

Relationship between crustal strain and groundwater level at wells in Hokkaido, Japan

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The natural fluctuation of groundwater level depends not only on the stress applied to an aquifer but also on the type of rock that comprises it. Linear poroelasticity provides a compelling relationship between fluid pressure and deformation of fluid-saturated rock, and is an excellent parameter for analyzing hydraulic phenomena. One linear poroelastic response, coseismic change in groundwater level, has been studied for many years (e.g., Igarashi and Wakita, 1991).

We have long-term data on groundwater levels measured at 19 wells in Hokkaido, Japan, an area where large earthquakes occur frequently (Akita and Matsumoto, 2004; Shibata et al, 2010). In addition, we have data on the coseismic changes due to six earthquakes with magnitude seven (M 7) or greater in the Hokkaido region from 1993 to 2004: the 1993 Kushiro-oki (M 7.6), the 1993 Hokkaido-Nansei-oki (M 7.8), the 1994 Hokkaido-Toho-oki (M 8.1), the 1994 Sanriku-Haruka-oki (M 7.5), the 2003 Tokachi-oki (M 8.0), and the 2004 Kushiro-oki (M 7.1).

We estimate strain sensitivities in two ways: (a) using the well response to tidal strain and (b) using coseismic changes in groundwater level based on historical data. The strain sensitivities estimated by the two different methods have good linear correlation. We also estimate loading efficiency using observational records and calculate bulk moduli from the loading efficiencies and strain sensitivities. The bulk moduli obtained in this manner are roughly consistent with laboratory values.

Reference

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