Long-term joint monitoring of self-potential and temperature with active thermometry for seepage surveillance at the Mactaquac Dam, New Brunswick, Canada

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A seepage monitoring study has been underway at the Mactaquac hydroelectric generating station as of April 2013 involving the joint monitoring of temperature and self-potential (SP) near the interface of an embankment dam and concrete diversion sluice way structure.

Two 50 m long boreholes were drilled in the concrete, parallel to the interface and ~0.5 m from the adjacent embankment core. Focused coverage of the interface was provided by fibre optic distributed temperature sensing (DTS) cables, heating cables, and 32 SP electrodes installed in the boreholes. In addition to the borehole instrumentation a 20 × 54 m surface electrode grid consisting of 30 SP electrodes were installed on the downstream slope of the embankment close to the concrete structure. SP and DTS signals are recorded continuously at sample rates of 1 min and 30 min respectively in the ongoing experiment.

The SP response recorded by the surface electrodes has been analyzed over a 20 month period, and reveals to be a complex superposition of electrical potentials likely influenced by dam seepage, temperature, rainfall, telluric currents, head pond flow, freezing, and electrochemical reactions. Qualitatively, the SP responses during each freshet event and the annual seasonal cycle shows some reproducibility from year to year.

The upstream heating cables were activated for a 27 day period in July of 2014. The corresponding temperature response during heating and cooling was recorded in an attempt to identify areas preferentially affected by advective heat transfer. The temperature response from active heating agreed well with the known position of the water table and preliminary results from numerical modelling, and revealed an anomalous area in the saturated zone. However the irregular failure of one of the heating cables during the heating period necessitates that the experiment should be repeated.

Further work will require analysis and modelling of the long term seasonal variations of temperature, and forward modelling of the electrokinetic response due to bulk seepage, head pond currents, and preferential seepage pathways.

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