Near-Surface Geophysics:
Seismic & GRP data for Site Characterization

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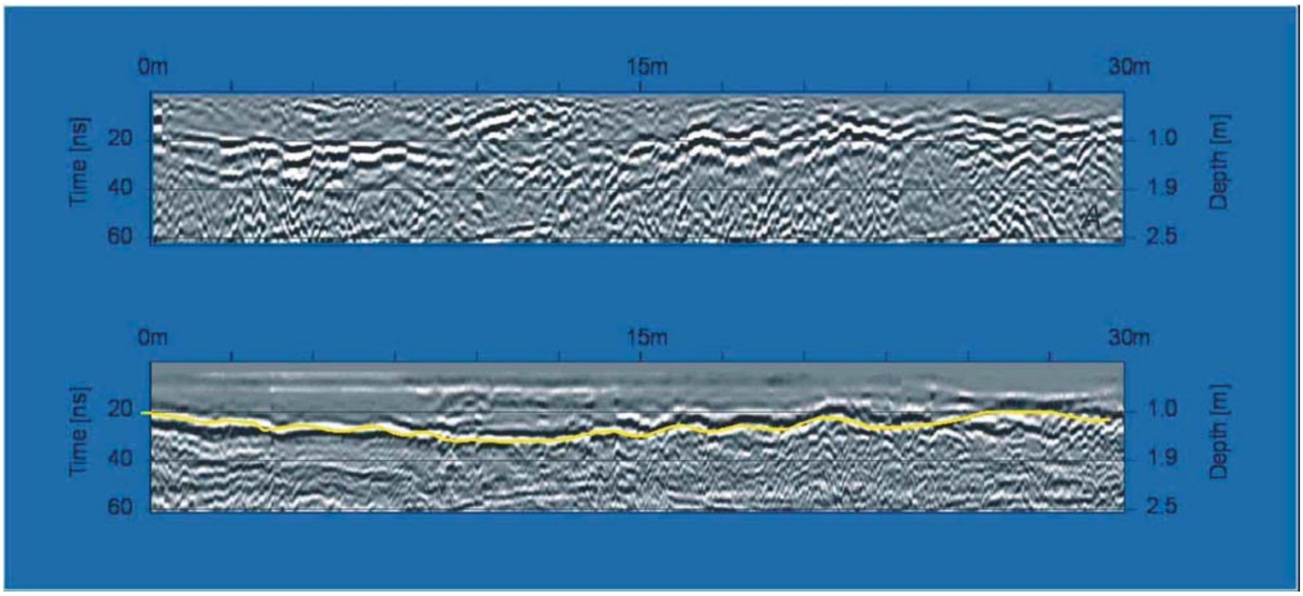
We integrate results of surface and borehole GPR surveys and Rayleigh-wave phase velocity analysis to reconstruct near-surface stratigraphy for environmental and engineering studies.

One of our test sites is a waste disposal with mixed industrial and solid urban waste piled on mixed alluvial and marine sequences in NE-Italy. The stratigraphic column includes sandy loams with variable fractions of silt and clay, a gravel and coarse sand aquifer and a limestone bedrock. Two shallow layers, an allochtonous soil up to 2m thick lying on coke ashes mixed with industrial debris (approximately 1m thick), attenuate the radar wave due to strong scattering and low resistivity thus reducing radar penetration to approximately 3 m. We performed surface and borehole GPR measurements to image subsurface layers and reconstruct the velocity field. Surface measurements were acquired and processed according to both single and multi-fold techniques.

Results were then validated by laboratory measurements of EM properties performed on core samples and by Finite-Difference Time Domain (FDTD) modelling.

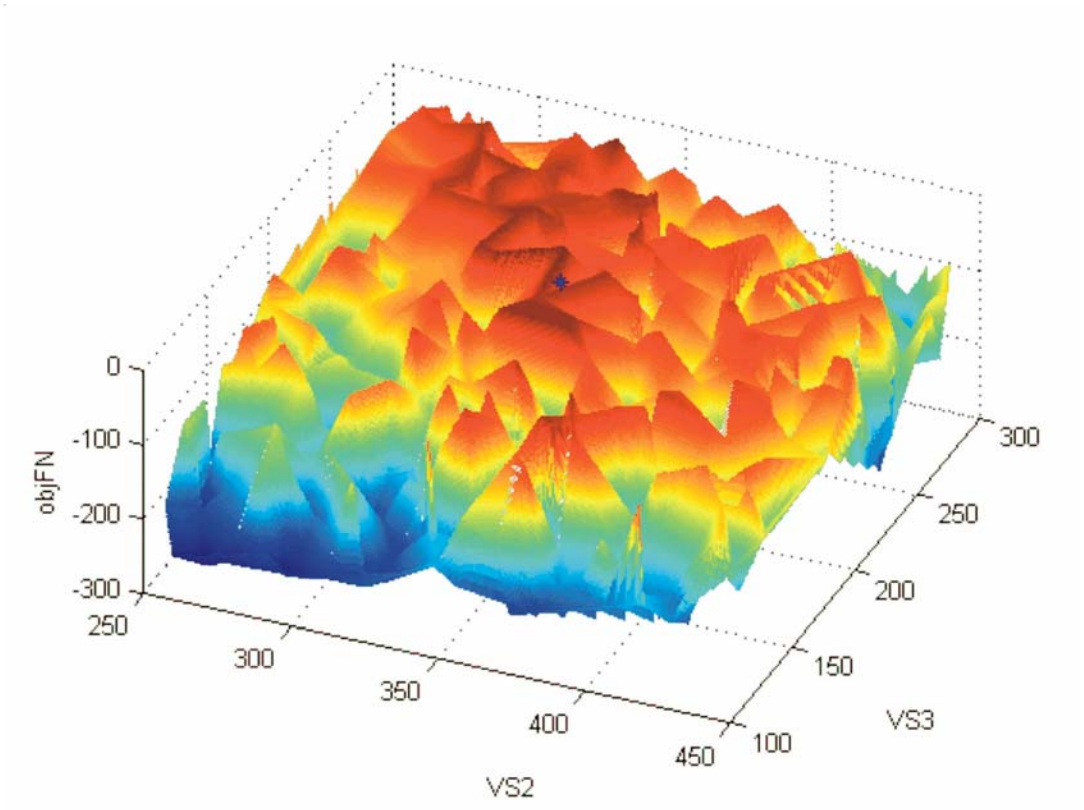


GPR data: single (upper) and multi-fold (lower) sections.

We reconstructed vertical shear-wave velocity profiles via *Multi-channel Analysis of Surface Wave* (MASW) to study deeper layers. Performances of three different phase velocity estimators (*f-k*, *Tau-p* and *phase shift*) were evaluated. We also investigated the role of some processing and acquisition procedures, with special emphasis on the number of traces able to optimise the ratio between information content and acquisition and processing costs. We showed that *phase shift* method is able to produce the best results in terms of accuracy and computation efficiency. In fact, *phase shift* method shows extremely stable results also when a reduced number of traces is considered and other methods fail due to spatial aliasing (*f-k*) or severe noise content (*Tau-p*) that prevents from unambiguous interpretation.

Dispersion curve inversion was attempted via Genetic Algorithms (GAs). In fact, common linear inversion procedures represent an approximate solution of the problem (markedly non-linear) and require the determination of a starting model that typically affects the final solution because of local minima, thus leading to “erroneous” subsurface reconstruction.

Genetic algorithms result often particularly attractive because they are generally not prone to “local-minimum” failure and are consequently particularly suitable for non-linear multi-modal problems as surface wave analysis.



Multimodality of Dispersion Curve Inversion
Fundamental mode dispersion curve for a 5-layer model was synthetically calculated and then inverted. *Root-mean-square* values (calculated versus observed phase velocities) were determined for a number of models while varying thicknesses and shear-wave velocities of two layers, having fixed to their proper (known) values all the other parameters. Here the objective function is plotted versus the two shear-wave velocities.

The difference between theory and practice is smaller in theory than it is in practice

(Claerbout's Classroom - http://sepwww.stanford.edu/sep/prof/gee/intro_html/node1.html)