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Characterization of Permeable Zones by the Measurement of Borehole Temperature

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Subsurface temperature distribution has become an important issue in hydrogeologic studies. The major heat transfer mechanisms in porous medium are conduction and convection. Temperature profile in geological formations with different thermal conductivity would be controlled primarily by heat conduction. The temperature change related to water flows is caused by heat convection. Consequently, temperature profiles are affected by a variety of factors, such as surface temperature change, well diameter, groundwater level change, and water flows inside the borehole. In this study, we use temperature probe as a well logging device to investigate the borehole conditions. There is the depth correction for the time lag problem resulting from the equilibration time of the sensors during the logging process. Then the field measurement was conducted in a 60-m deep well in a gravelly aquifer to characterize the temperature profile of screened zone. In the shallow depth, the change of temperature is primarily influenced by seasonal variation and daily fluctuation. Below the depth of 30-m, the change of temperature was subject to geothermal gradient. However, the slope of temperature profiles changed at approximately 42-m deep, the top of well screen, and it indicated the effects of heat convection in the aquifer. In addition, the measured temperature in the borehole may not represent the actual temperature of aquifer. The measured temperature in the screened section changed continuously in response to pumping, but stabilized an hour data when 2 to 3 times of the borehole water volume is extracted. This phenomenon is related to the temperature mixing with the upper borehole water and aquifer permeability. On the other hand, if the aquifer permeability is high enough, it may influence the temperature profile in borehole through the high flow velocity. The test results indicated that, in order to obtain the actual temperature or chemical constituents, we have to pump 2 to 3 times of the borehole water volume in advance. Another field test was conducted in open holes in the fractured rock formation to characterize the preferential flow area. Detection of the temperature profile anomaly often indicates the lateral water flow inside the open holes due to the forced convection. Compared with results of the other logging devices, we found that temperature logging is possible to locate some relatively permeable fracture zones.