Mapping complex hydrogeological structures and parameters by AEM – Part 2

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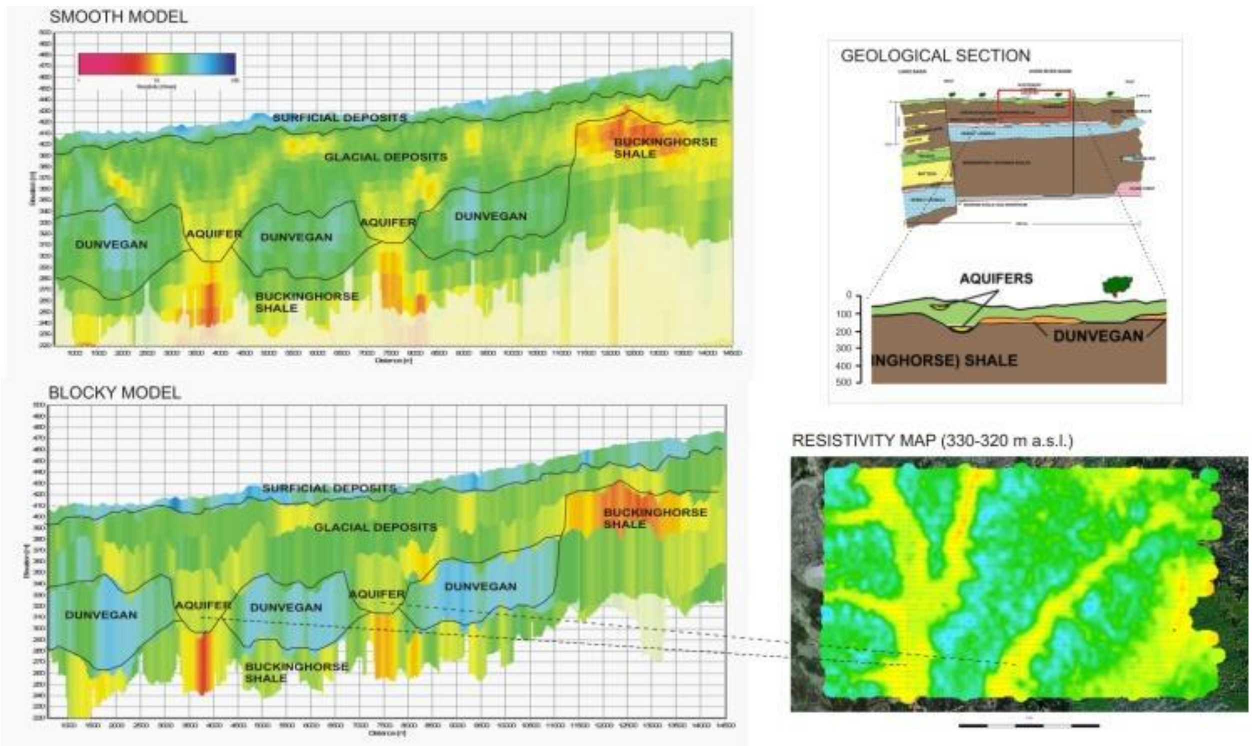
Airborne EM method can be considered by now a mature tool for Hydrogeophysics, since it is able to produce detailed resistivity mapping with great lateral and vertical resolution, so that to provide an effective improvement of the hydrogeological knowledges. Moreover the parameter sensed by AEM is strictly related to hydraulic conductivity, to hydraulic transmissivity and to salt content of groundwater. Hence, the use of AEM is becoming more and more important for planning hydrogeological studies (at the watershed scale) or productive wells' excavation.

Horn River Basin

Geoscience British Columbia begun a project to evaluate aquifers within the entire Horn River Basin, Canada. The hydrogeological target was a deep carbonate aquifer that should be used for fracking activities, as the survey area hosts one of the largest shale gas plays in Northern America. The considerable depth of this aquifer (usually more than 500 m) is out of the maximum depth of investigation of the SkyTEM system, but it was however able to provide information on the shallower hydrogeological units that must be preserved from any kind of contamination or interference. In spite of the poor available hydrogeological information, with regards to the shallower section of the subsurface, we consider the results of data inversion very promising, as Airborne EM was able to detect the main shallow hydrogeological features.

The attached figure shows a tentative comparison between the inversion results and a schematic geological section from the area (adapted from Petrel Roberston, 2010). The geological schematic section, shown on the right side, is referred to a generalized E-W profile and hence not necessarily coincident with the vertical resistivity profile, but it is however useful for the hydrogeological interpretation of the AEM results. First of all, the AEM prospect is able to resolve a thin resistive layer (30-50 ohm-m), due to surficial coverage, that lacks in the geological section, and that could be interpreted as weathered coverage. It is then well imaged a conductive response of the glacial deposits, probably due to the prevalence of till layers.



The more conductive lenses embedded within the glacial drift, can be associated to the small aquifers (both perched and at the bottom of incised paleovalleys), as shown by the geological section; their low resistivities can be explained by a high salt content of groundwater, as reported by the hydrogeological report. It must be noticed that the thickness of the glacial drift, as detected by the AEM data, agrees with the values shown in the geological section (between 60 and 100 m). The shape of these conductive paleovalleys is well imaged by the resistivity maps at 330-320 m a.s.l., shown in the bottom-right corner. From a hydrogeological point of view, then, it must be highlighted the relevant ability in resolving the lenses of the Dunvegan formation (composed by sandstones and conglomerates), having a more resistive response. The blocky modeling (below, on the left side) is more capable to resolve these units, showing some advantages in comparison with the multi-layered approach (top, left side). Once again, it is important to notice the good agreement between the thickness of the Dunvegan formation, as inferred by the geological data, and that one sensed by the geophysical prospectiona, that is to say some tenths of meters.

Finally, the conductive bedrock, that sometimes merges with the bottom of the deeper glacial aquifers, can be interpreted easily as the Buckinghorse Shale, that was eroded with different degrees by the glacial activity. Following this key of interpretation, the conductive channels imaged on the resistivity map, can be interpreted as wide and long paleovalleys, filled with coarse materials, saturated by mineralized water.

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