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Application of fluid conductivity logging to identify permeable zones in costal aquifer, Yeonggwang, Korea

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The understanding of origin of saline groundwater is one of important factors to verify the characteristics of seawater intrusion zone. Most western areas in Korea are a reclaimed land. So, it has been a very difficult issue to clearly identify whether the saline groundwater in the coastal area originates from remains caused land reclamation or seawater influx through permeable fractured rock. Although the hydro-geochemical analysis and fluid conductivity estimation by well logging have been utilized so far for identifying the origin of saline groundwater, the new approach is necessitated for quantitative analysis. Fluid conductivity logging has been applied in the boreholes to identify the origin of saline groundwater. Fluid conductivity logging was developed by Tsang et al. in 1990, and has been mainly used for the hydraulic characterization of fractured rocks. The cases applied for examining the characteristics of seawater intrusion zone have not been reported. Above technique is referred to fluid conductivity logging, ion logging, or by the trade name Hydrophysical logging. Fluid conductivity logging measures the fluid electrical conductivity with depth at different times in a well during ambient condition or pumping. Formation water flows into the borehole through aquifer such as permeable fractures or porous formation, and this water has a higher fluid electrical conductivity than the fresh water that is initially replaced into a borehole in case of coastal aquifer. Measured peaks with times therefore indicate the locations of permeable aquifer. In this study, profiles of fluid electrical conductivity were used qualitatively to identify the locations of permeable aquifer with higher fluid electrical conductivity. Equipments of fluid conductivity logging consist of fluid control unit and measurement unit of fluid conductivity. Fluid control unit performed the injection and pumping for the purpose of replacement of borehole fluid with different fluid conductivity, and flowmeters (Model KV-1-B, Flownics Co.) are attached fluid control unit for quantitative interpretation. Pumping and injection equipments are

MQ2-35 of Grundfos Company. The fluid conductivity has been measured by using geophysical well logging system (Robertson Geologging Co.) or CDT diver (Van Essen Co.). Especially, Inlet and outlet pipe are designed to utilize in case of PVC casing with inner diameter of 50 mm. Survey area is located in Baeksu-eup, Yeonggwang-gun, on the western coast of Korea. The geological logs of boreholes with core indicate that the geological structure comprises mud (from the surface to a depth of 5-20m), sand (to a depth of about 25 m), and granite rock (below an approximate depth of 25 m) (Hwang et al., 2003). Fluid conductivity logging has been performed at three boreholes (YK-8, YK-9, and YK-21), the depth of boreholes is about 50 m, and the diameter of boreholes is 3 inch. PVC casing is installed from surface to bottom of borehole YK-21 and fully slotted for monitoring. In case of borehole YK-8 and YK-9, steel casing is installed from surface to upper part (i.e., weathered zone) of granite rock. The fluid conductivity by geophysical well logging in borehole YK-21 and YK-8 & YK-9 are from 100 to 4,000 uS/cm, and more than 5000 uS/cm, respectively.

Profiles of fluid conductivity logs in borehole YK-21 located in the area with brackish ground water show three locations of permeable zone. Top permeable zone is sand layer the other are located in the fractured rock, and fluid electrical conductivity is about 400 uS/cm in sand, about 500 in fractured rock. From fluid conductivity logs, brackish groundwater in borehole YK-21 affected by sand aquifer and permeable fractured rock intersected by borehole simultaneously.

The saline aquifers flowing from the fractured rock have been verified from the result of fluid conductivity logging fulfilled in borehole YK-8 and YK-9. The measurement in two boreholes were implemented under the ambient condition and pumping both. The measurement under the pumping condition more clearly identifies permeable zone, and also the response of fluid conductivity is accelerated more. In case of YK-8, fluid conductivity value indicates about 9,000 uS/cm after the measurement for 4 hours. And no conductivity changes in the lower part of steel casing illustrates that there is no influx through sand layer. Since the confirmation of permeable zones obtained from fluid conductivity logging is impossible by a conventional caliper logging, we have implemented the higher resolution acoustic borehole televiewer logging for proving permeable fractured zones intersected by borehole. To both boreholes, the permeable fractured zone exhibiting high conductivity exists at a depth of 45 meter. As a result of fluid conductivity logging for three boreholes in the study area, it is estimated that saline groundwater is caused by seawater intrusion through fractured rock, although the effect by land reclamation partially remains. We are planning integrated analysis of fluid conductivity logging and hydro-geochemical data, and this approach might be usefully utilized in a reclaimed land for assessing the characteristics of seawater intrusion.