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Development of a borehole instrument for long-term temperature and self-potential measurements

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A subducting plate carries water into the Earth because it contains water in the form of pore water and hydrate minerals such as clay minerals. The water could have much influence on generation of earthquakes and magma. Therefore, it is important to investigate the distribution, movement and mode of the water in order to understand the earthquake and volcanism in subduction zones. Measurements of temperature and electromagnetic fields are ones of the promising methods which would provide key information on the water. Long-term measurements of temperature and electromagnetic fields, however, have just started in ocean areas. Furthermore, there is almost no such measurements within the oceanic crust where little disturbance by seawater is expected. From the above reasons, we are developing a borehole instrument for long-term temperature and self-potential measurements.

The instrument is intended to measure the distribution of temperature and difference of electric potential in a borehole for several years. It consists of a main unit on the seafloor, sensors in the borehole, and two cables which connect the sensors with the main unit. The main unit in a titanium pressure case contains a thermometer, electrometer, control unit, data logger, communication unit, and power supply unit. The sensors are 18 thermistors, 6 Ag-AgCl non-polarizing electrodes, and 4 Cu electrodes. The thermistors are attached to one cable (770 m) with separation distances of 20 to 100 m. The 8 electrodes with sub-cables (1 to 77 m) are connected with the end of the other cable (max. 1000 m). The 2 Ag-AgCl electrodes are attached on shallow points of the former cable.

The specifications are as follows. The thermometer measures temperature of maximum 18 points with a resolution of 1.0 ohm (0.005 deg) and a range of 0.5 to 32767.5 ohm (150 to 0 deg). The electrometer measures electric potential difference of 10 pairs of electrodes with a resolution of 1 micro-volt and a range of -1.0 to 1.0 V. Sampling intervals are 1 to 60 minutes. The data storage is a compact flash memory card. In the case of 64 MB memory, 500,000 data can be stored. Communication of commands and data between the main unit and an external computer is available through an RS-232C serial interface with a maximum speed of 115,200 baud. The power supply is lithium batteries (9V). Consumption currents are less than 70 mA during measurements and 0.3 mA in sleeping mode, respectively.

On December 7, 2001, we started a test measurement of the instrument in a test well (TG-2, 1298 m) in the Matsukawa geothermal field near Mt. Iwate. The deepest sensor was installed at a depth of 270 m (80~90 deg). The sensors were 10 thermistors and 4 Ag-AgCl and 4 Cu electrodes. The measurement is now continuing (February 28, 2002). This test will provide useful data for evaluating the sensitivity of sensors in high temperature environment and the stability and reliability of the instrument. It may also provide some information about the effect of casing pipe and wire rope on self-potential data. Furthermore, we will possibly detect some signals related to geothermal fluid flows.

In this presentation, we will report the outline of instrument and the result of test measurement in Matsukawa.