Different behaviors of groundwater pressures in two boreholes at the Yasutomi station of Geological Survey of Japan, AIST

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Geological Survey of Japan, AIST constructed the Yasutomi station in the fractured zone of Yasutomi fault, which is a part of the Yamasaki fault system. At the Yasutomi station, three boreholes named WELL-1, WELL-2, and WELL-3 were drilled within 10 meters of each other. The groundwater pressures in the three boreholes were measured. At WELL-2 and WELL-3, the perforated casings were set between depths of 144.1 - 149.6 meters. The rocks at the depths of the perforated casings of WELL-2 and WELL-3 are slate with cracks.

The tidal and barometric responses of the groundwater pressure at WELL-2 are greatly different from those at WELL-3. From the tidal response, amplitude ratios of groundwater pressure to volumetric strain were 139 Pa per 10^-8 strain at WELL-2 and 44 Pa per 10^-8 strain at WELL-3, respectively. If we assume that groundwater movement is neglected, the barometric responses of the groundwater pressure are estimated to -0.4 at WELL-2 and -0.8 at WELL-3, respectively.

Based on poroelastic theory, these relationships are formulated under the undrained condition as follows:

$dPp/de=dWP/de=KuB=2GB(1+vu)/3(1-2vu)$

and

$dPp/dPb=dWP/dPb+1=B(1+vu)/3(1-vu)$

where dPp is pore water pressure change in rock, dWP is groundwater pressure change in borehole, de is volumetric strain change, Ku is the undrained bulk modulus, B is Skempton's coefficient, G is the shear modulus, vu is the undrained Poisson's ratio, and dPb is barometric pressure change. From the two formulations, $dPp/de=139x10^8$ Pa and dPp/dPb=0.6 at WELL-2, and $dPp/de=44x10^8$ Pa and dPp/dPb=0.2 at WELL-3. Both dPp/de and dPp/dPb at WELL-2 are three times as large as those at WELL-3. It is considered that physical characteristics of the rocks at the depths of the perforated casings of WELL-2 and WELL-3 are different. An assumption that the value of B at WELL-2 is three times as large as that at WELL-3 can explain the observation results.