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# Groundwater Effect to Long-Term Changes of Strain at Rokko-Takao Station

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The strain changes observed at Rokko-Takao station in the band of a few months are caused by changes of discharge and precipitation. Decrease of discharge and precipitation result in the extension of strains and the maximum principal strain with the direction perpendicular to the Manpukuji Fault nearby the station. This extension suggests that the deformation of the crust occurred due to decrease of groundwater loading and the fracture zone of the fault contracts due to descent of pore pressure. In this study, we investigated the groundwater effect to the strain changes at Rokko-Takao station and calculated the hydraulic parameters such as permeability in the fracture zone by using the observed data of strain, discharge and precipitation.
Rokko-Takao station was established by Kyoto University. This station is located in the emergency evacuation road for the Shin-Kobe tunnel. In the station, the extensometer EX2 (N69 E) and three strainmeters ST1 (N81W), ST2 (N39E), ST3 (N21W) as well as the discharge meter were installed. The strain changes have the tidal strains and the atmospheric effects in the order of $10^{-8}$. We calculated the tidal strains and the atmospheric effects by applying the tidal analysis program BAYTAP-G (Tamura et al., 1991) to the observational strain data. Mukai and Otsuka (2 008) calculated the elasticity of the surrounding crust by applying the equation of stress and strain to the observed tidal strains and the predicted tides obtained by GOTIC2 (Matsumoto et al., 2001). When we used only major tidal constituents such as $O_1$and $M_2$in this calculation, the calculated Young modulus has the minimum value in the north direction. This anisotropic structure of elasticity indicates that the major parts of fractures have fracture cross section perpendicular to the north direction. Mukai and Otsuka (2009) indicated that the discharge changes depended on the tidal strain in the north direction particularly and obtained the similar anisotropic structure of elasticity by using the observational data of discharge.
The observed strains have the effect of room temperature in the order of $10^{-6}$. We removed the effect of room temperature during the period of 2000 to 2009 and obtained the residuals of strain. Dilatation and the principal strains calculated by using the residuals of strain showed the continuous extension about $10^{-6}$during a few months in 2003 and 2006. The direction of the maximum principal strain was about N30E. During those periods, decrease of discharge and precipitation were observed. The decrease of precipitation caused reduction of groundwater loading and the decrease of discharge was caused by descent of pore pressure. The maximum extension in the north-northeast direction caused by the decrease of discharge and precipitation agrees with the anisotropic structure of elasticity obtained by using the tidal strains.
We can estimate the hydraulic parameters of the surrounding crust by applying the model about groundwater migration to the observed data of strain and discharge. The model depends on the pore pressure, permeability and area size of fracture zone. In this study, we estimated these parameters and compared with the results obtained by using the tidal strains.

Keywords: strain, discharge, fracture zone, permeability