Shallow Subsurface Thermal Regime in the Akita Plain

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Although Geothermal Heat Pump systems (GeoHP) have commonly distributed in North America and European countries, the number of application of this is still few (approximately 200 systems at the end of 2000) in Japan. This is mainly due to the geological complexity of shallow deposits in Japan, which makes the planning of GeoHP systems a more difficult task. In most of the shallow deposits in Japan, subsurface temperature distributions are strongly affected by thermal advection due to groundwater flow as wells as by thermal conduction from deeper formation. Therefore, groundwater flow is one of the most important factors to be considered when planning GeoHP systems in Japan. Since the subsurface geothermal energy distribution in plains and basins in Japan is quite commonly determined by groundwater flow, the feasibility of the design criteria of GeoHP systems, such as the depth of heat exchange wells, number of wells, should be carefully examined based on groundwater information.

In this study, the mechanisms of groundwater flow in Akita Plain were investigated. The objectives of the study are (i) to develop the subsurface temperature distribution and (ii) to understand the groundwater flow system from recharging areas to discharge areas in Akita Plain that causes thermal advection of groundwater.

Subsurface temperatures were measured in household shallow wells, in deep wells constructed for snow-melting systems, on rivers and spring waters. Water samples were taken for the water quality analysis at the same time. At the shallow wells groundwater levels were measured to draw hydroisopleth maps. At deep wells, groundwater temperatures were surveyed every 2 meters to obtain temperature-depth profiles. Regarding water quality analysis, pH and electrical conductivity were measured on site, while main ingredients, oxygen and hydrogen stable corresponding object ratios were analyzed in the laboratory. The obtained results were compiled on contour maps to develop the subsurface temperature distribution maps and the hydrology environmental figures in the Akita Plain.

The above analysis showed that the subsurface temperature distribution in the Akita Plain is strongly affected by thermal advection by groundwater flow movements. The subsurface temperatures in the Akita Plain are low in the hilly area in the east side of the town, then increase toward the Sea of Japan in the west. The distribution of subsurface temperature and groundwater level shows that the groundwater in the Akita Plain is recharged in the hills in the east side and the south side of the town, then the two flow systems merges in the central part of the plain. Finally, the flow system discharges in the coastal area of the town. In the central part of the plain, anomalies of temperature profiles were observed due to the merger of two flow systems.

In the future study, more detailed groundwater level maps will be developed by collecting more exhaustive data in southern part of the Akita Plain. These results will be utilized on the development of 3D numerical simulation models of groundwater flow and heat transportation. Criteria of constructing GeoHP systems will be established using the 3D numerical simulation model to enhance the distribution of GeoHP systems in the Akita Plain.