Use of Self-potential (SP) method to understand the regional groundwater flow system

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The self-potential method (SP method) is one of the geophysical explorations technique originally used to explore the mineral deposit for mining purposes. Recently, this technique has been applied to understand the geothermal fluid flow in and around the volcanic area. As there exists various factors to affect the surface SP measurement, it is rather difficult to find out the major cause of self-potential generation because their complexity of the generation mechanism. In this application, the behavior of groundwater flow is thought to be as a kind of noise. However, in case of non geothermal area, groundwater flow flux should create substantial self potential at the area which is less complex than geothermal area. The self-potential created by the groundwater flow is mainly caused by the streaming potential represented by the electrokinetic factors such as groundwater potential and the ground resistivity (Ishido and Mizutani,1981). As there exist little SP study to understand groundwater flow system, we have conducted the field SP measurement and its numerical model consideration in the clear groundwater flow existing area.

A basin scale groundwater flow region including the mountainous ridge to the coastal area within one river-water catchment basin, which is geologically composed by the volcanic lava and tuff-breccia bedrock, was selected to apply the SP method. The study area is Shiranui town, Kumamoto, Kyusyu, Japan. In this area, following multi-hydrological studies have been conducted to understand the groundwater flow regime of the area: groundwater flow system study with observation boreholes and eivironmental isotopes, hydrometric observation for river discharge and precipitation for the regional water budget, micro-meteorological observation at different vegetation and altitude for the evapotranspiration measurement, submarine groundwater discharge investigation, geological borehole drilling, and 3D groundwater flow simulation, etc.

The observed SP results in the Eino-o basin show the upstream part from Furuyashiki village is comparatively simple water table shape (groundwater potential distribution) based on the regional large terrain, and the downstream part is comparatively complex water table shape (groundwater potential distribution) by the groundwater mount formed in the independent pyroclastic flow mountain body.

Moreover, SP numerical calculation results of assuming the groundwater flow of a simple mountain slope (Case1 (Mt. kamada model), Case2 (Valley model)) show the observed SP distribution in Eino-o basin. Therefore, SP numerical modelling of which the input value is the groundwater potential based on the groundwater flow simulation result intended for Eino-o basin is carried out. As a result, SP numerical modelling results show the upstream part from Furuyashiki village is 2-D groundwater flow responded to the regional large terrain, and the downstream part is 3-D groundwater flow responded to the local rough terrain including Mt. Kamada. It was confirmed that the understanding of the groundwater flow by using SP method was extremely effective.