Site characterization of the INGV station IV.EUCT – PAVIA

Working Group: **Claudia MASCANDOLA** **Sara LOVATI** **Marco MASSA**	Date: January 2018
Subject: **Final report illustrating measurements, analysis and results at IV.EUCT station**	

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

1. Introduction

In this report, we present the geophysical measurements and the results obtained in the framework of the 2017 agreement between INGV and DPC, named *Allegato B2: Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici* for the characterization of sites of the Italian National Seismic Network (RSN-INGV) with accelerometers and of the Italian Accelerometric Network (RAN-DPC). Here the results for station IV-EUCT are presented.

Geophysical measurements are 2D microtremor arrays that provide results in terms of dispersion curves, inverted to obtain shear-wave velocity (V_S) profiles for the studied area, suitable for assigning the EC8 class.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

2. Geophisical investigation

Figure 1 shows the location of the stations used for the 2D array.

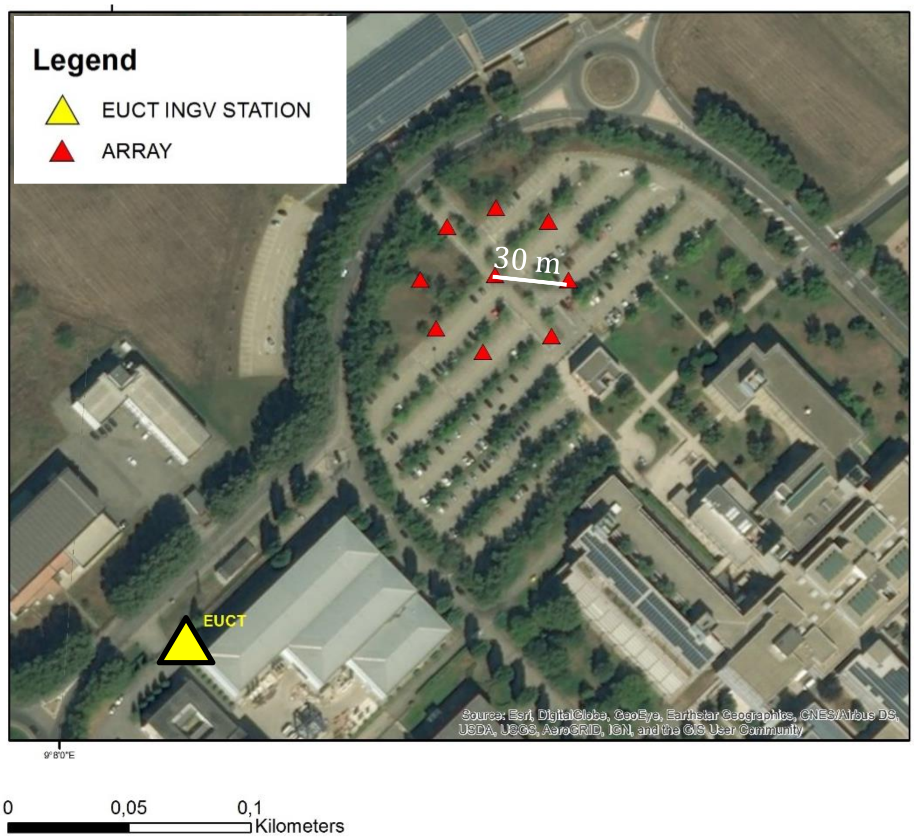


Figure 1: Plan view of the geophysical measurements performed at IV-EUCT site. The red points are the nine stations of the 2D array in passive configuration (all stations are equipped with Reftek R130 digitizer and Lennartz 3D-5sec velocimetric sensors). The yellow triangle indicates station IV-EUCT. The array is in a circular configuration with a ray of 30 m.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici”, (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

2.1 ARRAY MEASUREMENTS RESULTS

A 2D array was performed using 9 single seismic stations equipped with Reftek 130 digitizers and Lennartz 3d-5s velocimetric sensors. The common noise recording lasted about 2 hours.

A view of the 2D passive array survey is shown in Figure 2.

The seismic sensors were positioned in a circular geometry with ray of 30 m, as shown in Figure 2.

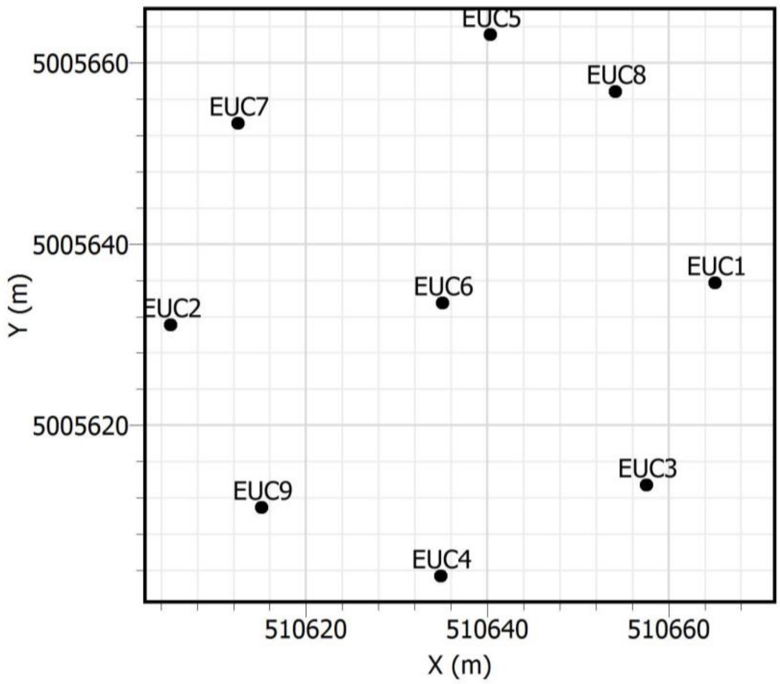


Figure 2: Top: installation of a station of the 2D array. Bottom: 2D Array geometry

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

The geometry of the array allows the performance described in Figure 3.

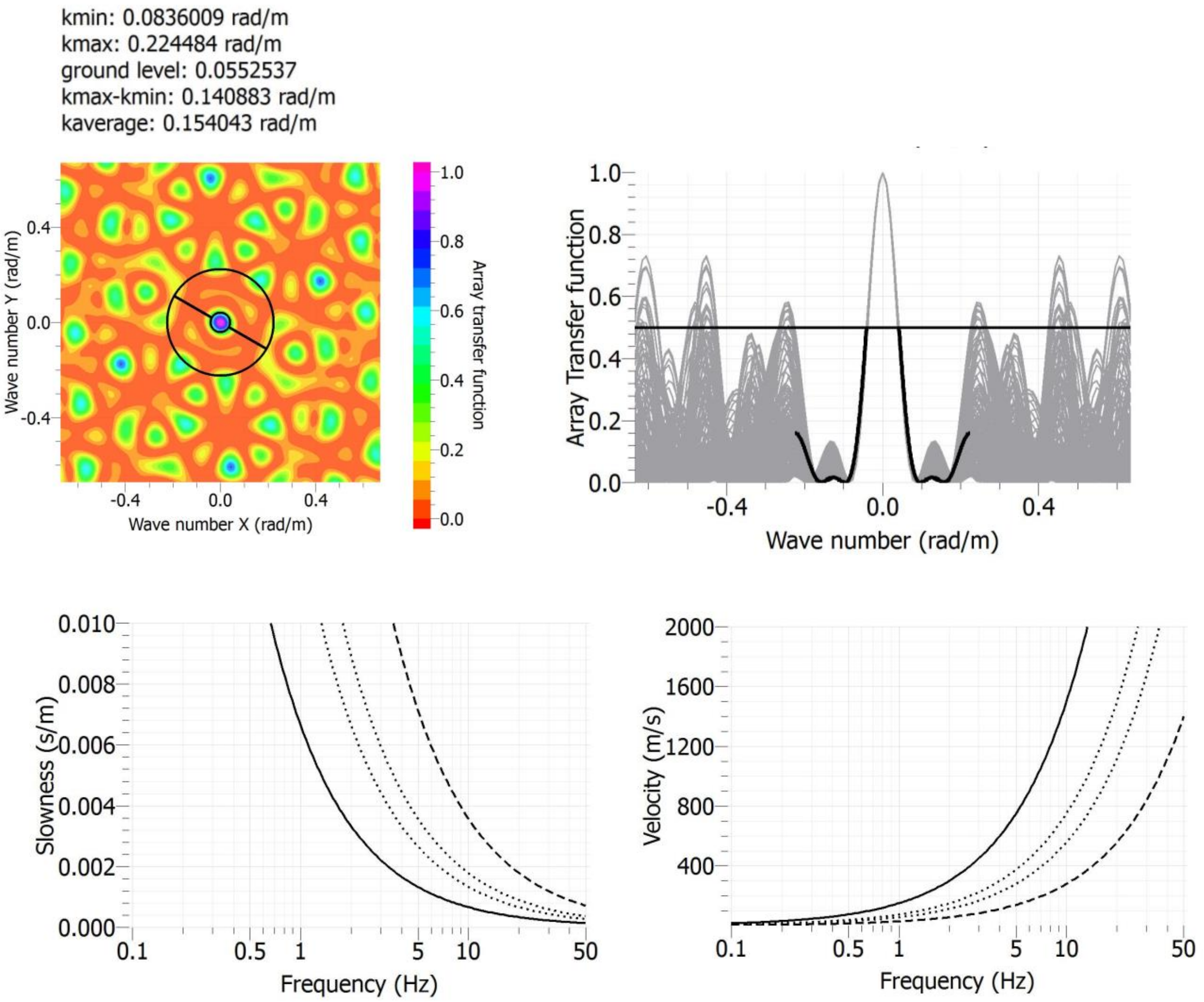
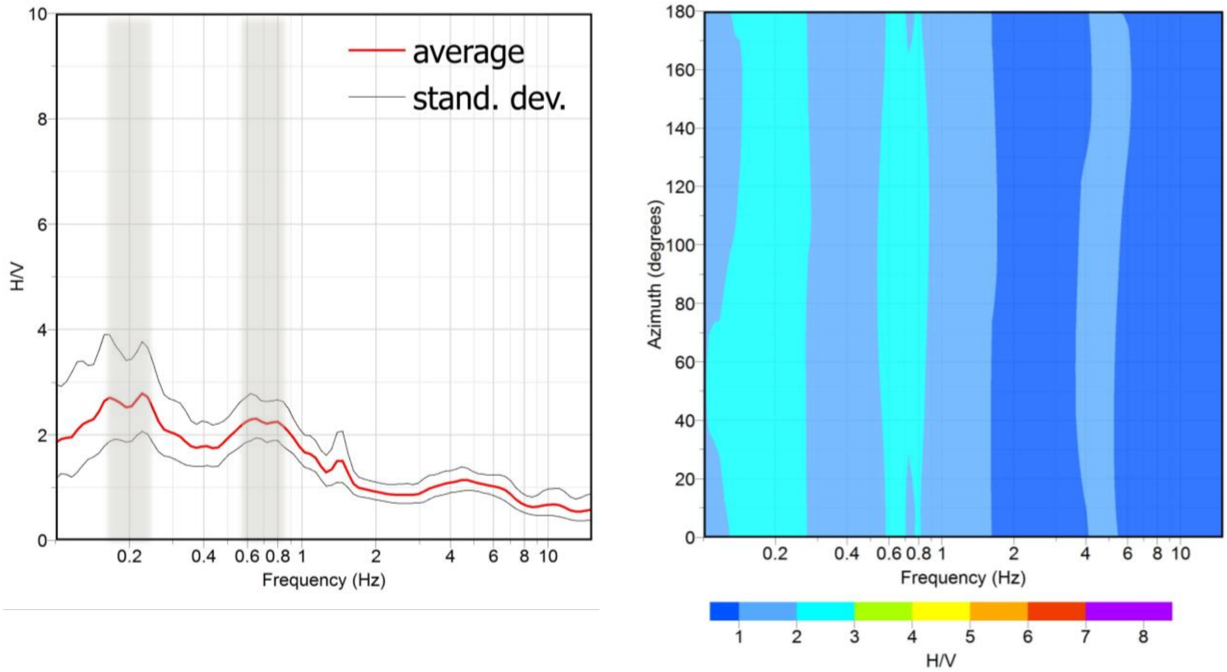


Figure 3: Theoretical Array Transfer function for the 2D array at IV-EUCT

In Figure 4, a representative H/V curve among the 9 stations of the array is reported, highlighting a first peak at 0.2 Hz and a second peak at 0.7 Hz. The analysis was performed with 120 s time windows and Konno & Ohmachi smoothing with the b coefficient set to 40. The rotated HV spectral ratios evidence consistently both the frequencies (0.2 and 0.7 Hz) showing no significant polarization effect.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

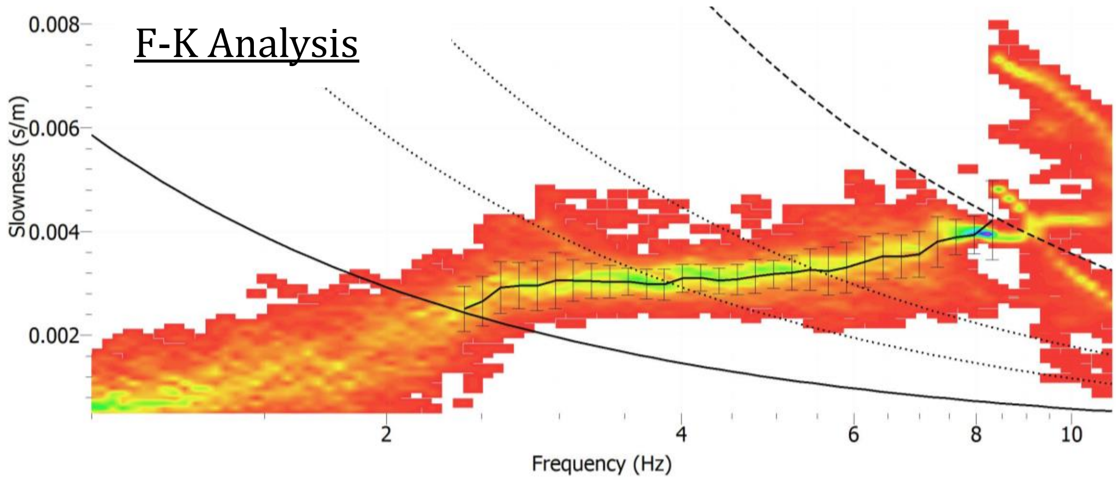


a) b)

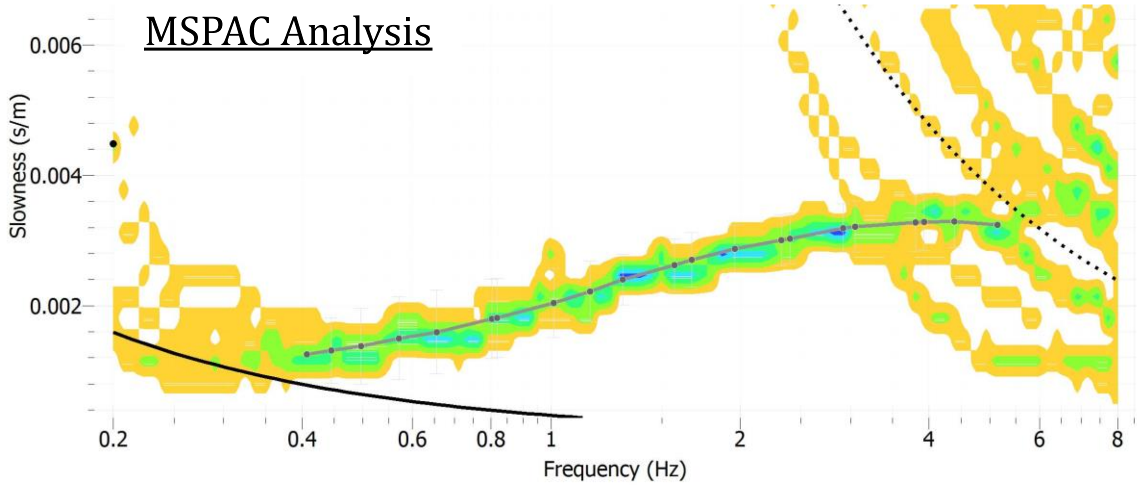
Figure 4: a) representative H/V curve and b) rotated H/V of the 9 seismic stations of the array

Data from the 2D array have been analyzed in terms of FK analysis and MSPAC analysis. The two techniques were both considered for the definition of the Rayleigh wave dispersion curve, fundamental mode only (Figure 5). For the analysis, we used the GEOPSY code (http://www.geopsy.org).

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741



a)



b)

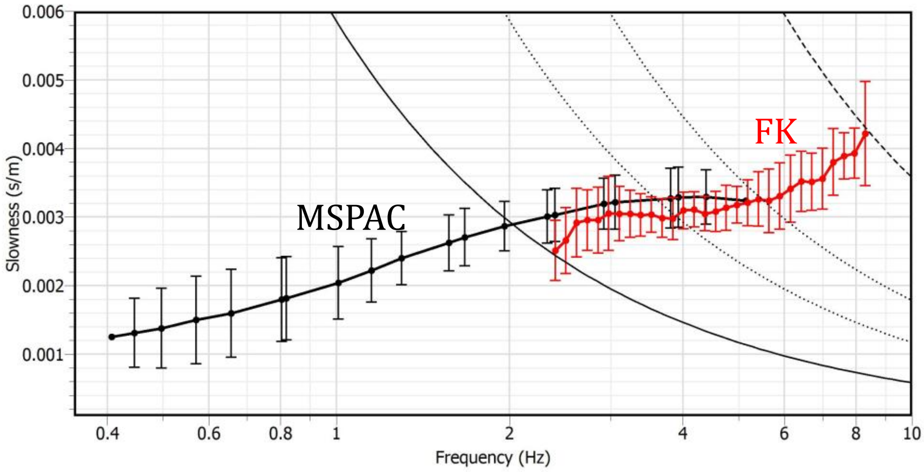
Figure 5: picked dispersion curve for the 2D array, with the FK method (a) and MSPAC method (b)

We interpret and assume that the dispersion curve obtained with the 2D array is relative to the fundamental mode of the Rayleigh dispersive waves.

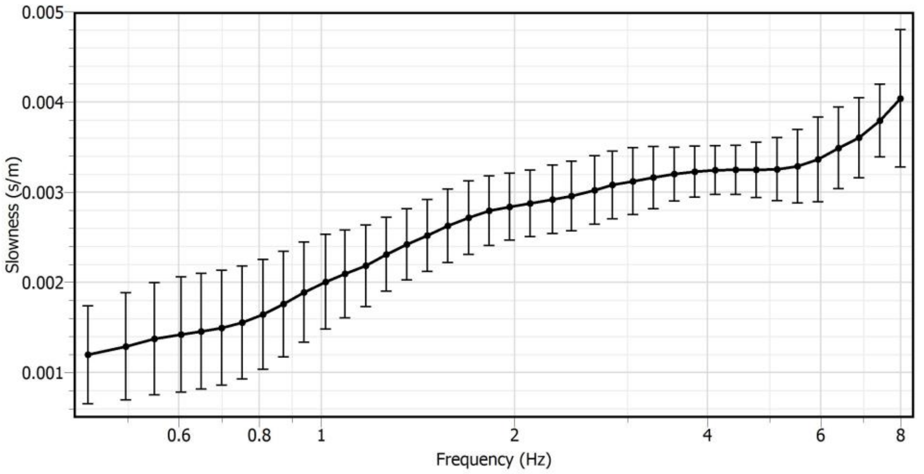
Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

3. Vs Model

Comparing the two dispersion curves in Figure 5, coming from the 2D passive array, we observe a good match (Figure 6a). In particular, the MSPAC method can better define the lower frequencies, whereas the FK method can better define the higher frequencies, therefore the final dispersion curve considered for the inversion is a combination between the two (Figure 6b).



a)



b)

Figure 6: a) comparison between the dispersion curves obtained with different methodologies; b) dispersion curve considered for the inversion.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

To proceed with the inversion, we estimate the ellipticity curve from the H/V curve (Figure 4a), considering in particular the flanks of the H/V peaks, where the influence of the Rayleigh waves is higher. Moreover, a common practice to reduce the contribution of other waves in the H/V flanks is to reduce the amplitude for the square root of 2 (Figure 7).

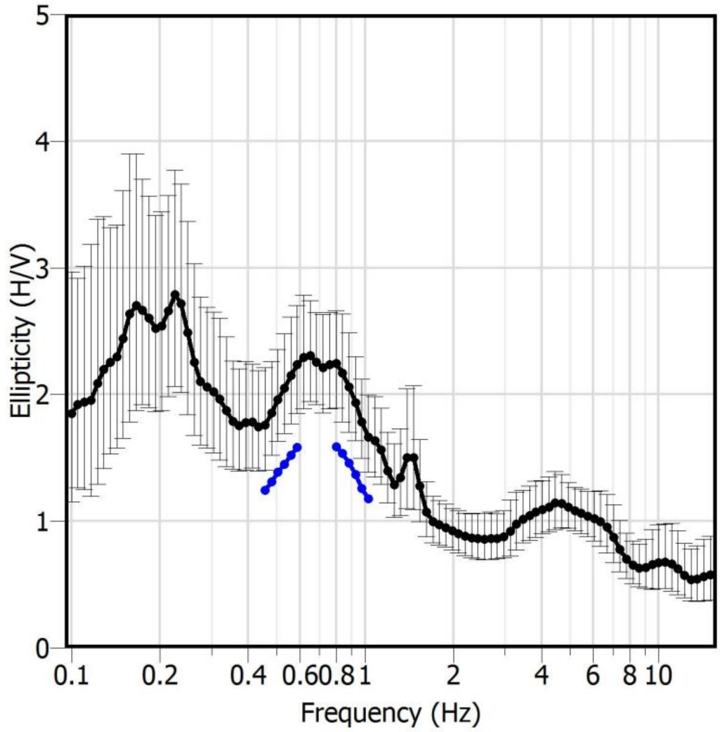


Figure 7: estimation of the ellipticity curve (blue) from the H/V curve (black).

Finally, we jointly invert the following targets:

1) Ellipticity curve as in Figure 7 (blue curves)
2) Rayleigh wave dispersion curve (fundamental mode) in Figure 6b

Figure 8 shows the comparison between the targets obtained experimentally and the ones expected for the Vs model proposed for this site.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

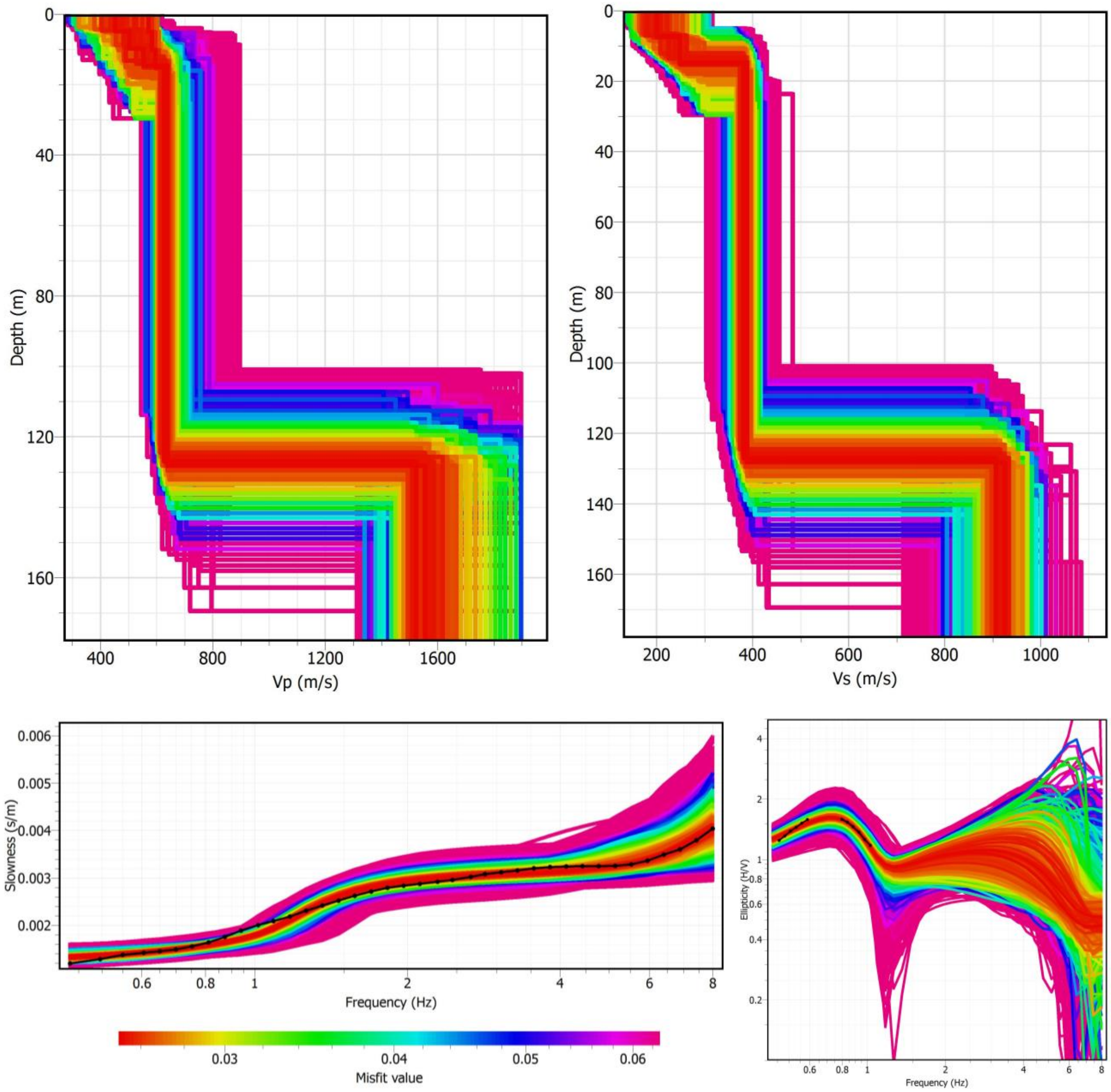


Figure 8: Inversion of the dispersion curve obtained with the 2D passive array, constrained with the H/V results.

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

The best-fit Vp and Vs model are proposed in Figure 9 and Tab 1.

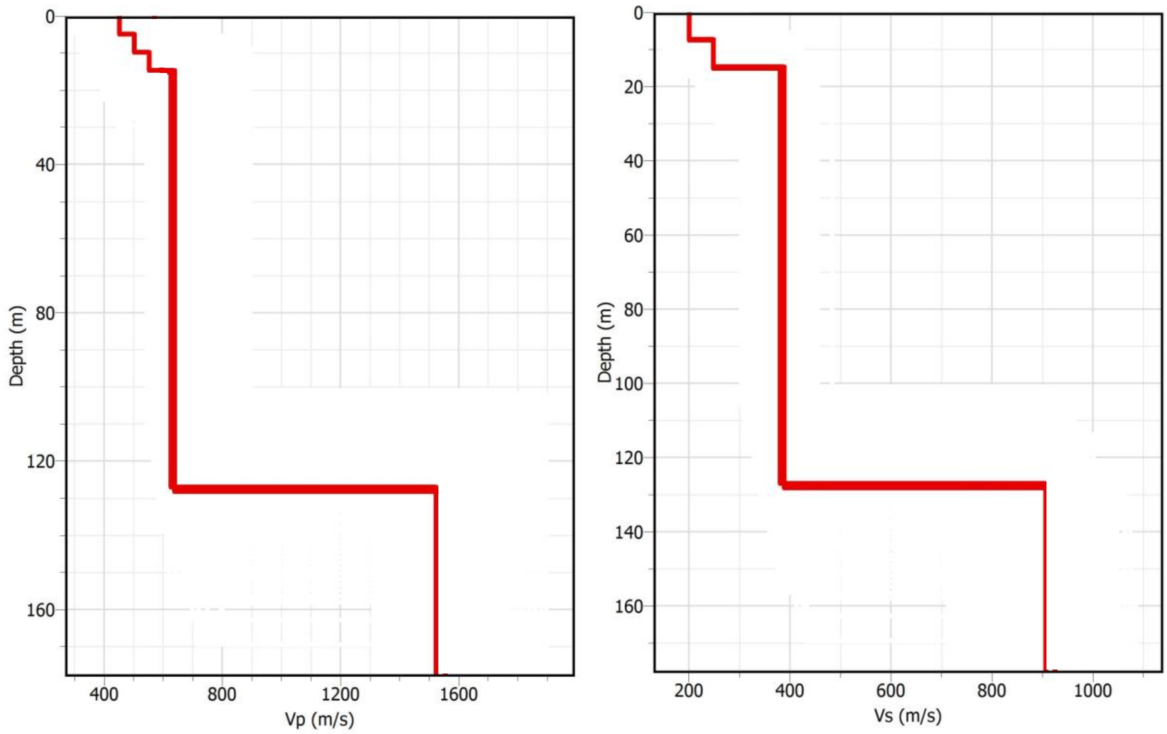


Figure 9: Best-fit model of Vp (left panel) and Vs (right panel) values

From	*To*	*Thickness (m)*	*Vs (m/s)*	*Vp (m/s)*
0	7	7	199	445
7	15	8	246	520
15	127	112	383	633
127			914	1540

Tab 1 Best-fit model

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

4. Conclusions

The H/V analysis for this site shows two H/V peaks at about 0.2 and 0.7 Hz respectively. The higher frequency peak at 0.7 Hz was considered for the analysis, as shown in Fig. 7 and 8, allowing to possibly relate the mentioned H/V peak with the seismic bedrock interface (Vs>800 m/s; NTC 2008) at 127 m of depth. The low frequency peak at 0.2 Hz was not investigated, but it could be related to a deeper interface not reached from the obtained velocity profile.

The V_{s30} retrieved from the joint inversion of the dispersion and ellipticity curves is 290 m/s (Tab 2), therefore IV-EUCT is classified as soil class C in terms of NTC 08 seismic classification.

V_{s30} (m/s)	***Soil class***
290	C

Tab 2: Soil Class

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

Disclaimer and limits of use of information

The INGV, in accordance with the Article 2 of Decree Law 381/1999, carries out seismic and volcanic monitoring of the Italian national territory, providing for the organization of integrated national seismic network and the coordination of local and regional seismic networks as described in the agreement with the Department of Civil Protection.

INGV contributes, within the limits of its skills, to the evaluation of seismic and volcanic hazard in the Country, according to the mode agreed in the ten-year program between INGV and DPC February 2, 2012 (Prot. INGV 2052 of 27/2/2012), and to the activities planned as part of the National Civil Protection System.

In particular, this document1 has informative purposes concerning the observations and the data collected from the monitoring and observational networks managed by INGV.

INGV provides scientific information using the best scientific knowledge available at the time of the drafting of the documents produced; However, due to the complexity of natural phenomena in question, nothing can be blamed to INGV about the possible incompleteness and uncertainty of the reported data.

INGV is not responsible for any use, even partial, of the contents of this document by third parties and any damage caused to third parties resulting from its use.

The data contained in this document is the property of the INGV.

[1]*This document is level 3 as defined in the "Principi della politica dei dati dell'INGV (D.P. n. 200 del 26.04.2016)"*

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741

Esclusione di responsabilità e limiti di uso delle informazioni

L'INGV, in ottemperanza a quanto disposto dall'Art.2 del D.L. 381/1999, svolge funzioni di sorveglianza sismica e vulcanica del territorio nazionale, provvedendo all'organizzazione della rete sismica nazionale integrata e al coordinamento delle reti sismiche regionali e locali in regime di convenzione con il Dipartimento della Protezione Civile.

L'INGV concorre, nei limiti delle proprie competenze inerenti la valutazione della Pericolosità sismica e vulcanica nel territorio nazionale e secondo le modalità concordate dall'Accordo di programma decennale stipulato tra lo stesso INGV e il DPC in data 2 febbraio 2012 (Prot. INGV 2052 del 27/2/2012), alle attività previste nell'ambito del Sistema Nazionale di Protezione Civile.

In particolare, questo documento1 ha finalità informative circa le osservazioni e i dati acquisiti dalle Reti di monitoraggio e osservative gestite dall'INGV.

L'INGV fornisce informazioni scientifiche utilizzando le migliori conoscenze scientifiche disponibili al momento della stesura dei documenti prodotti; tuttavia, in conseguenza della complessità dei fenomeni naturali in oggetto, nulla può essere imputato all'INGV circa l'eventuale incompletezza ed incertezza dei dati riportati.

L'INGV non è responsabile dell'utilizzo, anche parziale, dei contenuti di questo documento da parte di terzi e di eventuali danni arrecati a terzi derivanti dal suo utilizzo.

La proprietà dei dati contenuti in questo documento è dell'INGV.

[1]*Questo documento rientra nella categoria di livello 3 come definita nei "Principi della politica dei dati dell'INGV (D.P. n. 200 del 26.04.2016)".*

Cite as: Working group INGV "Convenzione DPC-INGV 2017 Allegato B2, Obiettivo 1 - TASK B: Caratterizzazione siti accelerometrici", (2017). Site characterization of the INGV station IV.EUCT PAVIA. doi: 10.5281/zenodo.1145741