Long-term temperature monitoring in a borehole on the coast of Lake Biwa

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Temperature changes at the ground surface, including results of surface environment changes, penetrate into subsurface rocks by thermal diffusion. If we monitor temporal variation of temperature at multiple depths for a long period, the obtained data will show how the temperature signals are actually transferred through formations. A 900 m deep borehole on the southeastern coast of Lake Biwa is a site suitable for such temperature monitoring experiments. It was drilled in 1992 and casing pipes were inserted down to 670 m to prevent the borehole wall from collapsing. The top of the hole is located inside of the building of the Lake Biwa Museum, providing us with an environment favorable for installing monitoring instruments.

The first temperature logging in this hole was conducted in September 1993, one year after the completion of drilling. We revisited the hole in April 2002 to obtain new temperature profile data and found that the temperature above 75 m increased significantly (by up to 1 K) in 8.5 years. It indicates that the temperature structure above 75 m was disturbed by some recent event(s) near the ground surface. To study this phenomenon further, we have made temperature logging repeatedly, which revealed that the temperature increase is still in progress with a slower rate.

We have also made continuous measurements of temperature at depths of 30 m (since October 2002) and 40 m (since April 2004). The obtained temperature records show slow but steady increases at about 18 mK/yr and 5 mK/yr at 30 m and 40 m respectively. Probable causes of these temperature variations are: 1) sudden rise in the average ground surface temperature due to construction of the museum building in 1996, which covered the top of the borehole, 2) increase in the depth from the surface due to fill-up of artificial sediment (6.7 m thick) on the original ground surface between 1982 and 1991. A simple combination of these two factors, however, cannot explain the observation that the temperature increase at 30 m is much larger than that at 40 m.

For obtaining more information on the nature of heat transfer and the causes of temperature variations, we installed a temperature sensor cable in the borehole in 2006. The cable has 10 thermistor sensors at depths of 15, 20, 25, 30, 40, 50, 60, 75, 100, and 130 m. It is connected to the temperature measurement unit controlled by a PC. After repeated measurement tests and improvement of the system, temperature monitoring was started in December 2006. The first temperature records (for 20 days) show a significant decrease in the temperature at 15 m, which probably results from the annual variation of the surface temperature. Through monitoring for a longer period, we will be able to make more quantitative and detailed analyses of the heat transfer process at this site.