

## Precursory and after-effect anomalous groundwater changes associated with the 2011 giant Tohoku earthquake of M9.0

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Clear precursory changes for the 2011 off the Pacific coast of Tohoku Earthquake of M9.0 was recorded in electric conductivity and temperature of groundwater, representing the changes on ion concentration and water temperature induced by the intrusion of water from deep underground, which is responsible to the crustal stress conditions. The observing point, Deyu Hot Spring, Agano City, Niigata Prefecture, is located 200km west of the end of the seismic fault of the earthquake. Since April, 2001, Mr. Sadao Kawakami has been manually measuring temperature and electric conductivity of groundwater at the hot spring. The measurement is conducted at an interval of one week for the water pumped up from the well. Furthermore, we have temperature data recorded automatically since December 7, 2008. Around the end of 2009 the conductivity started to decrease with clearly decreasing temperature, indicating stress relaxation underground. Then the conductivity tended to increase in May, 2010, and the temperature similarly turned to increase in December, the same year. The resultant precursory time is one year and several months. The conductivity data from this observation station had recorded precursors before the 2004 Niigata Chuetsu Earthquake of M6.8 and the 2007 Niigata Chuetsu-oki Earthquake of M6.8. Clear after-effect groundwater temperature rises were recorded at Nuruyu Hot Spring, Awaji City, Hyogo Pref., and Ushio Hot Spring, Unnan City, Shimane Pref. The rise time and height are 20 days and 70m degree in centigrade at Nuruyu, and 10 hours and several hours and 3.5 degree at Ushio, respectively.

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