COMBINING GROUND-BASED MEASUREMENTS TO ENABLE EFFICIENT AND EXHAUSTIVE HYDROGEOLOGICAL REGIONAL CHARACTERIZATION

M. Blouin[a] [martin.blouin@ete.inrs.ca], **E. Gloaguen**[a][erwan.gloaguen@ete.inrs.ca]
and **A.Pugin**[b] [andre.pugin@nrcan-rncan.gc.ca]

[a]Centre Eau - Terre - Environnement
Institut National de la Recherche Scientifique (INRS)
Québec, Canada

[b]Geological Survey of Canada (GSC)
Ottawa, Canada

Due to the increasing vulnerability of surface water, regional aquifer resource characterization is becoming a major concern. In addition, the knowledge acquired at the local scale is not completely transferable to the regional scale. As for local scale characterization, geophysical data can fill the gap between the sparse wells to interpolate the stratigraphy, but also, can be used as covariate data to infer hydrogeological properties. However, two major issues stress the difference between local and regional aquifer characterization. First, there is the resolution of the chosen geophysical method. For example, airborne TEM is very promising in defining regional stratigraphy, but fails when compared to logged electrical properties due to resolution differences. Second, in regional studies, as the conditions and the targets change throughout the covered area, it is often necessary to resort to multiple technologies to measure exhaustive properties of the soil. Thus, building a stratigraphic model that incorporates all the information available can represent a major challenge. Hence, geomodeller often use only the properties contrasts from geophysical data that outline lithological contact and drop the information available within each layer. Moreover, uncertainty and scale of measurement are not accounted for.

The studied area covers 9,000 square kilometers and consists in a marine and glacier deposit valley overlaying a fractured rock. With a view to hydrogeological modeling at the regional level, the proposed approach uses a similar methodology to the characterization of petroleum reservoirs based on geophysical, geological and borehole data. From 2009 to 2011, about 90 km of 2D surface reflection seismic, 200 electromagnetic surveys in the time domain (TDEM), 5 km of electrical resistivity tomography (ERT) and 60 cone penetrating tests (CPTu) were acquired and jointly processed. The locations of each survey were carefully chosen by using a coarse to fine scale approach. The seismic and TEM data were measured first on perpendicular lines that cross the entire area and the data were cooperatively processed. Then, the CPT and well location were chosen based on the seismic and TEM interpretation to minimize the costs and maximize the information on hydrogeological heterogeneity. ERT surveys were deployed over narrow targets identified on seismic data. The results were integrated together with conventional drilling information in a 3D GIS allowing straight-forward data processing validation. Thus, a reliability index is being granted to the different measurements and a stratigraphic sequence is established. Hence, the interpolation of surfaces representing the major lithological contacts is calculated using kriging with an external drift. The drift is built with seismic, TEM and conventional wells accordingly to the weight of confidence given to each information. Then, for each layer in the unconsolidated sediments, a facies distribution representative of the physical response of materials is determined.The collocated data measured with CPTu serves to infer the statistical relations between hydrogeological and geophysical data. The physical facies distributions are used to form different classes of mechanical and hydrogeological properties of these materials. Furthermore, these facies distributions will serve to identify high vulnerability areas of groundwater at the regional level.

The proposed methodology proved to maximize the information compared to a conventional approach while decreasing the costs. For example, an esker was jointly described by seismic and ERT data and then confirmed by a conventional well. This type of sediments was not suspected before and is almost undetectable using an approach based on well only. In addition, the optimized well location permits to define the relation between the geological, the hydrogeological and geophysical data. This allows interpolating the different properties with much accurate precision resulting in a better hydrogeological knowledge of the surveyed area. Finally, the data integration combined with the soil occupation, recharge and surface water will lead to a vulnerability map that will improve groundwater management and city development by local authorities.