Making of database for ground water using aquifer thermal energy storage (ATES) in Osaka area

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ABSTRACT

We have organized the aquifer distribution based on the ground information for introducing Aquifer Thermal Energy Storage (ATES) to the Western Osaka area, and studied the characteristics of the regional groundwater in the observation well. Of the confined aquifers, the Dg1 layer closest to the surface is excluded because it may cause ground subsidence, and the following Dg2 and Dg3 layers are applicable aquifers of ATES. We have developed a database system that allows identification of these strata, and data about observed groundwater quality, water head and water temperature.
Keywords: database; Aquifer; Osaka, composition

1 INTRODUCTION

In Osaka, cyclic sea-level changes are observed as the alternate layers of sand (gravel) and clay under the 600m depth to near surface in the Osaka plain area. The aquifer covered in this study is a sand gravel layer (1st aqueduct layer: Dg1) distributed beneath the clay layer (Ma13) of the Holocene, and the gravel layer (the second caught aquifer: Dg 2) distributed under the clay layer (Ma12). Using the long borehole data, three aquifers can be observed before 100m depth and distributed widely area around Osaka station to Nakanoshima area. So, the Osaka Plain is an area rich in groundwater. However, pumping is currently strictly regulated due to the severe ground subsidence caused by the massive pumping up of factory water in the 1960s.

In recent years, It is expected to be introduced Aquifier Thermal Energy Storage (ATES) is a technology that efficiently extracts the heat energy from the stratum (aquifer) that contains much groundwater and performs cooling and heating of the building, as energy saving, CO2 emission reduction, and alleviation of heat island phenomenon. For the first step, we have to resolve the characteristics of these aquifers (composition, distribution etc).

2 DISTRIBUTION OF AQUIFERS

Kansai Geo-informatics Network (KG-NET) is organized as a new system of management of GI-base in 2005. This organization collects the geotechnical and geological information of borehole data more than 60,000 data including Osaka plain area. GI-base is the database system of the KG-NET and platform to use these borehole data. Using this database and some geological core sample, the distribution of these gravel layer can easily understanding. Fig.1 shows each aquifer around in the central part of Osaka area. From these distributions, each aquifer is independent in the western part of Osaka. On the other hand, at the central and eastern part of Osaka plain called Uemachi uphill, those aquifers are converge on one. In order not to break each water quality environment, ATES system must to circulate in the same aquifer. Pair wells are constructed in the same aquifer, so it is easy to apply ATES to the western part of Osaka

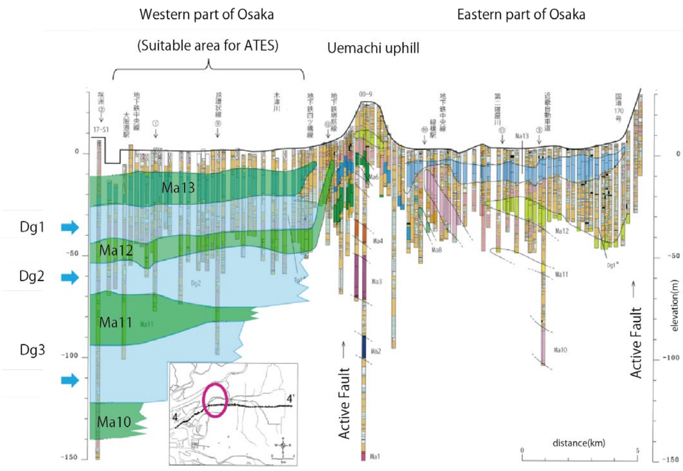

Fig. 1. E-W section of Osaka Plain

2.1 Dg1 Layer

1st aqueduct layer called Dg1 distributed beneath the clay layer (Ma13) of the Holocene. It is GL-20 --30m depth distributed under the alluvial marine clay layer. However, this Dg1 layer is not suitable for apply to ATES, because it may cause ground subsidence due to pumping. Rather, it is necessary to understand the distribution so as not to create an ATES well in the Dg1 layer (Fig. 2).

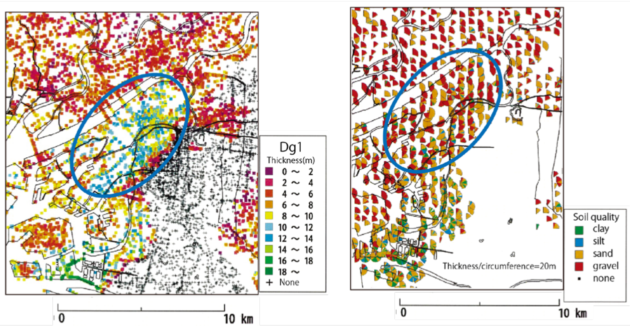

Fig. 2. Thickness (left) and quality (right) of Dg1
Circle is show the central area of Osaka

2.2 Dg2 Layer

The second caught aquifer (Dg 2) distributed under the clay layer (Ma12). It is GL-60 - -80m depth distributed under the Pleistocene clay layers (Ma12). Gravel rich layer is distributed around Osaka St. to Nakanoshima area (Central area of Osaka). This layer is suitable to apply to ATES system (Fig. 3).

More than deeper gravel layer can apply to ATES, however these gravel layer are more than GL-100m depth, so it is not realistic because the drilling cost is very high.

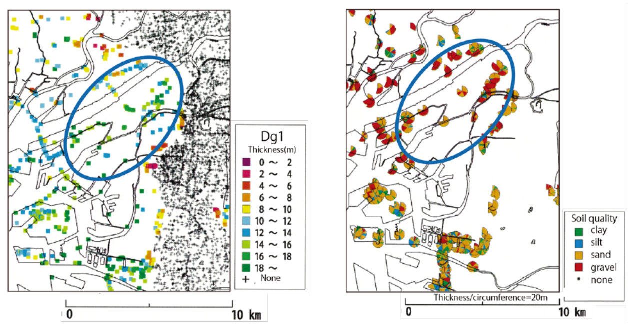

Fig. 3. Thickness (left) and quality (right) of Dg2
Circle is show the central area of Osaka

3 CHARACTERISTICS OF WATER QUALITY

Regarding the water quality, we analyzed the composition of the principal components etc. for groundwater sampled 4 times in total in April, July, October and Decemver 2018. Location map of monitering wells shown in Fig.4. As a result, it was revealed that both Dg 1 and Dg 2 were reductive and showed a Na - Cl type water quality composition; especially Dg 1 had a higher salt concentration (Fig.5). In addition, mineral composition analysis (XRD) of the fine grains obtained when filtering with a membrane filter of 0.45 micro meter was carried out, and it was found that amorphous iron oxide was included together with detrital grains (kitada et al, 2017, Ito et al, 2018). The abundance and the mineral composition of such fine particles present in the groundwater are important information in searching for effective use of groundwater in the future. The Dg 2 groundwater is about 18 degrees C throughout the year and The Dg 1 and Dg 2 aquifer are separate each other around Osaka station to Nakanoshima area on the point of the difference of water head and its behavior (Fig.6).

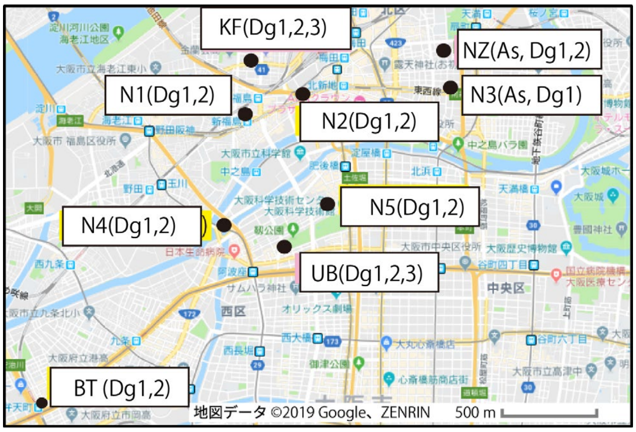

Fig. 4. Location map of monitoring well

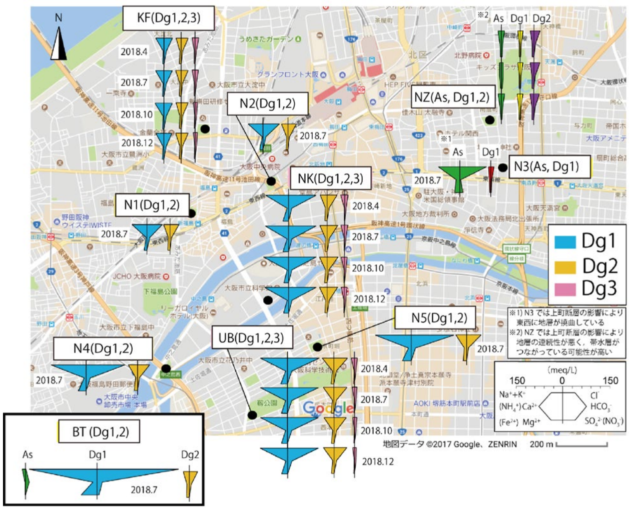

Fig. 5. Principal components of Aquifer

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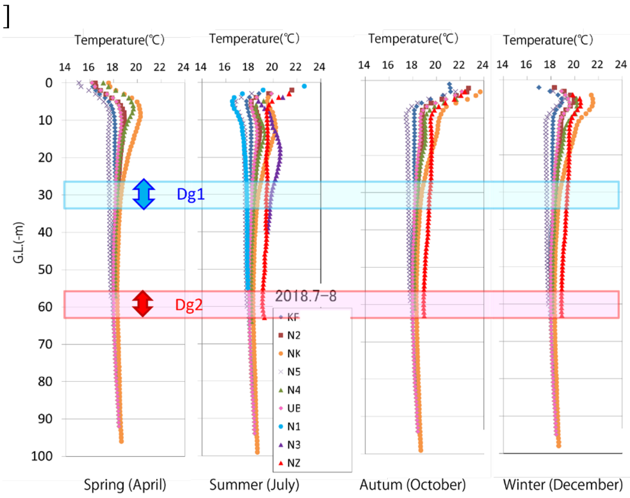


Fig. 6. Distribution of water temperature

From these studies, we can understand the characteristic about aquafers around western part of Osaka.

- Each aquifer is characterized and the water quality makes it possible to identify the aquifer
- Because the head of each point is almost the same and there is no seasonal change of water quality, in the West Osaka area, groundwater is almost stagnant and suitable for ATES.
- With the exception of the Dg1 layer, it is possible to use ATES for groundwater without fear of land subsidence.

Therefore, based on the operation of ATES, we constructed a database system that unifies regional boring data and information of groundwater characteristics and monitoring information.

4 DATABASE FOR GROUND WATER USING AQUIFIER THERMAL ENERGY STORAGE (ATES)

This database system is designed to be able to browse the location information of groundwater observation wells and measurement data of water level, water temperature, water quality, etc. in addition to the boring database. Fig. 7 shows the borehole data and the distribution of groundwater observation wells. The distribution of groundwater observation wells is shown in Fig.8. In these observation wells, water level measurement is performed continuously, and it is possible to view this data (Fig.9). Water quality measurement results conducted every season can be viewed by selecting each observation well (Fig.10).

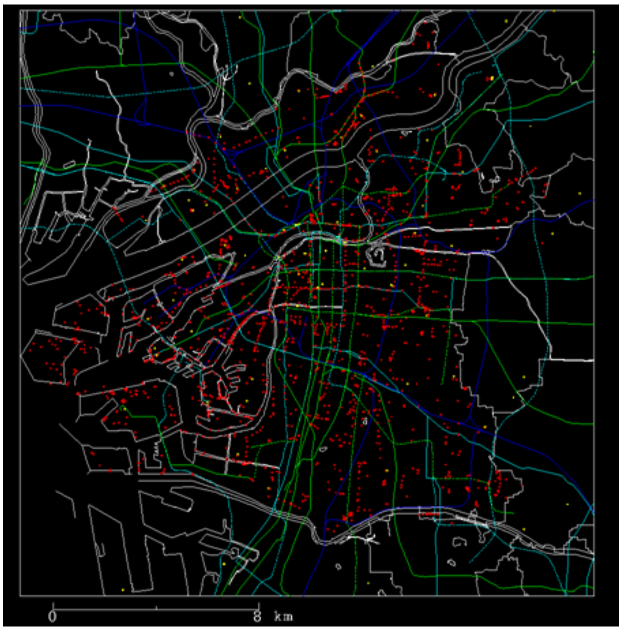
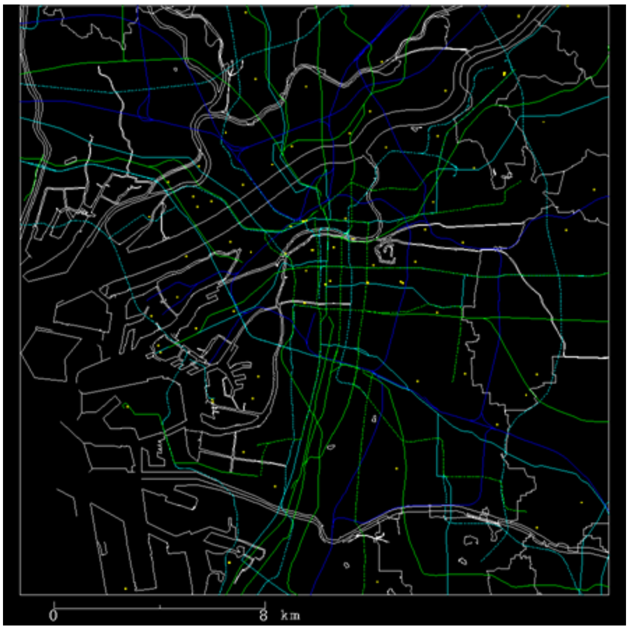


Fig. 7. Distribution of borehole data and groundwater observation wells



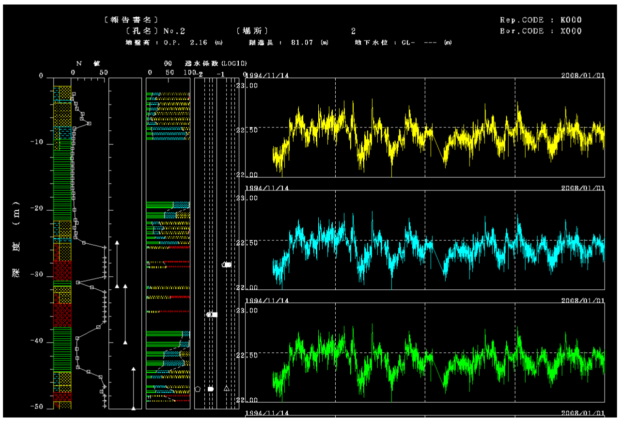


Fig. 9. Time change of water level

Fig.11 and Fig.12 show the Permeability distribution of drilling data estimated from particle size analysis results (Fujiwara, et. al, 2018). The selected boring data is displayed, and it is possible to know how much the permeability coefficient of the gravel bed is, and this system is effective as a preliminary survey when constructing wells.

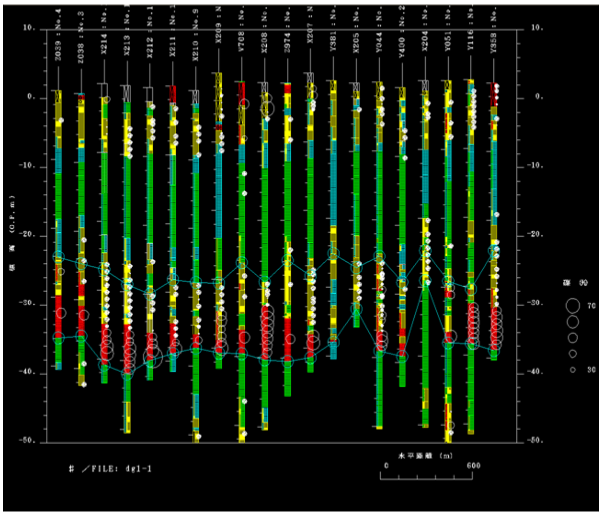


Fig. 11 Permeability distribution of drilling data estimated from particle size analysis results

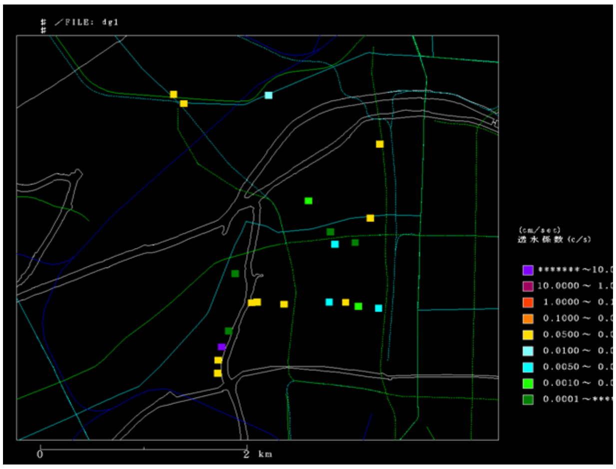


Fig. 12 Horizontal distribution map of hydraulic conductivity of boring data estimated from particle size analysis results

5 CONCLUSION

In the Western Osaka area, we studied the characteristics of groundwater and the distribution of aquifers for ATES application. Since each aquifer can be clearly divided and the water quality is different, it is possible to carry out maintenance and management for the aquifer using ATES while performing wide-area observation. The water temperature is stable 18 ° C throughout the year, and there is almost no change in water quality. It is desirable to consider the adaptation of ATES excluding the Dg1 layer which may cause ground subsidence. From the above, In this area, the aquifer is almost stagnant and is the best choice for ATES application.

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