ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Site characterization report at the seismic station IV.POFI – Posta Fibreno (FR)

Report di caratterizzazione di sito presso la stazione sismica IV.POFI – Posta Fibreno (FR)

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Subject: **Final report illustrating the site characterization for seismic station IV.POFI**	

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INTRODUCTION

In this report we present the geological setting and the geophysical measurements and results obtained in the framework of the 2019-2021 agreement between INGV and DPC, called *Allegato B2: Obiettivo 1 - TASK 2: Caratterizzazione siti accelerometrici (Responsabili: G. Cultrera, F. Pacor)* for the site characterization of station IV.POFI (Posta Fibreno - FR).

Location and coordinates are reported in Table A1.

Table A1.

CODE	NAME	LAT [°]	LON [°]	ELEVATION [m]
IV.POFI	POSTA FIBRENO	41.71743*	13.71202*	878**
ADDRESS	Unnamed road, 03030 Campoli Appennino (FR), Italy			

* Coordinates from ITACA (Nov. 2019) **Elevation from CTR 5k Regione Lazio

A. Geological setting

A1. TOPOGRAPHIC AND GEOLOGICAL INFORMATION

Topographic information related to the site are reported in Table A2. Table A3 summarizes all available geological maps from literature for geological analyses.

Table A2.

Topography	Description	Topography Class	Morphology Class	EC8 Class
	Flat surface, isolated slopes and cliffs with average slope angle i≤15°	T1	SL	B

*Reference table from ITACA (Nov. 2019)

Table A3.

Geological map	Source	Scale
IV.POFI	Geological Map of Italy Sheet N. 152 “Sora”	1:100.000
IV.POFI	Map of Itlay Sheet N. 152 “Alvito”	1:25.000
IV.POFI	Geological-technical map Seismic Microzonation	1:10.000

In Table A4 Geological and Lithotechnical Units (according to Seismic Microzonation classification; Technical Commission SM, 2015) are described and are concerned to maps of following chapters. The term “original” means the result comes from a preexisting cartography (Table A3); the term “deduced” means the result comes from an interpretation of a preexisting cartography according to the nomenclature of corresponding cartography.

Table A4

GEOLOGICAL UNITS		**LITHOTECHNICAL UNITS**	
"Geological Map of Italy Sheet N. 152 "Sora"*original* and Geological Map of Italy (1:50.000 scale) *deduced*		(MZS) *deduced*	
code	**description**	**code**	**description**
CIR	Calcari ciclotemici a Requienie (Aptian p.p-Albian)	LPS	Stratified Litotype
CIR	Calcari ciclotemici a Requienie (Aptian p.p-Albian)	SFLPS	Stratified, fractured/weathered Litotype
olo_{b6}	Red soil (Holocene)	MLdo	Inorganic silt, fine silty or clayey sand, clayey silt of low plasticity

A2. GEOLOGICAL MAP

In Figure A1 Geological Map is reported in a 1kmx1Km square around the station.

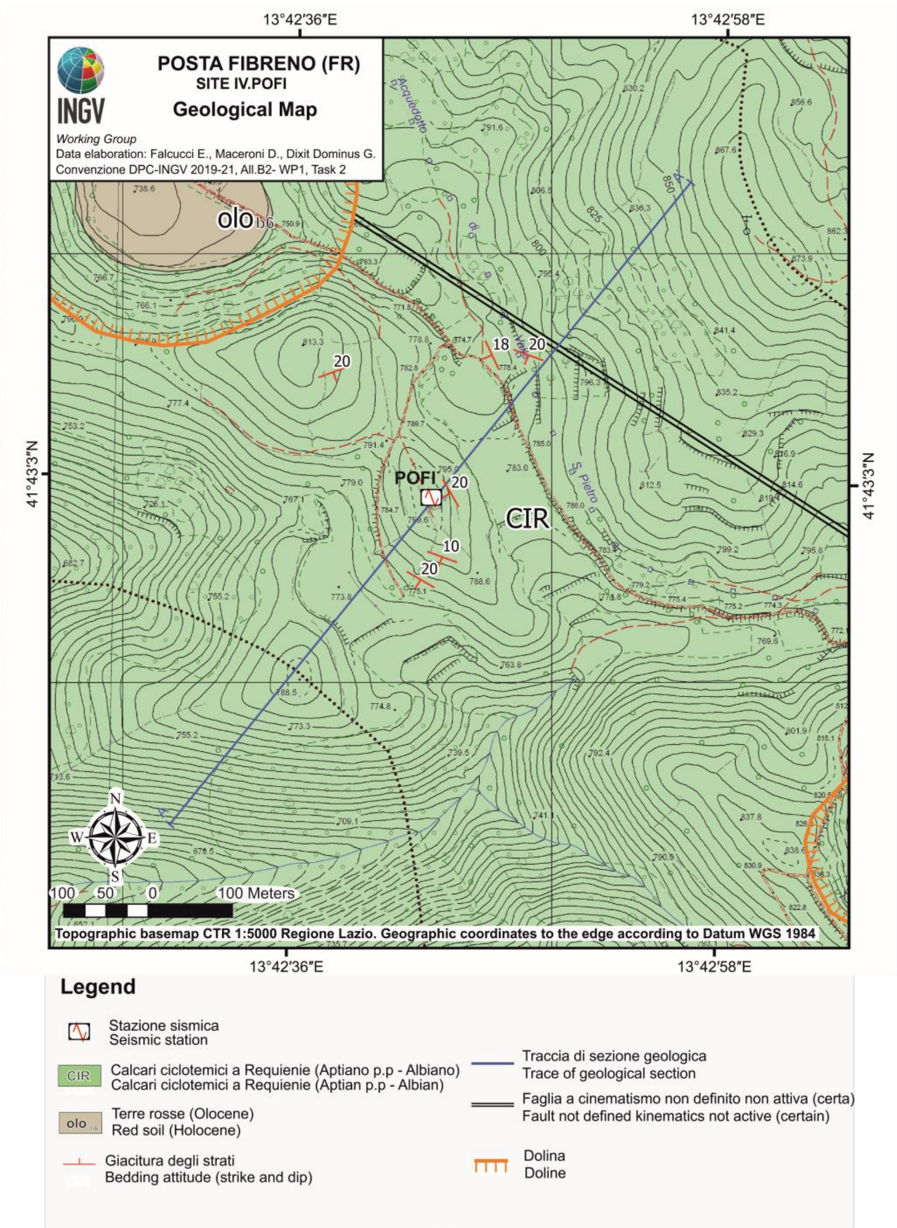

Figure A1. Geological map of seismic station IV.POFI. Scale 1:5.000.

The Geological Units are established according to the Geological Map of Italy sheet N.152 “Sora” (1:100.000 scale). In particular, the Unit “CIR” has been deduced according to the nomenclature of geological map of Italy (1:50.000 scale).

A3. LITHOTECHNICAL MAP

In Figure A2 Lithotechnical Map is reported in a 1kmx1Km square around the station.

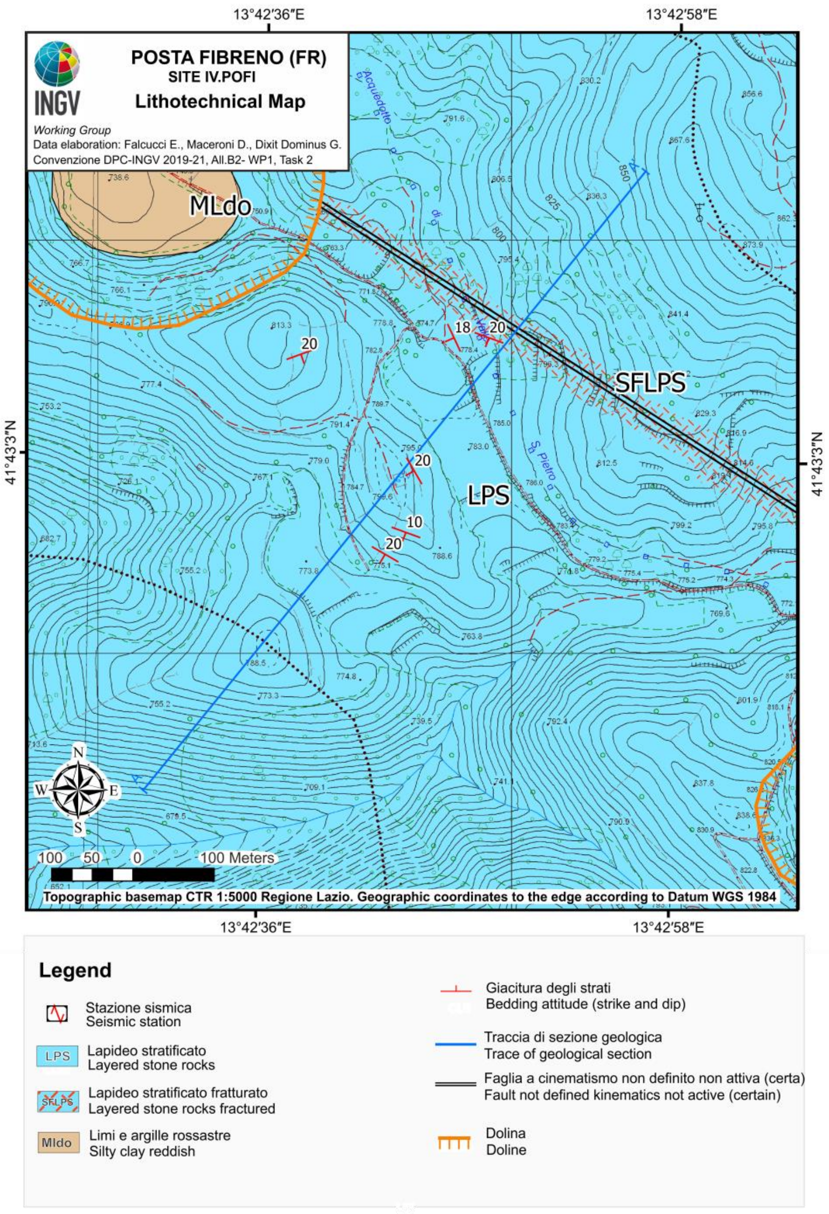

Figure A2: Lithotechnical map of the seismic station IV.POFI. Scale 1:5.000. The lithotechnical units are deduced according to the nomenclature of Seismic Microzonation Study (Technical Commission SM, 2015).

A4. SURVEY MAP

Figure A3 shows the Survey Map reporting both previous investigations and geophysical surveys conducted by INGV Working Group.

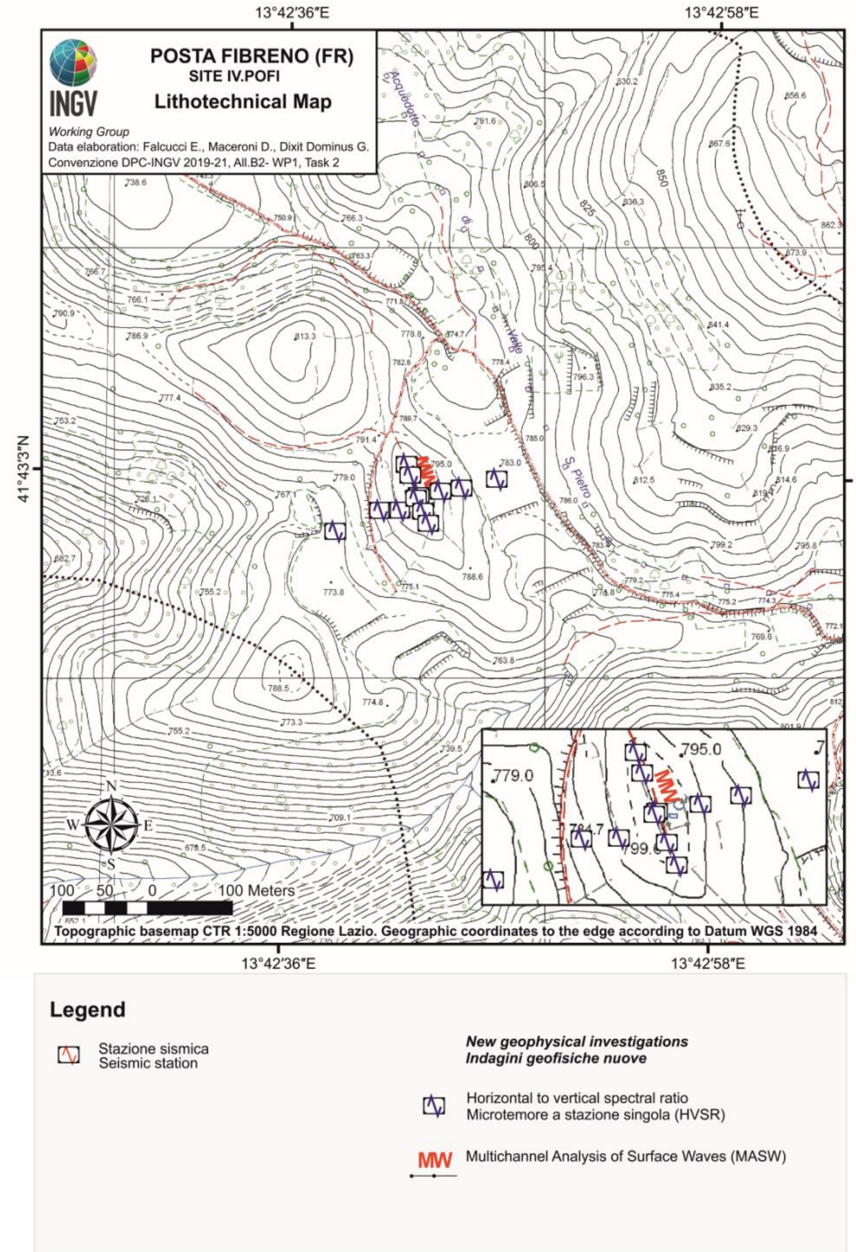

Figure A3: Map of the surveys in the surroundings of the station IVPOFI. Scale 1:5.000. The box at the bottom right contains a zoom of the area with the detail of the geophysical survey conducted by INGV Working Group for the seismic characterization of the site (Agreement DPC-INGV 2019-21, All. B2, WP1 - TASK 2, Velocity profile report IV.POFI)

A5. GEOLOGICAL MODEL

5.1 General description

The seismic station "POFI" is located in the Campoli Appennino area. The village is situated in the Comino Valley area, a central Apennines depression located on the south-eastern sector of the Roveto Valley, close to the limit between the southern sectors of the Lazio and Abruzzo regions.

From a geographical point of view, the Comino valley appears as a large basin, with an approximately circular shape of about 244 km2, surrounded by reliefs, that is, southward by Mt. Cairo to the south, Meta massif to the east, and Western Marsica Mountain group to the north. On the west, the valley is characterized by a hilly area that does not exceed 500 m altitude.

The study area is characterized by reliefs (up to about 2000 m high) made of Meso-Cenozoic limestone, belonging to the carbonate sequences of the Lazio-Abruzzo succession, the valley is partially filled by late Miocene turbidite sediments and the Plio-Quaternary continental deposits (Saroli et al., 2003).

This area is crossed by a regional tectonic structure, known as the Roveto Valley fault - Posta Fibreno fault, belonging to the "Val Roveto-Atina-Caserta Line". According to Saroli et al. (2006; 2012) the presence of this fault favoured the Formation and wide distribution of dolines along the NW-SE direction. According to mentioned authors, quaternary fault activity determined progressive lowering of the karst base level and, consequently, progressive and embedding of the karst systems. Such an evolution of the karstic system, suggested that the activity of the Roveto Valley fault persisted up to the present, at least in the area between Pescosolido and Posta Fibreno. As can be seen in Figure A4 POFI seismic station is located near to a fault line trending parallel to the Roveto Valley fault. This structure, reported with undefined kinematics in the available geological maps, shows no evidence of Late Quaternary activity (Saroli et al., 2012; submitted).

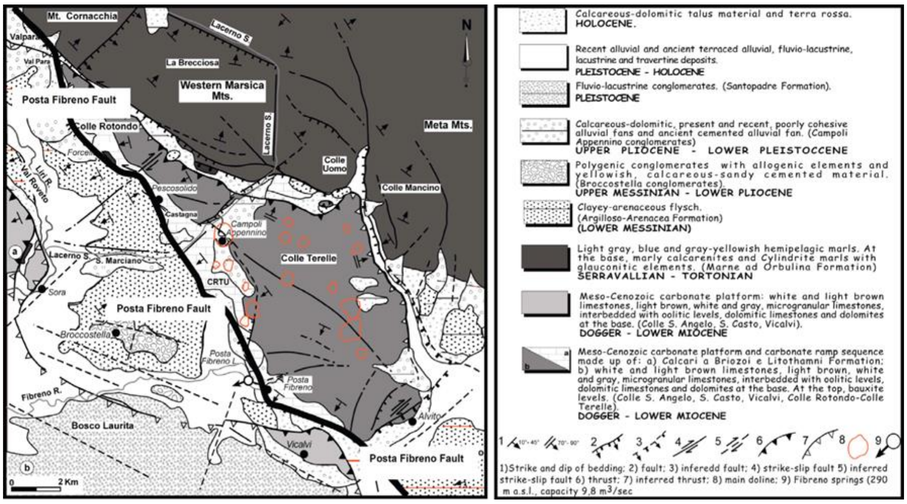

Figure A4: Geological and structural map of the investigated area, the red triangle indicates the POFI seismic station (modify from Saroli et al., 2012). The bold line is the trace of the Roveto Valley-Posta Fibreno fault.

5.2 Geological Section

The "POFI" seismic station is located on top of carbonate relief, located to the SE of Campoli Appennino village and the E of the Posta Fibreno Lake. This relief is affected by small karstic depressions and dolines. Among these, one of the largest is known as"Fossa Maiura", more than 100 metres deep and characterized by steep and flanks that is located few hundred metres to the SE of the seismic station.

The geological section (whose trace is indicated in fig. A1 and A2) shows the geological and structural features of the study area (Figure A5). The section, traced across the seismic station site, is derived from the analysis of the information reported in the Geological Map available in the literature (Table A2.), the geophysical investigations and the geological field surveys. In particular, the field analysis confirms the presence of Meso-Cenozoic carbonate bedrock in the seismic station area. The limestone is slightly weathered, showing an overall bedding dip towards the southwest (Figure A6) (N70°, 20°; N110°20°, N150°,20°; N120°,20°; N110°,10°). Some shear planes are observed affecting the bedrock, with a direction compatible with the trace of above mentioned tectonic structure reported in this area in the available geological map, and that affects the Fossa Maiura doline. Hence, the seismic station is located on a monoclinal structure made of Meso-Cenozoic carbonate bedrock gently dipping towards the SE that, along the northwestern sector, is affected by a fault with undefined kinematics.

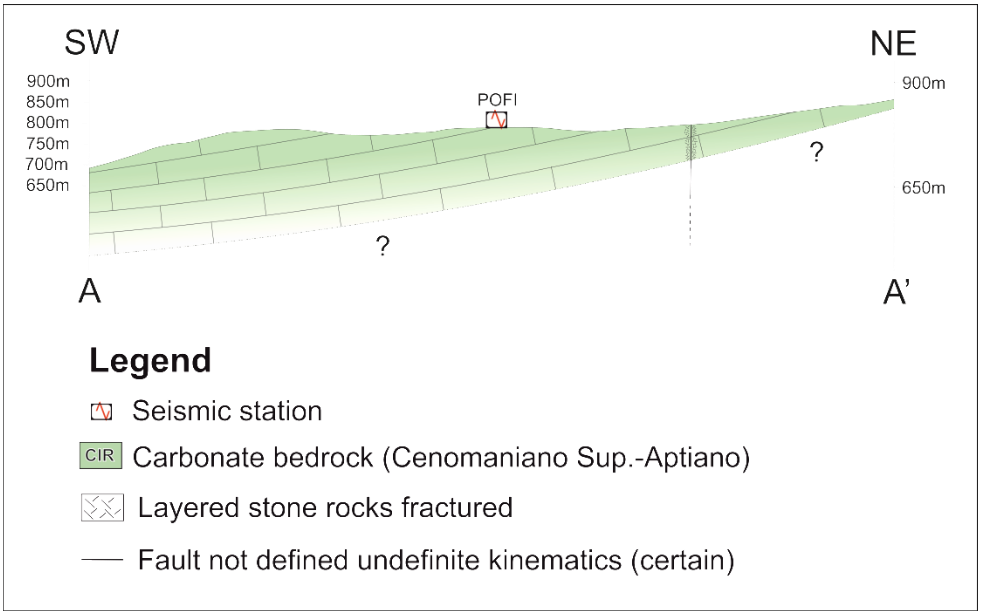

Figure A5: Geological cross section of the area of the POFI seismic station

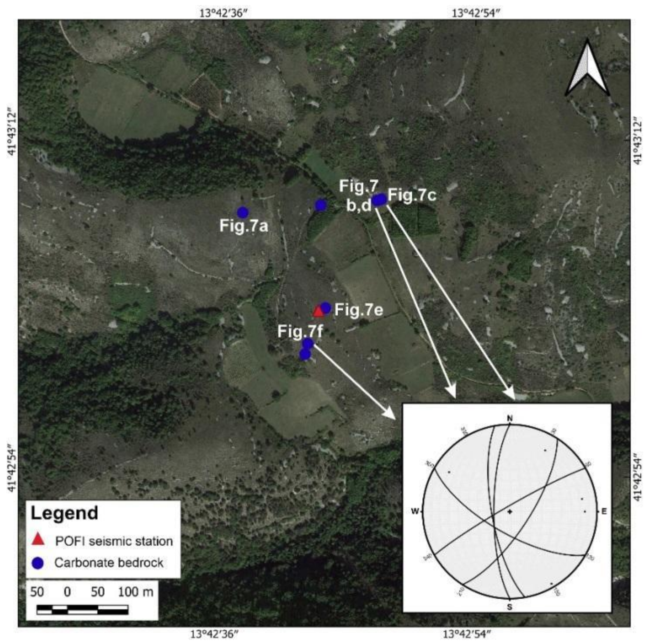

Figure A6: Satellite map (Google Earth) that shows the location of carbonate bedrock cropped out in the seismic station area. The stereonet shows the plot of the shear planes affecting the limestone.

Figure A7: a) Limestone cropping out in the NNW sector of the seismic station area. The dashed yellow line indicates the bedding of the limestone (the inset shows a detail of a layer); b) Carbonate bedrock cropping out in the NNE sector of the seismic station area, affected by shear planes (close-up view in "d", indicated by the dashed red line). Bedding of the limestone is marked by the dashed yellow line; c), e) and f) Limestone (bedding is marked by the dashed yellow line) affected by shear planes (indicated by the dashed red line) in the S sector of the seismic station area.

5.3 Subsoil model

Field observations coupled with information derived from the available geological maps allowed to derive a 2D geological model (down to about 100 m depth), underneath the IV.POFI seismic station site (Figure A8). The geological model obtained has been also compared to the new geophysical investigations, performed by the INGV Working Group, for the seismic characterization of the site and for the definition of body waves velocity profiles. Excluding the first meter, made of slightly fractured limestone bedrock, the first 20-30 m beneath the site consists in the layered limestone bedrock of the "CIR" Formation, that preserves its primary mechanical characteristics, i.e. affected by no evident fracturing.

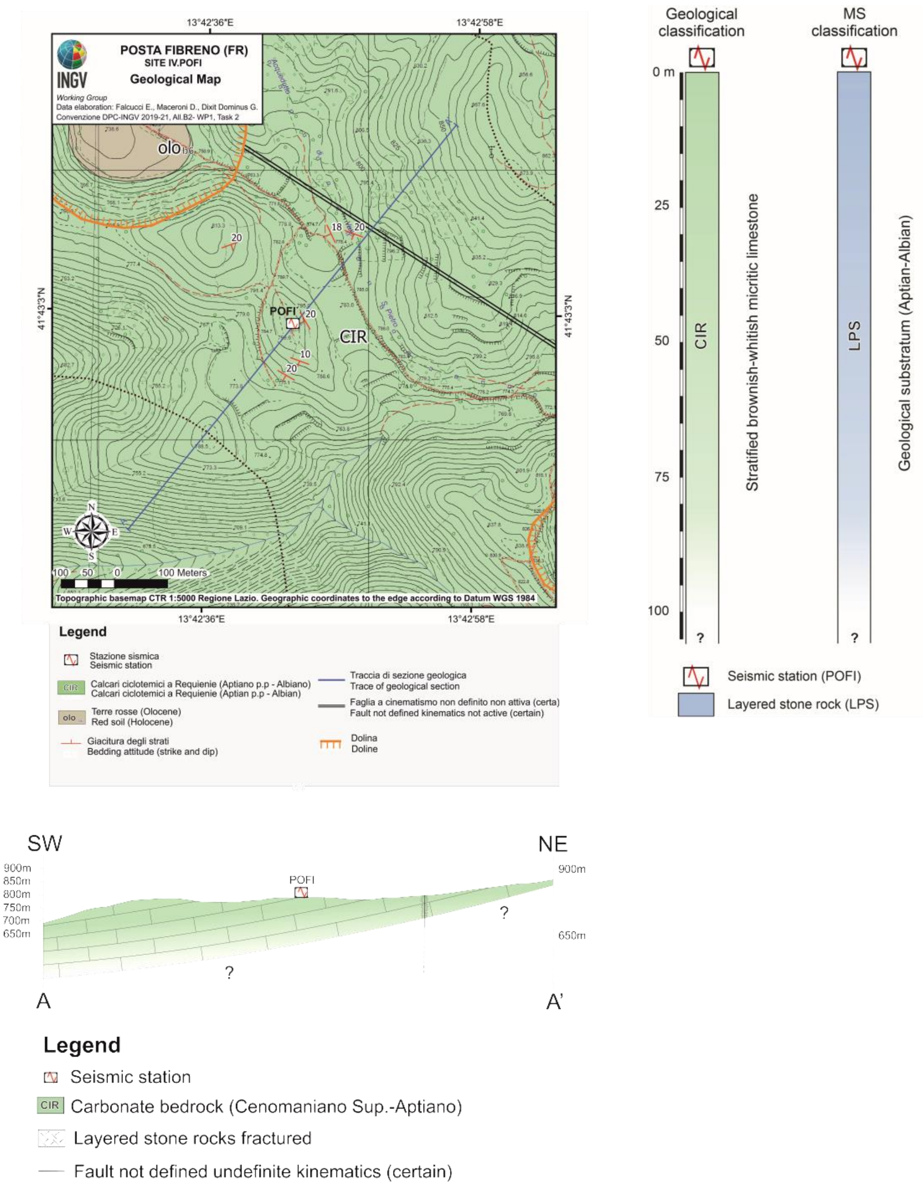

Figure 8: Bottom – Geological section crossing seismic station IV.POFI. Right – Subsoil model under IV.POFI and classification according to nomenclature of geological map of Italy 1:50.000 and according to Seismic Microzonation (MS)

B. Vs profile

B1. GEOPHYSICAL INVESTIGATIONS

With the aim of determining a 1D-velocity model representing the subsoil underlying the seismic station, we performed different geophysical investigations in the area around the IV.POFI seismic station. We carried out a MASW survey by using 72 vertical geophones deployed in linear configuration and, in addition, we installed 12 temporary seismic stations to record ambient noise. Figure B1 shows the location of linear array and of temporary seismic stations deployed in the target area near to the IV.INTR station (red triangle).

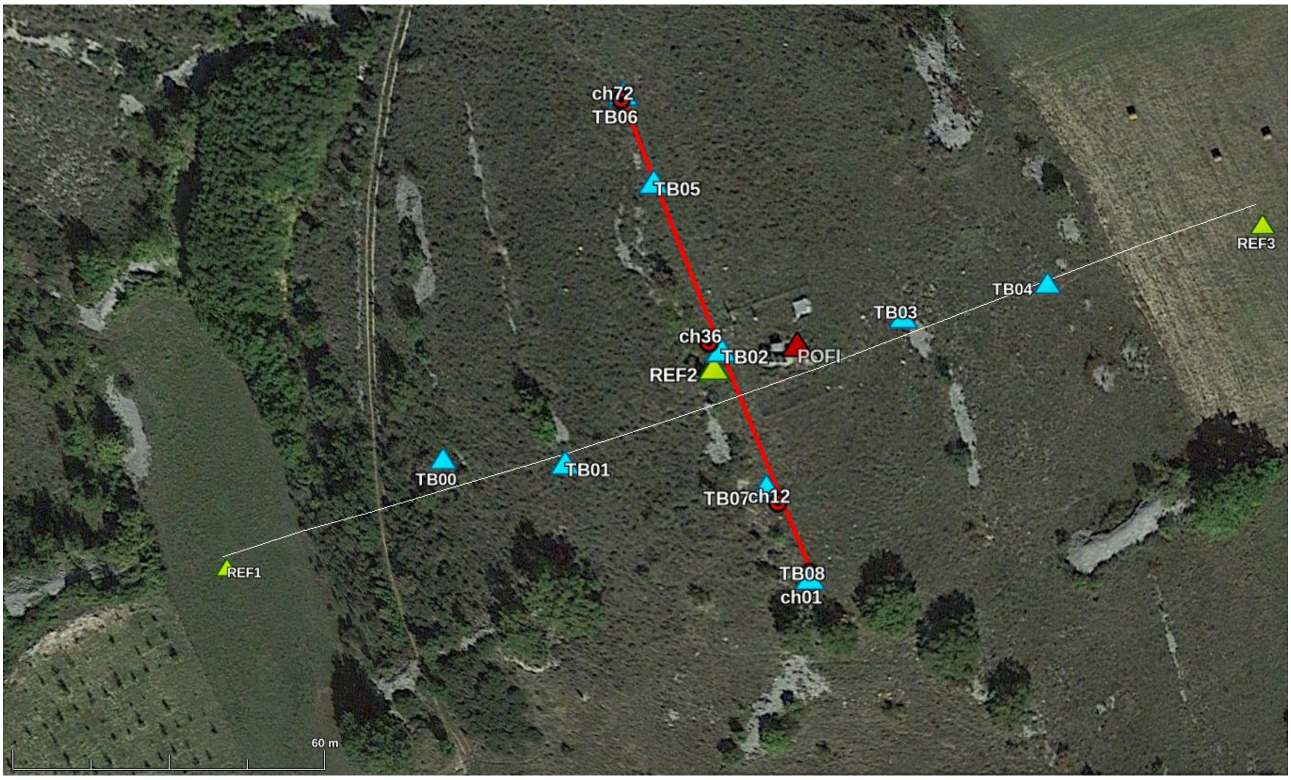

Figure B1: Map of Posta Fibreno - FR (image from Google Earth http://www.earth.google.com) showing: the position of IV.POFI station (red triangle), the line of 72 geophones (red line) used for active MASW and the positions of temporary seismic stations installed during the survey (azure and green triangles).

The geophysical surveys were performed around the permanent seismic station by locating the seismic instruments in the most suitable areas for their installation. The line of geophones has been installed at the top of the hill, following the dirt road, quite flat, which leads to the seismic station. For the temporary seismic noise measurements, part of the stations have been located

following the same line used for geophones, and the remaining part following a line orthogonal to the first one (white line of Figure B1).
The MASW survey was performed using the data acquired by 72 vertical geophones (with natural frequency of 4.5 Hz) equally spaced of 1 m. Seismic noise was acquired by 12 seismic stations: 9 Terrabot (named as TB0X) station (made by Sara srl) equipped with tri-axial geophones (having 4.5 Hz as natural frequency) and a 24 bit digitizer; 3 stations composed by a Lennartz-5s sensor coupled to a Reftek130 digitizer (named as REFX in Figure B1). Measurements were acquired on 01 October 2021 when we benefited of favorable weather conditions (sunny day without wind). Figure B2 shows some pictures taken during the performed measurements.

Figure B2. Pictures taken during the measurements day: (left) site hosting the IV.POFI seismic station; (middle) examples of temporary seismic stations in ambient noise acquisition installed on 01 October 2021; (middle) linear array installed in the same date for active MASW acquisition.

B1.1 HV noise spectral ratios

The temporary seismic stations acquired the data for about 3.5 hours that were used to compute the H/V spectral ratios at different measurement points. Figure B3 shows the H/V computed for all the 12 temporary stations. The amplitudes of the H/V spectral ratios are very different from each other with the stations equipped with the geophonic sensors (TB0X) providing, on average, larger spectral ratio amplitudes than stations equipped with the 5s sensor (REFX). This could be related to the instrumental bandwidth that for geophonic sensors is more limited (starts from 4.5 Hz upwards) compared to 5 s sensors. Beyond the amplitudes, the spectral shapes of the different H/V results are quite similar to each other and emphasize 3 significant peaks at frequencies of about 0.3 Hz; 1.2 Hz; 2.2 Hz. In figure B4 there are the H/V spectral ratios computed from data acquired at permanent IV.POFI station during the ongoing geophysical campaign. In this case, no significant spectral peaks are present in the results. We also computed daily H/V spectral ratios on data acquired over an 11-month time window (Figure B5) starting from 2020-08-01 obtaining similar results, i.e., the absence of significant peaks at the station for the entire analyzed time window, in contrast to the results obtained from the temporary noise measurements. These different results need further investigation and now we are not able to provide an explanation for the different behavior of the temporary stations compared to the permanent one. We can hypothesize that the different type of installation of the stations (for the permanent one, the sensor is in a shallow well and placed on a pillar embedded in the ground) may influence the recording, but this hypothesis needs future investigations. For now, also based on the high variability of H/V amplitudes at temporary seismic stations, we prefer to consider the results produced analyzing the permanent station data more robust than the temporary stations. In the following, we will therefore consider the spectral ratio of the permanent station IV.POFI as representative of the investigated area.

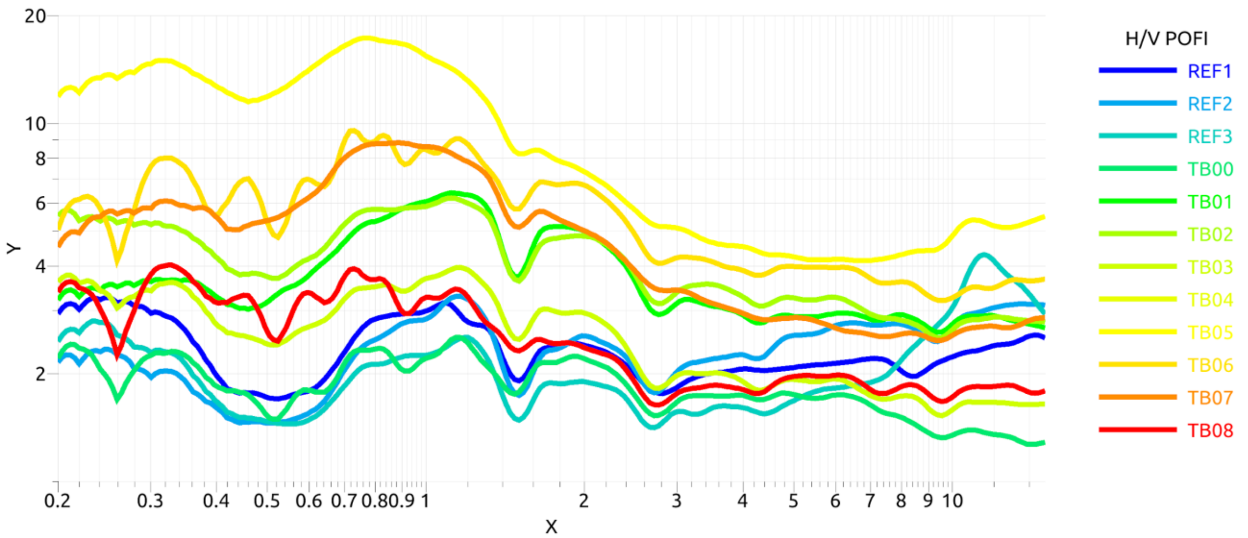

Figure B3. Results of H/V analysis performed on data acquired at 12 seismic stations installed during the geophysical survey. The mean H/V spectra are shown in different colors associated to the measuring stations.

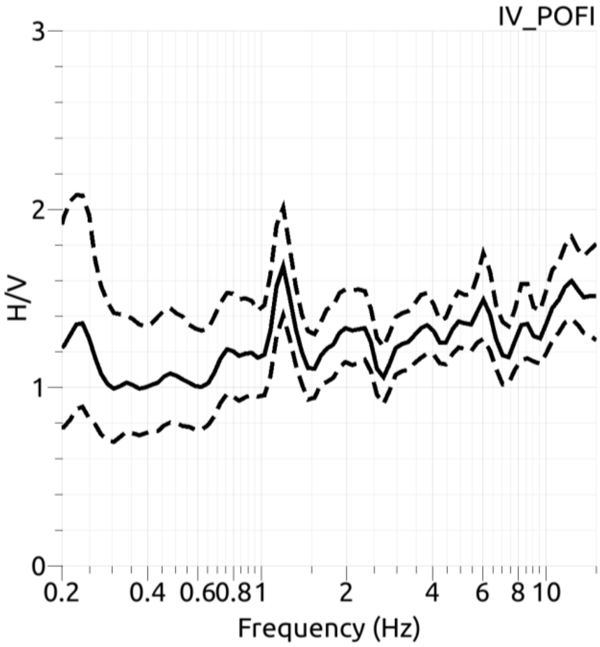

Figure B4. Results of H/V analysis performed on about 3.5 hours of data acquired at IV.POFI station during the ongoing geophysical campaign.

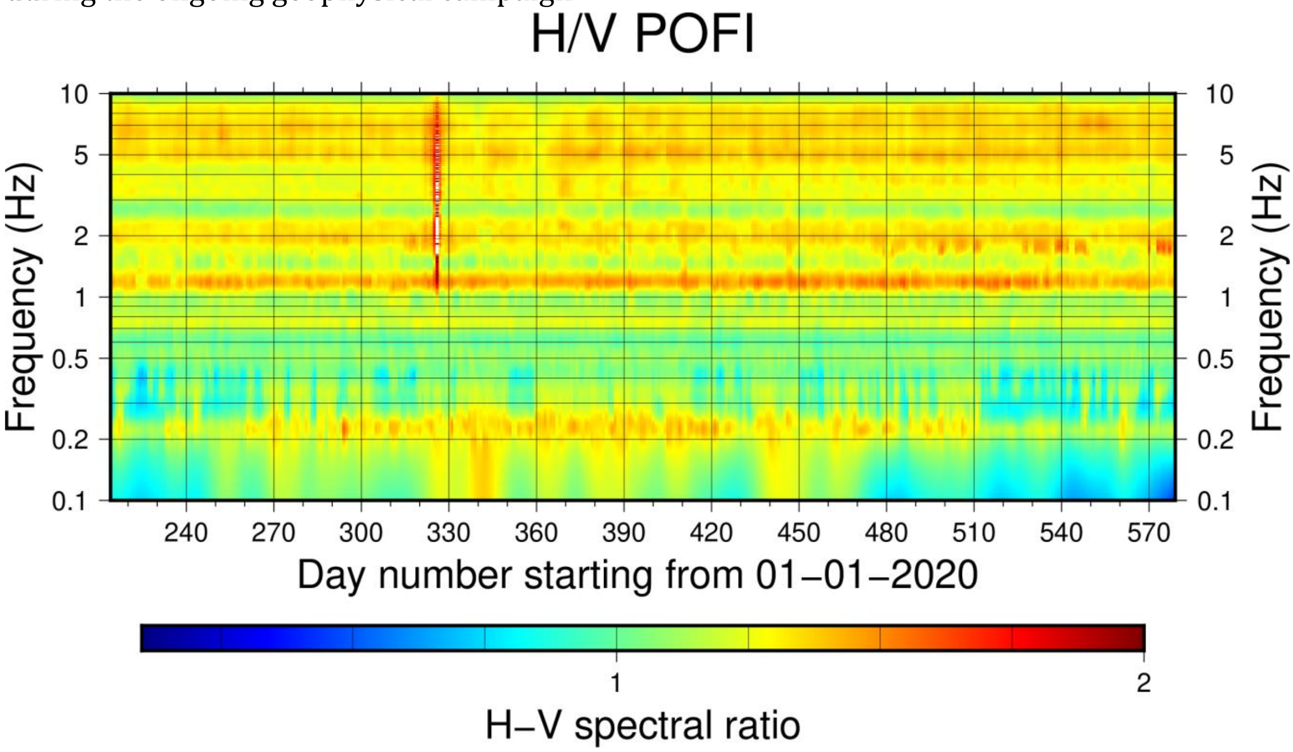

Figure 5: Daily H/V spectral ratios computed using more than 11 months of data acquired at IV.POFI station starting from 2020-08-01.

B1.2 Dispersion curves from linear array

The 72 vertical geophones were deployed along a straight line and were equally spaced of 1 m. For the MASW analysis, we acquired the seismic signals produced by the impact of a 5 kg hammer on the ground. The shots were made along the line at distances (offset) of -5 m, -1 m, 35.5 m, 72 m, 76 m from the position of the first geophone (ch01 in Figure B1 considered at 0 m). In each shot point, the measurements were repeated at least three times in order to increase data redundancy, thus trying to better verify the results obtained. The seismic data were acquired using three multi-channels systems (Geode manufactured by Geometrics, each of which manages 24 channels) using a sampling rate of 0.125 ms, the acquisition length was set to 2 s. The figure B6 shows the seismic section obtained by inserting all the seismograms acquired for the source located at -5 m at the different geophones. In the figure is well evident the seismic phase related to the first arrivals that reach the last geophone at time 0.03 s, if we consider the source-receiver distance for the last geophone (76 m), we can derive a first rough estimate of Vp equal to about 2500 m/s (estimated as 76m/0.03s). Surface waves are also quite clear and are recorded at the last geophone starting from 0.065 s, which translates into a first rough estimate of surface velocity of about 1200 m/s (estimated as 76m/0.065s).

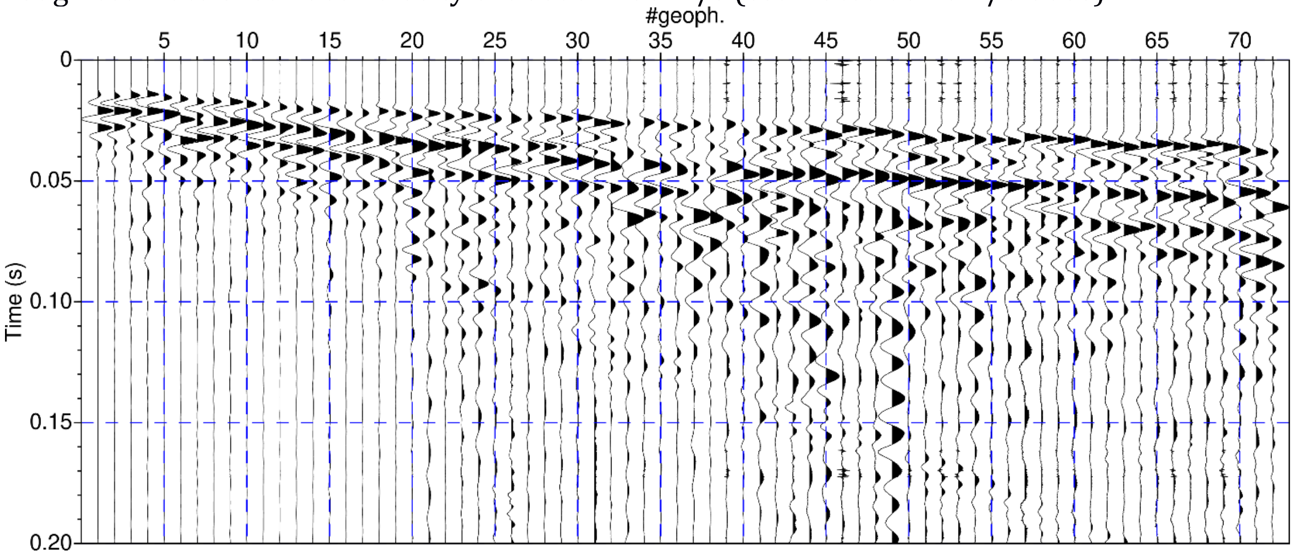

Figure B6: Common Shot Gather seismic section composed by all seismograms acquired by the different geophones for the same shot located at -5 m.

The acquired data were processed using the *GEOPSY* software tools (www.geopsy.org) in order to extract the surface-wave dispersion properties of subsoil by applying frequency-wavenumber (FK) transform to the seismic signals. Figure B7 shows the results obtained with the linear active survey (MASW).

The picking of dispersion curves was carried out manually (black lines in Figure B7). In general, the best results are those obtained for shots at -5 m and 76 m and the quality of the results gradually deteriorates as the source-receiver offset decreases. The picking of the dispersion curves has been carried out for the various results produced from shots located in the different positions of the acquisition line.

In order to obtain a new dispersion curve in a complementary way with respect to the MASW technique, the seismic noise recorded at the geophones of the linear array (about one hour of signal digitized at 250 sps) were cross-correlated between the different stations pairs. The obtained cross-correlation functions were then analyzed through a Constant Velocity Stack analysis (CVS, Vassallo et al. 2019). Figure B8 shows the results obtained by cross-correlation and by CVS analysis with the related dispersion curve (black line). The results obtained from CVS are consistent with those derived from the MASW, and allowed us to extract information on the dispersion in the frequency band 30-55 Hz.

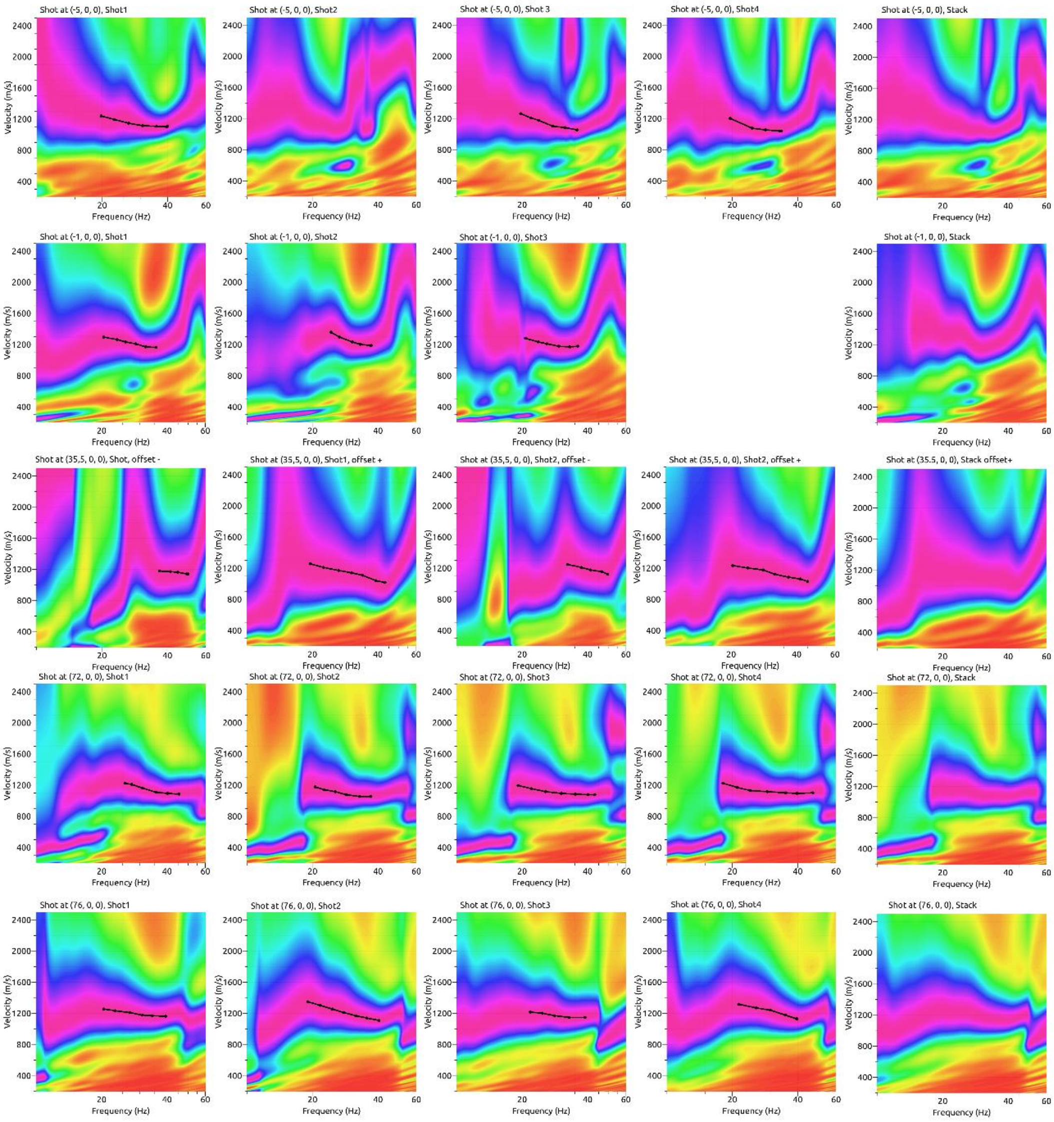

Figure B7. FK analysis. The results obtained by MASW analysis are shown for each shot location; from top to down the source position is -5 m, -1 m, 35.5 m, 72 m, 76 m. Plots in the same horizontal row refer to the same shot location and the black curves lines represent the picked dispersion curve. The plots in the last column on the right represent the stack of all results associated to the corresponding shot positions.

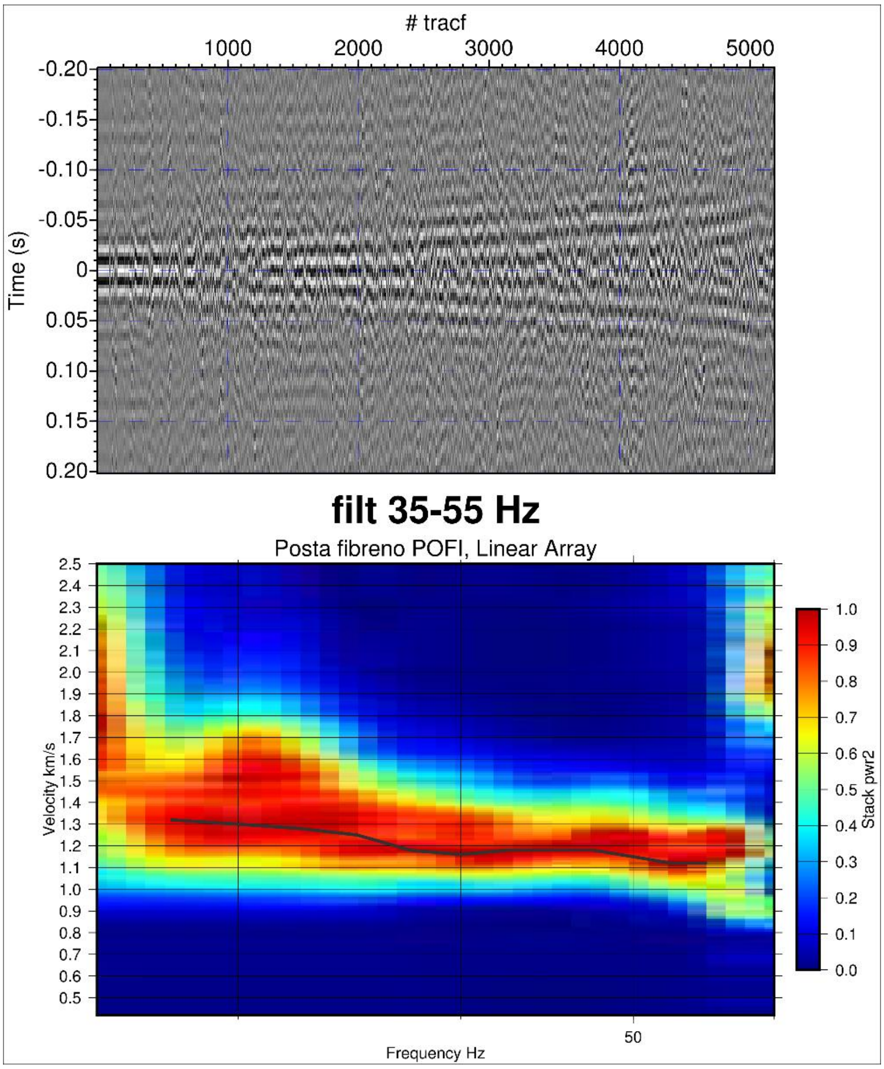

Figure B8. Results obtained by cross-correlation analysis performed on passive data acquired by 72 geophones. Top: cross-correlation functions for the different station pairs and filtered in the band 35-55 Hz. Bottom: results obtained by Constant Velocity Stack analysis on cross-correlation functions, the black line represents the picked dispersion curve.

B2. Seismic Velocity Model

Figure B9 reports all the extracted dispersion curves from the linear array of geophones. We combined all the picked dispersion curves from MASW and cross-correlation analysis in order to obtain the final dispersion curve used as target in the inversion procedure (the green curve of Figure B9).

To proceed with the inversion step, the dispersion curve derived from the vertical component of motion was associated with the fundamental mode of surface Rayleigh-wave. Then, we inverted through the *GEOPSY* tool the apparent surface-wave dispersion curve for recovering the shear-wave velocity (Vs) model.

The resulting velocity models obtained from the inversion of the dispersion curve are shown in Figure B10. We tested several simple starting model-parameterization composed of different uniforms and linear velocity increase (with depth) layers over half-space, keeping in mind the limited depth of maximum investigation associated with our dispersion curve (in the range 21-32 m). The best Vp and Vs models (i.e. lowest misfit) resulting from the inversion are shown in Figure B11 and Table B1. After a first layer of 1 m thickness, Vs reaches immediately high velocity values of about 1200 m/s, in good agreement with the geological evidence collected and obtained for the investigated site that reports, at only few meters of depth, a layered limestone bedrock ("CIR" Formation, figure A8).

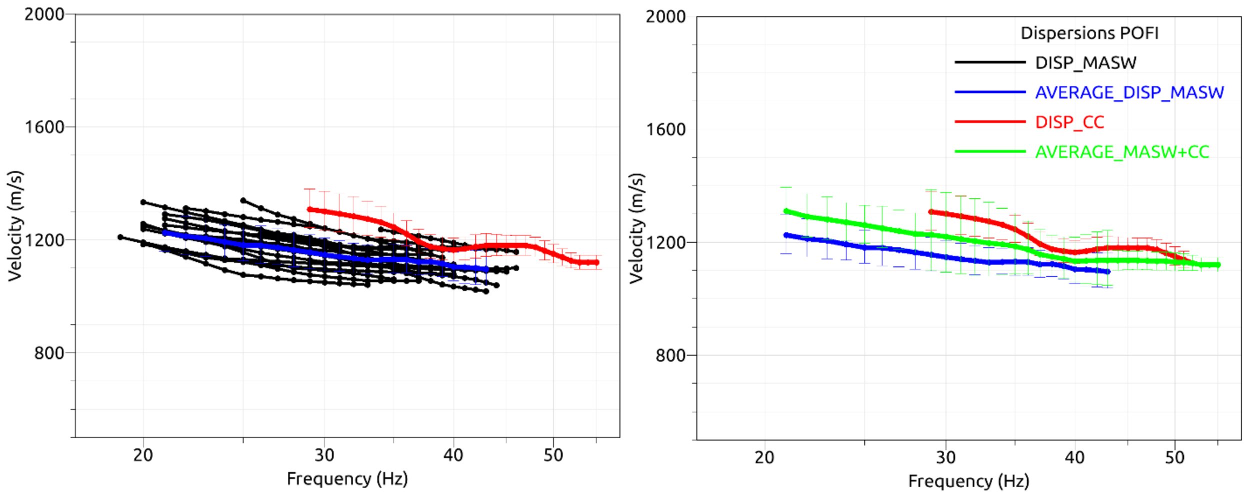

Figure B9. Left: manually-picked dispersion curves from the MASW results (black lines) and associated averaged curve (blue line); dispersion curve from the CVS on cross-correlation functions (red lines). Right: curve used as input data of inversion procedure (green line) obtained by averaging the two dispersions from MASW (blue curve) and from CVS analysis (red curve).

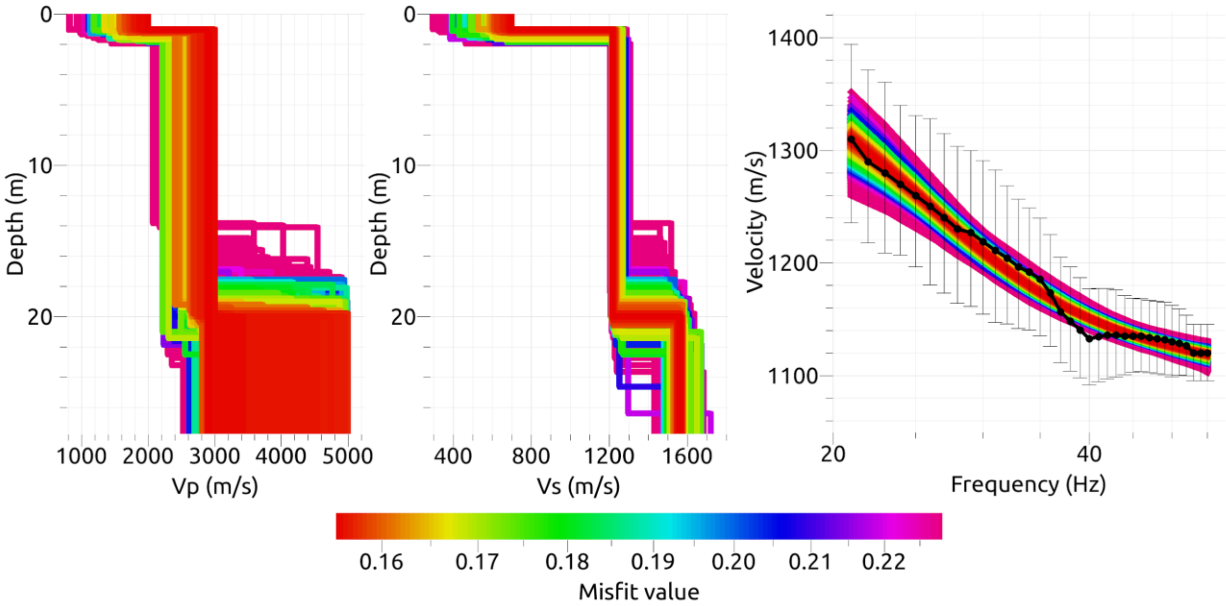

Figure B10. Models derived from the inversion of the experimental dispersion curve. Vp models on the left, Vs models in the middle and theoretical dispersion curves on the right (the experimental dispersion is shown in black). The color scale is proportional to the misfit between experimental curve and theoretical models. The best Vp and Vs model (i.e. lowest misfit) are presented in Figure B11.

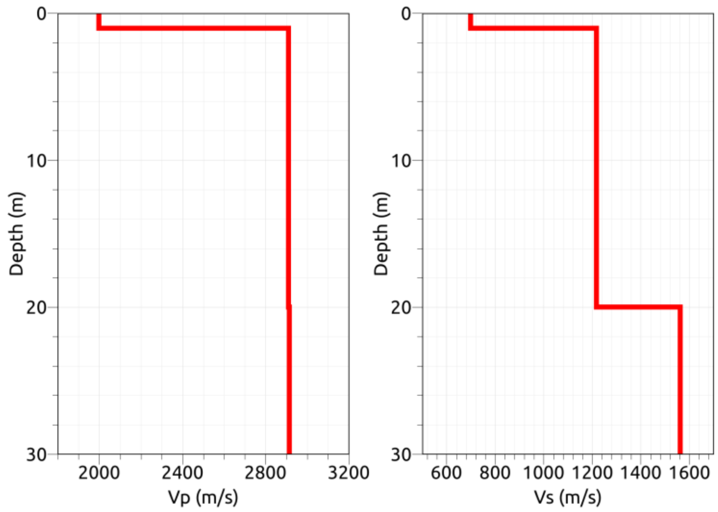

Figure B11. Best Vp and Vs models (among the models shown in Figure 15) obtained after the inversion of the experimental apparent surface-wave Rayleigh dispersion curve.

Table B1. Best-fit model

From (m)	To (m)	Thickness (m)	Vp (m/s)	Vs (m/s)
0	1	1.	1998.5	699.8
1	19.98	18.98	2910.2	1217.5
19.98	--	--	2913.1	1563.1

B3. Conclusion

Surface-wave analysis at IV.POFI station indicates that high Vs seismic velocities observed at shallow depths characterize the site. The best Vp and Vs models (i.e. lowest misfit) resulting from the inversion are shown in Figure B11 and Table B1.

H/V noise spectral ratios of the temporary stations installed during the survey show different spectral peaks that, however, are not obtained from the analysis performed on the IV.POFI permanent seismic station.

The active linear array of geophones provided a final dispersion curve from 20 Hz to 55 Hz (Figure B9), and the inversion procedure resulted in the Vs models of Figure B10 and B11 where the bottom bedrock layer is found at a depth of 1 m (Table B1).

The V_{S30} retrieved from the best inverted model is 1280.5 m/s (Table B2), therefore IV.POFI is classified following EC8 or NTC08 as soil class A. Following the definition of $V_{S,eq}$ within NTC18, since the value of 800 m/s is reached at a depth of 1 m, $V_{S,eq}$ is equal to 699.8 m/s and the site can be related to class B.

We highlight that this site was previously related to class A in the Itaca database, where in absence of direct velocity measurements the site classification was assigned only considering the outcropping lithotypes.

Further investigations will be needed to explore the disagreement between H/V results obtained from the noise measurements at temporary stations and at the permanent IV.POFI station. However, they are beyond the goal of the present study.

Table B2. f_0 value, and soil class following NTC08 and NTC18.

f_0 (Hz)	**Note**
No peak	The absence of a peak in the H/V spectral ratios is supported by analyses performed on data acquired from the permanent station IV.POFI. However, we have to investigate the disagreement between results obtained from the H/V on the noise measurements at temporary stations and at the permanent IV.POFI station.

V_{S30} (NTC08 or EC8)	**Soil Class**
1280.5 m/s	A

$V_{S,eq}$ (NTC18)	**Soil Class**
699.8 m/s	B

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[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)"

GENERAL INFORMATION

Authors	Institutions	Contacts [email]	Compiling date [DD/MM/YY]
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Station description

Station name	Network code	Latitude [WGS84]	Longitude [WGS84]	Sensor depth [m]
POFI	IV	41.71743	13.71202	At ground level

Site characterization summary

Indicators				
fo +/- std [Hz]	Value	No Peak	Quality index Qi1	0.67
	References	This report		
	URL of report	http://hdl.handle.net/2122/15054		
Velocity profiles [YES/NO]	Value	YES	Quality index Qi1	1
	References	This report		
	URL of report	http://hdl.handle.net/2122/15054		
Vs30 +/- std [m/]	Value	1280.5+/-200	Quality index Qi1	1
	References	This report		
	URL of report			
Surface geology [short description]	Value	limestone	Quality index Qi1	1
	References			
	URL of report			
Seismological bedrock depth +/- std [m]	Value	1+/-1	Quality index Qi1	1
	References			
	URL of report			
Site class EC8	Value	A	Quality index Qi1	1
	References			
	URL of report			
Engineering bedrock depth +/- std [m]	Value	1+/-1	Quality index Qi1	1
	References			
	URL of report			

Distance from the seismic station [m]		Final quality index (Final_QI)	Comments
min	min		
10	40	0.96	QI2=0.92 and QI3=1

RESONANCE FREQUENCY

fo +/- STD [Hz]	No Peak
Quality index 1	0.67

Source	Earthquake	☐	Ambient noise	☑

Ambient noise

Method	H/V	☑	Ellipticity	☐	Other	☐
fo +/- std [Hz]	No Peak					

Experiment date [DD/MM/YY]	Distance from station [m]	Lat. [WGS84]	Lon. [WGS84]
01/10/2021	0		

Environment

Weather conditions	Sunny	Windy	Rain
	✓		
Soil-sensor coupling	Earth	Asphalt	Artificial
	✓		
Urbanization	None	Dense	Scattered
	✓		

Equipment

Sensor	Type [acc/vel]	manufacturer	cut-off frequency [Hz]
Digitizer	Type	Manufacturer	Sampling frequency [Hz]
Measurement	Number	Duration [min]	

Analysis

Software	geopsy
Smoothing type (e.g. triangular, Konno-Ohmachi, ...)	Window length [s]
Konno-Ohmachi	60

Fo uncertainty estimate from

Fo from individual windows	H/V curve width	Manual picking

Earthquake

Method	HVSR	☐	SSR	☐	GIT	☐	Other	☐
fo +/- std [Hz]								

Recording period [DD/MM/YY]		Number of earthquakes
from	to	

Epicentral distance [km]		Magnitude range	
from	to	from	to

HVSR

Seismic phase	P	S	Coda	S + coda	All

window duration [s]	Min	Max

SSR

Seismic phase	P	S	Coda	S + coda	All
Reference station	Lat. (WGS84)	Lon. (WGS84)			

window duration [s]	Min	Max

GIT

Parameters	Free (to be inverted)	Imposed
Reference paper		
Reference station	Lat. (WGS84)	Lon (WGS84)

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Vs30

Vs30 +/- STD [m/s]	1280.5
Quality index 1	1

Source	Geophysical measurements	✓	Geotechnical measurements		Digital Elevation Model (DEM)		Geology		DEM & Geology	

Geophysical measurements

Method	Surface waves methods (active, passive methods)		Borehole methods (DH, CH, PS-Logging)	
Vs30 +/- STD [m/s]	From Vs(z)	✓	From Down-Hole	
	1280.5+/-200			
	From Vr40		From Cross-Hole	
	From Vsz-Vs30 correlation		From PS Logging	
Reference relationship Vsz - Vs30				

Geotechnical measurements

Method	N-SPT		CPT		Shear strength		OTHER	
Vs30 +/- STD [m/s]								

Experiment date [DD/MM/YY]	Distance from station [m]	Lat. [WGS84]	Lon. [WGS84]

Reference relationship Vs30-geotechnical parameter		
	N-SPT	
	CPT	
	Shear strength	
	Other	

Geology

Method	Geological map		Stratigraphic log	
Vs30 +/- STD [m/s]				

Geological map scale			
Geological unit name			
Stratigraphic log	Experiment date [DD/MM/YY]	Lat. [WGS84]	Lon. [WGS84]
Reference relationship Vs30-geology			
Reference relationship Vs30-Stratigraphic log			

Digital Elevation Model

Vs30 +/- STD [m/s]				
DEM resolution		Slope range (degree)	from	
			to	
Reference relationship Slope - Vs30				

DEM & Geology

Vs30 +/- STD [m/s]	
Reference relationship Slope - Vs30 - geology	

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Vs profile

Quality index 1	1

Source

Non-invasive methods (active and/or passive seismics)			
Active surface waves	✓	Refraction	
Passive surface waves	✓	Refection	
HV / ellipticity			

Invasive methods (measurement in borehole)	
Cross-hole / Down-hole	
Geotechnical methods (CPT, SPT, ...)	
PS-Logging	

Non-invasive : surface waves methods

Experiment date [DD/MM/YY]	Distance from station [m] Min	Distance from station [m] Max	Lat. [WGS84] center location	Lon. [WGS84] center location
01/10/2021	10	40	41.717414	13.711847

Active surface waves acquisition layout

Minimum receiver spacing (m)	1
Profile length (m)*	71
Geophones number	72
Number of profiles	1

** Provide the length for the various profiles (e.g. 46 m, 94 m)*

Geophone cut-off frequency (Hz)	4.5
Geophone type (vertical / horizontal)	vertical
Geophone manufacturer	Geospace
Source (hammer, vibrator, ...)	hammer
Digitizer type	Geode
Digitizer manufacturer	Geospace

Weather conditions	Sunny	Windy	Rain	Soil-sensor coupling	Earth	Asphalt	Artificial	Urbanization	None	Dense	Scattered
	✓				✓				✓		

Passive surface waves acquisition layout

Number of sensors	72
Minimum array aperture	1
Maximum array aperture	72
Number of arrays	1
Minimum duration [min]	60

Sensor cut-off frequency (Hz)	4.5
Sensor type (vertical / horizontal)	vertical
Sensor manufacturer	Geospace
Digitizer type	Geode
Digitizer manufacturer	Geospace

Weather conditions	Sunny	Windy	Rain	Soil-sensor coupling	Earth	Asphalt	Artificial	Urbanization	None	Dense	Scattered
	✓				✓						

Type of dispersion and/or H/V estimates

		Reference paper (Name, Journal, DOI)
Rayleigh DC	✓	
Love DC		
Ellipticity		
H/V (DFA, EHVR)		
H/V (SH)		

Dispersion curves

	Rayleigh	*Love*
Min wavelength (m)	20	
Max. wavelength (m)	70	
Min. phase vel. (m/s)	1100	
Max. phase vel. (m/s)	1320	
Modes (R0, L0, ...)	R0	

H/V or Ellipticity curves

Min. frequency (Hz)	Max. frequency (Hz)

Inversion

Rayleigh waves	✓	Love waves		Ellipticity curves		H/V (DFA, EHVR)		H/V (SH)		resonance frequency	

A priori information used in inversion	seismic refraction		stratigraphic log		geotechnical information		water table depth	

Inversion algorithm/code	Dinver
Reference	

Non-invasive : body waves methods

Experiment date [DD/MM/YY]	Distance from station [m]		Lat. [WGS84] center location	Lon. [WGS84] center location
	Min	Max		

Acquisition layout

Receiver spacing (m)	
Profile length (m)*	
Geophones number	
Number of profiles	
Shot spacing (m) - reflection meas.	

** Provide the length for the various profiles (e.g. 46 m, 94 m)*

Geophone cut-off frequency (Hz)	
Geophone type (vertical / horizontal)	
Geophone manufacturer	
Source (hammer, vibrator, ...)	
Digitizer type	
Digitizer manufacturer	

Weather conditions	Sunny	Windy	Rain	Soil-sensor coupling	Earth	Asphalt	Artificial	Urbanization	None	Dense	Scattered

Processing methods

		Reference paper (Name, Journal, DOI)
classical refraction		
refraction tomography		
classical reflection		
advanced method		

Invasive methods

	Down-Hole	Cross-Hole	PS-Logging	SPT	CPT	OTHER
Borehole depth (m)						
Geophone type						
Source type						
Distance between wells						
Depth resolution (m)						
Latitude (WGS84)						
Longitude (WGS84)						
Distance from station (m)						
P-wave velocity						
S-wave velocity						

Processing methods

		Reference paper (Name, Journal, DOI) or ASTM norm
Down-Hole		
Cross-Hole		
PS-Logging		
SPT		
CPT		
OTHER		

Authoritative velocity profile

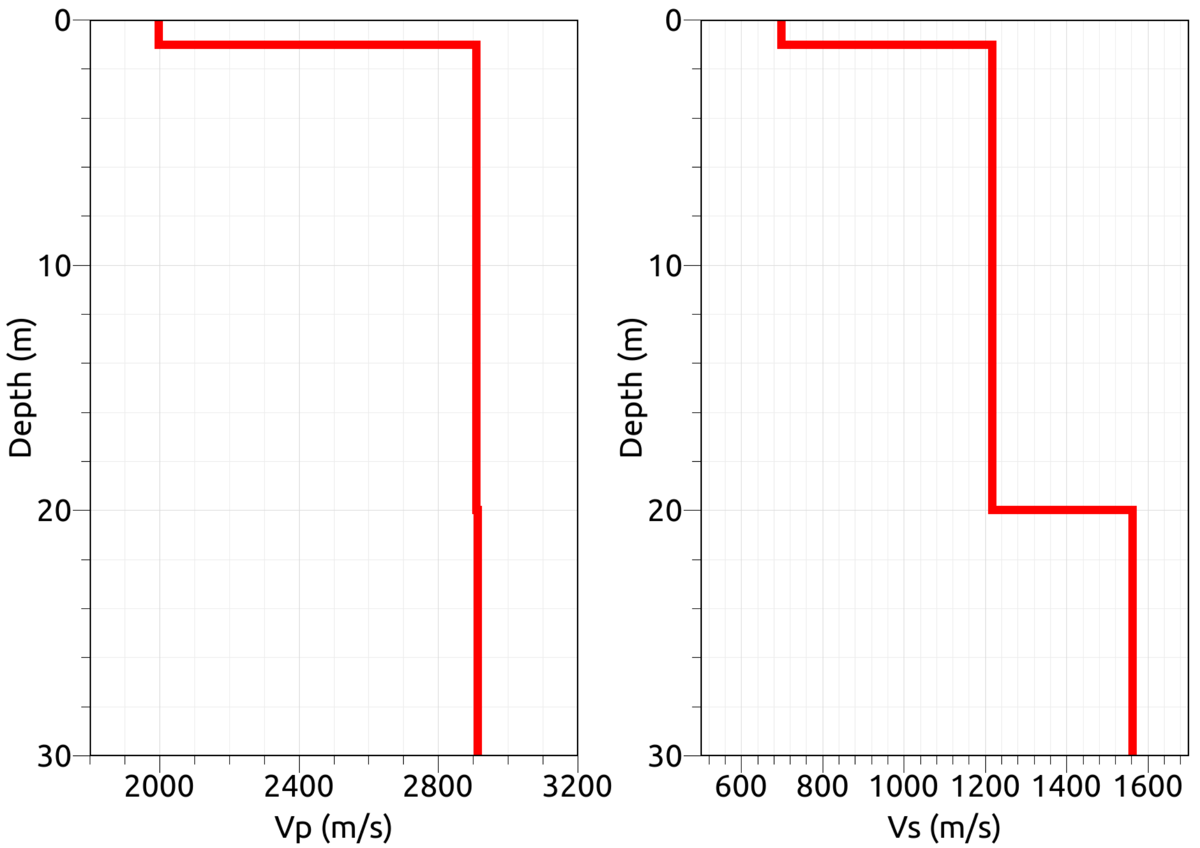
Note: You do not have to fill in all the columns. You can provide either single values for Vp or Vs (e.g. profiles derived from borehole measurements) or either a range for Vp and Vs (e.g. profiles derived from stochastic surface waves inversion)

Is Vs derived from Vp ?	**Yes**	☐	**No**	☑

Top depth (m)	Bottom depth (m)	Vp (m/s)	STD Vp (m/s)	Vs (m/s)	STD Vs (m/s)
0	1	1998.5		699.8	
1	19.98	2910.2		1217.5	
19.98	--	2913.1		1563.1	

Vs range		Vp range	
Vs min (m/s)	Vs max (m/s)	Vp min (m/s)	Vp max (m/s)

Figure with authoritative velocity profiles



Surface geology

Quality index 1	1

Source	Cartography (geological, lithological, ...)		Field survey	X	Stratigraphic log	

Geological map

Map reference	Geological Map of Italy Sheet N. 152 “Sora”;Geological-technical map Seismic Microzonation	
Map scale	1:10000	
Map sheet		
Predominent geologic/lithologic unit	Name :	CIR
	Description :	Calcari stratificati
	Age :	(Aptian p.p-Albian)
	Thickness :	
	Rock mass structure :	
Fault presence		
Weathering		
Cross-section	X	

Field survey

Map reference		
Map scale		
Predominent geologic/lithologic unit	Name :	
	Description :	
	Age :	
	Thickness :	
	Rock mass structure :	
Fault presence		
Weathering		
Cross-section		

Stratigraphic log

log depth (m)	

Top depth (m)	Bottom depth (m)	Stratigraphic description

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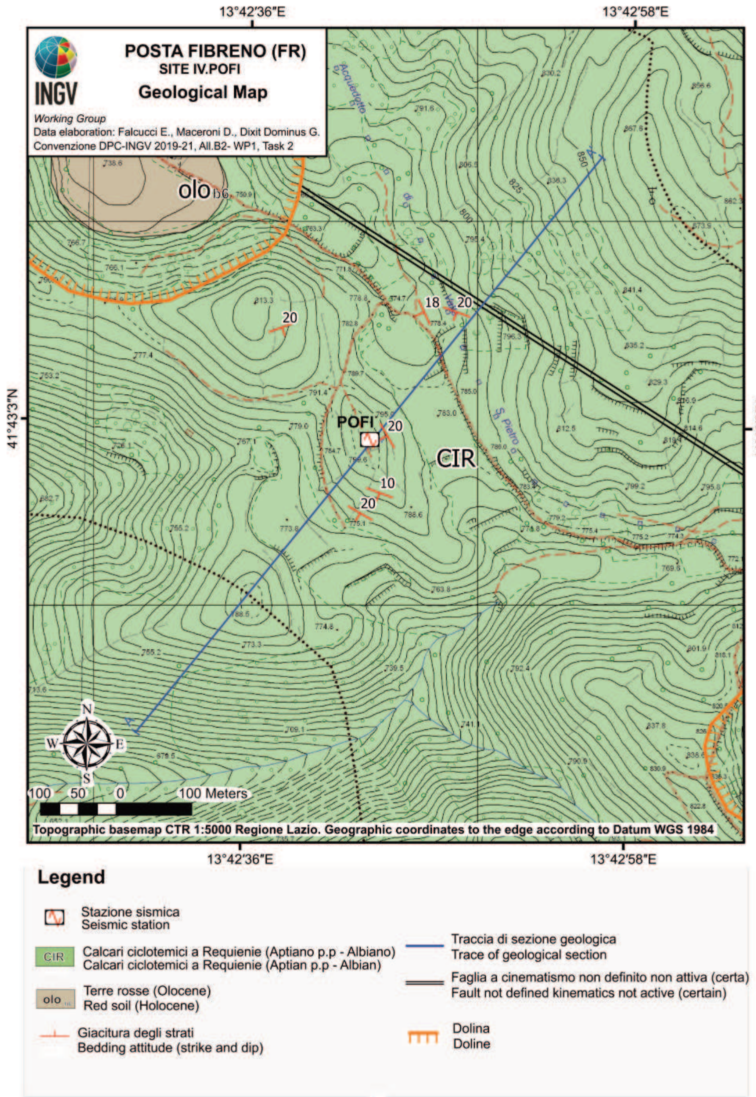
Surface geology

Map



Site class

Site class	A
Quality index 1	1

Reference building code for site classification (EC8-1, EC8-2, NEHRP, national code, ...)	EC8，NTC18

Source	Geophysical measurements	✓	Geotechnical measurements		Digital Elevation Model (DEM)		Geology		DEM & Geology	

Reference relationship geology - soil class	
Reference relationship slope from DEM - soil class	
Reference relationship slope from DEM - geology - soil class	

Parameters for deriving soil class as prescribed in building code	Vs30

Seismological bedrock depth

Depth +/- STD [m]	1
Quality index 1	1

Source	Vs profiles	✓	Geology		Other (gravity, seismic refraction, TDEM, ...)	
	Resonance frequency		Stratigraphic log			

Vs profile

	Non-invasive methods	Invasive seismic methods	Geotechnical methods
Bedrock depth +/- STD(m)	1+/-1		
Bedrock Vs +/- STD(m)	1217.5+/-200		
Bedrock Vp +/- STD(m)	2910.2+/-400		
Is Vs derived from Vp ?	Yes ☐ No ✓		

Resonance frequency

Bedrock depth +/- STD(m)	
Reference relationship Fo - bedrock depth	

Geology

Bedrock depth +/- STD(m)	
Bedrock geological unit	
Reference	

Stratigraphic log

Bedrock depth +/- STD(m)	
Bedrock geological unit	
Reference	

Other methods

	Bedrock depth +/- STD(m)	Reference
Gravity		
Seismic refraction		
Seismic reflection		
TDEM		

Engineering bedrock depth

Depth +/- STD [m]	1
Quality index 1	1

Reference Vs related to engineering bedrock in m/s	800	Reference building code for site classification (EC8-1, EC8-2, NEHRP, national code, ...)	EC8, NT18

Source	Vs profile	✓	Geology		Stratigraphic log	

Vs profile

	Non-invasive methods	Invasive seismic methods	Geotechnical methods
Bedrock depth +/- STD(m)	1+/-1		

Is Vs derived from Vp ?	Yes		No	✓

Geology

Bedrock depth +/- STD(m)	
Bedrock geological unit	
Reference	

Stratigraphic log

Bedrock depth +/- STD(m)	
Bedrock geological unit	
Reference	

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