Hill, I.A., Taira, A., Firth, J.V., et al., 1993
Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 131

37. *DATA REPORT*: PRESSURE DEPENDENCE OF SITE 808 SEDIMENT THERMAL CONDUCTIVITY[1]

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INTRODUCTION

Thermal conductivity of marine sediments is an important physical property for determining heat flow through the ocean floor. Since the first marine heat-flow measurements in 1950 (Revelle and Maxwell, 1952), most thermal conductivity measurements have been made on core samples in laboratories. Such laboratory conductivity must be corrected for in-situ pressure and temperature conditions. Ratcliffe (1960) presented correction coefficients for the pressure and temperature effects deduced from experimental results, and these coefficients have been applied to both surface cores and drill-hole samples.

Recent improvements in heat-flow instruments have enabled accurate in-situ thermal conductivity measurements (e.g., Hyndman et al., 1979; Jemsek and Von Herzen, 1989). Davis (1988) compared conductivities measured in situ with those measured on core samples and corrected following Ratcliffe's method. The values agree well, suggesting that Ratcliffe's coefficients cannot be significantly incorrect. However, the correction for pressure by Ratcliffe (1960) was derived from experiments on several water-saturated sedimentary rocks and pure water only. It is thus important to investigate the pressure dependence of thermal conductivity of marine sediments to test the applicability of Ratcliffe's correction.

For this purpose, Kinoshita (1992) measured thermal conductivity of core samples recovered from ODP Hole 799B in the Japan Sea under hydrostatic pressures from 0 to 100 MPa. The data obtained on thirteen samples show that thermal conductivity increases with pressure, and on average the pressure dependence is not much different from that given by Ratcliffe (1960). In this report, we add results of the same experiment on two samples from ODP Site 808 at the toe of the Nankai accretionary prism.

EXPERIMENT

Three soft-sediment samples were taken on board from undisturbed cores recovered from Holes 808A and 808B. Each sample is one-quarter round and 7 cm long. We planned to take more samples, but could not find an undisturbed part large enough for this experiment in most cores, mainly due to gas expansion and drilling disturbance. The samples were carefully scooped out immediately after the cores were split, covered with plastic plates, and waxed so that they would not be deformed and not lose pore water while being stored in a refrigerator.

In a laboratory, thermal conductivities of these samples were measured by the needle probe method (Von Herzen and Maxwell, 1959) under hydrostatic pressures. A needle containing a heating wire and a temperature sensor was inserted into each sample. The sample was coated with thin plastic film and silicone rubber, and then installed in a pressure vessel filled with oil. Thermal conductivity of the sample is determined from the rate of temperature rise of the needle while it is heated. The measurement system is described by Kinoshita (1992).

We started measurements at nearly atmospheric pressure and increased the confining pressure stepwise up to about 50 MPa, which corresponds to the hydrostatic pressure at the depth where the samples were cored. Measurements were made twice at each pressure to evaluate uncertainty of the results. For one of the three samples (131-808A-1H-2, 101–108 cm), reliable data could not be obtained, probably because this sample was so soft that it was deformed and not in good contact with the needle probe. The results obtained for the other two samples (131-808A-9H-2, 113–120 cm, and -808B-7X-4, 49–55 cm) are presented below. Sub-bottom depths of these samples are 71 and 174 m, respectively.

RESULTS

The difference between two thermal conductivity values measured at the same pressure, ranges from 0.001 to 0.031 W/m · K and the average is 0.015 W/m · K. The main cause of the difference may be error in calculation of conductivity from the measured temperature vs. time data, generally about 0.01 W/m · K. Some other sources such as unstable thermal contact between the needle and the sample might also contribute. We thus estimate the error in each measurement to be 0.010 to 0.015 W/m · K. Any systematic error can be neglected because we are interested in relative change of thermal conductivity.

The mean of two measurements at each pressure is plotted in Figure 1. We believe the probable error in the mean value is smaller than that in each measurement and estimate it to be about 0.01 W/m · K. The measured thermal conductivity generally increases with pressure but scatters around the general trend beyond the estimated error, especially on the shallower sample (131-808A-9H-2). Similar scattering was also observed on the Japan Sea samples. Compaction of the samples might occur nonuniformly and produce a heterogeneous conductivity structure that significantly varies as the confining pressure increases.

We fit the data to a straight line (Fig. 1) to compare the results with Ratcliffe's relation. The rate of thermal conductivity increase with pressure is 1.7% and 0.74% per 10 MPa on Sections 131-808A-9H-2 and -808B-7X-4 respectively, while Ratcliffe's correction coefficient is 0.54% per 10 MPa. We further calculated the ratio of the conductivity at 30 MPa (k_{30}) to the conductivity at atmospheric pressure (k_{atm}), following Kinoshita (1992). It is 1.016 for Ratcliffe's correction, and 1.022 and 1.049 on the present samples. The data from the Japan Sea samples (Kinoshita, 1992) are shown together in a histogram in Figure 2. Most of the k_{30}/k_{atm} values fall between 1.00 and 1.05, though some samples give a higher ratio. No clear correlation can be found between the k_{30}/k_{atm} ratio and lithology or porosity of the samples.

CONCLUSIONS

The results of the present study and Kinoshita (1992) showed that thermal conductivity of marine sediments from the Japan Sea and Nankai accretionary prism increases with the confining pressure, and the rate of increase is generally less than 1.7% per 10 MPa. Therefore

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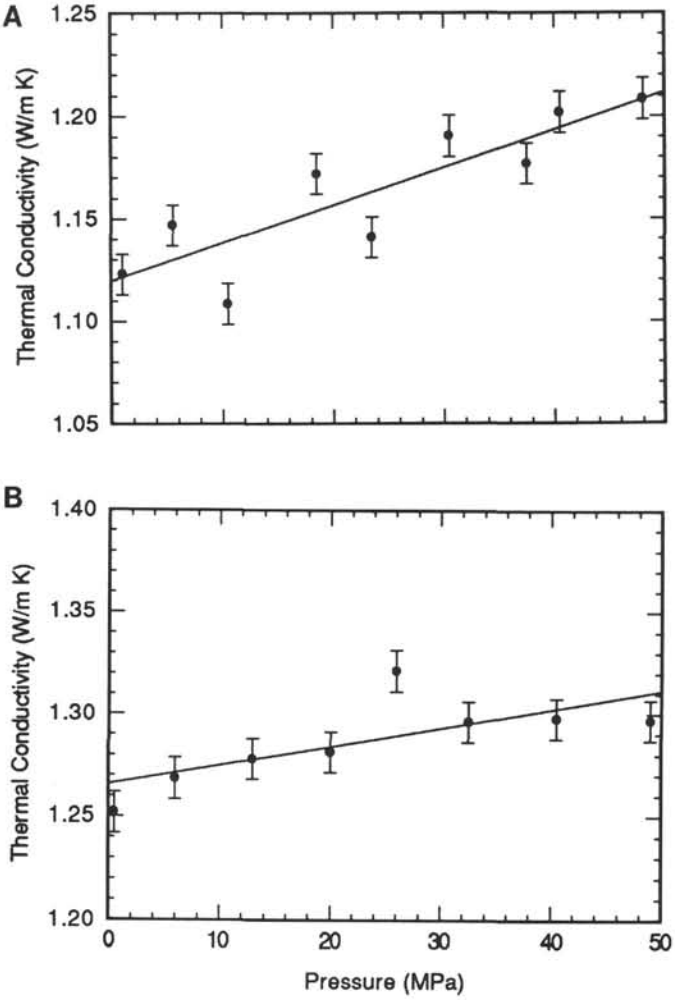

Figure 1. Mean thermal conductivity of core samples vs. hydrostatic confining pressure with the estimated probable error of 0.01 W/m · K. Solid line is the least-squares fit to a straight line. **A.** Sample 131-808A-9H-2, 113–120 cm. **B.** Sample 131-808B-7X-4, 49–55 cm.

there is a possibility that the pressure correction is larger than Ratcliffe's coefficient but the difference cannot be very large.

It should be noted, however, that the measured rate of conductivity increase with pressure may not be treated as the pressure correction coefficient. We compacted the samples under hydrostatic pressure keeping pore water inside the silicone rubber coating. This condition is different from that in the reversal of rebound process of a core sample while coming up from its original depth to the sea surface. For further discussion, it is necessary to conduct experiments in more ideal conditions and/or to make a theoretical investigation to combine the present results with the correction factor. Comparison between conductivity measured in situ and conductivity measured on core samples at many stations will be also useful.

ACKNOWLEDGMENTS

We thank S. Makita for assistance in the experiment and an anonymous reviewer for helpful comments.

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Date of initial receipt: 24 September 1991
Date of acceptance: 25 March 1992
Ms 131SR-141

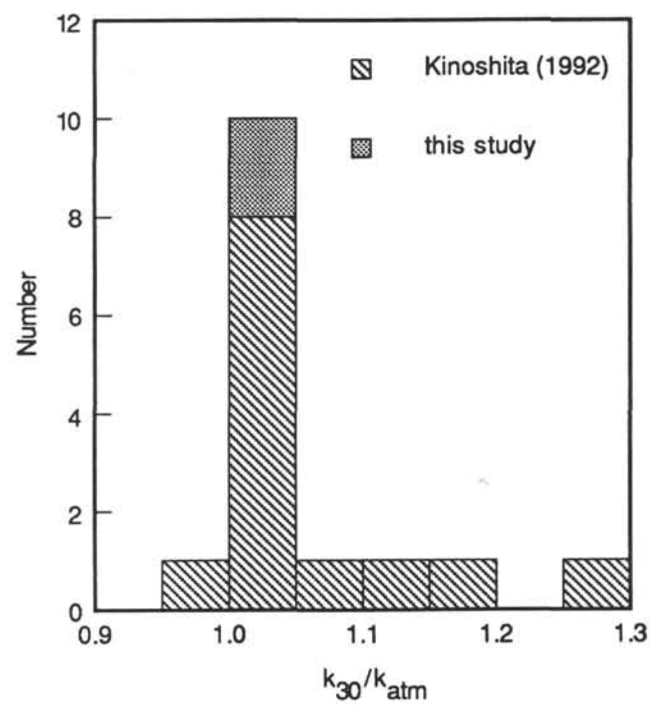

Figure 2. Histogram of the ratio of thermal conductivity at 30 MPa (k_{30}) to that at atmospheric pressure (k_{atm}) for the results of this study and for Kinoshita (1992).