file name	winMASW-case-study6-joint-FVS.pdf
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A wonderful example of joint analysis of Surface Waves acquired using only horizontal geophones (radial component of Rayleigh waves and Love waves) and analyzed in a *Full-Velocity Spectrum* perspective

[registered users who renovated the *maintenance* service can obtain the datasets and compare their analyses with the ones presented here]

case study#6

Joint Analysis of Rayleigh & Love waves in a *Full-Velocity Spectra* perspective

A short note about terminology

Velocity Spectra and *Dispersion Curves*

Since different authors can use these two expressions in a slightly different perspective, in order to avoid misunderstandings it is important to clarify these expressions are used.
In all our documents the two expressions have a very clear and distinct meaning and refer to two totally-different concepts (so different practical use).

By *velocity spectrum* we mean the *matrix* representing the propagation velocity as a function of the frequency (see figure on the left). The matrix (thus the colors) actually represents a sort of "correlation factor" for each frequency-velocity point (in the picture below the red means "high correlation").
This is obtained by transforming the raw seismic data (originally in the *offset-time* domain) into the *frequency-velocity* domain. This means that a *velocity spectrum* is an objective "entity" derived from the raw seismic data without any interpretation from the user.

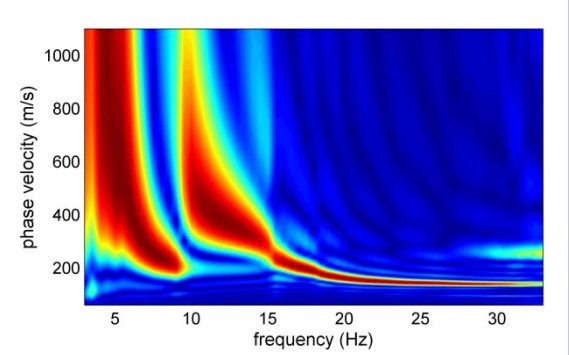
On the opposite, a *dispersion curve* (on the right side) is a curve (a set of *frequency-velocity* points) representing the surface-wave dispersive properties (for various modes).

Pay attention: this curve can be related to two (totally different) operations:

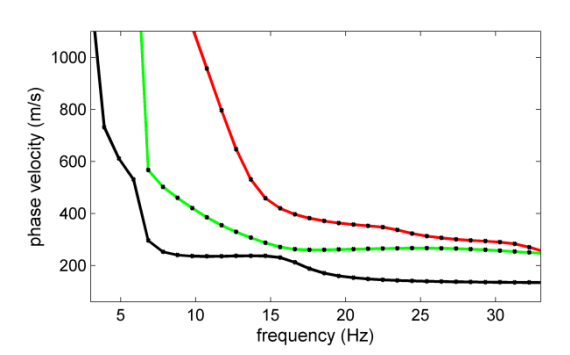
1) it can be the theoretical modal dispersion curve of a tentative model

or

2) the *interpreted* dispersion curve of a seismic dataset (from the *velocity spectrum* a *dispersion curve* is picked as *interpretation* - thus as a subjective "entity")



velocity spectrum



dispersion curve(s)

Incidentally, in the presented *velocity spectrum* (on the left), in spite of the fact that the signal between 10 and 33Hz is apparently continuous, it is noteworthy that, as a matter of fact, the signal between 10 and 15Hz belongs to the first higher mode while the signal for frequencies larger than 15Hz pertains to the fundamental mode, thus putting in evidence that the continuity of a signal does not mean that a single mode is involved (see also Dal Moro, 2011).
The solution of this kind of possible ambiguities is represented by the joint analysis (see reported references).

The presented *dataset* was acquired for geotechnical purposes in Lazio (Italy) just at the foothill of a mountain relief (see Figure 1), in an area where the superficial sediments are fundamentally represented by silt and clay.

Figure 1. The investigated area.

Acquired data are reported in Figure 2: both Rayleigh (radial component acquired using horizontal geophones) and Love waves appear to contain a large amount of higher modes which do not have to be considered as a kind of "noise" or problem but, on the opposite, as a source of relevant information capable (when properly considered) to better constrain the deepest layers.

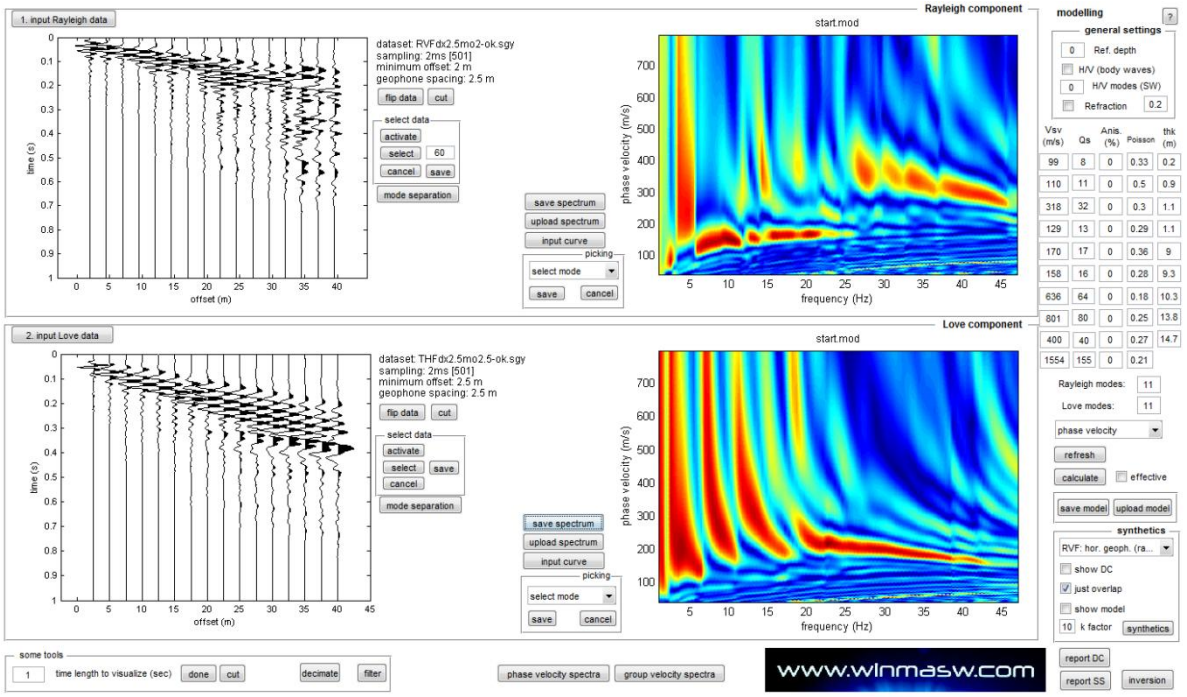


Figure 2. Field data. *Upper panel*: Rayleigh waves (radial component - RVF); *lower panel*: Love waves (THF).

Data were processed in order to jointly invert the velocity spectra related to both the RVF and THF components.

Figures 3 and 4 report the results of the performed analysis: the overall consistency of the observed and synthetic data appears clearly remarkable since the correspondence between the observed (on the left) and modeled (on the right) velocity spectra is in fact apparent.

Finally, Figure 5 reports the identified V_S (shear-wave velocity) model.

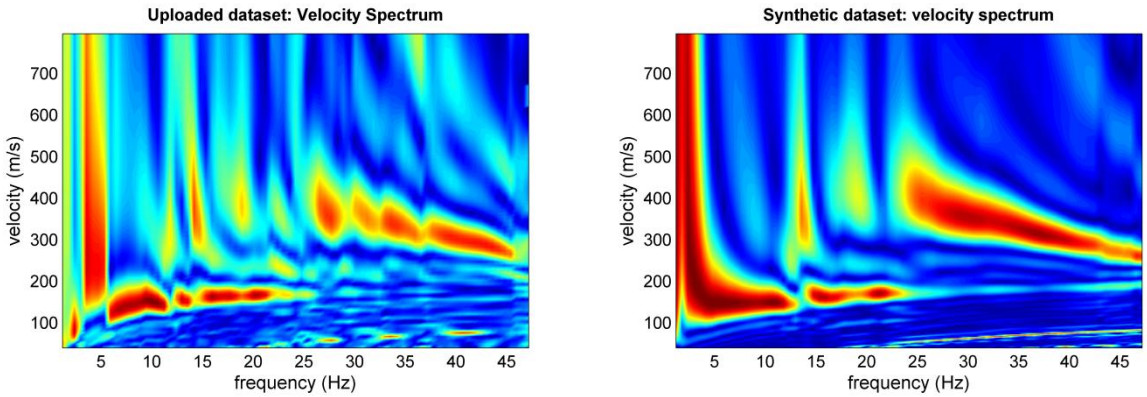


Figure 3. Rayleigh waves (radial component - RVF): on the left the field data, on the right the synthetics of the retrieved model (reported in Figure 5).

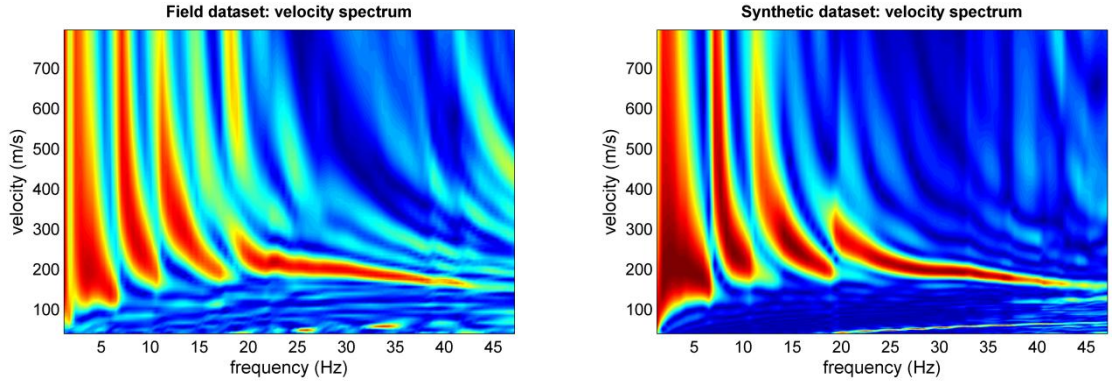


Figure 4. Love waves (THF component): on the left the field data, on the right the synthetics of the retrieved model (reported in Figure 5).

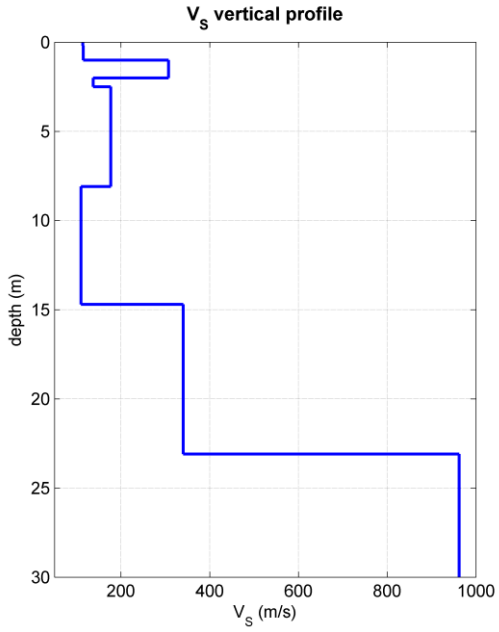


Figure 5. Identified V_S model.

Few final remarks

1. the use of horizontal geophones represents a quick and effective way to acquire both Rayleigh (radial component) and Love waves.

2. The radial component of Rayleigh waves is not "less important" than the vertical ones. It is different (energy distribution among the different modes can be different) with respect to the vertical one (because the respective Green's functions are different) but equally important (see papers reported in the *References*)

3. the *Full-Velocity Spectrum* approach (computationally intensive) allows the full exploitation of all the modes present in the field data thus a very-well constrained inversion procedure that will eventually result in a robust subsurface V_S model (that *winMASW* computes also considering the effects of attenuation).

Acknowledgements

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References

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For the Italian readers: