Constraint of fault geometry for Japanese historical earthquakes based on groundwater anomaly

*Yasuyuki Kano[1]

1. Research Institute for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University

Ground water anomalies associated with earthquakes were repeatedly documented in historical sources. From the observation of change in well water level we can extract information of strain change. Coseismic deformations produce volumetric strain change of crust. The spatial distribution of the strain change can be used to constrain geometry of the source fault. Poroelastic theory and modern borehole observations show that volumetric contraction or extension of 0.1 to 1 microstrain yield 10 cm to 1 m increase or decrease. Although small strain changes cannot be sensed or observed by people, the mechanical coupling between rock and water amplifies strain change to observable change in groundwater. Japanese historical earthquake documents show that well water level change was observed at the time of the 1703 Kanto and 1855 Hietsu earthquake. The source area of the 1703 Kanto earthquake is estimated to be off the coast of Boso Peninsula, Japan. A well became empty at a village near southern end of the peninsula, which may be caused by ground water level drop associated with volume extension of the crust. Another well located in middle of the peninsula showed no change, which may be attributed to smaller strain change. The spatial distribution is consistent with coseismic deformation predicted from a source model constrained by geomorphological examination. The source fault of the 1855 Hietsu earthquake is located at the Atotsugawa fault, central Japan. Decreases in well water were observed at a village close to Toyama bay, which may be attributed to volumetric extension. The location of the village is close to node of four quadrant pattern of volumetric strain predicted from geometry of active fault trace and distributions of damages of houses at the time of the earthquake. The observed decrease of well water level and volumetric extension can be used to constrain the fault geometry more accurately.

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