW/m².