A trial for earthquake prediction by precise monitoring of water level and deep water temperature

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In order to predict forthcoming earthquakes off Miyagi prefecture, we have precisely observed groundwater temperature in a borehole since June 20 in 2004. The instrument we use is the Yamauchi-type quartz thermometer with the resolution of 0.0002 deg. C and the data acquisition rate is one/minute. The borehole is 1,200 m deep and penetrates the fault zone of the active Nagamachi-Rifu fault at about 825m depth. The concept of our ground water observation is that fault zones are natural amplifier of crustal strain, and hence at 825m depth we set the temperature sensor. The following is the summary of our results.

1. We found mysterious intermittent temperature fluctuations caused by natural convection.
2. The character of temperature fluctuations depends on the depth.
3. The noise level of our measurement system is ca. 0.0005 deg. C.
4. The strain change with earth tide, ca. 2x10ˆ-8, causes the temperature change of ca. 0.001 deg. C.
5. The statements 4 and 5 above suggest that our observation system can detect the strain change of ca. 1x10ˆ-8. By using a computer simulation code MICAP-G released by Okada (1992) and Naito & Yoshikawa (1999), it corresponds to the earthquake with M6 off Miyagi Prefecture.
6. We detected successfully the preseismic and coseismic temperature signals for the earthquake off Miyagi Pref. on Dec. 2, 2005 (M6.6) which is largest one since our observation started.

The statement 2 above suggests that we have to find the most appropriate depth for our temperature observation. Therefore we moved our sensor at the depth interval of 5 m and compared those data. Moreover in order to reduce the influence of natural convection, we put some stoppers 2.5 m upper and below the sensor. The temperature change at the depth of 830 m is different from the other depths; the fluctuation is of the highest frequency with 3-times larger amplitude. This may be attributed to the perpetual motion through the fault zone at the depth of 825 m. So we decided to monitor the temperature changes just at this depth.

What are any other causes of the temperature changes except for crustal strain? We set a water level indicator with the resolution of 1 mm in the same borehole. The data acquisition rate is one/10 minutes. The data showed the water level changes correlative with earth tide (ca. 25 mm amplitude), atmospheric pressure (4 mm/hPa), and rain fall with time lag of about a half day (3 mm/ml/day). The amplitude of the temperature fluctuation correlative with the earth tide is close to that estimated from the water level change by earth tide. However, even the change of atmospheric pressure of 50 hectopascals never causes temperature change, neither does the rain falls. Thus we can summarize as follows.

1. The water temperature at 830 m depth is independent of atmospheric pressure and rain falls.
2. In general the level (and temperature) of water can be changed by both tidal force itself and the crustal strain by tidal force. However, since the temperature is not affected by atmospheric pressure and the phase of temperature changes delays 3 hours from earth tide, then we conclude that the temperature fluctuations observed are not due to tidal force itself but the crustal strain by earth tide.