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掘削同時検層データを用いた海底下高温流体の温度と流体量の推定
Estimation of under-seafloor fluid on temperature and volume from the logging-while-drilling data

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In July of 2014, offshore drillings on Iheya-North Knoll, Okinawa Trough, was executed as part of Next-generation technology for ocean resources survey, which is a research program in Cross-ministerial Strategic Innovation Promotion Program (SIP). In this expedition, logging-while- drilling (LWD) and measuring-while-drilling (MWD) were inserted into 5 holes around Iheya-North (original) site (C9011 ? C9015) and in Iheya-North Aki site (C9016) to investigate spatial distribution of hydrothermal deposit and geothermal fluid reservoir. LWD tools are supplemented by a measurement-while-drilling tool that is located above the LWD tools in the bottom-hole-assembly. In this expedition, arcVISION and TeleScope were integrated as LWD and MWD respectively. The arcVISION obtained physical properties along borehole (resistivity, natural gamma-ray), and the TeleScope collected drilling mechanics data and transferred them to the surface by mud pulse telemetry. Both of these tools included annular pressure-while-drilling (APWD). Annular pressure and temperature were monitored by the APWD to detect possible exceedingly-high-temperature geofluid. In addition, drilling fluid was continuously circulated at sufficient flow rate to protect LWD tools against high temperature (non-stop driller system).

At C9012 and C9016, the arcVISION clearly detected temperature anomaly at 234 meter below the seafloor (mbsf) and 80 mbsf, respectively. Temperature quickly increases at that depth and it would reflect the existence of high-temperature heat source. During the drilling, however, drilling water was continuously circulated at high flow-rate (2600L/min) as stated above. Thus the measured temperature is not exactly in-situ temperature, but the profile of the temperature reflects the temperature variation of each stratigraphic layer of the bore hole.

To investigate the detail of the heat source, such as in-situ temperature and quantity of heat, we performed numerical analyses of thermal fluid and energy-balance, assuming two types of the heat source: A) hot fluid shifting with circulated water, and B) immobile layer like hot rock-bed. First, thermal fluid-flow analyses were conducted for estimation on how much the circulating water disturbed temperature of heat source. We combined equation of continuity, Navier-Stokes equation, and temperature equation. These equations were solved simultaneously with simplified Marker and Cell method. The fluid flow and its temperature between borehole wall and drilling pipe were simulated. The heat source temperature was also calculated by time. As the results, heat source A (fluid) could raise temperature of the circulation water as hot fluid injected and mixed with the cold water. On the other hand, heat source B was cooled by the circulation water immediately after the hot rock-bed was drilled. It should be required to have over 1000C of source temperature to make sure to keep the circulation water as warm as the thermometer measured at 234 mbsf in C9012A. APWD also recorded the abrupt rise in fluid pressure with the temperature anomaly for several minutes. Considering this synchronism between temperature and pressure, we assessed the high temperature fluid, such as geothermal fluid, is plausible as the heat source. Second, we estimated in-situ temperature and volume of the fluid heat source. From increase in temperature and flow rate of the circulation water, the quantity of heat supplied to the water was calculated as 3.5 GJ. This abundant heat would be brought by injection and mixing of geothermal fluid. The relationship between the temperature and injected volume of thermal fluid are constrained by the quantity of heat as: $Vf = 1.33 \times 10^5/Tf^2 - 257/Tf + 2.73$, where Vf is fluid volume injected to the borehole (m3) and Tf is fluid temperature (C). Thus, we estimated that the in-situ temperature and volume of the geothermal fluid are >150C and <6.3 respectively, causing the temperature anomaly in C9012A.

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