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Short-term Change of Permeability after Tohoku Region Pacific Coast Earthquake Observed at Rokko-Takao Station

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The 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011 caused the step-like increase of groundwater discharge by 250ml/s as well as the step-like changes of strain by about 10^{-7} at Rokko-Takao station. The magnitude of the atmospheric pressure admittance of groundwater discharge increased by 80% just after the earthquake compared with before the earthquake. The pressure admittance has been recovering to the original level in about one year after the earthquake. The station is located in the fracture zone of Manpukuji fault. It is considered that the change of the pressure admittance on the earthquake was caused by the increase of permeability due to outflow of plugging components such as mud from the fracture zone. In this study, we estimated the secular change of permeability of the fracture zone nearby the station and investigated the characteristics of re-plugging of the fracture due to accumulation of mud and so on.

Rokko-Takao station is located in the emergency evacuation road for the Shin-Kobe tunnel, and crosses Manpukuji fault with the east-west strike. In the station, three components strainmeter (ST1:N81^{o}W, ST2:N39^{o}E, ST3:N21^{o}W), three extensometers in the direction of N69^{o}E (EX2, EX3, EX4), the groundwater discharge meter and the groundwater level meter were installed. The observation has been performed continuously with the sampling intervals of 0.5 second and 10 minutes. We calculated the tidal strains by applying the tidal analysis program BAYTAP-G (Tamura et al., 1991) to the observed data of strain. Mukai and Otsuka (2008) reported that the tidal amplitudes of strain had been recovering secularly by a few % per year since 1995 Hyogoken Nanbu Earthquake. It was considered that the healing of the fracture zone caused increase of the Young's modulus and reduced the tidal amplitudes.

The ordinary seepage rate of groundwater at the station is about 550ml/s. The groundwater discharge rate increased to 800ml/s just after the earthquake. After the earthquake, the groundwater discharge rate decreased to 300ml/s in a few days and recovered to the original rate in a few months. Strain steps due to the earthquake at the station showed the positive dilatation about 10^{-7}, which was calculated by using the fault model of Geographical Survey Institute. The low discharge of groundwater during a few months after the earthquake might be caused by the decrease of pore pressure due to the extension of the surrounding crust. On the other hand, the rapid increase of groundwater discharge on the earthquake might be caused by the increase of permeability due to the outflow of plugging components such as mud from the fracture zone.

The pressure admittance of the groundwater discharge in 2010 was estimated to be +3.4ml/s/hPa, which was positive in case that decrease of the atmospheric pressure caused the increase of groundwater discharge. This admittance shows that groundwater is drawn from the fracture zone by decrease of the atmospheric pressure. We estimated the variations of the pressure admittance by applying BAYTAP-G to the groundwater discharge observed since March 12, 2011. In this calculation, we obtained the pressure admittances for four terms. Each term was 90 days and was shifted by 67 days from the previous term. The pressure admittance just after the earthquake was estimated to be +6.1ml/s/hPa. We considered that this large pressure admittance was caused by the increase of permeability as mentioned in case of the increase of groundwater discharge on the earthquake. The pressure admittance has been decreasing to +4.0ml/s/hPa at the end of 2011. It is suggested that the plugging of the fracture due to accumulation of mud and so on caused the short-term decrease of permeability. This plugging of the fracture might be beginning to the long-term healing process of the fracture zone shown by analysis of the tidal strain.

Keywords: groundwater discharge, strain, permeability, The 2011 off the Pacific coast of Tohoku Earthquake