Responses of the groundwater level to crustal strain: Observation of 1 Hz sampling at Akan hot-spring wells, Hokkaido, Japan

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There are many reports describing groundwater level responses to crustal strain in the past. Mainly two models of response mechanisms are considered as follows: (1) a strain model that is reflecting crustal strain by elastic behavior of aquifer, and (2) a fracture model that is caused by groundwater flow through fractures. We have conducted detail analyses for evaluating these models by using high sampling data of groundwater pressure gauge and volumetric strainmeter.

Two groundwater level observation wells (ak1: 1061 m-deep, ak4: 102 m-deep) locates at the hot spring area of Akan-lakeside, Hokkaido, Japan. High sampling data of 1 Hz are used for analyses, of which resolution seems less than 1 mm of water level fluctuation (Takahashi et al., 2006). Lithologies around the wells are pumice tuff, tuff silt, tuff breccia and sandstone for the shallower part than 370 m and the basement of dacite lapilli tuff for the deeper part. Strainers of the well ak1 are opened in the basement, and that of the ak4 are in shallow aquifer of pumice tuff. Strain data are obtained by the Sacks-Evertson borehole volumetric stainmeters from two observation wells: Kusharo (KUT: 180 m deep) and Kamikineusu (KMU: 110 m deep) (Takanami et al., 1998). The strain data are also sampled by 1 Hz.

Long period strain for barometric and tidal responses were analyzed by Baytap-G and Gotic2. Calculated strain sensitivities of the wells are 3.42 [mm/10^{-8} strain] for the ak1, and 0.59 [mm/10^{-8} strain] for the ak4. Short period responses to crustal strain caused by the Chishima island off shore earthquake (07/01/13, M8.2) and the Tokachi off shore earthquake (07/02/17, M6.2) were analyzed by filtering and spectrum analyses as well as Baytap-G and Gotic2. As results, the ak1 well shows step-like response which is consistent with strain step estimated by the method of Okada (1992). Concerning about short period responses, the ak1 follows to strain changes as small groundwater level fluctuation as a few mm, and strain records from 20 to 30 seconds period. On the contrary, the water level of the ak4 changes upward for the both earthquakes, that is different states estimated only from the crustal strain change. The groundwater level change of the ak1 is explained by the strain model, however, that of the ak4 should be considered as a multiple model of the strain model and the fracture model. We conclude that this kind of high sampling observation of water level is very effective to consider hydraulic properties of aquifer responding to crustal strain.