# Trigger and Mechanism of Co-seismic Groundwater Level Changes

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In order to detect co-seismic groundwater level changes and to make clear the mechanism of the phenomenon, we started continuous groundwater level observations with 1-hour sampling in Togari Crustal Activity Borehole Observatory with a depth of 350 m (TGR350) at Central Japan in May 1998. Since July 2000, we have been performing groundwater level observation with 1-hour sampling and continuous crustal movement observations with 1-Hz sampling, faster than the previous interval (e.g. 1 min, 1 hour).

In the period from May 1998 to June 2005, 17 groundwater level changes in response to local and distant earthquakes were observed, 9 of which were observed simultaneously with dynamic tilt and strain variations. The common and dominant feature in all observed co-seismic groundwater level changes is “rise”. Other significant features are as follows: The largest co-seismic change is 2.078 m, which was response to the 2004 Off the Kii Peninsula Earthquake (Mj 7.4 with the epicentral distance of 250 km), and the smallest change is 0.011 m, which was response to the 2005 Central Aichi Prefecture Earthquake (Mj 4.7, 38 km). Other 3 notable co-seismic changes are due to major earthquakes that are 0.204 m caused by the 1999 Taiwan Chi-Chi Earthquake (Mw7.7, 2100 km), 0.814 m by the 2003 Tokachi-oki Earthquake (Mj 8.0, 910 km), and 0.101 m by the 2004 Sumatra-Andaman Earthquake (Mw 9.0, 5800 km).

We investigated the relationship between the peak amplitude of co-seismic groundwater level changes and peak-to-peak amplitude of dynamic strain and tilt variations. The following results are obtained:
[1] There are clearly positive correlation between the peak amplitudes of co-seismic groundwater level change and peak-to-peak amplitudes of dynamic strain/tilt variations. [2] Co-seismic groundwater level changes are caused by dynamic strain/tilt variations with peak-to-peak amplitudes only above a certain threshold value. [3] No co-seismic groundwater level changes occur below the threshold value. The discovery of the threshold value is resulted only from our continuous observation of crustal movement with the higher sampling rate of 1-Hz than before.

On the basis of our groundwater observation, our finding of the threshold of dynamic strain/tilt variations, actual geological and hydrological information in and around TGR350, and applying the 1-dimensional finite porous aquifer model, we propose a new mechanism of the co-seismic groundwater level changes. The essence of it is as follows: There is a low-permeable fault near TGR350. In general, the fault consists of cracks, clogged with fault clay and breccia. When the seismic wave passes, it generates dynamic strain/tilt variations in and around the fault. If the dynamic strain/tilt variations exceed a certain threshold, the removal of fault clay and breccia occurs in the cracks. Consequently, incremental flow of groundwater through the fault is produced, and then the pore pressure increases over the steady state in the area downstream of the fault, and the groundwater level rises. After reaching the level peak, new clogging is generated by the redeployment of fault clay which caused by the groundwater flow, and the incremental flow through the fault decreases. Then the pore pressure condition seems to return to a new steady state.