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Change of groundwater behavior caused by 2011 Tohoku earthquake detected from pore pressure and gravity

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At the Kamioka mine, Gifu prefecture central Japan, several kinds of apparatus, such as seismometer, strainmeter, tiltmeter and laser extensometer, have been installed. We have been monitoring pore pressure and barometric pressure at this mine. Pore pressure remarkably decreased at the time of the earthquake, although the hypocentral distance of 2011 Tohoku earthquake is 528 km. This reduction of pore pressure was equivalent to 2-3 m decrease of groundwater level. It was the largest response during the observation period. The pore pressure reduction had continued for a few days. We anticipated the causes of the reduction were creation of new water path or permeability increase. We focused on Earth tide which can be assumed that it's effect is almost constant. We extracted Earth tidal response of pore pressure by the tidal analysis program BAYTAP-G (Tamaura et al., 1991). We compared it before and after the earthquake and the amplitude of M2 constituent reduction was seen from 22 to 16 Pa. O1 constituent also slightly responded to the Tohoku earthquake and these results indicate the rock property change. We estimated the hydraulic diffusivity to evaluate permeability of rock. From the analysis, adopting theory of linear poroelasticity and diffusion equation, we found that diffusivity increased about two fold after the Tohoku earthquake (Kinoshita et al., 2015). If these results are real, other instruments should also capture the change of diffusivity and groundwater behavior induced by earthquake.

The superconducting gravimeter have been installed at the same mine. This observation started in 2004 which is located 2.5 km apart from our pore pressure monitoring point. We analyzed gravity data by the same method as used for the pore pressure analyses. We suppose that if permeability of rock increases, gravity should be changed because gravity reflects the density of underground. The tidal response of gravity is clearer than that of pore pressure and we can compare the other constituents (Q1, M1, N2 constituents). While gravity analysis has difficulty because of large disturbance caused by heavy snow around this region in winter in the case of the Kamioka mine. Imanishi et al. (2014) indicates that the data of gravimeter has decreased after the Tohoku earthquake and it could not be explained only by the crustal deformation. It implies that the density change occurred. We will show the tidal analysis results of pore pressure and superconducting gravimeter, and report the hydraulic parameter change after the Tohoku earthquake.

Keywords: pore pressure, superconducting gravimeter, Tohoku earthquake, Earth tide