# Groundwater and Coastal Phenomena Preceding the 1944 Tsunami

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Extensive reconnaissance surveys were systematically carried out over the epicentral area of the 21 Dec.1946 $M_w$ 8.1 Nankai earthquake. Based on the surveys, groundwater levels of shallow wells mostly in unconfined aquifers changed before and after the 1946 Nankai earthquake. The changes of groundwater levels occurred on the coastal areas of Shikoku and Kii peninsula near the periphery of the aftershock area.

In addition to the coseismic changes, about one week prior to the earthquake, groundwater levels also dropped along the 400 km long coast. The groundwater on almost all sites became muddy or salty suggesting that the sea-water had intermingled with fresh-water aquifers. Immediately after the quake the drop or rise of groundwater level also occurred extensively over the area of Shikoku and Kii Peninsula. The sign of coseismic water-level change at wells varied but the drop was predominant in most areas.

Two years preceding the Nankai earthquake, the Mw8.1 Tonankai earthquake of December 7, 1944 occurred. This quake occurred east of Kii Peninsula with its source size still controversial. Moreover, since this quake happened during the World War II, investigations for both the seismological and reconnaissance data of the earthquake were not taken properly due to severe censorship. Therefore, the change in groundwater levels associated to this event is uncertain. Since then and more than 60 years after the earthquake, interviews with local people have been conducted. From these interviews, it was found that very few people took notice of any change of the water from the wells. The investigation is still in progress, but there is little hope in finding any groundwater level changes before and after the quake. However, there was a witness who observed bubbles generated in the seawater before the tsunami struck. This is most probably gases in the soil that were pressured and squeezed into the seawater due to the surface loading by the tsunami. This suggests that the area, at the very least, is quite sensitive to pressure changes. The seawater bubbling phenomenon, however, cannot be related to preseimic deformation.

Although there was a legend in the region regarding the drop and rise of water levels on wells, there was no eyewitness for such occurrence during the 1944 event. In one instance, however, a man made the following accounts regarding his father who had a prior knowledge of tsunami, the well water level lowering before the tsunami, and the retreat of sea water preceding the tsunami waves. Immediately after the shaking, his farther checked for both the wells and seawater levels but could not find either of the phenomena. Thus, his father decided to stay. Unfortunately, the tsunami inundated the area and he was killed.

The preseismic drop in groundwater level of shallow unconfined aquifers is possibly due to the drainage of shallow groundwater into the underlying confined aquifers. Dilatations in the aquifers could have allowed the drop of the groundwater level in shallow unconfined aquifers wherein the sea water migrated into the fresh water aquifers. This drainage was possibly caused by opening of fractures in the confined layers due to dilatation that widely took place in the crust over the epicentral area.

A possible interpretation for the dilatation is attributed to a slow slip on the plate interface or associated splay faults. A slow slip on a fault can sufficiently produce volume changes in an order of $10^{-6}$ over the coastal areas that are comparable to the amount of coseismic volume changes. Such slow slip is likely to occur in a transient zone at depths 30-40 km between the coupled and stable-sliding zones on the slab interface.

On the contrary, prior to the 1944 event there was no significant precursory ground water change at the eastern part of Kii peninsula, which could be another variety of precursory deformations, associated with subduction events.