Mechanical properties of surface sediments estimated from frictional heating on east slopes in the Japan Trench

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1. Introduction
Marine heat flow measurements have been conducted on the northwest Pacific plate off the Japan Trench since the 1960s, and a large amount of data was accumulated by recent intensive surveys (Yamano et al, 2014). Generally, the heat flow is obtained in the following way. 1) a heat flow probe (hereafter probe) of several meters in length attached with several temperature sensors is penetrated into sediments in order to measure the geothermal gradient, 2) thermal conductivity of the sediments collected at or around the penetration point is measured, 3) the heat flow at the point is calculated from the geothermal gradient and the thermal conductivity. The geothermal gradient can be calculated from the temperature data obtained with the sensors attached along the probe. In general, right after the probe penetration into the seafloor, the sensor temperature increases rapidly by about 1 K due to frictional heating and then gradually approaches the sediment temperature at the sensor depth. But, in the area off the Japan Trench, we found that there are horizons with extraordinarily large frictional heating, where the temperature rise by frictional heating exceed 5 K (hereafter anomalous heating horizon). The anomalous heating horizons might correspond to some hard and/or consolidated layers. The purpose of this study is to understand the relationship between the anomalous heating horizons and the mechanical properties of sediments.
2. Survey area and the research cruises
Heat flow was measured at 69 points using a 3 m long probe during the cruises YK14-21, KS-14-17 and KS-15-16. Sediment samples were obtained at two sites in the survey area (KR09-16 HFPC01 and KR10-12 HFPC01) using a piston corer with temperature sensors attached along the core barrel.
In this study, we used four measurement devices attached to or in combination with the probe in order to obtain information on the penetration process; 1) Temperature sensors (sampling rate: 10 sec, except for eight sites with a rate of 1 sec). 2) Tiltmeter (30 sec). 3) Wire tension meter (1/10 sec). 4) Accelerometer (1/100 sec). Because we cannot directly observe the penetration process, we should indirectly understand the penetration process (e.g., penetration start time and end time) using above four data.
3. Result
The core sediments, KR09-16 HFPC01 (274.5 cm in length) and KR10-12 HFPC01 (181.0 cm in length), are mainly composed of silty clay with diatoms. Tephra layers were observed at 120 - 145 cm and 155 - 180 cm in KR09-16 HFPC01 and at 100 - 102 cm and 140 - 148 cm in KR10-12 HFPC01.
Anomalous heating horizons were detected in a depth range from 150 cm below seafloor (hereafter cm-bsf) to 300 cm-bsf. The frictional heat generated at the horizon tends to be higher at eastern and northern parts in the survey area.
The results of this study indicate that the anomalous heating horizon continuously extends sub-parallel to the seafloor, and there is a regional variation in the amount of heat generation. We suppose that the anomalous heating horizons result from a hard layer with lateral variation of the thickness, corresponding to the tephra layers observed in the core samples. However, the subbottom depths of the anomalous heating horizons, ranging from 150 to 300 cm-bsf, are several tens of centimeters deeper than those of the tephra layers in the samples. We intend to make further investigation on the problem of this depth difference.

Keywords: Pacific plate, Heat flow, Tephra layer

