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In the hydrogeological characterization of sedimentary rocks, hydraulic properties of fault and cap rock structures are important factors. Although, the certainty of a hydrogeological model depends on the amount of geological or hydrogeological data, mainly obtained from boreholes, it is indispensable to make a preliminary model from a small amount of data obtained in the early stage of field investigation, and improve the details of the model as the number of observations increases. In sedimentary rocks, several aquifers often have different hydraulic heads, caused by various reasons such as surface topography, long-term change of sea level, or cap rock structures that were not explicitly observed during geological investigations in boreholes.

In this study, we used the steady-state hydraulic head distribution obtained in the pressure monitoring (or the water level monitoring) during the drilling of boreholes as the observed data, and applied numerical inversion code iTOUGH2 to construct alternative hydrogeological models for the Horonobe underground research laboratory site of Japan Nuclear Cycle Development Institute. We applied random sampling for the coverage of an assumed cap rock, and two models for the hydrogeological structure of faults in the study area. The following are the main results of this study.

1. It is necessary to assume a low permeability cap rock structure that was not clearly observed in boreholes, to reconstruct the deep high-pressure zone as a characteristic hydraulic feature in this site.

2. The numerical inversion with random sampling of cap rock shows that if the cap rock coverage is larger than 75%, the observed hydraulic head profile can be reproduced.

3. The hydrogeological structure of the fault dominates the vertical groundwater flow in the vicinity of the fault.

4. The hydraulic head profile of the deeper zone is controlled by the hydrogeological structure of a steep fault in this area. Thus, the increase of hydraulic head in the deeper zone, and numerical inversion can determine the hydrogeological structure of the fault.

From these results, numerical inversion using the steady state head distribution has proven to be a useful method to construct a preliminary but quantitative hydrogeological model from a small amount of data obtained in the early investigation stage.