53. GEOTHERMAL OBSERVATIONS ON THE JAPAN TRENCH TRANSECT

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A number of observations made on Legs 56 and 57 provide information on the subseafloor temperature structure, both past and present. High resolution temperature logs were made at Holes 438A, 439, and 440B. Maximum thermometer readings were made at the bottom of Holes 438A and 439.

The circulation of seawater at bottom-water temperatures in the borehole during drilling usually lowers temperatures greatly, and it takes a long time for the hole to reequilibrate with the surrounding rock. During Legs 56 and 57 special care was taken to keep circulation rates as low as possible or periods of circulation as brief as possible. Both procedures helped to reduce the initial disturbance and the time of reequilibration. The theory of Jaeger (1961) was used to determine the disturbance due to circulation and correct the measured profiles.

At Hole 438A, the circulation rates were relatively low and corrections of 15 to 20 per cent to the temperature log profile were calculated (see Figure 1). The best-fitting gradient to the corrected points is 32°C/km. Higher circulation rates were used at Hole 439, and the corrections were correspondingly higher (about 25 to 35 per cent). The calculated undisturbed gradient is 36°C/km. These results are in good agreement with the extrapolated maximum thermometer readings. Hole 440 was drilled with high circulation rates over a period of about 130 hours, and corrections of 30 to 36 per cent were determined. The undisturbed gradient at this site is 24°C/km. This value cannot be compared with maximum thermometer readings, since the bottomhole temperature (approximately 9°C) is less than the surface water temperature.

Hundreds of thermal conductivity measurements were made on core samples from Legs 56 and 57 (Figures 2 and 3). When the average conductivities at Holes 438, 439, and 440 are combined with the undisturbed gradients given in the foregoing, heat flows of 28 mW m^{-2}, 32 mW m^{-2}, and 22.5 mW m^{-2}, respectively, are indicated.

These values indicate that present temperatures below these sites are anomalously low compared to typical ocean basin values. Extrapolation of the heat flow values at Sites 438 and 439, using a layered thermal conductivity model of the crust of the fore-arc region, indicates a temperature of 250° to 300°C at the top of the downgoing slab, which is 15 to 20 km below the site. At Site 440, temperatures at the subducted oceanic crust interface (5 km sub-bottom) may be less than 100°C. Low temperatures and heat flows are to be expected at the edge of a margin actively underthrust by cold oceanic lithosphere (see, for example, models of Minear and Toksöz, 1970; Oxburgh and Turcotte, 1970).

Earlier heat flow determinations along the northeast coast of Honshu have an average value of 32 mW m^{-2} (Uyeda and Hôrai, 1964). The values at Sites 438 and 439 are in excellent agreement, suggesting that much of the fore-arc region is characterized by heat flow of about this value. Several sea floor measurements have been made on the inner wall of the Japan and Kuril trenches. The mean of these observations is 24 mW m^{-2}, which again is in good agreement with the borehole measurement at Site 440.

The gradient measurement on the midslope terrace to a depth of 500 meters is the most reliable value of heat flow on the landward wall of a deep sea trench. The low gradient is to be expected, because the oceanic lithosphere with a surface temperature near zero is underthrusting the sedimentary mass at rates of nearly 100 km/m.y. (Minster and Jordan, 1978). The heat flow through the floor of the Northwestern Pacific is 45 to 50 mW m^{-2} (Vacquier et al., 1966). This value is typical for Mesozoic oceanic lithosphere. The heat flow at the midslope terrace is further reduced by the sediments rapidly accumulating over the subducting lithosphere. If we follow a point on the surface of the subducting lithosphere as it moves from the trench axis to a point below the midslope terrace, a distance covered in about 250,000 years, we see that in that period of time the sediments increase from a thickness of a few hundred meters to nearly five kilometers. The heat flowing from the oceanic lithosphere is largely absorbed by this column of sediments. Other heat sources, such as frictional heating within the zone of shearing, may contribute to the heat flow. However, this heat cannot be very great in view of the low flux.

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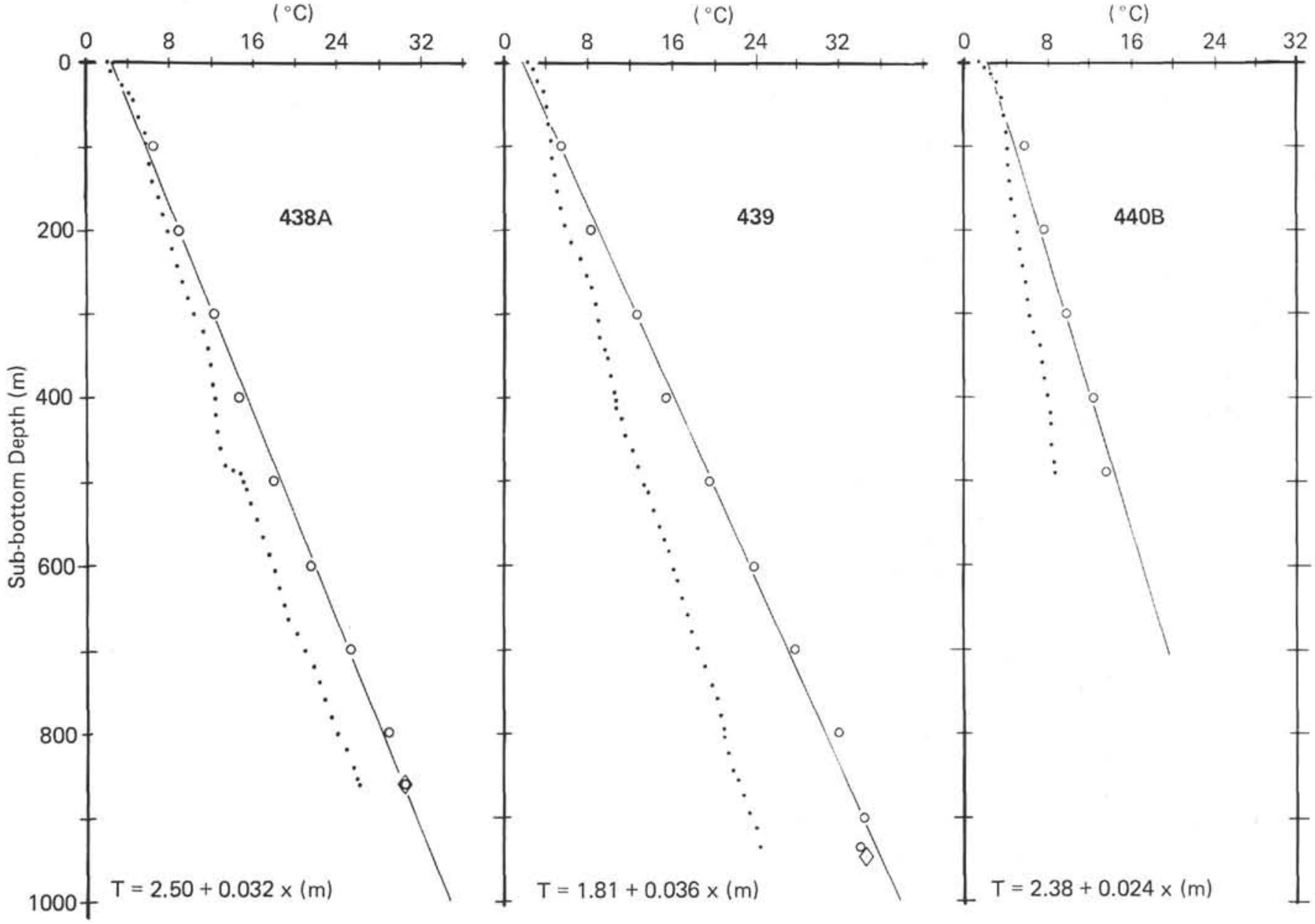

Figure 1. *Graphs of the temperature logs (small dots) and corrected temperature points (open circles) at Holes 438A, 439, and 440B. The straight lines are the best-fitting gradients to the corrected points.*

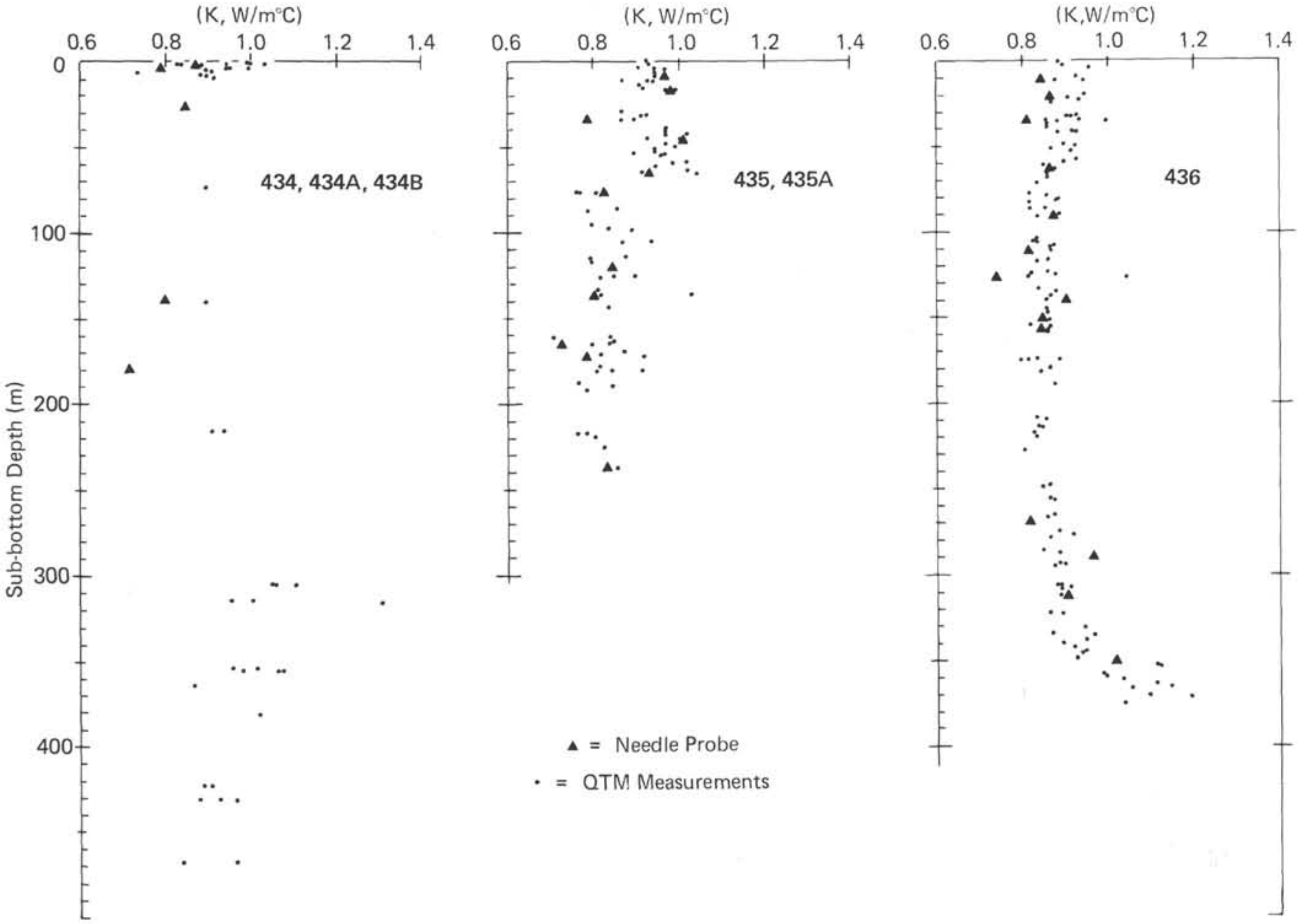

Figure 2. *Graphs of thermal conductivity observations on Leg 56 (Sites 434, 435, and 436). The small dots represent values made with the QTM[(R)] instrument, manufactured by the Showa Denko Company of Japan. The triangles are values measured by the standard needle probe technique.*

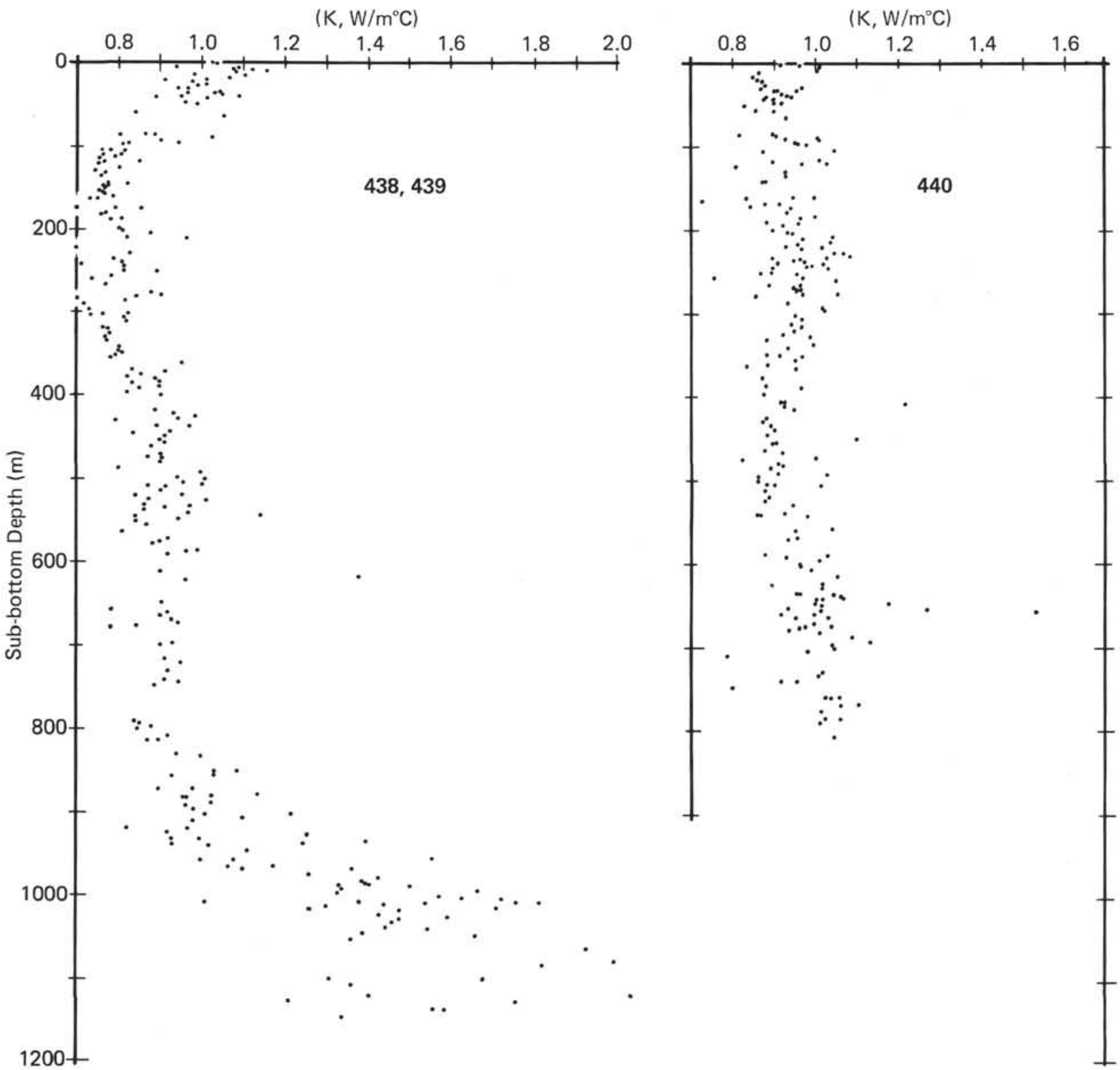

Figure 3. *Graphs of thermal conductivity measurements at Sites 438, 439, and 440. All measurements were made with the QTM(R) instrument.*