

# Observation of Radon and Hot Spring Water with 2011 Tohoku Earthquake in Gifu Prefecture, Central Part of Japan

Shigeki Tasaka<sup>\*1</sup>, Masaya Matsubara<sup>1</sup>, Norio Matsumoto<sup>2</sup>,  
Keika Horiguchi<sup>2</sup> and Fumiaki Tsunomori<sup>3</sup>

1. Information and Multimedia Center, Gifu Univ.

2. Geological Survey of Japan, AIST

3. Graduate School of Science, Univ. Tokyo

We have observed over 14 years of the radon concentration and the flow rate, in Wariishi Hot Spring at the northern part of Gifu Prefecture. Hot Springs is located about 2km south from the Atotsugawa active faults. Hot spring has been flowing artesian water from a depth of 850m at the perforation length is 1300m,. The flow rate is 30 liter/min. Hot spring temperature is 40 deg. Fig.1 is location map of the observation in Wariishi hot spring. Flow rate is continuously measured at intervals of a second, using an electromagnetic flow meter.

During the period of Apr. 12, 2011-Mar. 9, 2011, the oscillations of hot water of 10 events were observed due to the Tohoku earthquakes of the magnitude 6.0 or higher. These earthquakes are a foreshock, main shock, six aftershock and two induced earthquakes. Fig. 2 is the result of observation of the oscillations of hot spring with the main shock and three aftershocks in 14:41 to 15:36 Mar. 11, 2011. The oscillations with the main shock are as follows: Initial changes of hot spring due to the P-wave, decreased 6.2 liter/min. Hot spring water has stopped twice about 22 seconds due to the S-wave, and the amount water was increased more than 72 liter/min, twice about 19 seconds. Radon is dissolved in hot springs water, are extracted using a gas-liquid mixer, we are continuously measured every 10 minutes using two type of

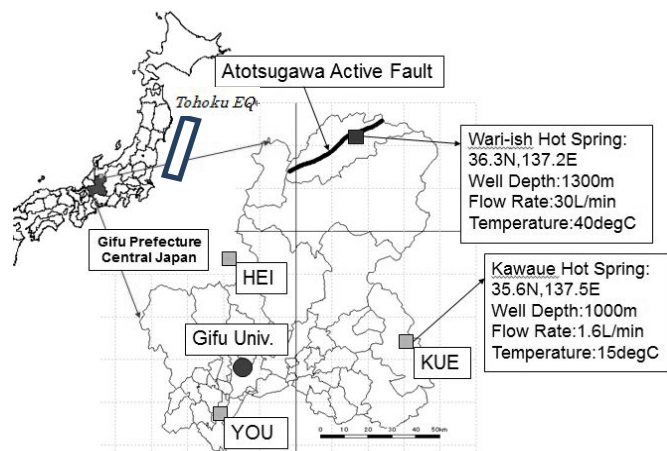


Fig.1 Location map of the observation in hot spring

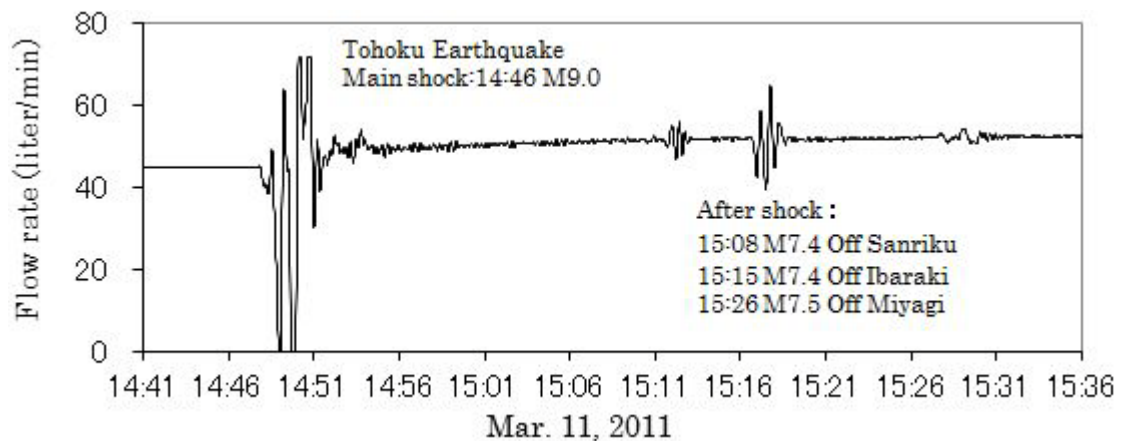


Fig.2 Observation of the oscillations in hot spring with Tohoku earthquake

radon detector by electrostatic collection and PMT/ZnS(Ag) scintillator.  $F_w$  and  $C_w$  was the flow rate and radon concentration in spring water, and  $F_a$  and  $C_a$  was the flow rate and radon concentration in the air of injection into the gas-liquid mixer.  $C_w$  spring water radon concentration can be calculated by the following formula.

$$C_w = C_a(F_a/F_w + \alpha), \quad \alpha = 9.12 \cdot (273 + T) / (17 + T) \cdot 273$$

$\alpha$  is the solubility of radon at water temperature  $T$  deg., and  $C_{a0} \ll C_w$ .

Fig.3 is the observation results of radon concentration and flow rate in Wariishi hot spring with Hida earthquake(Feb.27,2011) and Tohoku earthquakes(Mar.11,2011). The flow rate was increased to 46.2 from 28.8 liter/min with Hida EQ and increase to 62.8 liter/min with Tohoku EQ. The radon concentration was not changed with earthquakes, the values show the periodic changes by annual variation, winter season 4Bq/liter and summer season 3Bq/liter.

Hot spring increases rapidly at intervals of 30 to 100 minutes on a regular basis. The relationship between earthquake occurrence and magnitude and period of change was discussed on the geyser.

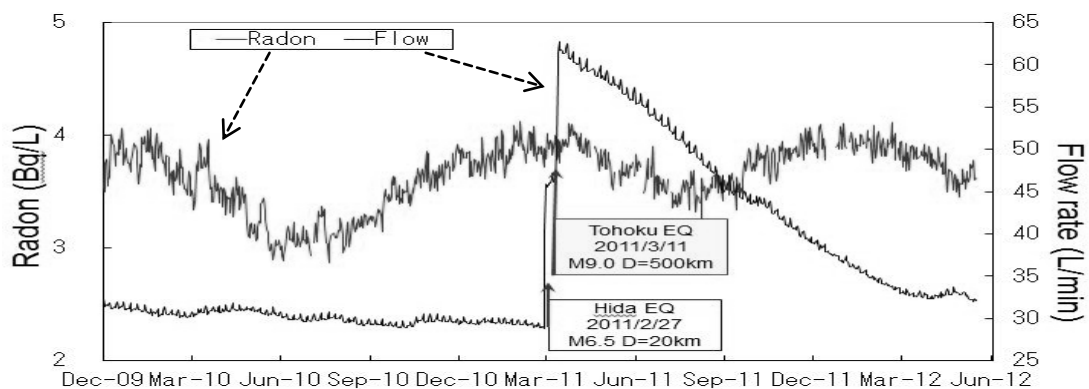


Fig.3 Observations of radon and flow rate with Hida and Tohoku earthquake