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Effect of heterogeneity of hydraulic conductivity on groundwater flow and spontaneous potential

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Spontaneous potential(SP) is the electrical potential mainly generated by thermoelectric, chemical and streaming potentials in the subsurface. The flow of groundwater is often recognized as a dominant source of SP. Using this feature, many attempts have been done to quantify groundwater flows in the soil.

The SP anomalies according to the groundwater are often associated with the direction of groundwater flow as a primary interpretation. Therefore, it is believed that the inverted gradient of SP corresponds with the direction of groundwater flow. However, the distribution of SP is influenced by not only the direction of groundwater flow but also the inhomogeneous of subsurface. Actually, the previous studies show that inhomogeneity of permeability and coupling coefficient has an effect to the SP anomaly. Thus, the distribution of SP is influenced by the existence of subsurface heterogeneity, but the detailed studies are few.

In this study, we developed the numerical codes for SP simulation: we simulated the natural groundwater flow and the distribution of SP according to the flow along a topographic slope. We discussed the effect of parameters, such as permeability and slope angle on the groundwater flow to the distribution of SP. Our simulation shows that the SP anomalies appear just above the boundaries of permeability. These anomalies are due to the charge that occur on the boundary- where the flow passes. This effect was prominent in case that the permeability contrast was large. In addition to this effect, our simulation results show that the additional SP anomaly appears at the discharge of groundwater caused by the effect of slope angle and permeability. Our simulation suggests that the SP is influenced by the groundwater flow and inhomogeneity of permeability and we suppose a new method to obtain the information of groundwater flow and permeability from the SP observation.

Keywords: spontaneous potential, hydraulic conductivity, groundwater flow