Under Ground Water Observation in Wari-ishi Hot Spring, Gifu Prefecture

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Wari-ishi hot spring is located on the Atotsugawa Active Fault, where is Kamioka-Town in the north of Gifu Prefecture. The hot spring, with a depth of 850 meters, is an artificial well which emits water at about 30 l/min. The Kamioka-Town office persons who manages the hot spring, had measured the water temperature using a bulb thermometer and the water flow rate using a water bucket, on every Monday over a period of 20 years. There have been three co-seismic and a pre-seismic phenomena associated with seismic activity over the last 20 years.

1) decreased by 34% before the 1983 Central Japan Sea earthquake (M7.7)
2) increased by 18% after the 1984 Western Nagano earthquake (M6.8)
3) increased by 5% after the 1986 Northern Nagano earthquake (M5.9)
4) increased by 11% after the 1993 Offshore Noto Peninsula earthquake (M6.6)

Since Wari-ishi hot spring is suitable for the observation of groundwater, we have carried out continuous monitoring of the radon concentration, the water temperature and the water flow rate of the groundwater. We began the research of the observation of the survey of the hot spring on July 7, 1998.

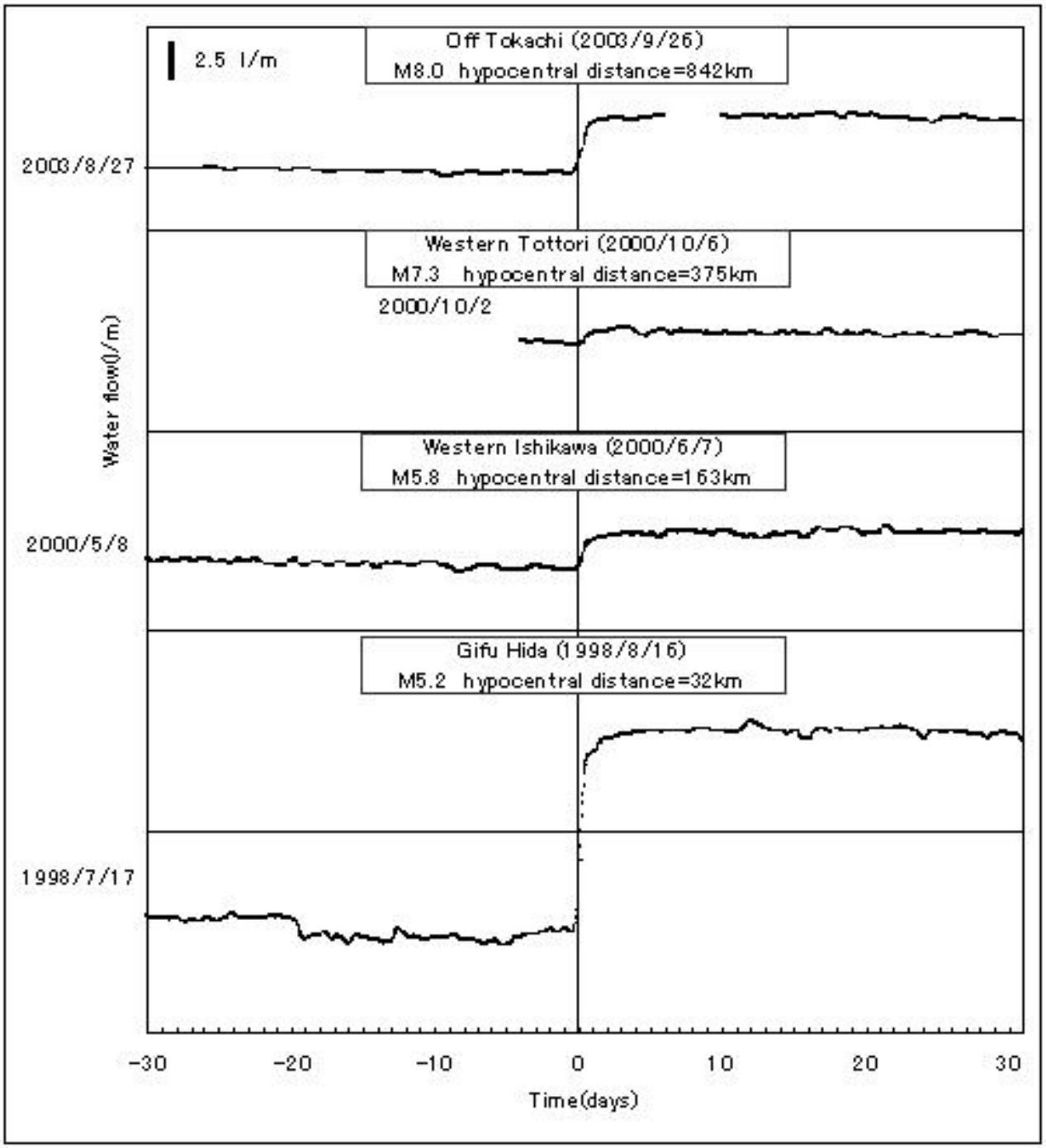
The co-seismic changes in the amount of the hot water by the electromagnetic flow meter were observed for this observation period, as the following four earthquakes.

5) increased by 43% after Hida region of Gifu Prefecture earthquake on August 16, 1998 (M5.2)
6) increased by 7% after West off Ishikawa Prefecture earthquake on June 7, 2000 (M5.8)
7) increased by 3% after Western Tottori Prefecture earthquake on October 6, 2000 (M7.3)
8) increased by 10% after Off Tokadhi earthquake on September 26, 2003 (M8.0)

There were pre-seismic phenomena of the series of earthquakes at Hida region of Gifu Prefecture from August 7, 1998. Wari-ishi hot spring is located about 32km from the epicenter. The amount of the hot spring water has decreased from 29 l/min to 27.3 l/min before 3 weeks of the earthquake occurrence. There was the co-seismic change at Wari-ishi hot spring, where the water temperature went up about 1.5deg and the water flow rate increased by 41 l/min, from 28.3 l/min, on Hide region of Gifu Prefecture earthquake of a magnitude of 5.4 at August-16, 1998. The amount of the water decreased to 30 l/min of the original amount one year later.

The water flow rate at Wari-ishi hot spring has periodic fluctuations mainly induced by the earth's tides. We applied the time series analysis using the BAYTAP-G program. The trend component are elimivated from the observed water flow rate by subtracting estimates of the atmospheric and tidal responses with lagged terms of the noise component. The noise component of water flow rate is related with the amount of gas in hot spring. The co-seismic decrease of the amount gas were observed in Gifu Hida region earthquake and Off Tokadhi earthquake. The pre-seismic change of the amount gas is one of the important information from the crustal strain changes associated with earthquake.

The volumetric strain induced by the eight earthquakes have been calculated by the published parameters of dislocation models, and compared with the co-seismic water flow rate changes.


2.5 l/m
Off Tokachi (2003/9/26)
M8.0 hypocentral distance=842km
2003/8/27
Western Tottori (2000/10/6)
M7.3 hypocentral distance=375km
2000/10/2
Water flow(l/m)
Western Ishikawa (2000/6/7)
M5.8 hypocentral distance=163km
2000/5/8
Gifu Hida (1998/8/16)
M5.2 hypocentral distance=32km
1998/7/17
-30
-20
-10
0
10
20
30
Time(days)