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Effects of permeability on Self Potential: numerical experiment and application to a real data

OZAKI, Yusuke[1*], MIKADA, Hitoshi[1], GOTO, Tada-nori[1], TAKEKAWA, Junichi[1], TSUJIMURA, Maki[2], Fatma HACHANI[2]

[1]Kyoto Univ. Grad. School of Eng., [2]Graduate School of Life and Environmenta

The objective of this study is to elucidate effects of permeability on self potential (SP) and feasibility how the SP profile is useful to detect the subsurface permeability structure. SP is the electrical potential mainly generated by the groundwater flow. In general, the SP is affected by the permeability, electrical conductivity and coupling co-efficient. Although the distribution of permeability is an important parameter for the groundwater flow, the effects of permeability on SP have not been well discussed, especially in field data interpretation. In this study, we simulated the groundwater flow and SP to estimate the effects of permeability on SP.

First, we simulated the groundwater flow and SP under the rainfall condition to express natural groundwater flow and SP. Our simulation results show that the magnitude of SP is proportional to the difference of height of water table, and less correlation to the thickness of vadose zone. The dominant factors that decide the magnitude of SP were permeability and the mass of precipitation. Then, we simulated the groundwater flow and SP affected by the heterogeneity of permeability. Here, the groundwater flow is calculated under the condition with the fixed hydraulic head in this case. The anomalies of SP on the surface appear just above the lateral edge of anomalous permeability zones. These anomalies reflect on the groundwater flow around the heterogeneity of permeability. As a result, we found that the high permeable heterogeneity generated the larger anomalies than low permeable one.

Finally, we simulated the groundwater flow for interpretation of observed SP in the Saijo City. We could simulate the similar pattern of SP profile with two different models. One model has the uniform permeability and heterogeneity of electrical conductivity and coupling co-efficient. The other has the heterogeneity of permeability, electrical conductivity, coupling co-efficient. We compare the observed information of groundwater flow to simulated groundwater flow results. The area of recharge and discharge of model that the permeability is not uniform were similar to the observed area of recharge and discharge. From these results, the model with heterogeneity of permeability is better than the other in this area. We conclude that importance of permeability on interpretation of observed SP is indicated by these forward calculations. In the future, it could be possible to estimate the subsurface structure of permeability from both SP profile and the information of groundwater flow.

Keywords: Self Potential, Simulation, Permeability, Groundwater Flow