Velocity profile report at the seismic stations IV.IOCA and IT.CML - Casamicciola Terme, Ischia

Working Group:	Date: December 2018
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Subject: **Final report illustrating measurements, analysis and results for stations IV.IOCA and IT.CML**	

Convenzione DPC-INGV 2018, Allegato B2: Obiettivo 1 - TASK B: "Caratterizzazione siti accelerometrici" (Coord.: G.Cultrera, F. Pacor). **Cite as:** Working group INGV "Agreement DPC-INGV 2018, Allegato B2, Obiettivo 1 - TASK B", (2018). Velocity profile report at the seismic stations *IV.IOCA and IT.CML-Casamicciola Terme, Ischia*. doi: 10.5281/zenodo.2281845

Summary

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1. Introduction

In this report we present the geophysical measurements and the results obtained, in the framework of the 2018 agreement between INGV and Civil Protection Department (DPC), called *Allegato B2: Obiettivo 1 – Task B: Caratterizzazione siti accelerometrici (Responsabili: .G. Cultrera, F. Pacor),* for the site characterization of the Italian accelerometric networks. Here the results for IV.IOCA (Latitude: 40.7468, Longitude: 13.9014), belonging to the Italian National Seismic Network (RSN-INGV), and IT.CML (Latitude: 40.74698, Longitude: 13.90129), belonging to the Italian Strong Motion Network (RAN-DPC), are presented.

We installed a 2D array of seismic stations in passive configuration at the top of Grande Sentinella hill (Casamicciola Terme, Ischia island) for studies of site seismic characterization of IV.IOCA and IT.CML stations (these two stations are about 20 m distant from each other). Using surface-wave analysis, we provide results in terms of frequency resonance peaks and dispersion curves inverted to obtain shear-wave velocity (V_S) profiles for the studied area. The inverted models are suitable for determination of the average Vs velocity in the uppermost 30 m (Vs30) and assigning then the EC8 soil class category.

2. Geophysical investigation

Grande Sentinella area is situated in the municipality of Casamicciola Terme (NA), in the northern sector of Ischia island. Figure 1 shows the location of the seismic stations used for the 2D arrays deployed in the target area and the positions of IV.IOCA and IT.CML stations.

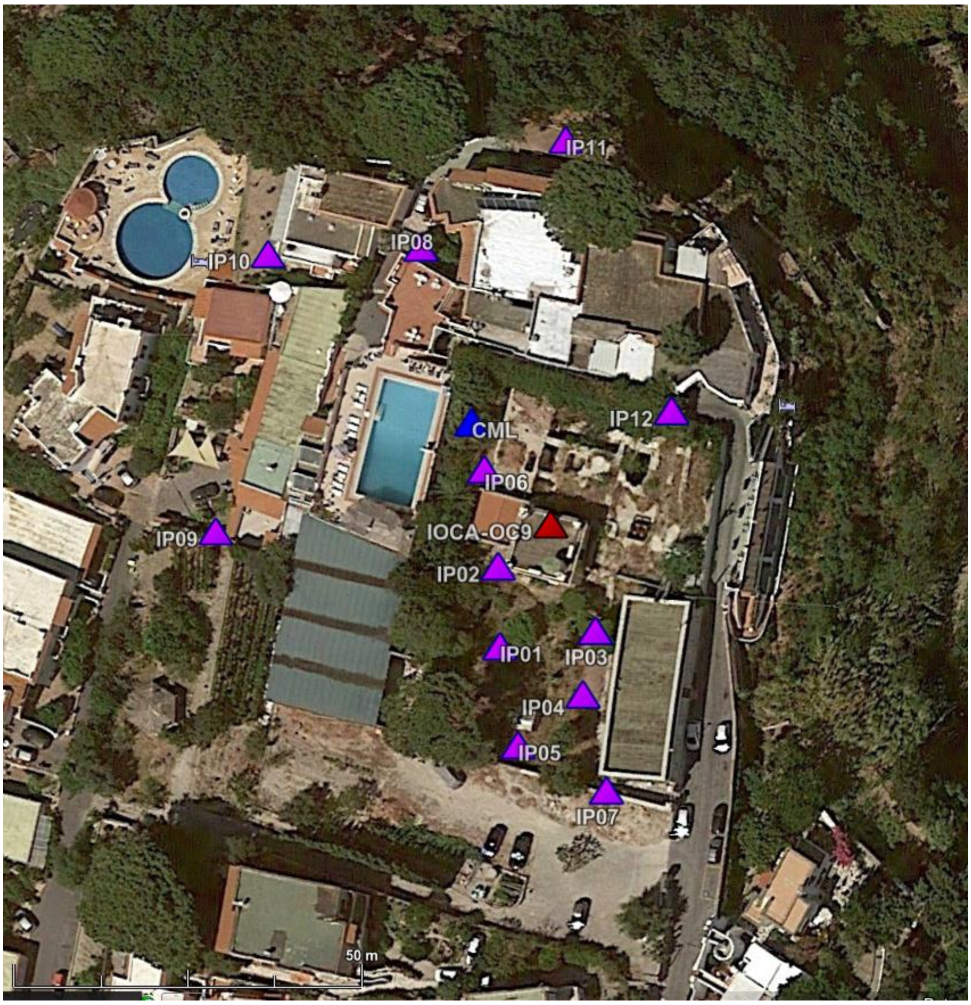

Figure 1: Plan view of the 2D seismic array deployed in Casamicciola Terme, around IV.IOCA and IT.CML stations (red and blue triangle, respectively). The purple triangles shown the positions of the twelve stations of 2D array deployed in passive configuration. All stations are equipped with Reftek R130 digitizer and Lennartz 3D-5 s velocimetric sensor.

2.1 Array measurements results

The array was performed using 12 single seismic stations equipped with Reftek 130 digitizers and Lennartz 3d-5s velocimetric sensors and their position is shown in Figure 2. The common noise recording lasted approximately 5 hours. The measurements were recorded the 29th of May 2018. A maximum aperture of 88 m characterizes the array, and a view of fieldwork is shown in Figure 2. The seismic stations were located in the investigated area following a two-dimensional geometry with irregular spacing, as shown in Figure 2.

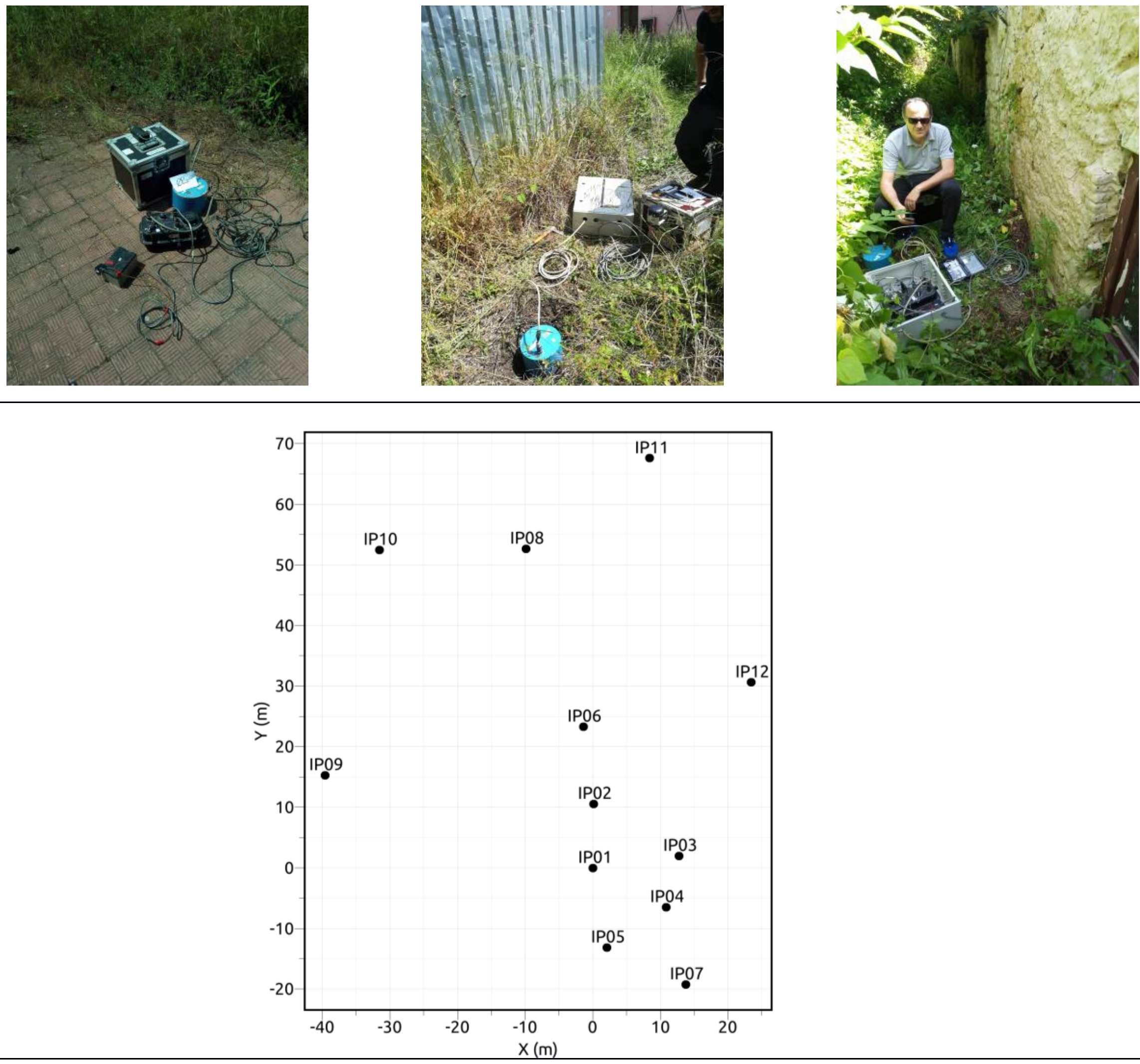

Figure 2: Top: Examples of three installations of IP04 (left) IP05 (middle) and IP06 (right) seismic stations. Bottom: 2D Array geometry.

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The geometry of the array allows the performance in terms of wavenumbers described in Figure 3, where there are several plots of theoretical Array Transfer Function.

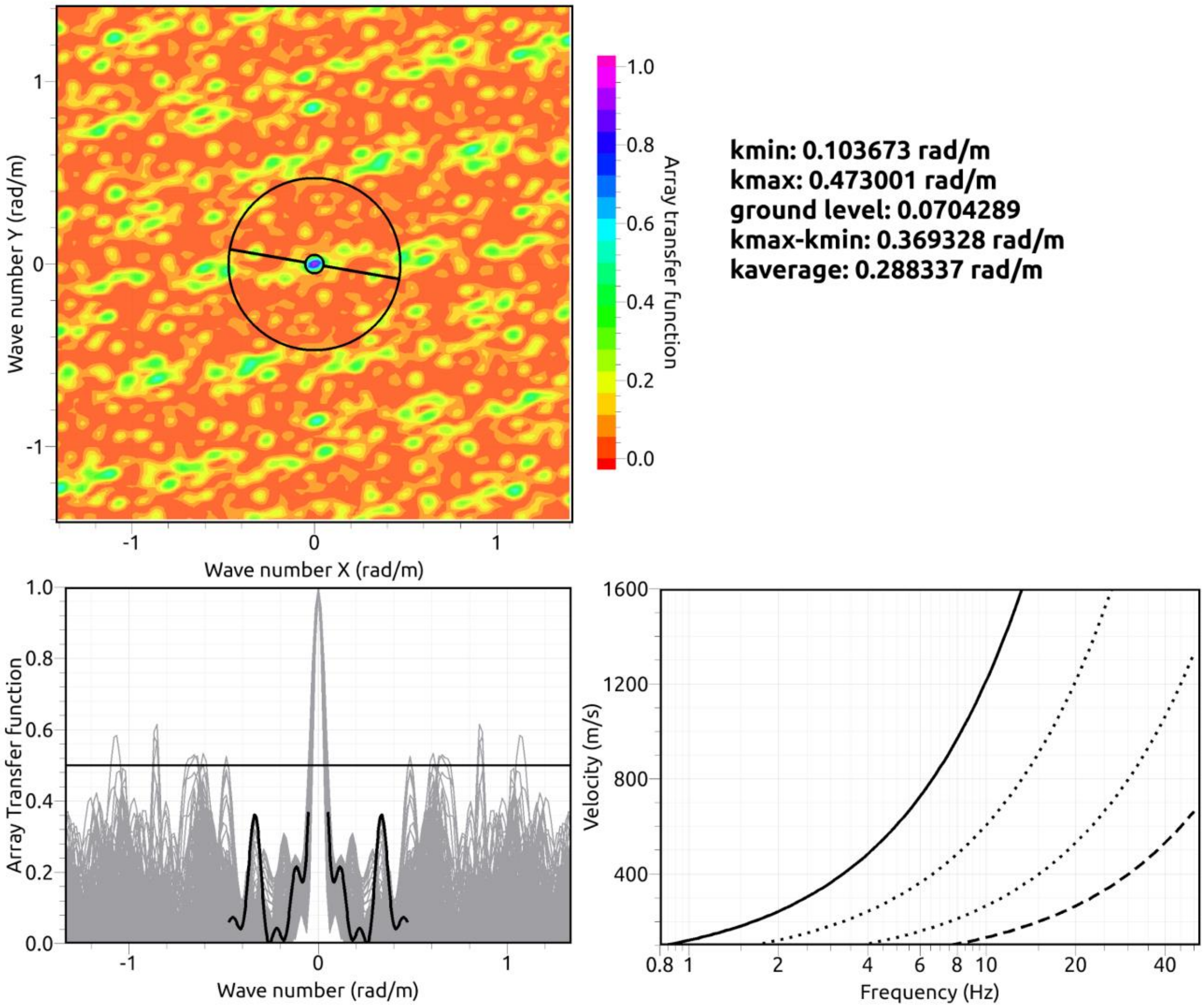

Figure 3: Theoretical Array Transfer function of the 2D array with alias and resolution curves in velocity-frequency representation.

Figure 4 shows the computed H/V curves for the 12 stations. There is a good agreement of the H/V shapes showing a good matching in the investigated frequency range (except for station IP03 that show H/V amplitudes lower than the others stations for periods lower than 0.4 Hz). We observe two resonance frequencies, the first one (f_0) at about 0.5 Hz, that correspond to the maximum value of a wide peak in the 0.4 – 0.6 Hz, and the second one at 1.6-1.7 Hz with amplitudes (at different stations) between 5.5 and 8.5. For most of the measurement sites, the rotated HV spectral ratios evidence a coherent polarization effect in the frequency range 1.5–1.8 Hz with azimuth between 100°-130° (see Figure 5). In the same frequency range, only

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stations IP10 and IP11 (located at the North edge of Grande Sentinella hill) show an isotropic pattern from the polarization analysis.

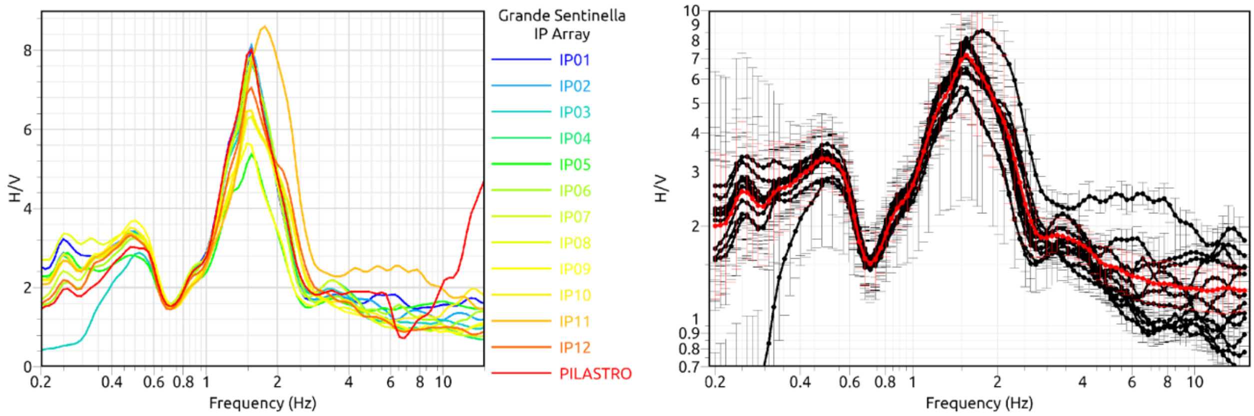

Figure 4: H/V curves of the 12 stations. Left: H/V curve (mean values) for all stations. Right: plot in logarithmic scale of single station H/V curves and standard deviation (in black) and the averaged H/V curve (in red).

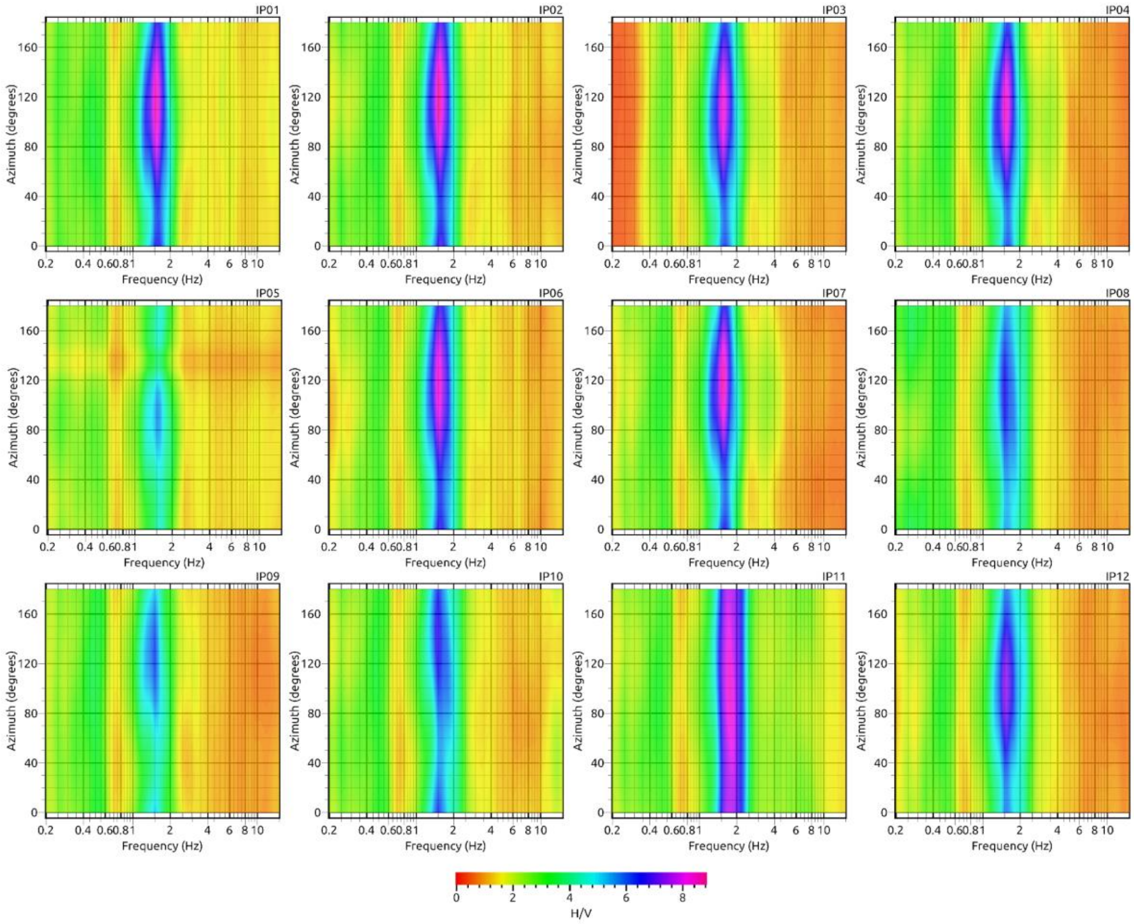

Figure 5: Rotating H/V curves at the 12 stations of the array.

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The data from the 2D array have been analysed in terms of conventional frequency-wavenumber (FK) analysis and applying the MSPAC method (Bettig et al. 2001) to the vertical component of the acquired noise.

The results using the vertical components were interpreted in terms of Rayleigh surface waves by means of GEOPSY software (http://www.geopsy.org). Figure 6 shows the dispersion curves derived from the FK (a) and MSPAC (b) analysis. Figure 6c shows the interval of resolution of the spatial autocorrelation values (black grey dots curves) contributing to the selected phase slowness of the MSPAC method. This method provides the spatial autocorrelation curves for all the possible station pairs (Figure 7).

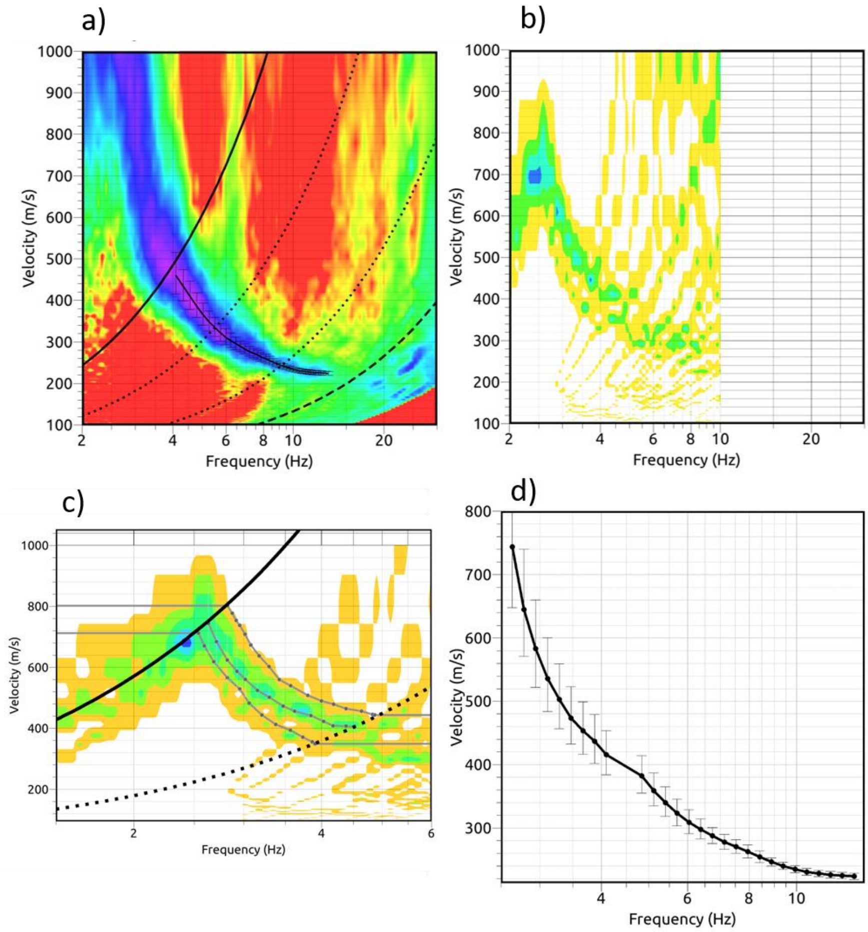

Figure 6: Picked dispersion curve in the velocity-frequency plan from the FK (a) analysis applied to the vertical component of measurements. Dispersion from MSPAC analysis (b). Interval of dispersion curve for the resolution of the spatial autocorrelation values (c) contributing to the selected phase velocity of the MSPAC method. Dispersion curve obtained integrating FK and MSPAC results (d).

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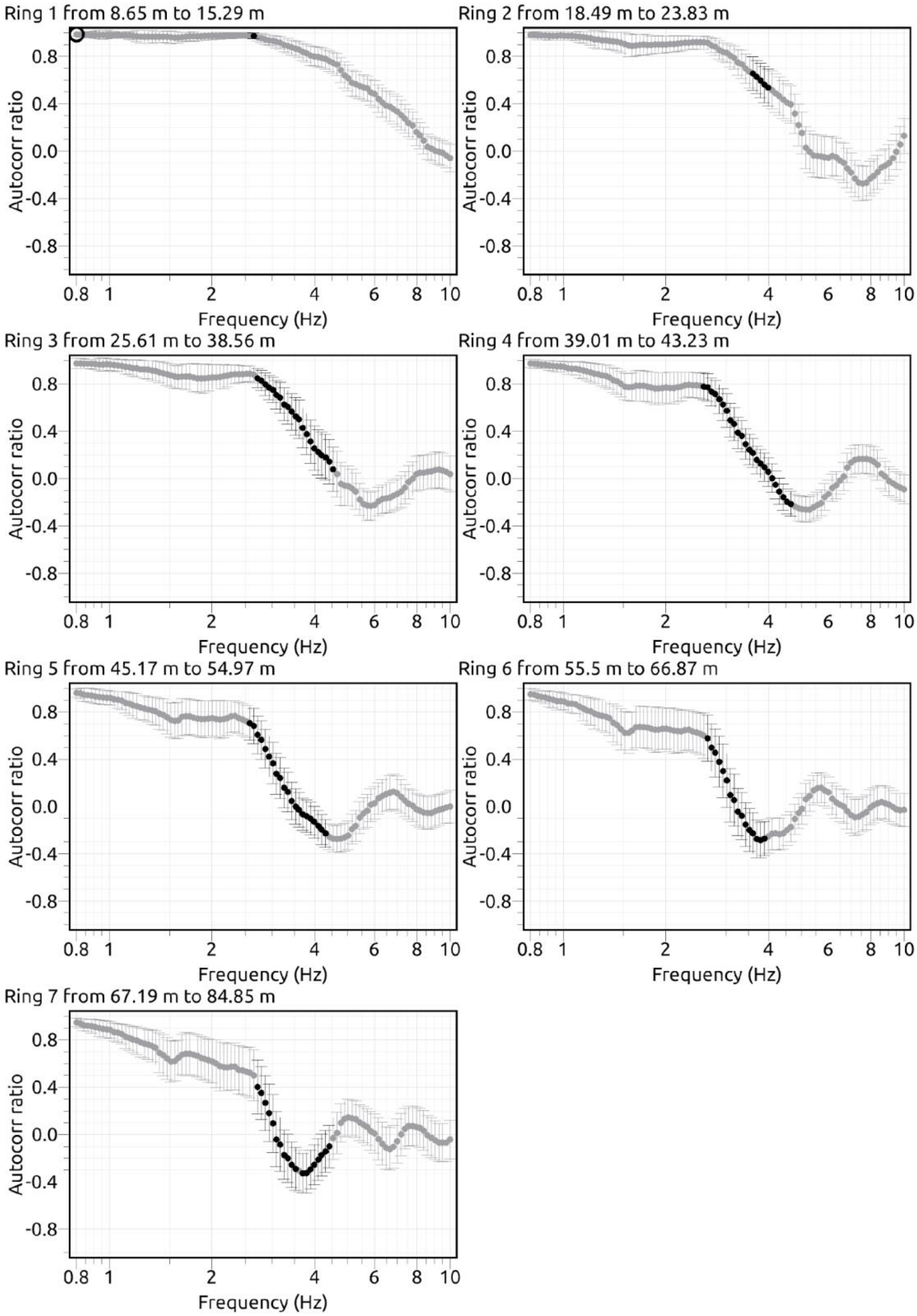

Figure 7: Selected spatial autocorrelation values (black dots) contributing to the selected phase slownesses in MSPAC results in Figure 6.

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3. Vs model

To proceed with the inversion step, we assume the dispersion curve derived from the vertical component of motion associated to the fundamental mode of Rayleigh surface-waves.

To summarize, the data used during the inversion process were:

1) Dispersion curve shown in Figure 6d obtained from FK and MSPAC analysis;
2) Ellipticity curve in terms of Rayleigh fundamental mode in the interval 0.4-1.0 Hz (Figure 4, right);
3) Fundamental frequency (F_0=0.5 Hz).

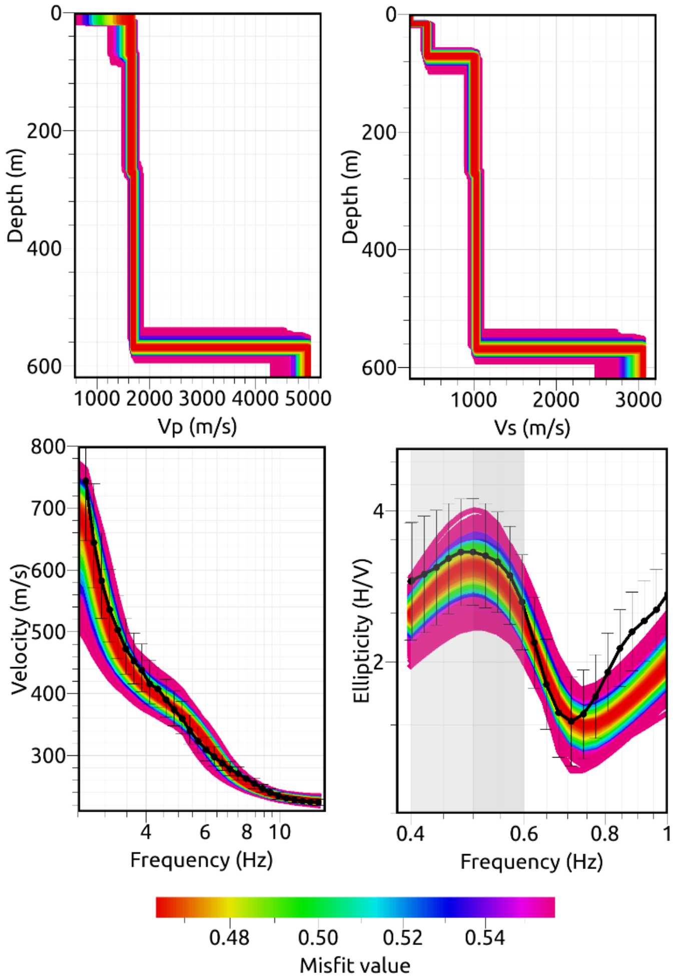

Figure 8: Inversion of the dispersion curves obtained with 2D FK and MSPAC dispersions from array data and constrained with the H/V results.

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The resulting models after the inversion step are shown in Figure 8. We obtained a good fit between experimental and theoretical curves using a model parameterization composed of four main layers over half-space. The best Vp and Vs model (i.e. lowest misfit) resulting from the inversion are proposed in Figure 9 and Table 1.

Focusing on the Vs models of Figure 9, the results indicate a very uppermost layer (thickness < 13 m) with Vs around 230 m/s, a second layer (depth approximately from 13 to 55 m) with a Vs around 435 m/s; the third layer characterized by Vs value of about 1000 m/s; the fourth layer, which represents the bedrock, with a Vs value of about 3000 m/s. The half-space is found at about 570 m depth.

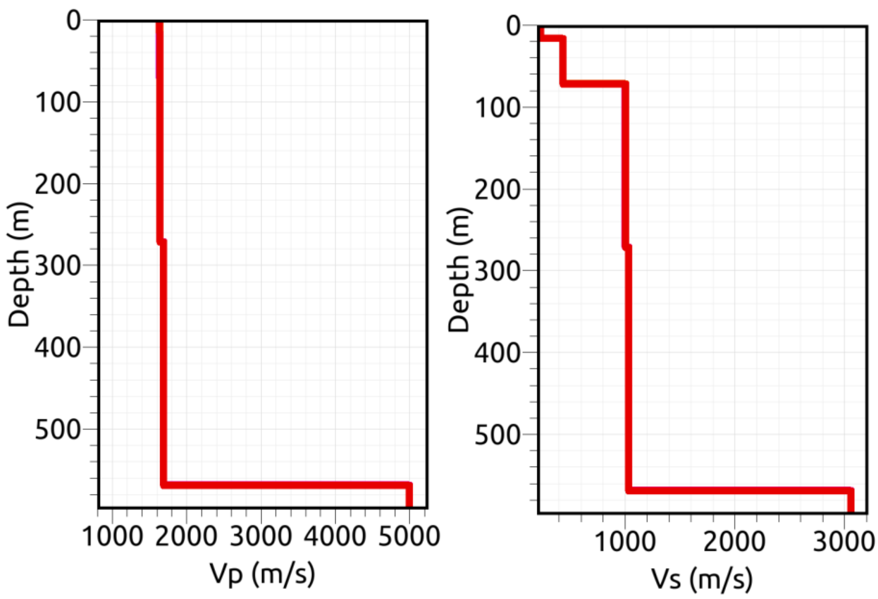

Figure 9: Best-fit model of Vp (left panel) and Vs (right panel) profiles (extracted from the ensemble of Figure 8).

From (m)	*To(m)*	*Thickness (m)*	*Vs (m/s)*	*Vp (m/s)*
0	13,5	13,5	233	1638
13,5	69,0	55,5	435	1641
69,0	269,5	200	1005	1642
269,5	567,5	298	1035	1691
567,5		?	3060	4997

Table 1: Best-fit model

4. Conclusions

The surface-wave analysis on seismic data acquired around IV.IOCA and IT.CML stations (Casamicciola Terme, Ischia) allowed the reconstruction of a Vs and Vp velocity model defined up to depth of about 570 m. Two resonant peaks are observed at the array stations, the first one at 0.5 Hz and a second one is present at 1.6-1.7 Hz. The ellipticity curve is used during the inversion and it constrained the deepest parts of best fit models.

The inversion results show three main seismic contrasts (Table 1) at 13.5 m (where the Vs increases from 233 m/s to 435 m/s), 69 m (where Vs increases from 435 m/s to 1000 m/s), 570 m (where Vs increases from 1000 m/s to 3000 m/s). We can propose an interpretation of the velocity profile based on the general geological assessment of the area. The first 13 meters could be linked to the presence of shallow colluvial deposits. A second layer of about 60 m could be related to debris avalanches, then a quite stiffer layer, related to the ignimbritic tuffs, and a final layer of trachytic lavas (very stiff).

The Vs30 retrieved from the best-inverted model is 344 m/s (Table 2), therefore the investigated area is classified as class C soil type following the NTC08 and NTC18 seismic classification.

Vs30 (m/s)	Soil Class
344	C

Table2: Soil Class

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