GAINING INSIGHTS ABOUT HYDROSTRATIGRAPHY AND FLOW THROUGH FRACTURED ROCK BY USING HIGH SENSITIVITY THERMAL GRADIENT LOGGING

Peeter Pehme, G360 Institute for Groundwater Research; Beth Parker, G360 Centre for Applied Groundwater Research; Jessica Meyer, G360 Institute for Groundwater Research

Hydrogeologists have used thermal variations in the subsurface for decades to characterize groundwater recharge and discharge, both on a regional basis as well as to resolve local groundwater-surface water interactions. Although temperature profiles in open boreholes have provided some support for those analyses, often vertical, cross-connected water flow along the open borehole annulus limits the usefulness of temperature logs and creates a bias as water moves in or out of only a few of the most transmissive fractures.

Irregularities in thermal gradients through the heterothermic zone, generally 40-50 meters thick, are primarily caused by variations in groundwater movement. Therefore, temperature logging should be highly diagnostic of contrasts in groundwater flow with depth. The thermal vector probe (TVP) uses four high sensitivity temperature sensors orientated to the earth's magnetic field with fluxgate magnetometers to measure spatially orientated thermal gradient data (Pehme et al 2014). We present insights about groundwater flow through fractured rock achieved by measuring the three-dimensional characteristics of the thermal gradient using a TVP probe in boreholes that are temporarily sealed with a FLUTe flexible fabric liner to eliminate borehole cross-connection. The vector components of the thermal gradient are compared against hydraulic responses measured in network of multilevel systems installed in a dolostone aquifer beneath Guelph, Ontario Canada as both monitoring datasets provide insights on variations in groundwater flow in response to a large-scale pumping test. The data show that both the direction and magnitude of the thermal vector varies in a consistent manner with the measured hydraulic gradients from the multilevel systems. The results confirm the usefulness of measuring highly detailed thermal gradient data to provided increased resolution of boundaries and characteristics of hydrogeologic units within the heterothermic zone.