Application of AEM to geotechnical and engineering issues

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Applied Geophysics to Engineering, Geotechnics and Environment is generally synonymous of shallow target, but, at the same time, it demands a detailed reconstruction of the subsurface. Our capabilities in advanced processing, allow to achieve a great detail and resolution, both along the vertical and the horizontal directions. Moreover the technological innovation of the AEM systems made possible to acquire good data starting from very early time (a few microseconds) that translates into very shallow information.

The final product of an AEM survey, when adequately processed, is the resistivity model of the subsurface, down to a depth of about 200-300 m and with lateral resolution that can reach a few tens of metres. Resistivity is one of the most versatile and useful physical parameters for engineering, as it is influenced by water content, fracturation, permeability, and so on. Undoubtedly the possibility to get a very dense sampling facilitates the geotechnical interpretation, as it is easier to follow the main structures that could have an engineering importance (fracturaction, cavities, coverage, landslides, and so on).

In order to improve the degree of accuracy and resolution, it is moreover possible to exploit the use of apriori info, derived from stratigraphic data of boreholes or from different geophysical prospections that are more often used in Engineering (seismic, ERT). The a-priori information is treated as an extra data set, by taking into account location, values, uncertainty, and expected lateral variability. The information it contains is spread to the location of the neighbouring AEM soundings. Constraints and uncertainties are usually different depending on data types and geology.

An example of results achievable from an AEM prospection on the study of landslides, is provided from an area in Sicily, Italy, where a composite earthflow has involved the formation of the “Argille Varicolori”, that is a clayey rock (Fig. 1). The thickness of the landslides is of about 15-20 m, as shown by the vertical resistivity profile, and it is surprising the capability of the method to resolve a so low resistivity contrast: the earthflow has a resistivity of about 15 ohm-m, while the clay substratum is a little more conductive (7-9 ohm-m). By inspecting these results, we can argue that there are at least two distinct earthflows, contrarily to the geological data reported by the map.

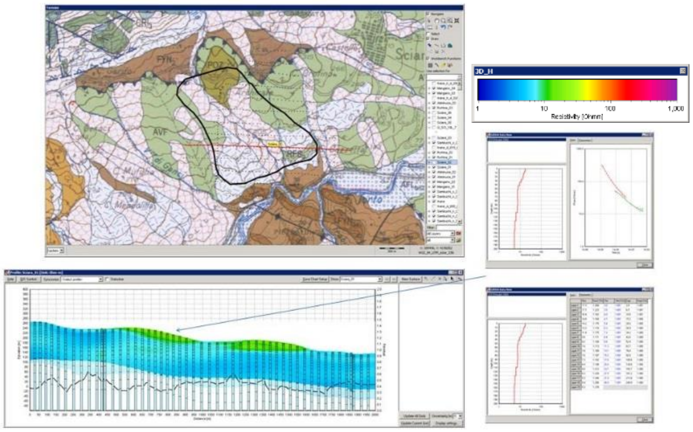


Figure 1

It is worth of mention that no apriori info or constraints were used in the inversion of data: this is the outcome of a smoothed inversion, taking into account 19 thin layers, having fixed thickness, so that only resistivity is completely free to vary, without any constraint. Consider that the residuals of the models are very low (mostly below 0.5), that means an excellent fitting of the data. The results at figure 1 represent secondary deliverables within the VIGOR project, in which the main use of AEM was to contribute to geothermal modelling.

A further contribute to improve the results of AEM modelling can be represented by the use of apriori info. We will show examples drawn from a hydrogeological investigation in Manitoba (Canada) that can assume however a specific engineering significance. The results of high resolution seismic reflection and ERT surveys were imported into the AEM (VTEM) dataset, as layers, entered as a grd file, showing the depth to the bedrock, that coincides with the conductive shale.

Adding a-priori also reduced uncertainty in the resistivity values of the overlying layers which become more resistive although no a-priori information was added directly to those layers. Hence a-priori constraints can help refining the resolution of otherwise poorly determined parameters. Fig. 2 shows the improvement achievable by means of stratigraphic constraints provided by seismic reflection: the top vertical resistivity profile was obtained without any apriori info; the black lines represent two main reflectors detected by seismic.

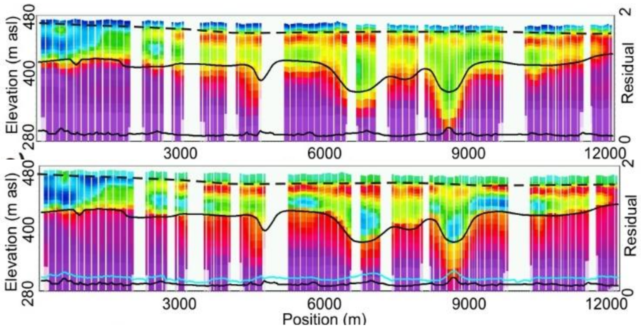
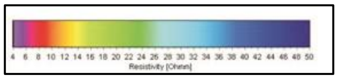


Figure 2



There is a good agreement for the shallower one, that seems to coincide with the bottom of a resistive coverage. Deeper, the bedrock reflector follows a marked increase in conductivity. There are some disagreements in the deeper sectors (between 6000 and 10000 m), and in the incised valleys, where the depth of the conductive shale seems overestimated with respect to the seismic reflector. By applying the constraint offered by the depth of the two reflectors (bottom vertical resistivity profiles), as detected by seismic, there is an important improvement throughout the models. As expected, the bedrock is better resolved, with a significant reduction of local 3D effects in the AEM data within the narrow incised valleys. The resistivity of parts of the glacial sediments also increased, showing resistive structures within the buried valleys which are in better agreement with boreholes data.

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