UNIVERSITÀ DEGLI STUDI DI TRIESTE

MICROZONAZIONE sismica

H/V

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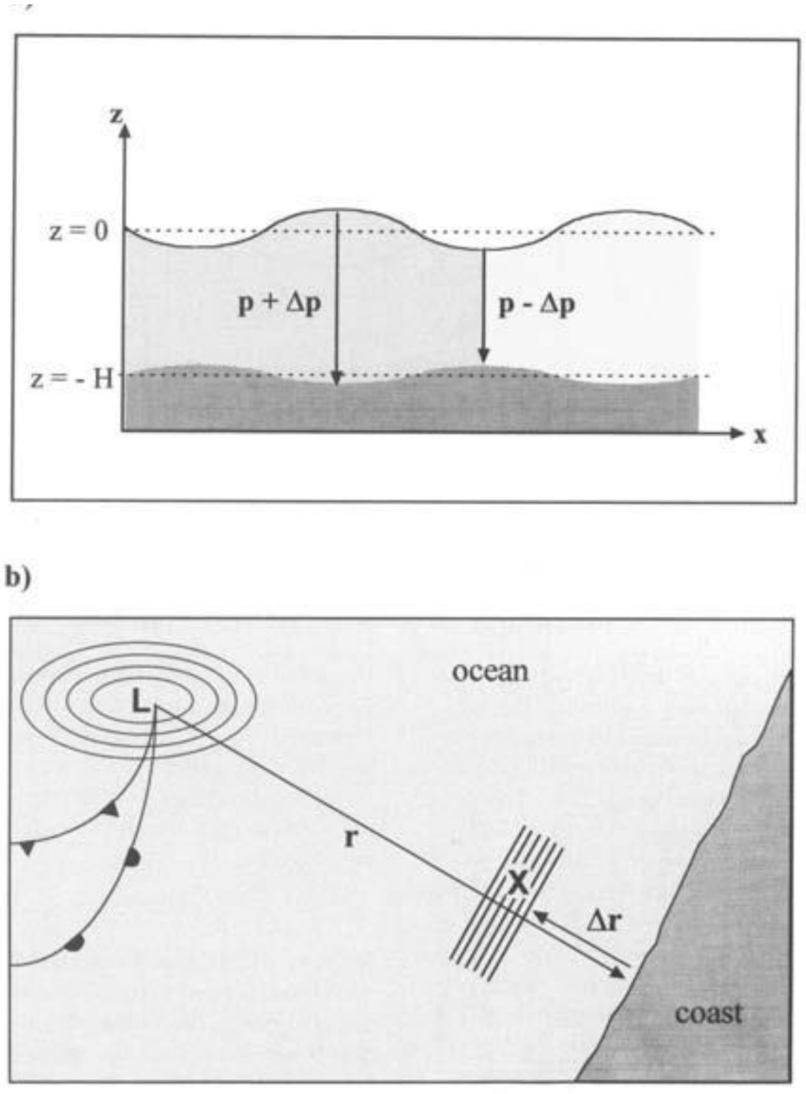
- At low frequencies ($f < f_{nh}$ » 1Hz), the origin is essentially natural, with particular emphasis on ocean waves, which emit their maximum energy around 0.2 Hz. These waves can be seen very easily on islands and/or during ocean storms. Higher frequencies (around 0.5 Hz) are emitted along coastal areas due to the interaction between ocean waves and shorelines. Some lower frequency waves (f << 0,1 Hz) are also associated with atmospheric forcing, but this frequency range has little interest for engineering seismology. Higher frequencies (> 1 Hz) may also be associated with wind and water flows

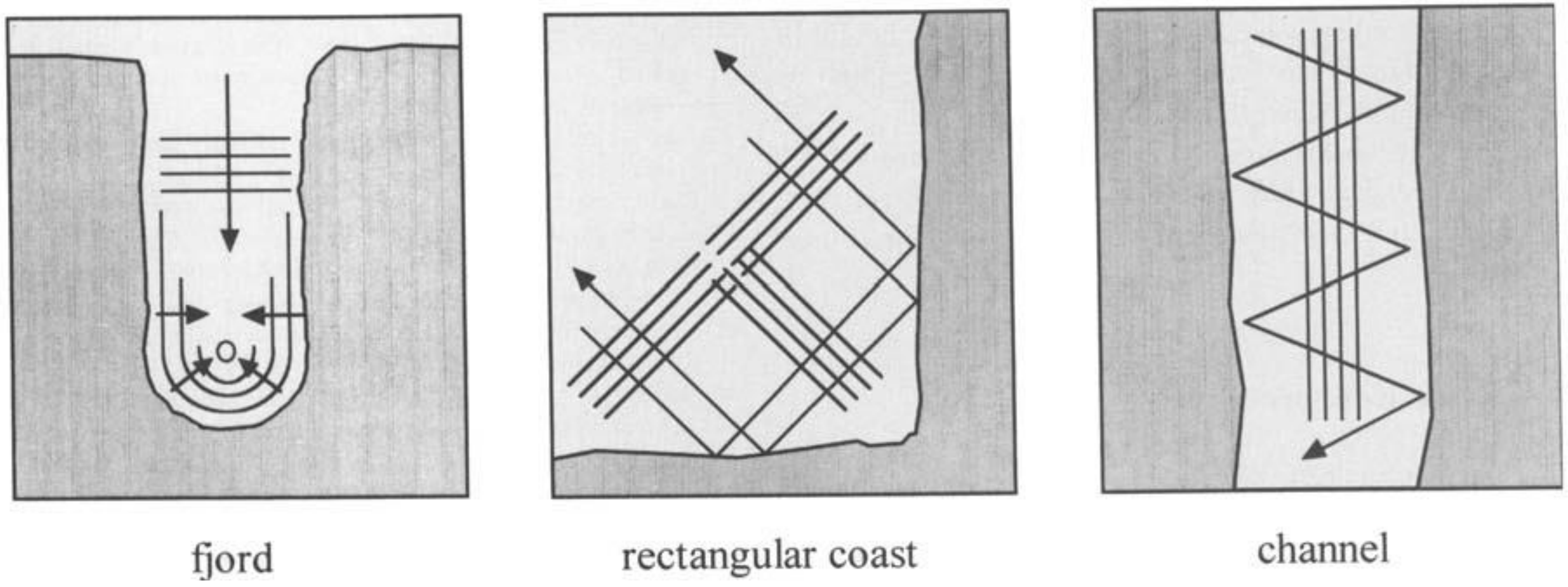
- At higher frequencies ($f > f_{nh}$ » 1Hz), the origin is mostly related to human activity (traffic, machinery); sources are mostly localized on the earth's surface (except for a few sources such as subways) and often show strong day/night and week/weekend variability.Translated with DeepL.com (free version)

	Natural	**Human**
Name	Microseism	Microtremor
Frequency	0.1 – f_{nh} (0.5 Hz to 1 Hz)	f_{nh} (0.5 Hz to 1 Hz) – > 10 Hz
Origin	Ocean	Traffic / Industry / Human activity
Incident wavefield	Surface waves	Surface + body
Amplitude variability	Related to oceanic storms	Day/ Night, Week / week-end
Rayleigh / Love issue	Incident wavefield predominantly Rayleigh	Comparable amplitude – slight indication that Love waves carry a little more energy
Fundamental / Higher mode issue	Mainly Fundamental	Possibility of higher modes at high frequencies (at least for 2-layer case)
Further Comments	Local wavefield may be diffe-rent from incident wavefield	Some monochromatic waves related to machines and engines. The proximity of sources, as well as the short wavelength, probably limits the quantitative importance of waves generated by diffraction at depth



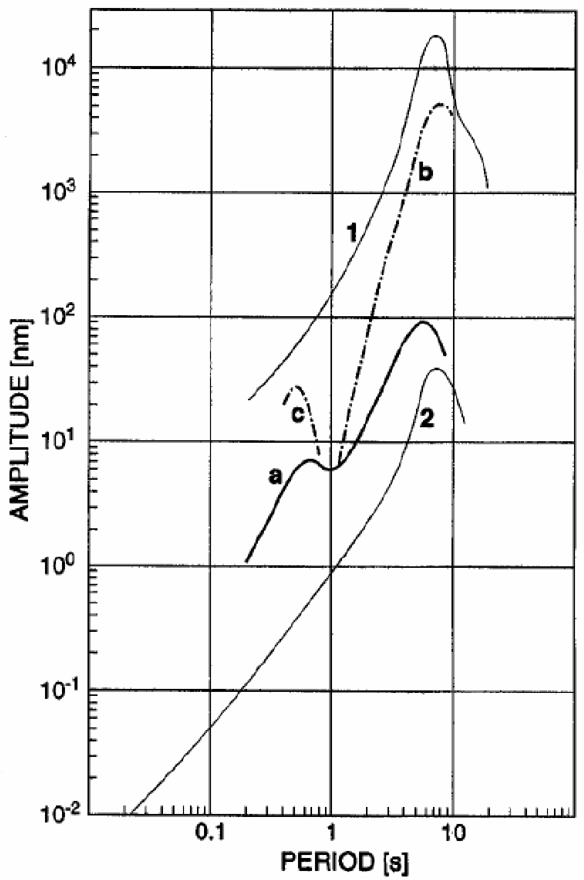
Patterns of generation of (a) primary and (b) secondary microseisms. L - low pressure area of the cyclone, X - interference area where waves with half the period of ocean waves develop.

Primary ocean microseisms are generated only in shallow waters in coastal regions. Here wave energy can be converted directly into seismic energy by changes in vertical pressure, or by wave splitting on the shores, which have the same period as water waves (T >> from 10 to 16 s). Compare the spectra of the microseisms, there is a close relationship between the two data sets. In contrast, secondary oceanic microseisms can be explained as generated by the superposition of ocean waves of equal period traveling in opposite directions, thus generating mid-period standing gravitational waves. These standing waves cause nonlinear pressure perturbations that propagate without attenuation to the ocean floor. The X-interference area can be off-shore where the propagating waves in one direction generated by a low-pressure area L overlap with waves traveling in the opposite direction after being reflected from the coast. But it could also be in the far deep ocean when waves, excited first at the front front of the low-pressure area, later interfere with waves generated by the cyclone's rear front. The horizontal and vertical noise amplitudes of marine microseisms are similar. The motion of the particle is of the Rayleigh wave type, that is, elliptical polarized in the vertical propagation plane. Translated with DeepL.com (free version)



Esempi di geometrie della costa che forniscono condizioni di interferenza adeguate per la generazione di microseismi secondari.

While the harmonic components of transient seismic signals radiate from localized sources of finite duration is coherent and their phase relationships defined by the phase spectrum, this is not the case for ambient seismic noise. The latter is caused by a diversity of different, spatially distributed, mostly uncorrelated and often continuous sources. Seismic noise forms, therefore, a more or less stationary stochastic process without a defined phase spectrum. The same is true for electronic instrumental noise and thermal noise of seismic mass motion. Early efforts, in the years of analog seismology, to obtain a quantitative measurement of seismic noise as a function of frequency was based on the envelopes of peak amplitudes in given time intervals for seismic noise at different times of the day and year. Such presentations are not adequate when based on records, or filtered time series, of different bandwidths and it is impossible to resolve spectral details.



Envelopes of maximum and minimum peak amplitudes for rural environments as determined from analog seismograph records of different types over a long period of time (curves 1 and 2: high and very low noise sites, respectively) together with envelope curves of peak noise amplitudes at the MOX station, Germany, at times of minimum (a) and maximum noise.

Due to the stochastic nature of seismic noise the amplitude spectrum and phase spectrum cannot be calculated. We must, therefore, determine the *power spectral density* P(w) which is the Fourier transform of the autocorrelation function:

$$p(\tau) = < f(t)\, f(t+\tau) >$$

The symbol <> indicates the average over time.

$$P(\omega) = \int_{-\infty}^{\infty} p(\tau) \exp(-i\omega t)\, d\tau$$

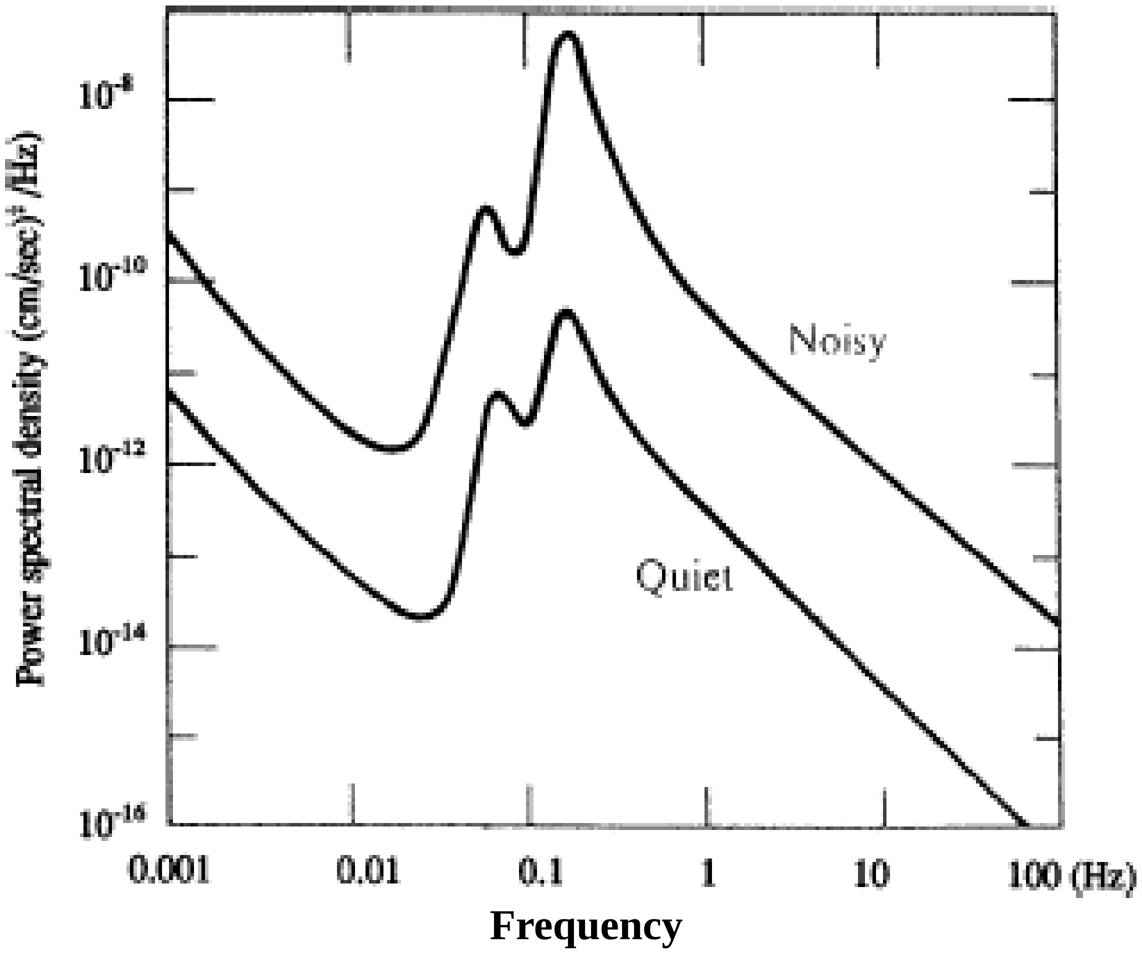
Depending on whether ls f(t) is a displacement, velocity or acceleration the units of P(ω) are:

$$m^2 / Hz \qquad (m/s)^2 / Hz \qquad (m/s^2)^2 / Hz$$

Conoscendo il valore del *power spectral density* $P_d(\omega)$, si può calcolare i rispettivi valori in velocità (P_v) o accelerazione (P_a),
Knowing the value of power spectral density $P_d(\omega)$, one can calculate the respective values in velocity (P_v) or acceleration (P_a),

$$P_v(\omega) = P_d\,\omega^2 = 4\pi^2 f^2 P_d$$

$$P_a(\omega) = P_d\,\omega^4 = 16\pi^4 f^4 P_d = 4\pi^2 f^2 P_v$$



Power spectral density in velocity of ambient seismic noise under noisy and quiet conditions for a typical seismic station on compact rock.

Da: New Manual of Seismological Observatory Practice – NMSOP
CHAPTER 4: Seismic Signals and Noise (Peter Bormann)

Power spectral density in velocity of ambient seismic noise under noisy and quiet conditions for a typical seismic station on compact rock.

$$10\log\left[\left(a_1/a_2\right)^2\right] = 20\log\left(a_1/a_2\right)$$

then the energy density spectrum in dB, referred to

$$1\left(m/s^2\right)^2/Hz$$

can be written:

$$P_a[dB] = 10\log\left(P_a/1\left(m/s^2\right)^2/Hz\right)$$

Da: New Manual of Seismological Observatory Practice – NMSOP
CHAPTER 4: Seismic Signals and Noise (Peter Bormann)

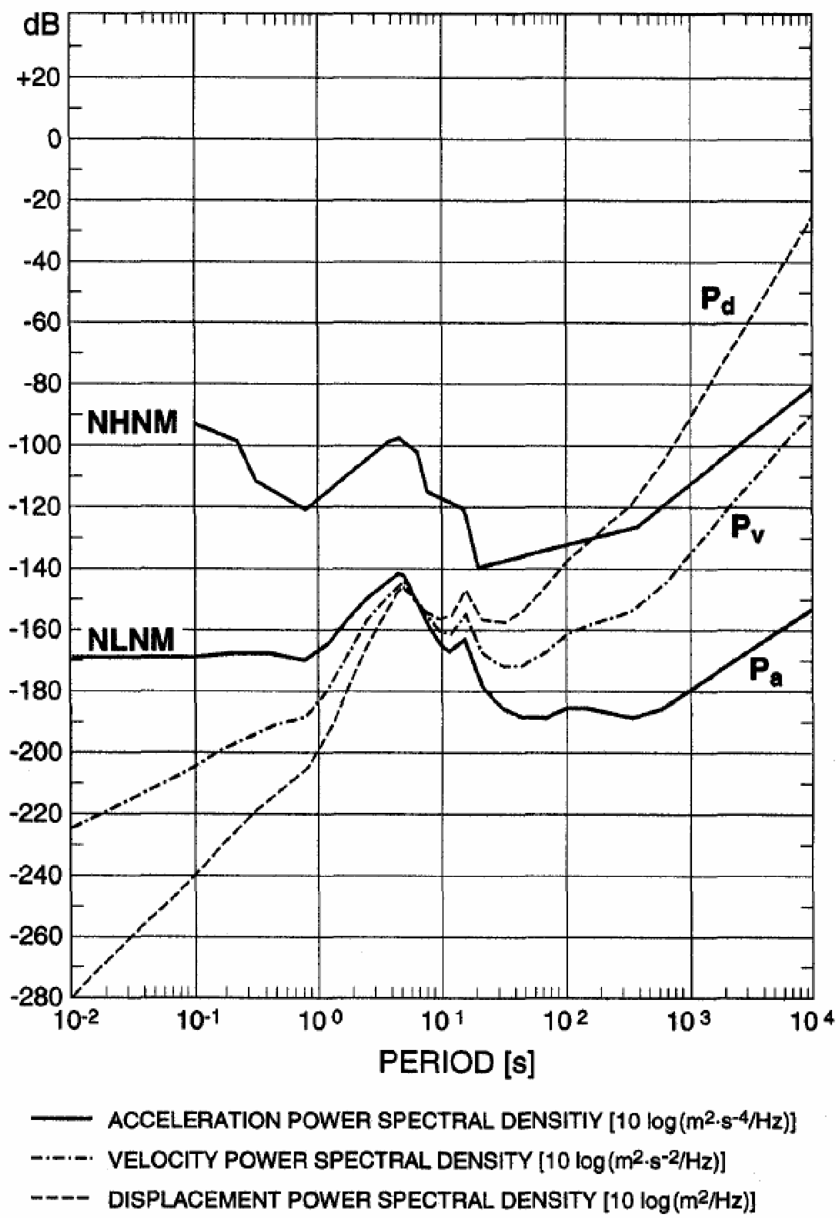
And by substituting the period T=1/f it can be written:

$$P_v[dB] = P_a[dB] + 20\log(T/2\pi)$$

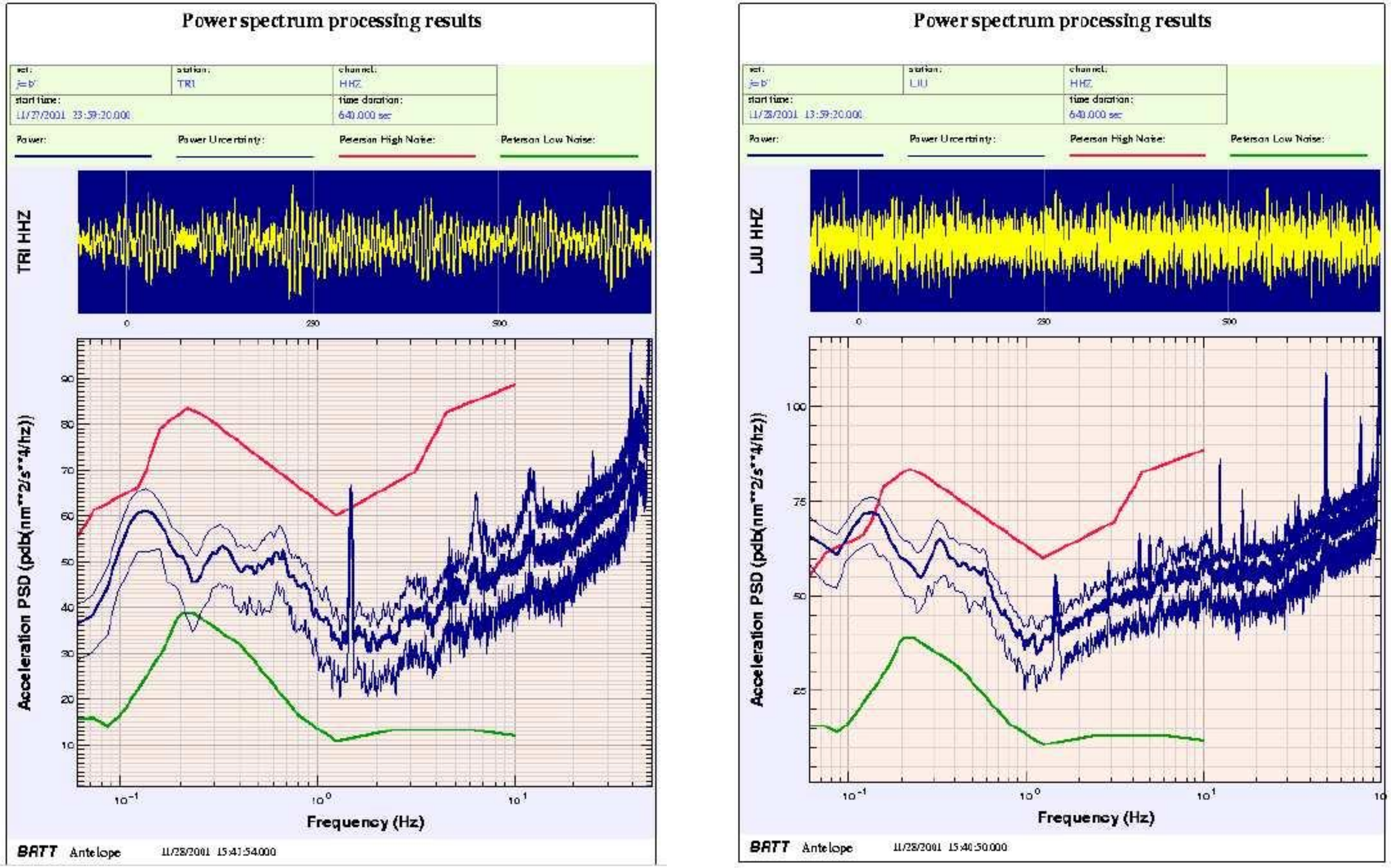
e

$$P_d[dB] = P_a[dB] + 40\log(T/2\pi) = P_v[dB] + 20\log(T/2\pi)$$

Da: New Manual of Seismological Observatory Practice – NMSOP
CHAPTER 4: Seismic Signals and Noise (Peter Bormann)



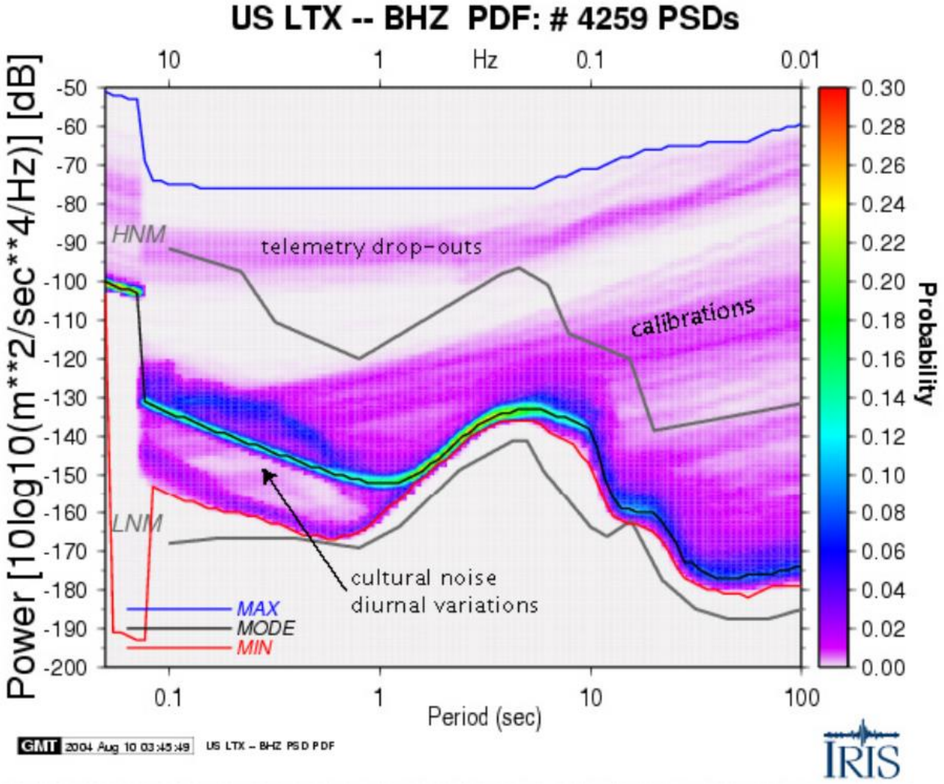
Envelope curves of power spectral density in accelerating **P_a** noise (in units of dB related to $1(m/s^2)^2/Hz$) as a function of period. The curves define the new global high (NHNM) and low noise (NLNM) models that are currently the standard accepted curves for the generally expected limits of earthquake noise. Exceptional noise can exceed these limits. For NLNM, correlated curves have been calculated for displacement and spectral power **P_d** and **P_v** density in units of dB versus $1(m/s)^2/Hz$ and $1(m/s)/Hz$ are also given.



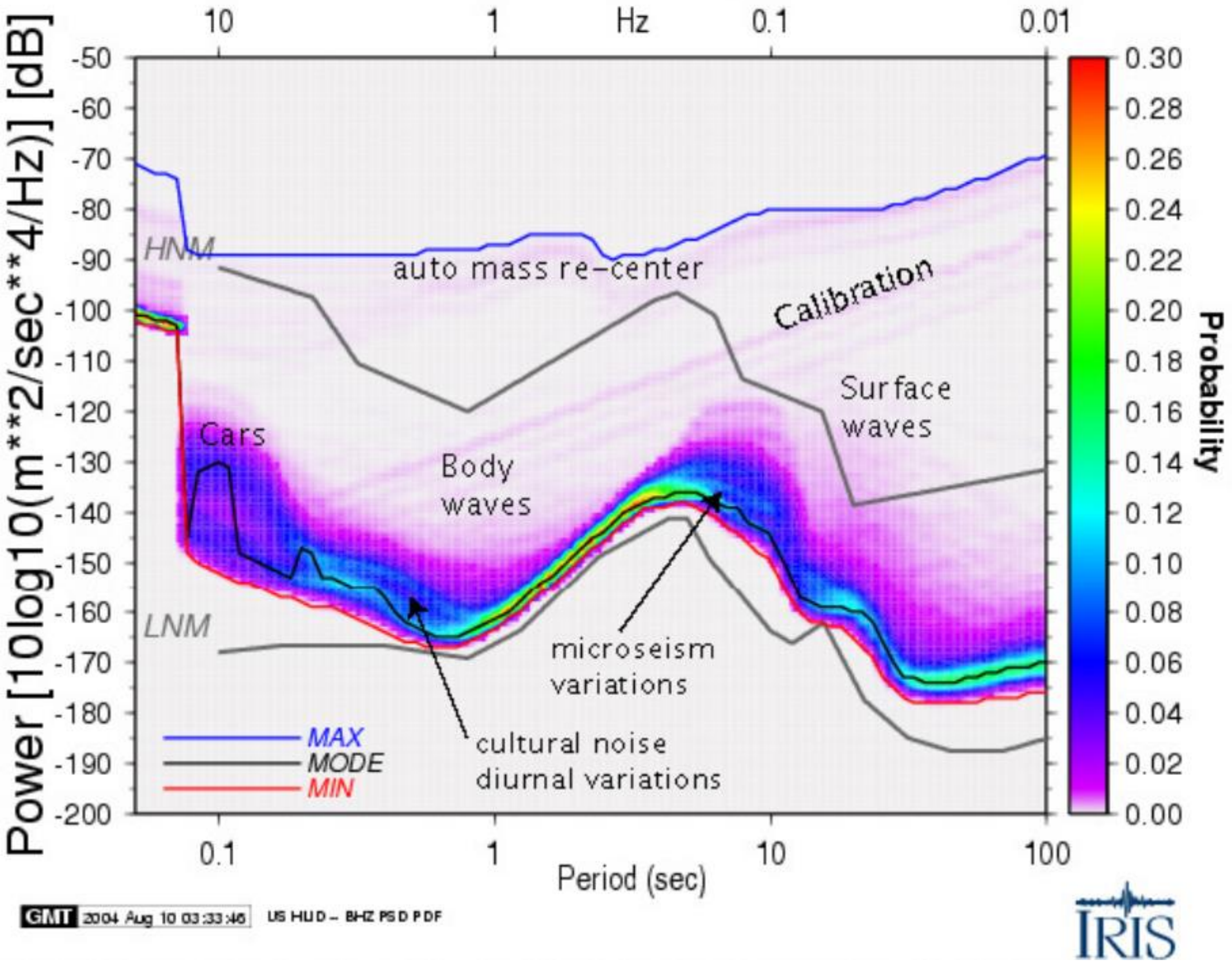
Power spectral density in accelerazione relative a circa 10 minuti di rumore registrato rispettivamente presso le stazioni larga banda TRI di Trieste e LJU di Lubiana.

A probability density function (PDF) can be used to visualize seismic power spectral density (PSD).

Long, continuous, overlapping (50 %) time series segments are processed. Earthquakes, system transients, and/or anomalies in the data cannot be removed. The instrument transfer function is removed from each segment, producing ground acceleration (for easy comparison with the LNM). Each one-hour time series is divided into 13 segments, each approximately 15 minutes long and overlapping by 75%, with each segment processed by removing the mean and long-term trend; using a sine function for tapering; applying the FFT. The segments are then averaged to provide a PSD for each segment of the 1-hour time series.The probability of a given power occurring in a given period is plotted for direct comparison with high- and low-noise Peterson models (HNM, LNM).

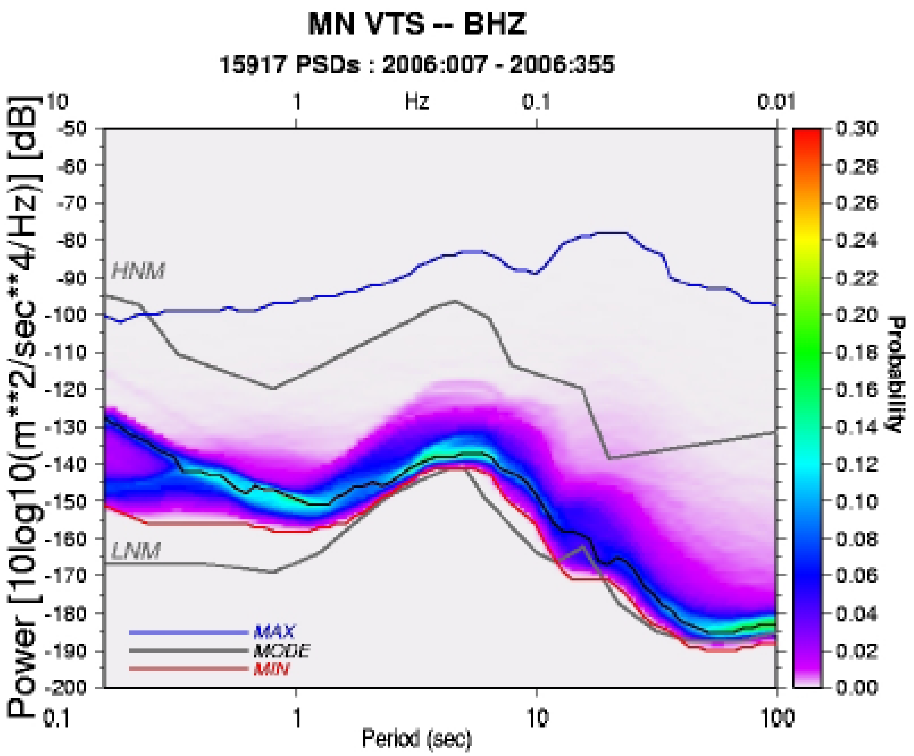


Example PDF for the BHZ component of the LTX station, with some artifacts and signals identified. The LTX station, was instrumental for the original Peterson Low Noise Model; however, due to increased cultural noise (0.1-1s, 1-10Hz) the higher probability power levels (mode, black line) are now significantly higher than the Peterson Low Noise Model (LNM). The minimum signal (red line) will approach the LNM less than 2 percent of the time, indicating that the station's minimum noise does not reflect real ambient noise conditions across the entire spectrum. Instead, ambient noise conditions are best represented by the highest probability mode (black line)

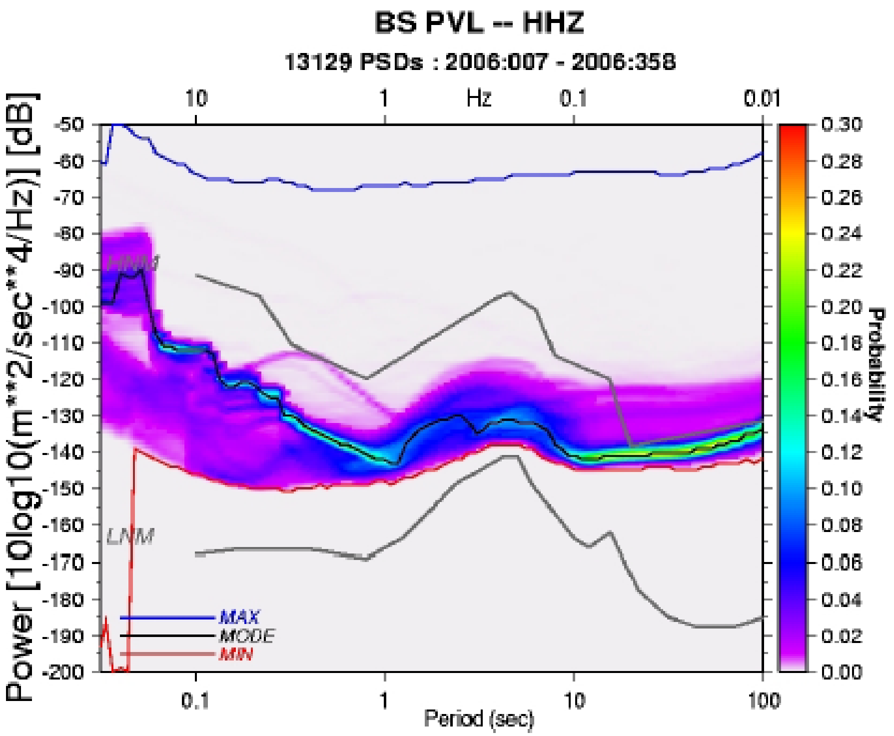


HLID station about 10 km from Hailey Idaho. Automobile traffic along a dirt road only 20 meters from the HLID station creates a noise increase of 20-30 dB at a period of about 0.1 second (10Hz). This type of cultural noise is observed in PDFs as a low probability region at high frequencies (1-10Hz, 0.1-1s). Body waves occur as a low-probability signal at the 1-second interval while surface waves are more powerful at longer periods. Recent automatic calibration and mass calibration pulses are displayed as low probability events in the PDF.

ANALISI ANNUALE



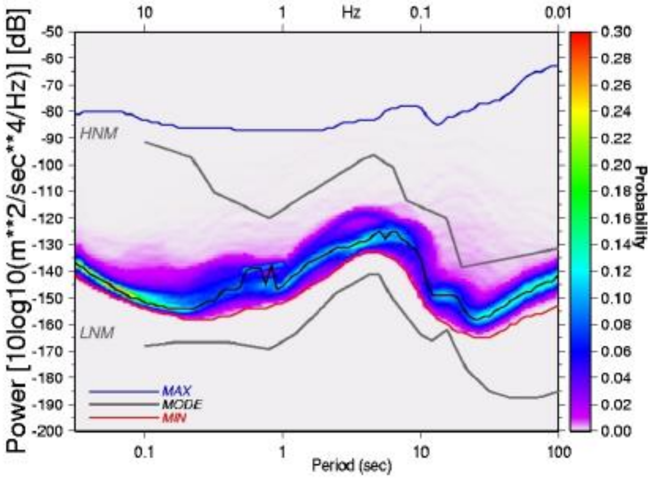
Annual PDF distribution for the BB VTS seismic station.



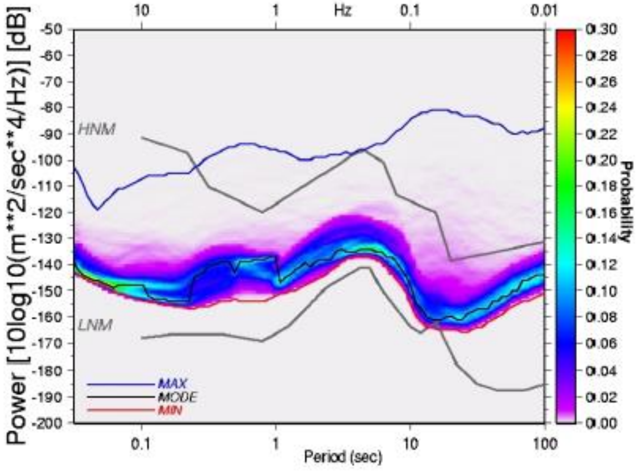
Annual PDF distribution for BB seismic station PVL

ANALISI SEASONAL ANALYSIS

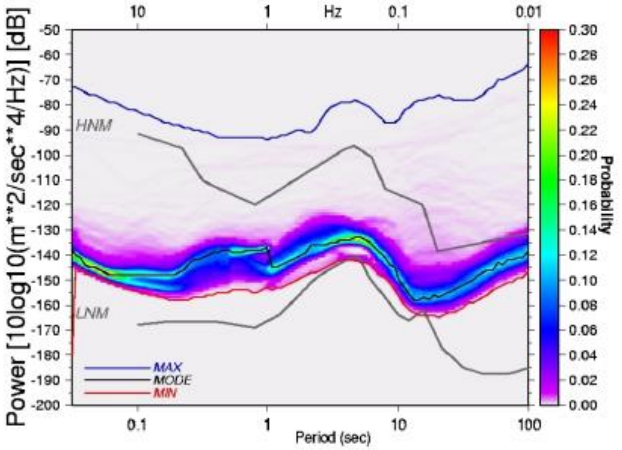
Distribuzione del noise relative alla componente HHZ alla stazione MPE durante le diverse stagioni.



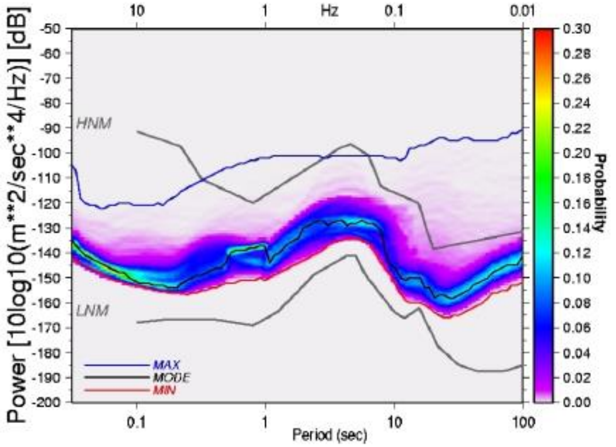
WINTER



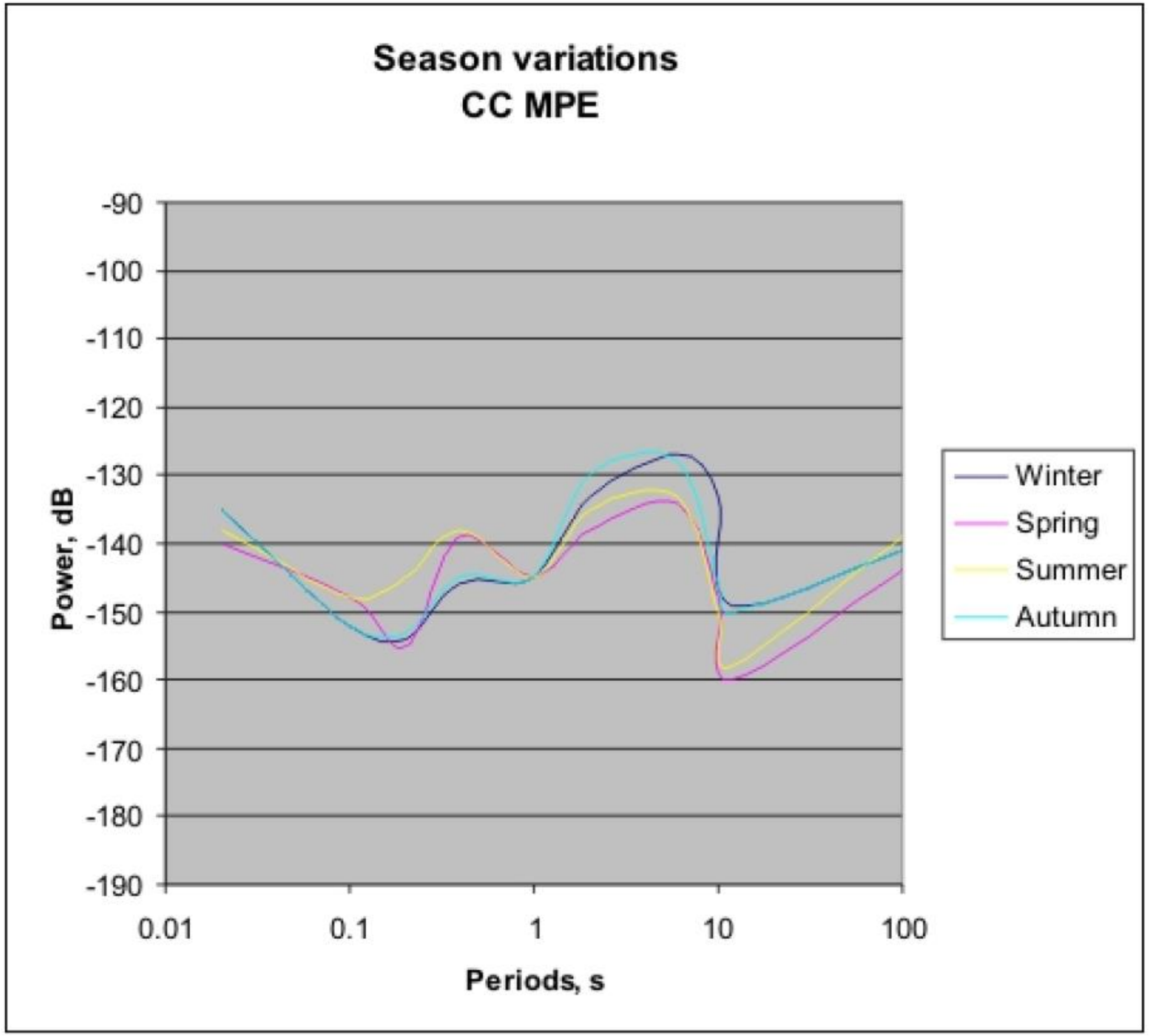
PRIMAVERA



SUMMER



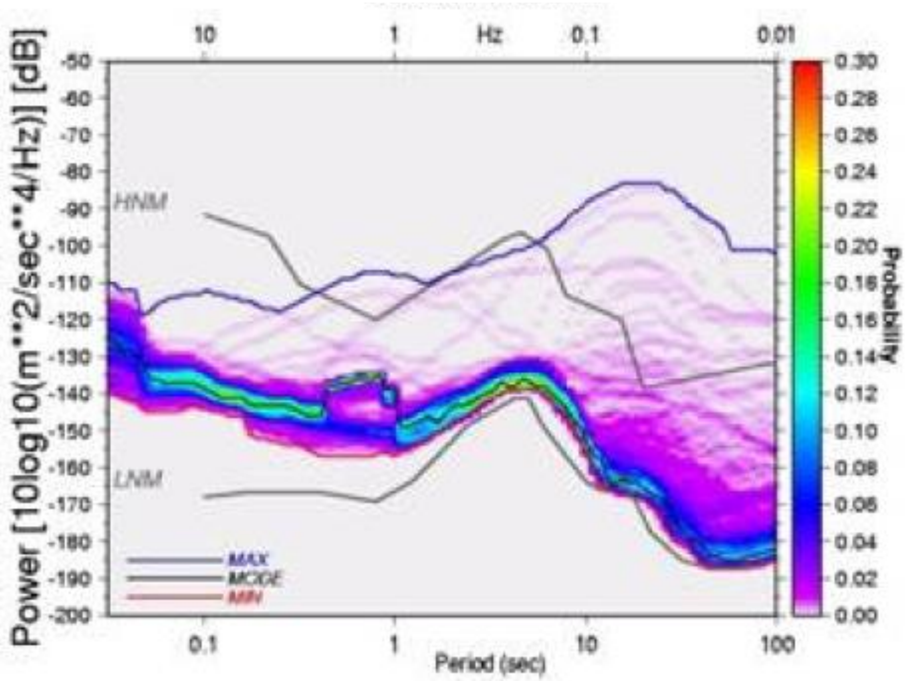
AUTUNNO



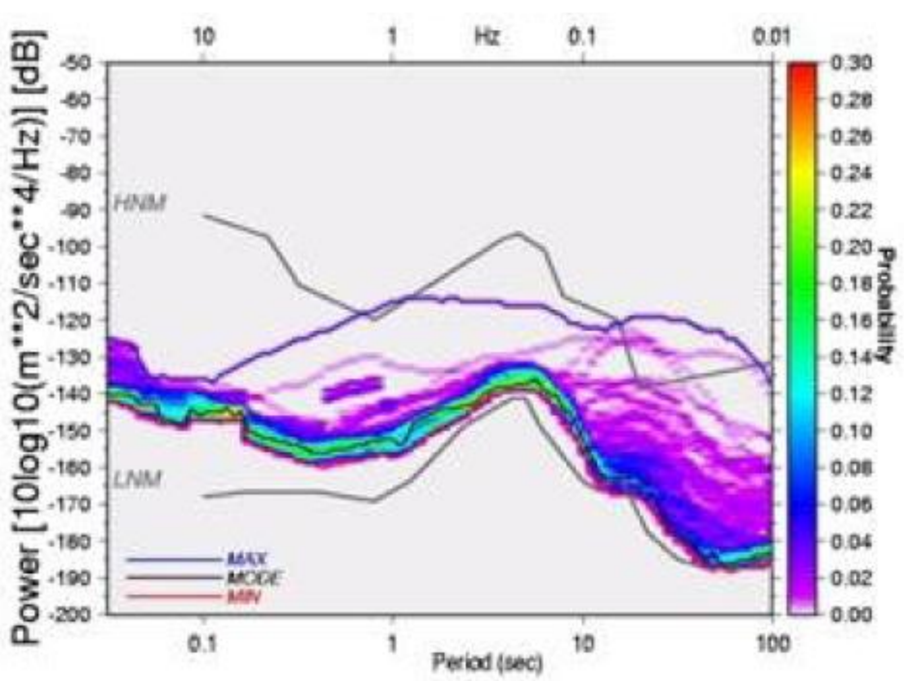
Season variations
CC MPE
Power, dB
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
0.01
0.1
1
10
100
Periods, s
Winter
Spring
Summer
Autumn

ANALISI GIORNALIERA

Distribuzione giornaliera del noise relativo alla componente HHZ alla stazione MMB.

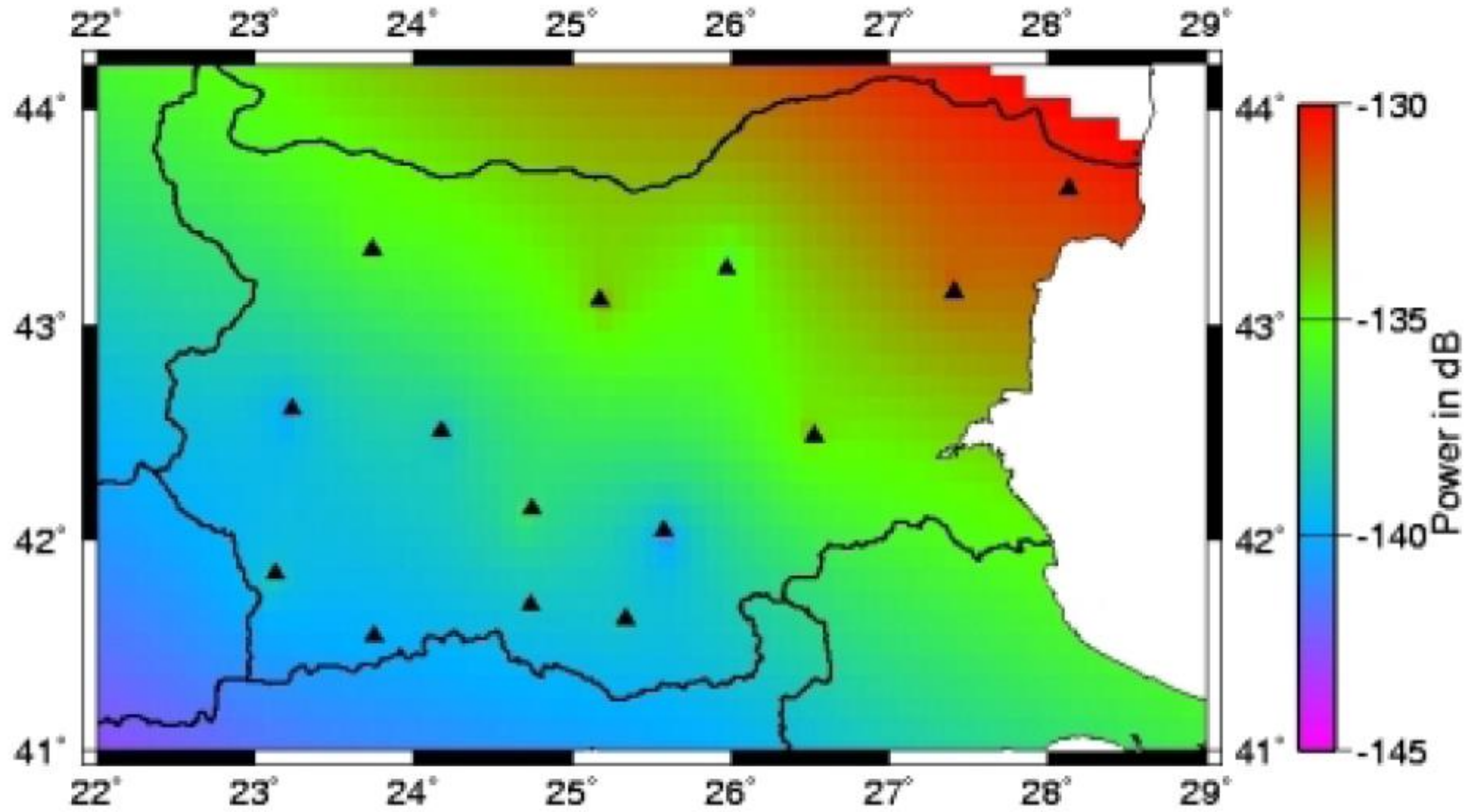


Registrazione dalle 6 alle 22 per il periodo di 10 giorni, dal 9 al 19 Maggio del 2008.



Registrazione dalle 22 alle 6 per il periodo di 10 giorni, dal 9 al 19 Maggio del 2008.

8 - 1.8sec Band [0.12 - 0.55Hz]



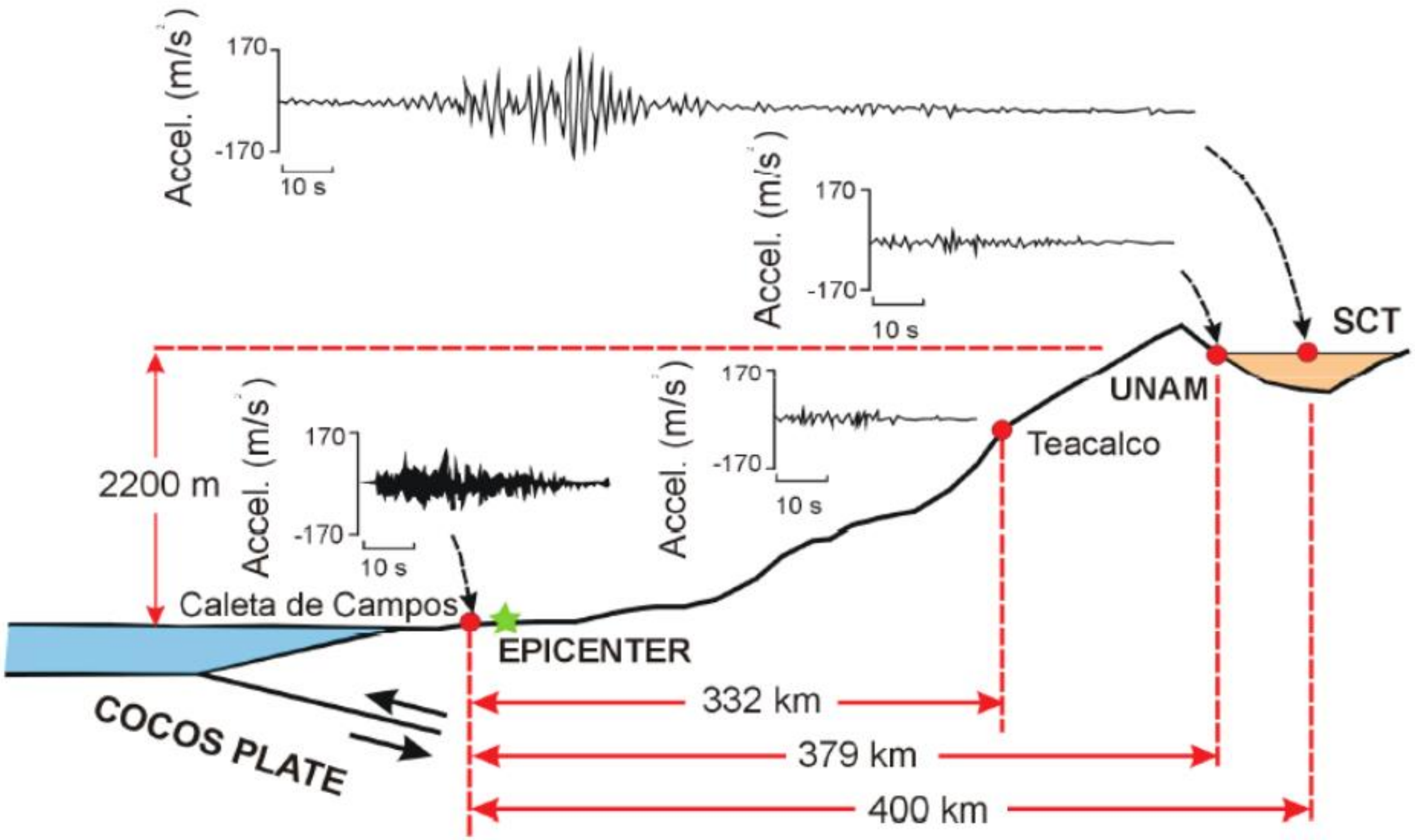
Distribution of seismic noise from the average of PDF curves in the interval from 1.8s to 8s for the Bulgarian seismological network.

STATION SITE NAME: ______________ ______________ COORDINATES: N ___° ___' ___.___" W ___° ___' ___.___"		SITE #: ______			DATE OF ANALYSIS: ___/___/_____ DATE OF VISIT: ___/___/_____			ACTUAL DISTANCE
		HARD MASSIVE ROCK, GRANITE, QUARTZITE, ETC.			HARDPAN HARD CLAY, ETC.			
		RECOMMENDED MINIMAL DISTANCES [km]						
		A	B	C	A	B	C	[km]
1. Oceans, with coastal mountains system		300	50	1	300	50	1	
2. Oceans, with broad coastal plains		1000	200	10	1000	200	20	
3. Inland seas, bays, very large lakes, with coastal mountain system		150	25	1	150	25	1	
4. Inland seas, bays, very large lakes, with broad coastal plains		500	100	5	500	100	5	
5. Large dams, high waterfalls, large cataracts	a	40	10	1	50	15	5	
	b	60	15	5	150	25	10	
6. Large oil or gas pipelines	a	20	10	5	30	15	5	
	b	100	30	10	100	30	10	
7. Small lakes	a	20	10	1	20	10	1	
	b	50	15	1	50	15	1	
8. Heavy reciprocating machinery, machinery	a	15	3	1	20	5	2	
	b	25	5	2	40	15	3	
9. Low waterfalls, rapids of a large river, intermittent flow over large dams	a	5	2	0.5	15	5	1	
	b	15	3	1	25	8	2	
10. Railway, frequent operation	a	6	3	1	10	5	1	
	b	15	5	1	20	10	1	
11. Airport, air ways heavy traffic		6	3	1	6	3	1	
12. Non-reciprocating power plant machinery, balanced industrial machinery	a	2	0.5	0.1	10	4	1	
	b	4	1	0.2	15	6	1	
13. Busy highway, mechanized farms		1	0.3	0.1	6	1	0.5	
14. Country roads, high buildings		0.3	0.2	0.05	2	1	0.5	
15. Low buildings, high trees and masts		0.1	0.03	0.01	0.3	0.1	0.05	
16. High fences, low trees, high bushes, large rocks		0.05	0.03	5 m	0.06	0.03	0.01	

Topic	Recommended minimal distances of seismic sites from sources of seismic noise
Author	Amadej Trnkoczy (formerly Kinemetrics SA); E-mail: amadej.trnkoczy@siol.net
Version	Sept. 1999

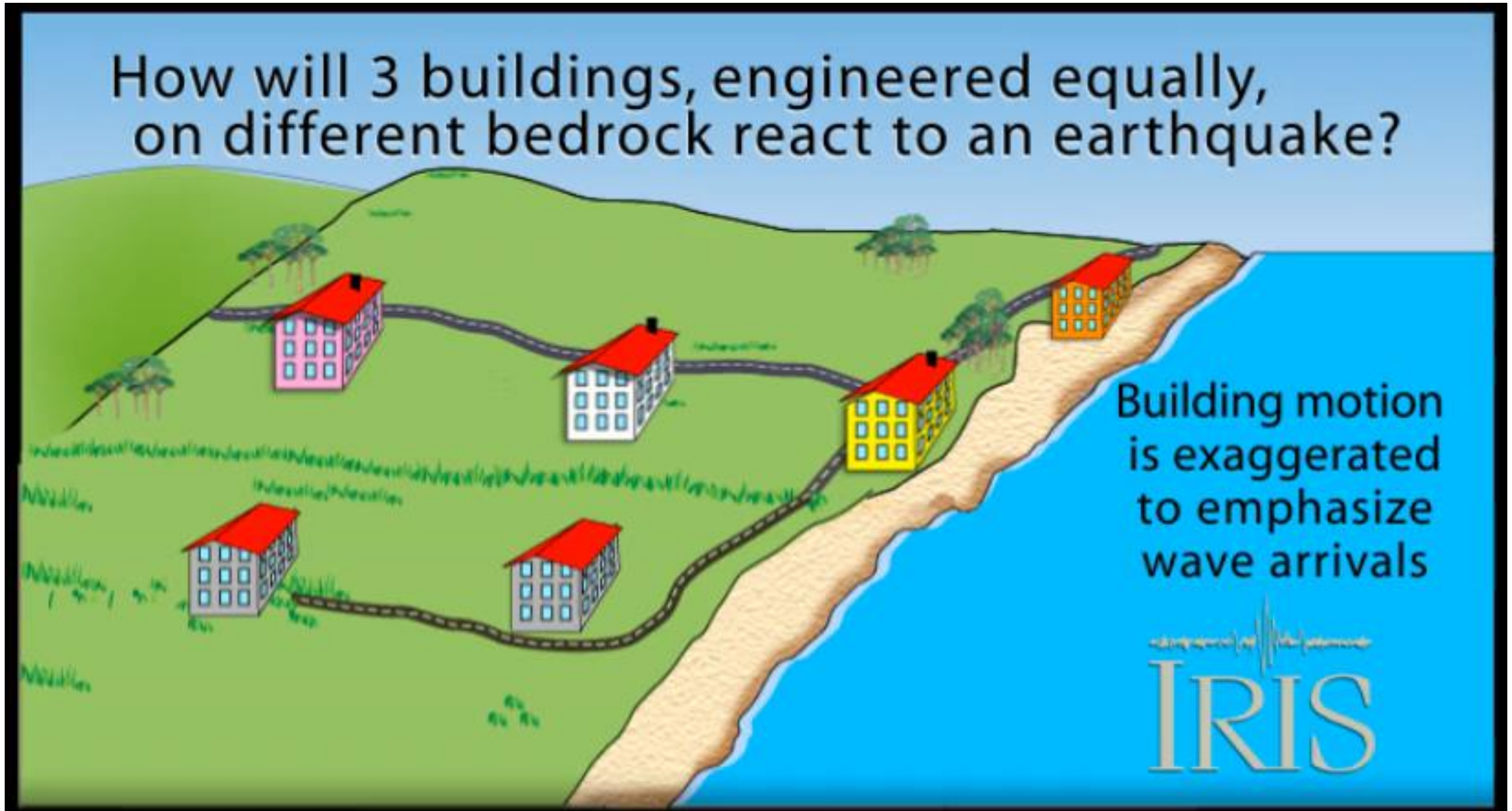
LEGEND:

- A SP seismic station with a gain of about 200,000 or more at 1 Hz
- B SP seismic station with a gain from 50,000 to 150,000 at 1 Hz
- C SP seismic station with a gain of approximately 25,000 or less at 1 Hz
- a Source and seismometer on widely different geological formations or that mountain ranges or valleys intervene
- b Source and seismometer on the same geological formation and with no intervening alluvial valley or mountain range



Schema sismogrammi relativi alla citta del Messico che mostrano l'amplificazione del bacino dove sorge Citta del Messico.

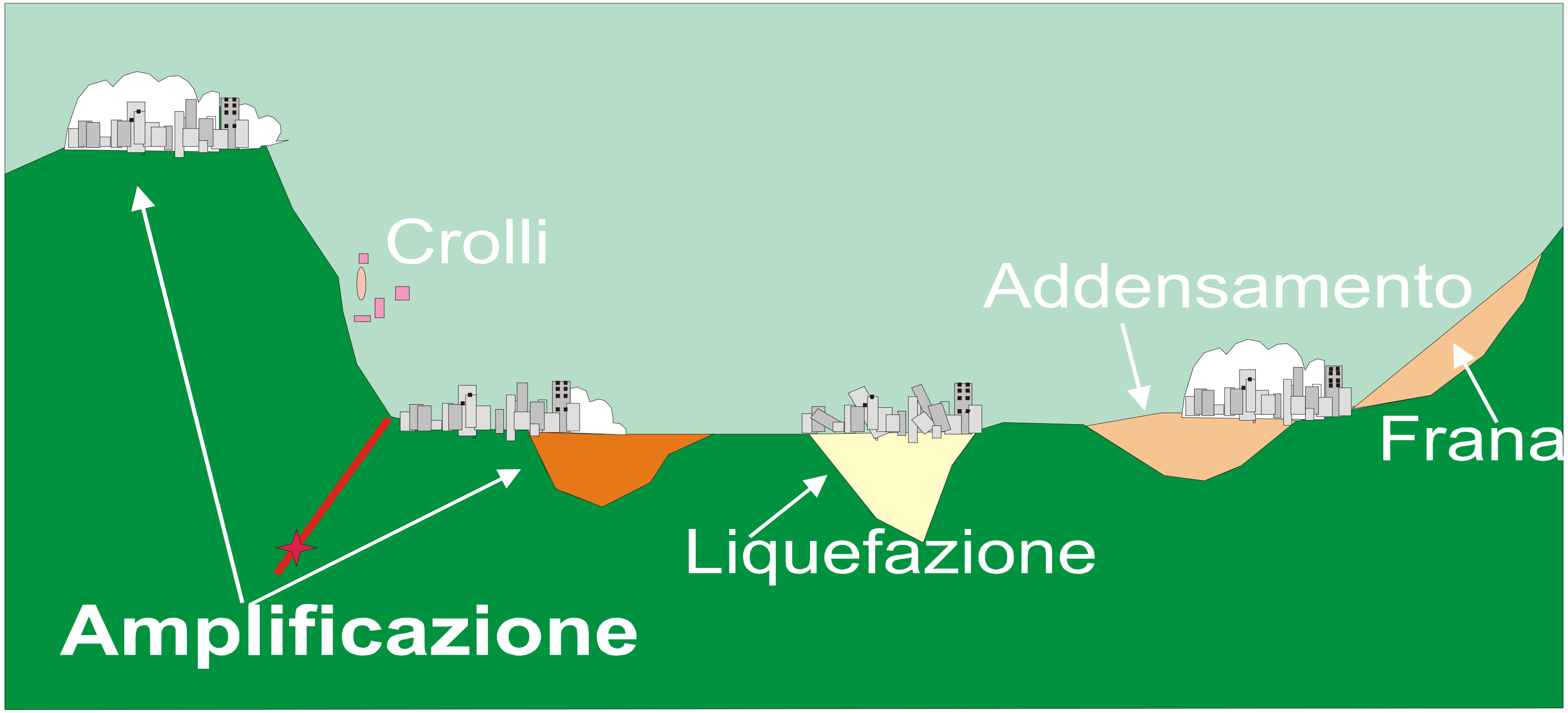

Why do certain buildings fall in earthquakes?
Using *analogies* to understand *resonant frequency**
*Natural frequency of vibration determined by the physical parameters of the vibrating object.
IRIS
Classroom demo at end of this animation
NSF



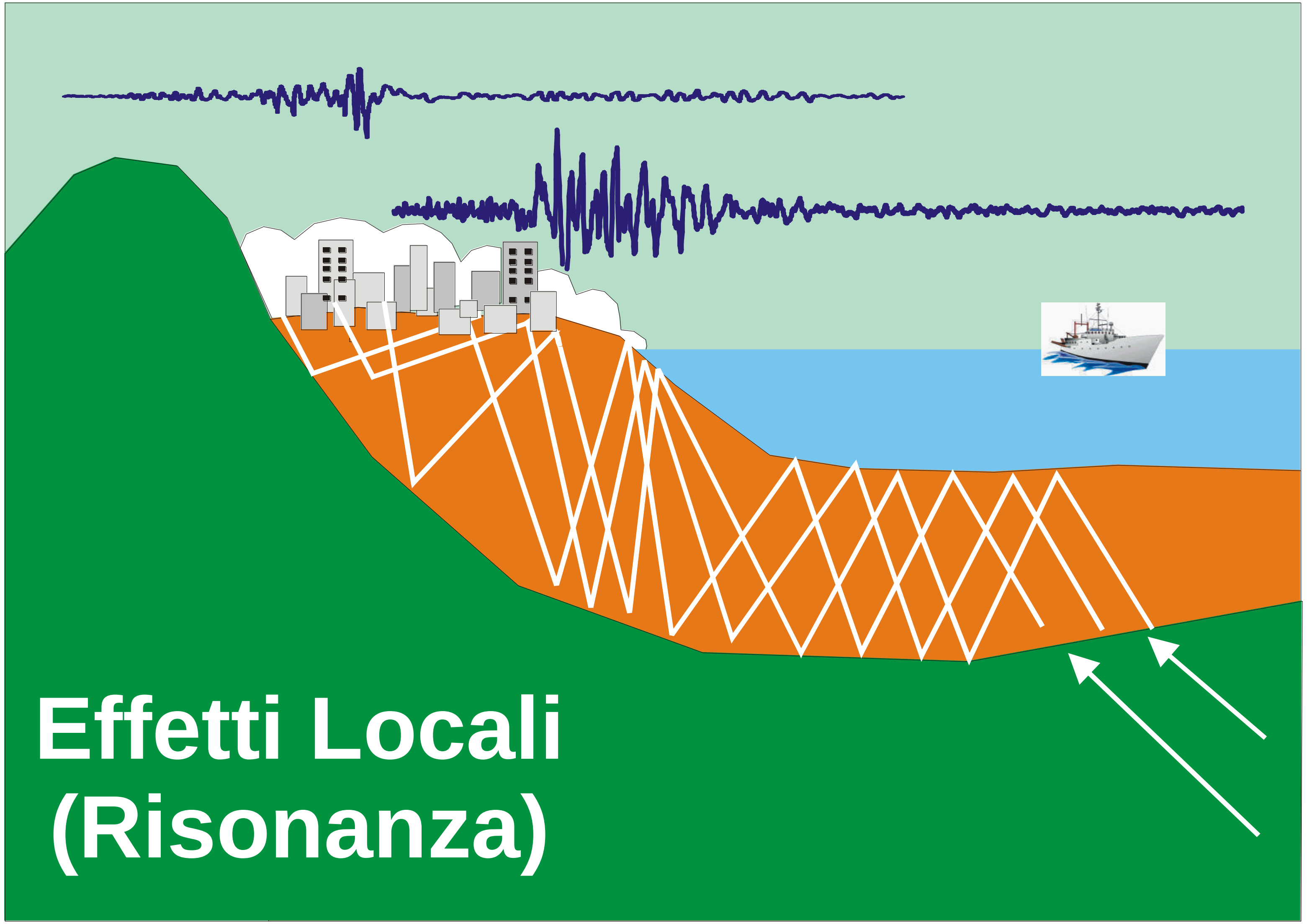
Two variables affect damage during earthquake:

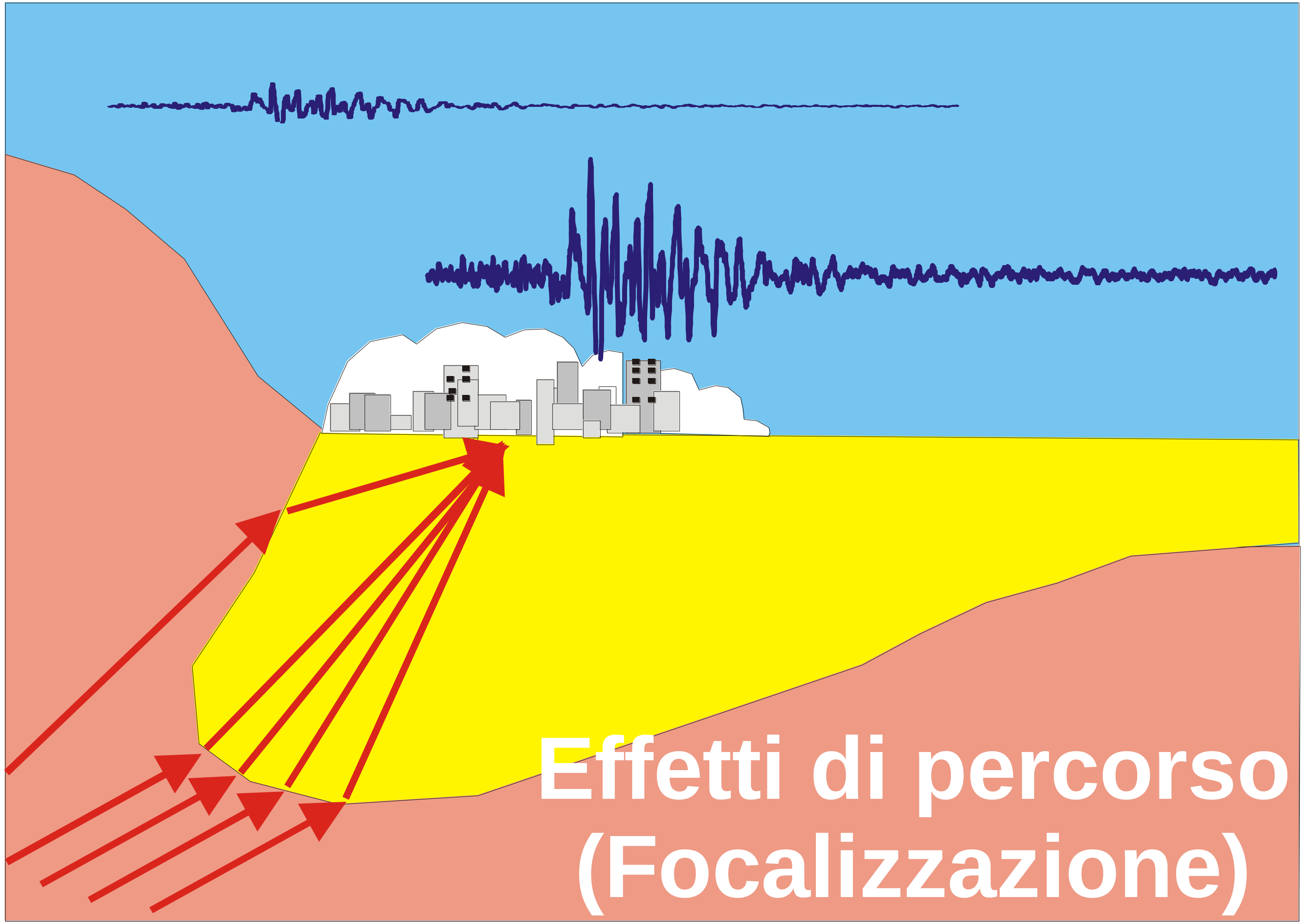
1) Intensity of shaking (*felt motion, not magnitude*)
2) Engineering

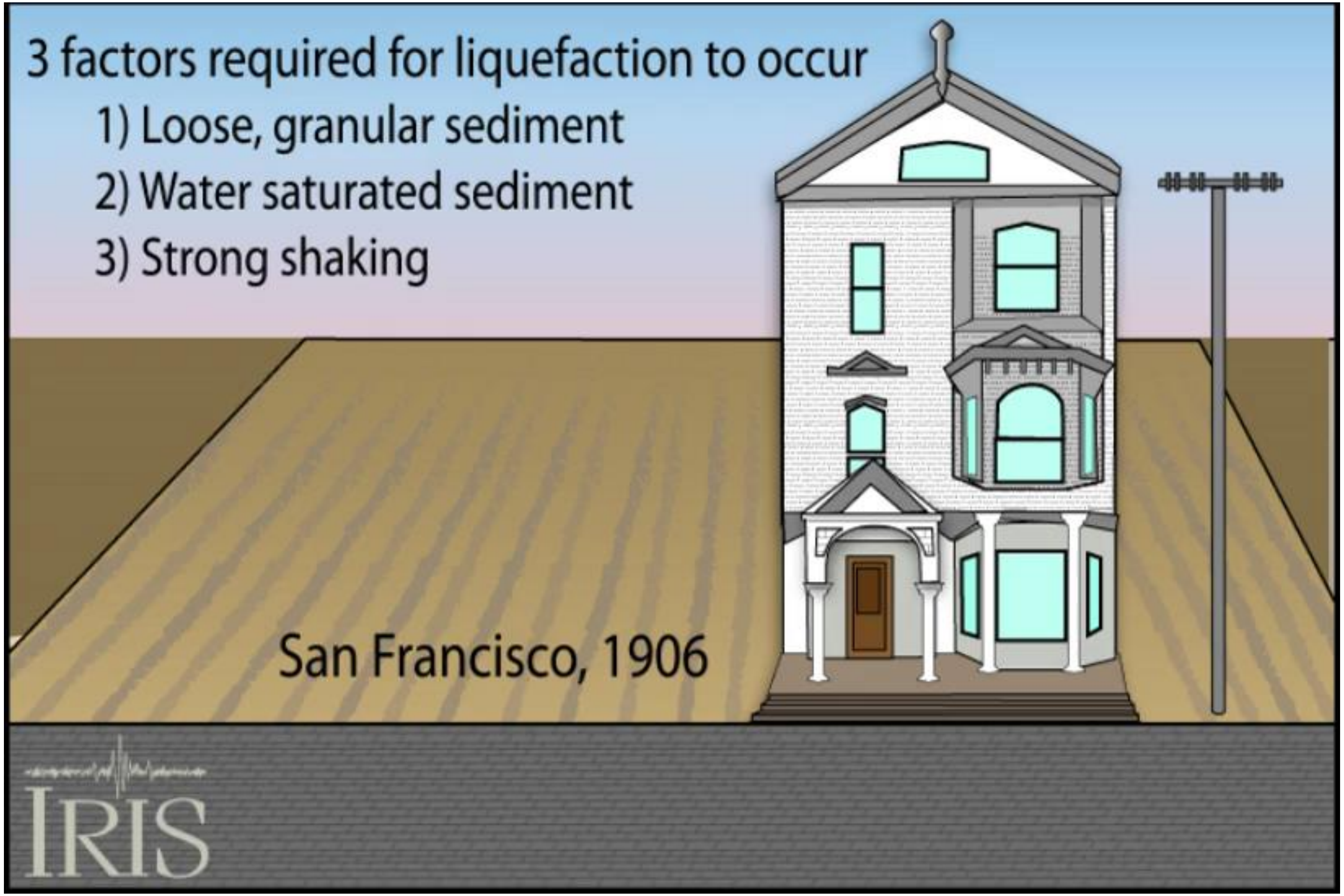
Un terremoto genera delle oscillazioni del suolo, indotte dalla propagazione di onde sismiche attraverso il terreno. Le onde sismiche, propagandosi nello strato più superficiale della crosta terrestre, subiscono riflessioni e rifrazioni causate dalle eterogeneità della crosta stessa. In certe condizioni ed in presenza dei suoli superficiali le onde sismiche vengono amplificate o attenuate a seconda delle caratteristiche meccaniche del mezzo.

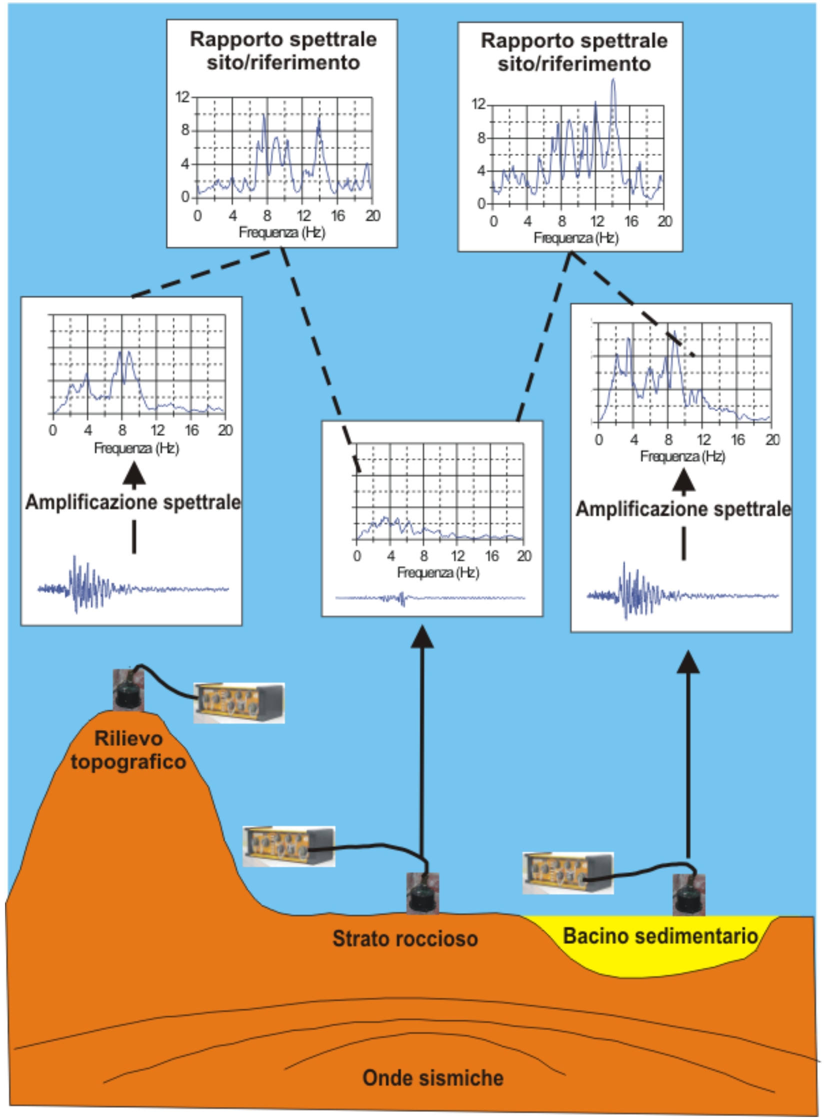


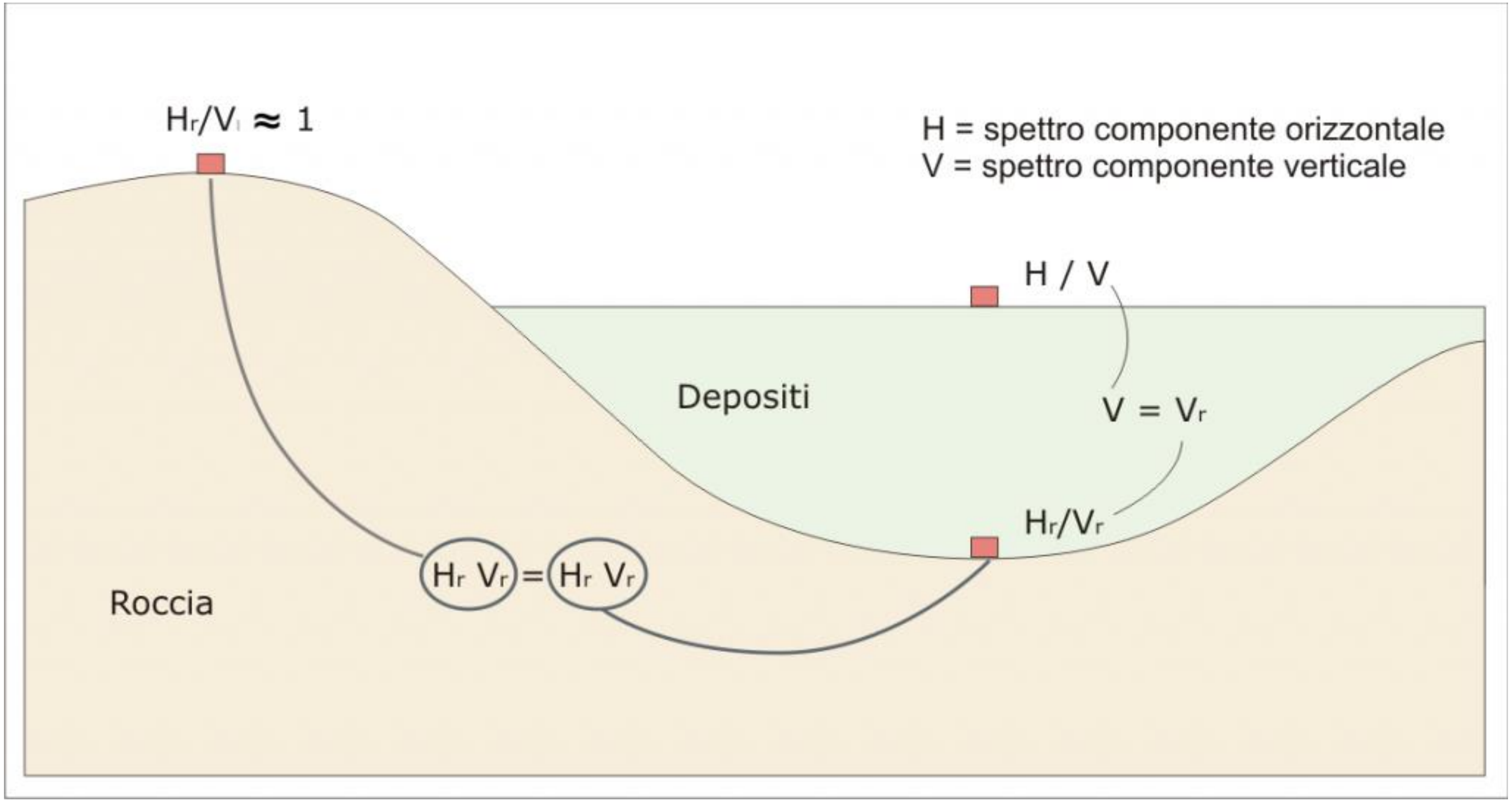
Crolli
Addensamento
Frana
Liquefazione
Amplificazione


Effetti Locali
(Risonanza)

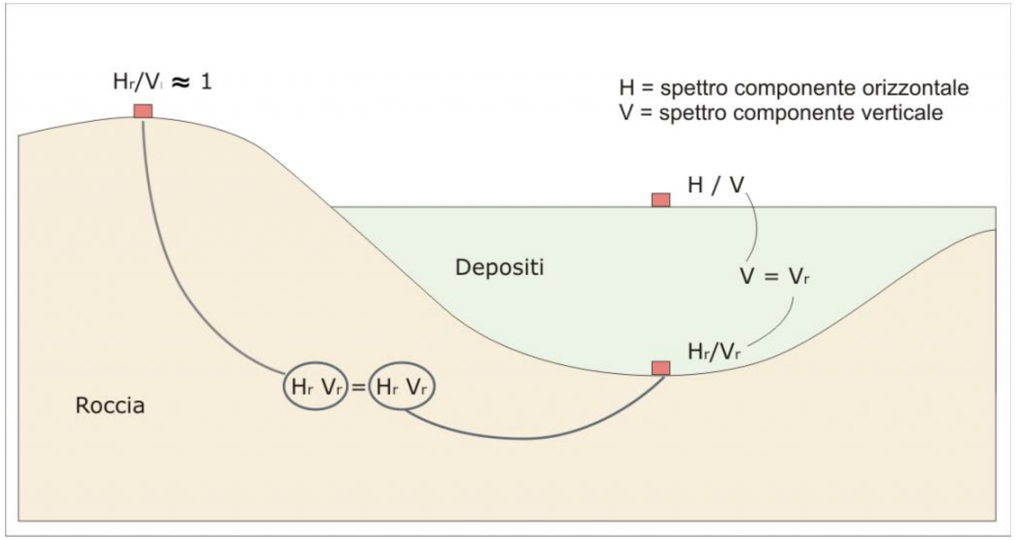

Effetti di percorso
(Focalizzazione)


3 factors required for liquefaction to occur
1) Loose, granular sediment
2) Water saturated sediment
3) Strong shaking
San Francisco, 1906
IRIS


Rapporto spettrale sito/riferimento
Rapporto spettrale sito/riferimento
Frequenza (Hz)
Amplificazione spettrale
Amplificazione spettrale
Rilievo topografico
Strato roccioso
Bacino sedimentario
Onde sismiche



Hr/Vr ≈ 1
H = spettro componente orizzontale
V = spettro componente verticale
H / V
Depositi
V = Vr
Hr/Vr
Hr Vr = Hr Vr
Roccia



In genere, l'effetto di amplificazione e dovuto alla geologia superficiale e viene espresso come rapporto tra l'ampiezza dello spettro di Fourier della componente orizzontale del moto in superficie (H_s) e quella alla base dello strato (H_r):

$$T_s = \frac{H_s}{H_r}$$

Il fattore di amplificazione può essere ottenuto tramite la relazione:

$$S = \frac{T_s}{T_r} = \frac{H_s}{H_r} * \frac{V_r}{V_s}$$

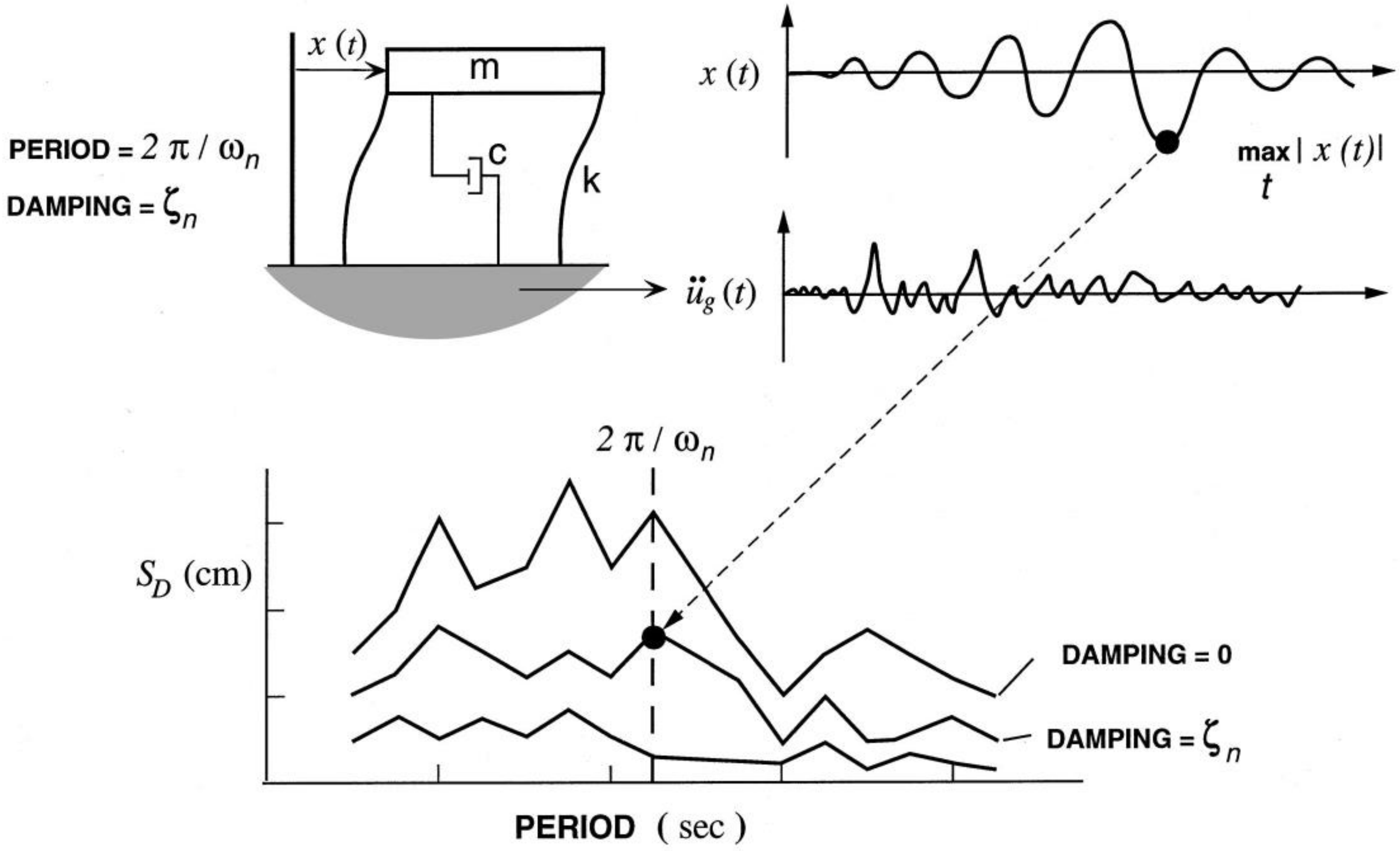
Ed essendo:

$$\frac{V_r}{H_r}=1$$

Risulta:

$$S = \frac{H_s}{V_s}$$

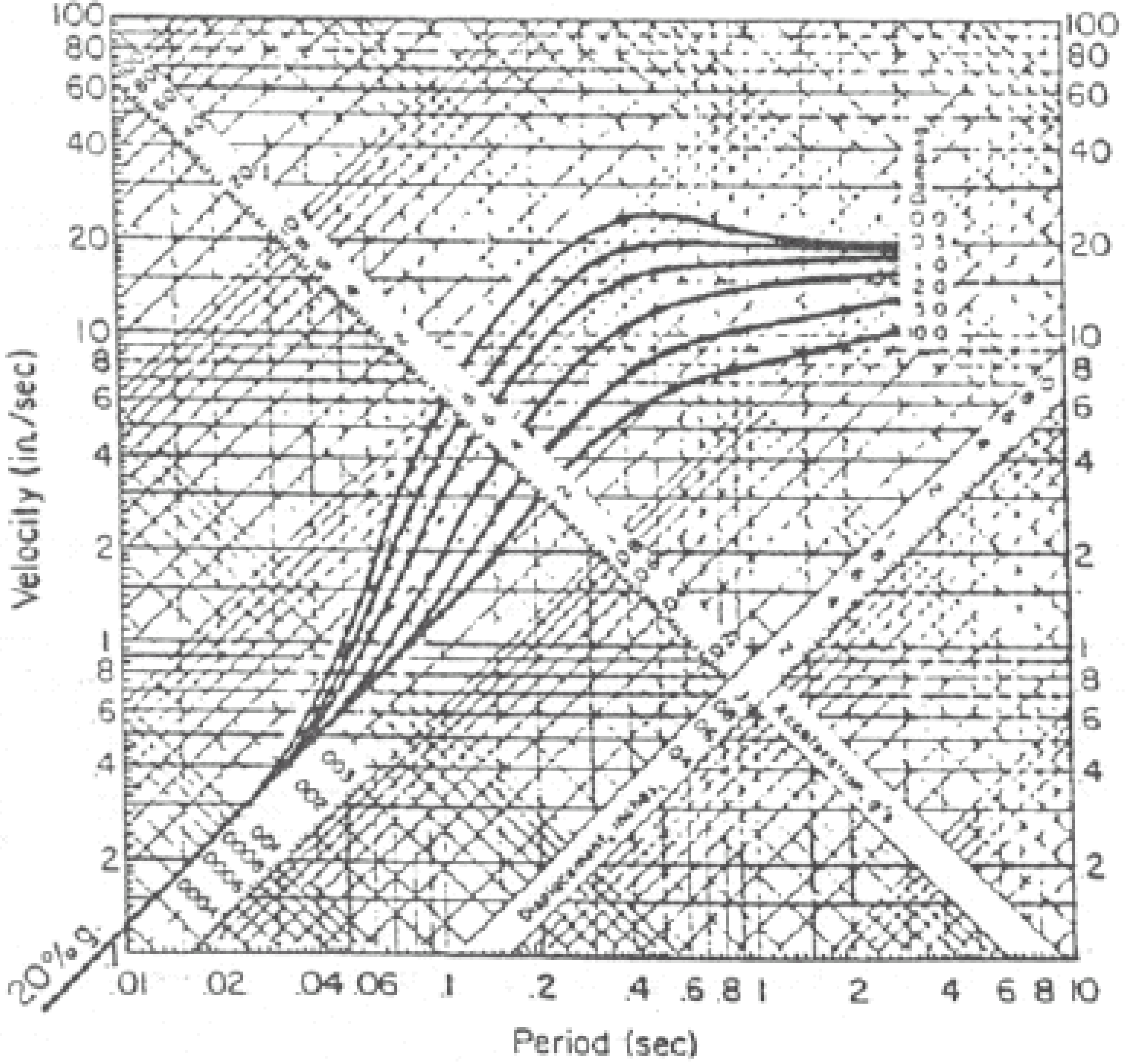
Nakamura afferma che il picco massimo nel grafico H/V permette di identificare la frequenza di risonanza con l'amplificazione ad essa correlata.

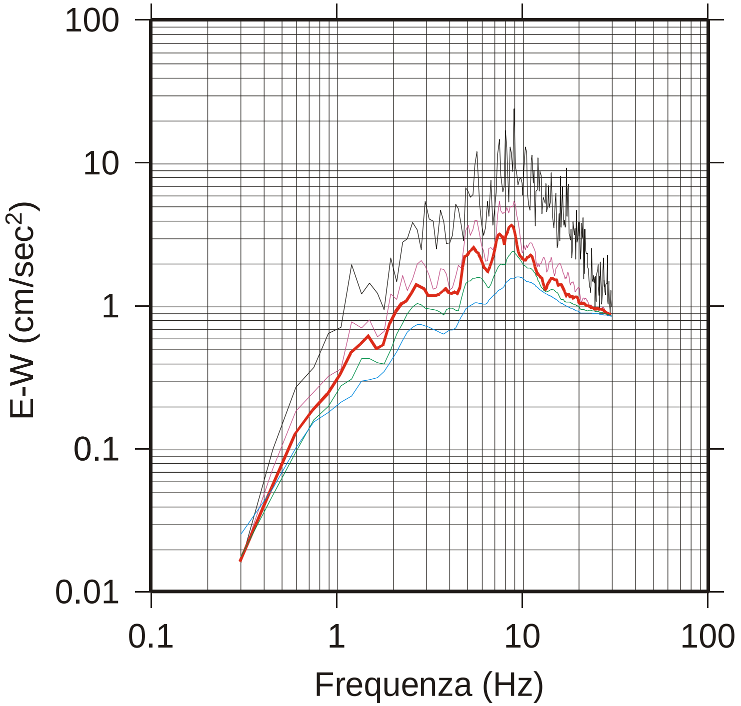

x (t)
m
c
k
PERIOD = 2 π / ω_n
DAMPING = ζ_n
x (t)
max | x (t)|
t
ü_g (t)
2 π / ω_n
S_D (cm)
DAMPING = 0
DAMPING = ζ_n
PERIOD (sec)

If $x_g(t)$ denotes the displacement impressed on the ground by the earthquake and x(t) the displacement of the mass m with respect to the ground, the differential equation governing the forced oscillation problem is written:

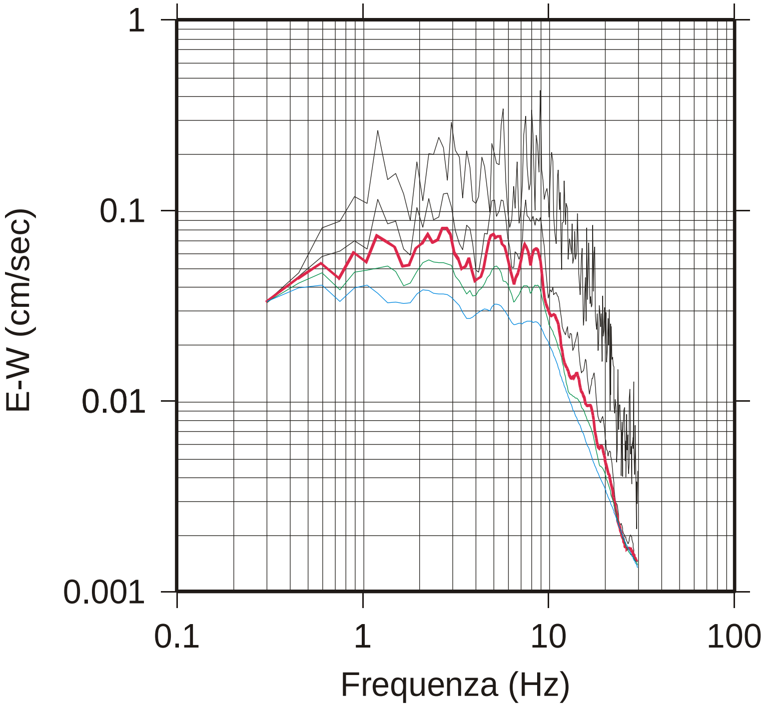
$$m\ddot{x}(t) + b\dot{x}(t) + kx(t) = -m\ddot{x}_g(t)$$

where constant k is the stiffness of the system and b is the constant associated with the viscous-type system damper.

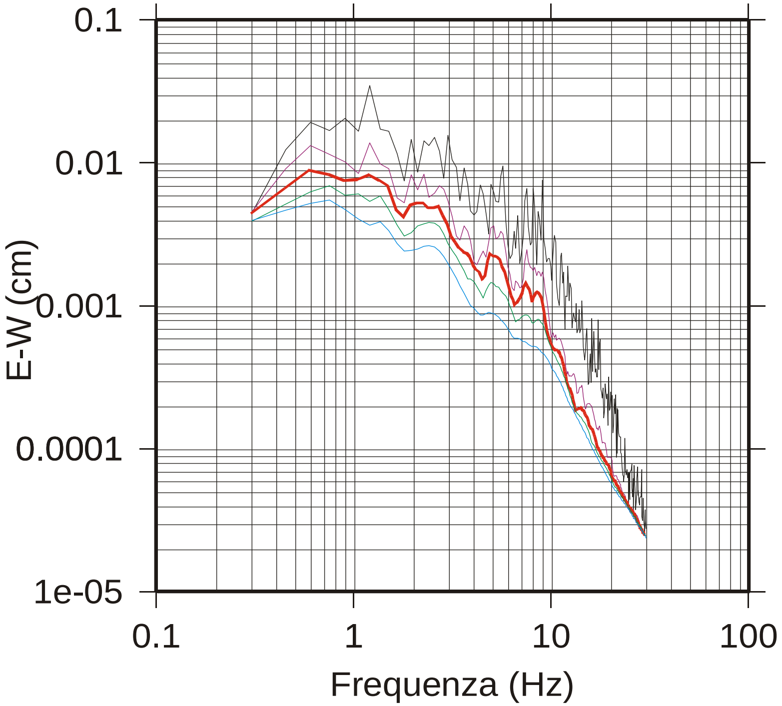

Velocity (in./sec)
Period (sec)
20%g
Damping
100
80
60
40
20
10
8
6
4
2
1
.8
.6
.4
.2
.01
.02
.04
.06
.1
.2
.4
.6
.8
1
2
4
6
8
10



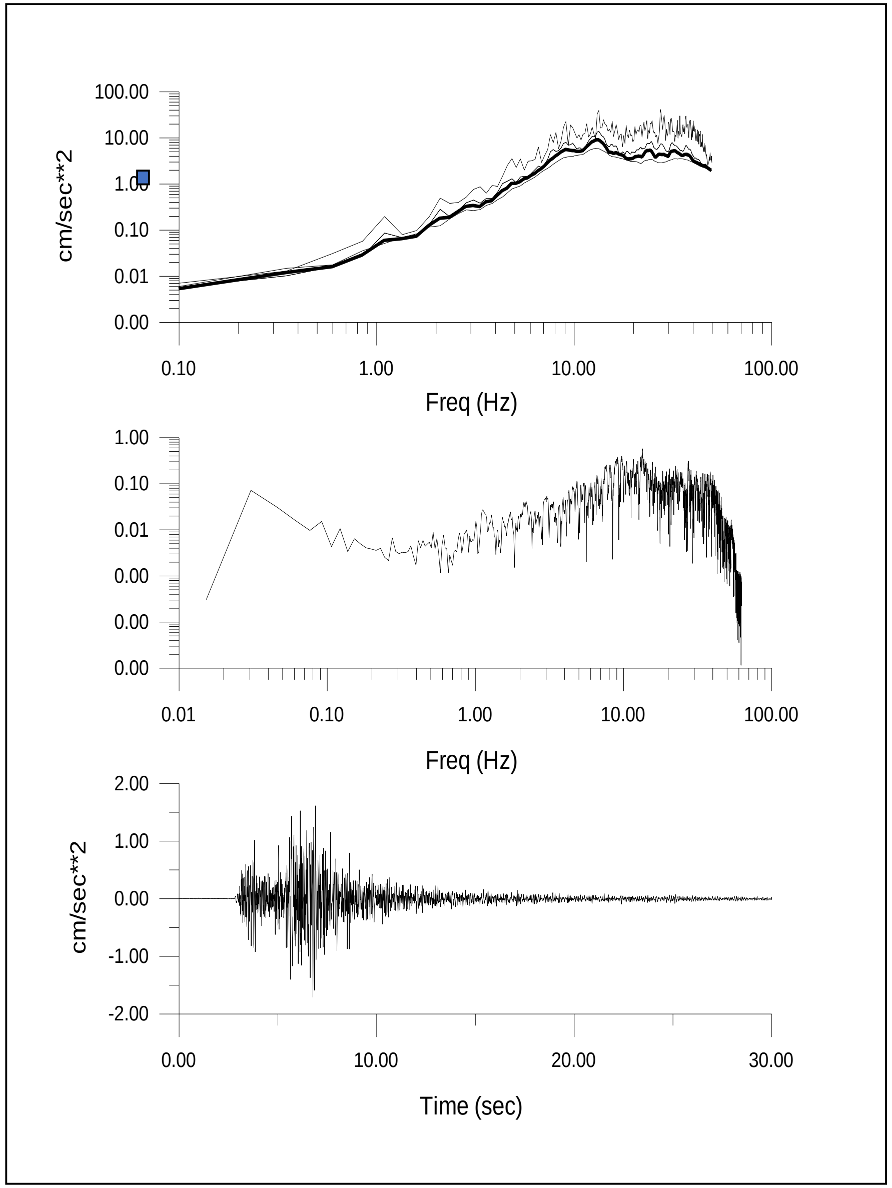
100
10
1
0.1
0.01
E-W (cm/sec^2)
0.1
1
10
100
Frequenza (Hz)

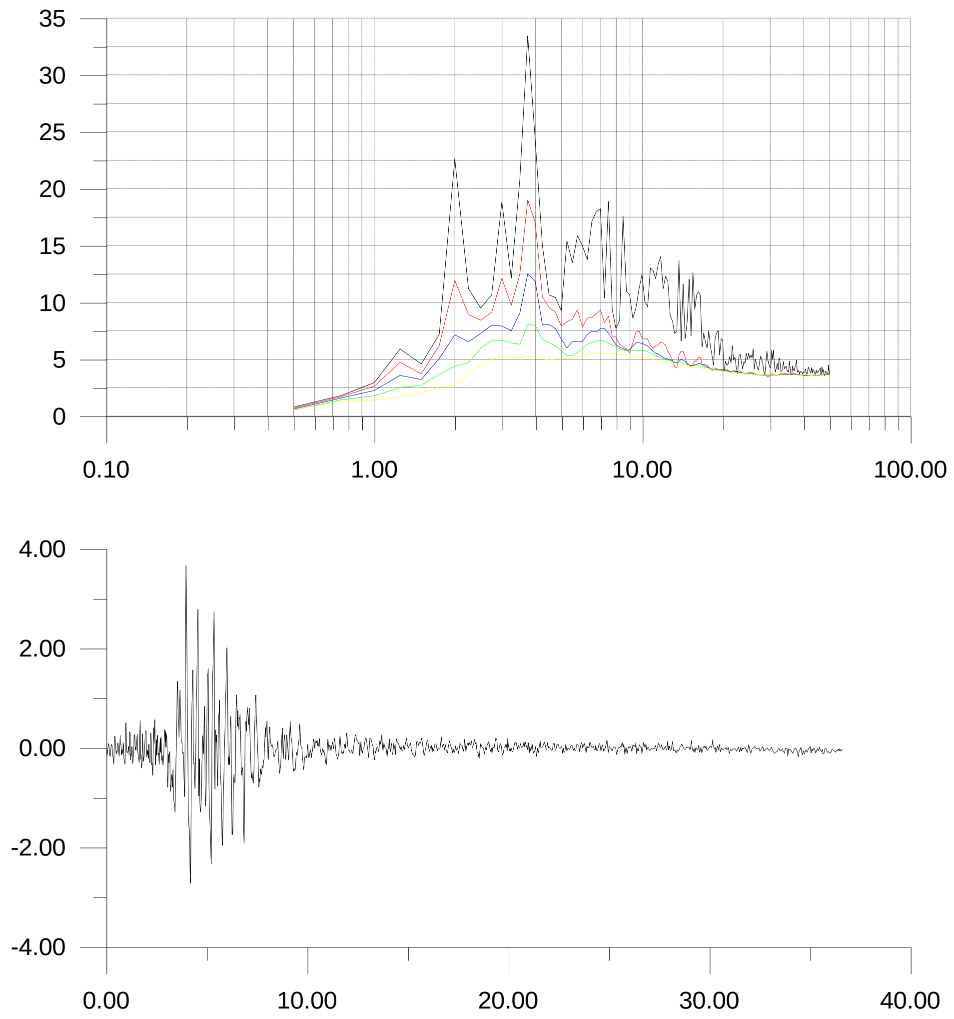


1
0.1
0.01
0.001
E-W (cm/sec)
0.1
1
10
100
Frequenza (Hz)



0.1
0.01
0.001
0.0001
1e-05
E-W (cm)
0.1
1
10
100
Frequenza (Hz)


100.00
10.00
1.00
0.10
0.01
0.00
cm/sec**2
0.10
1.00
10.00
100.00
Freq (Hz)
1.00
0.10
0.01
0.00
0.00
0.00
0.01
0.10
1.00
10.00
100.00
Freq (Hz)
2.00
1.00
0.00
-1.00
-2.00
cm/sec**2
0.00
10.00
20.00
30.00
Time (sec)

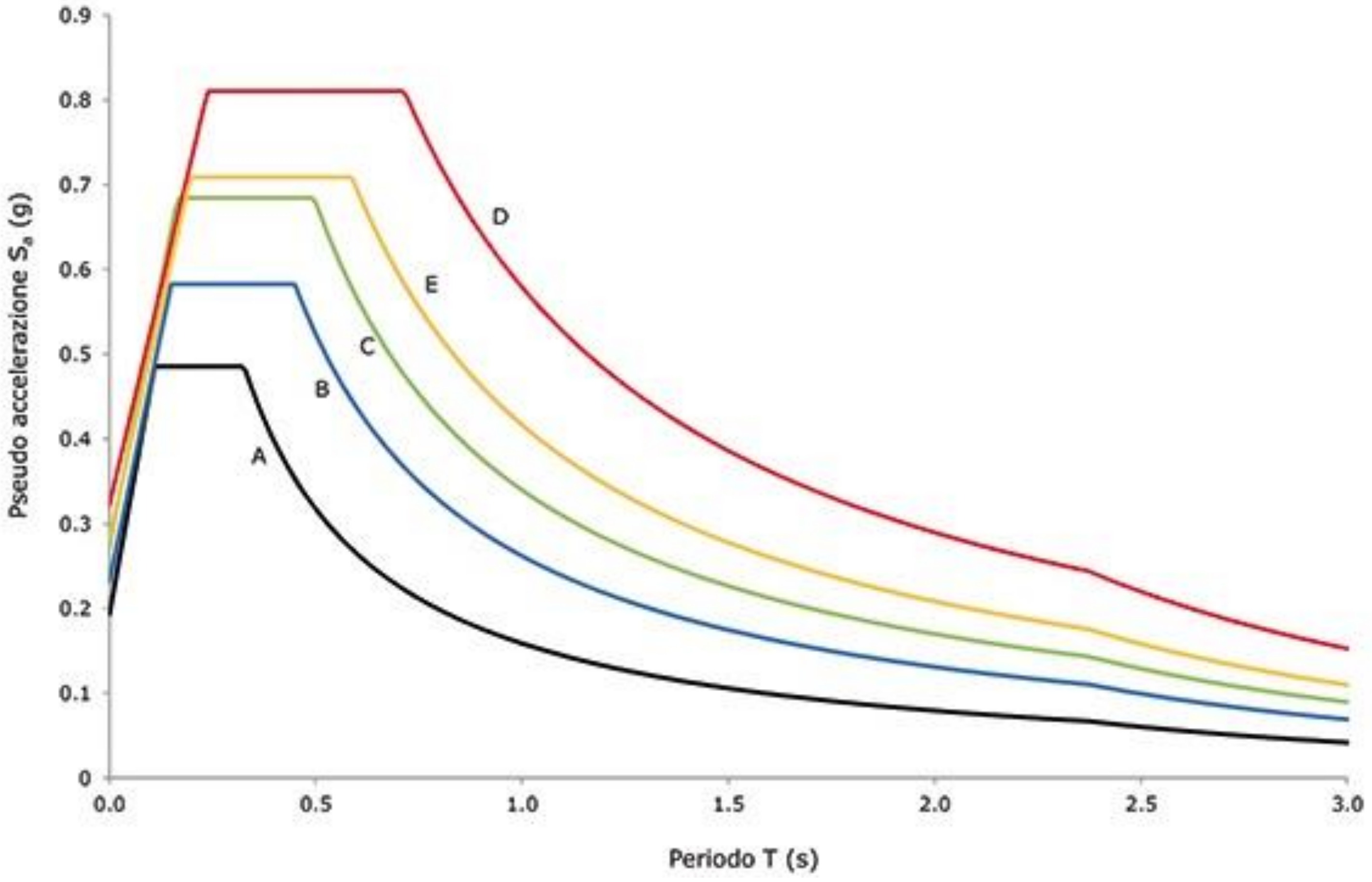

35
30
25
20
15
10
5
0
0.10
1.00
10.00
100.00
4.00
2.00
0.00
-2.00
-4.00
0.00
10.00
20.00
30.00
40.00

Categorie di sottosuolo nelle NTC-08

A	*Ammassi rocciosi affioranti o terreni molto rigidi* caratterizzati da valori di **V_{S30} superiori a 800 m/s**, eventualmente comprendenti in superficie uno strato di alterazione, con spessore massimo pari a 3 m.
B	*Depositi di terreni a grana grossa molto addensati o terreni a grana fina molto consistenti*, con spessori superiori a 30 m, caratterizzati da un graduale miglioramento delle proprietà meccaniche con la profondità e da valori di **V_{S30} compresi tra 360 m/s e 800 m/s** (ovvero $N_{SPT,30} > 50$ nei terreni a grana grossa e $c_{u,30} > 250$ kPa nei terreni a grana fina).
C	**Depositi di terreni a grana grossa mediamente addensati o terreni a grana fina mediamente consistenti**, con spessori superiori a 30 m, caratterizzati da un graduale miglioramento delle proprietà meccaniche con la profondità e da valori di **$V_{S,30}$ compresi tra 180 m/s e 360 m/s** (ovvero $15 < N_{SPT,30} < 50$ nei terreni a grana grossa e $70 < c_{u,30} < 250$ kPa nei terreni a grana fina).
D	**Depositi di terreni a grana grossa scarsamente addensati o terreni a grana fina scarsamente consistenti**, con spessori superiori a 30m, caratterizzati da un graduale miglioramento delle proprietà meccaniche con la profondità e da valori di **$V_{S,30}$ inferiori a 180 m/s** (ovvero $N_{SPT,30} < 15$ nei terreni a grana grossa e $c_{u,30} < 70$ kPa nei terreni a grana fina).
E	Terreni dei sottosuoli di tipo C o D per spessore non superiore a 20 m posti sul substrato di riferimento (con $V_s > 800$ m/s).

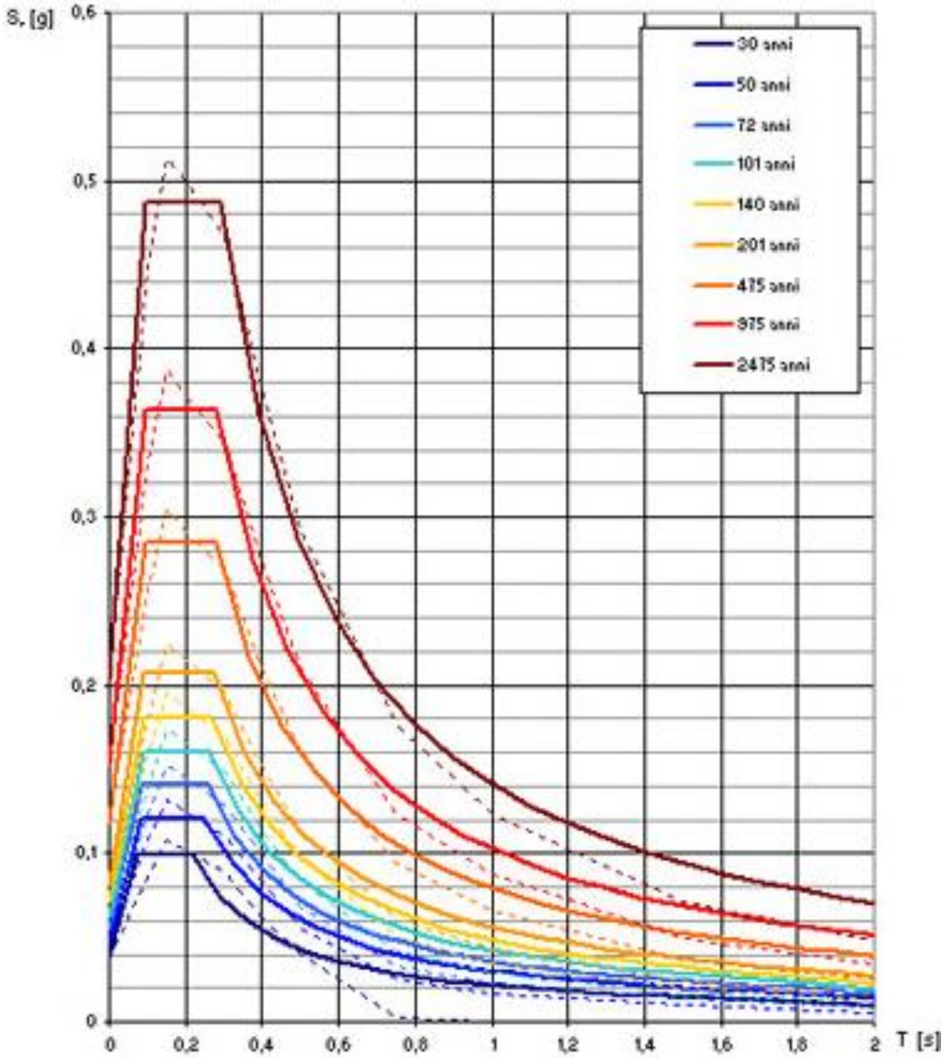
S1	Depositi di terreni caratterizzati da valori di V_{S30} inferiori a 100 m/s (ovvero $10 < c_{u30} < 20$ kPa), che includono uno strato di almeno 8 m di terreni a grana fina di bassa consistenza, oppure che includono almeno 3 m di torba o di argille altamente organiche
S2	Depositi di terreni suscettibili di liquefazione, di argille sensitive **o qualsiasi altra categoria di terreno non classificabile nei tipi precedenti**

Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza



Spettri di normativa per le diverse classi di suolo

Spettri di risposta elastici per i periodi di ritorno T_R di riferimento

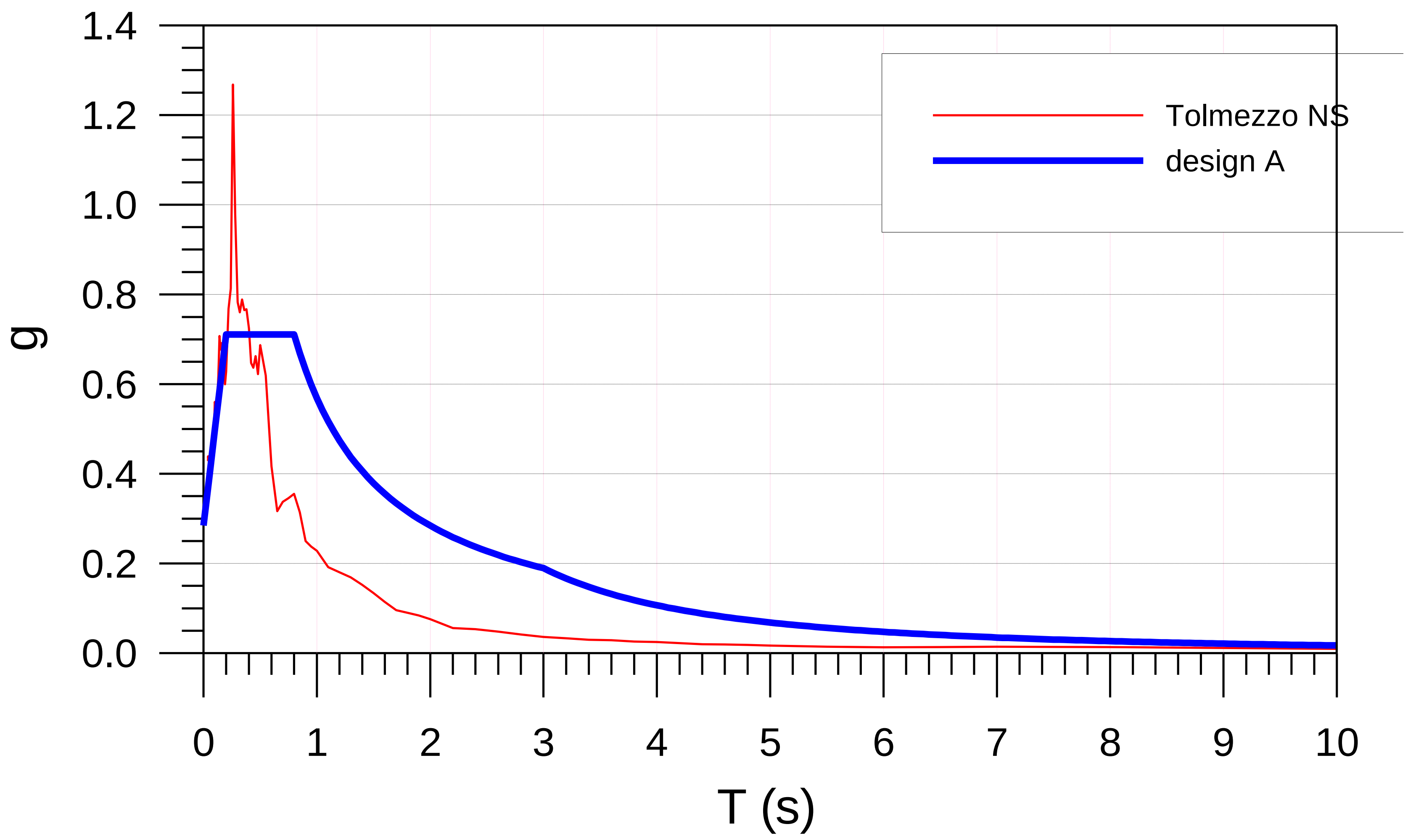


NOTA:
Con linea continua si rappresentano gli spettri di Normativa, con linea tratteggiata gli spettri del progetto S1-INGV da cui sono derivati.

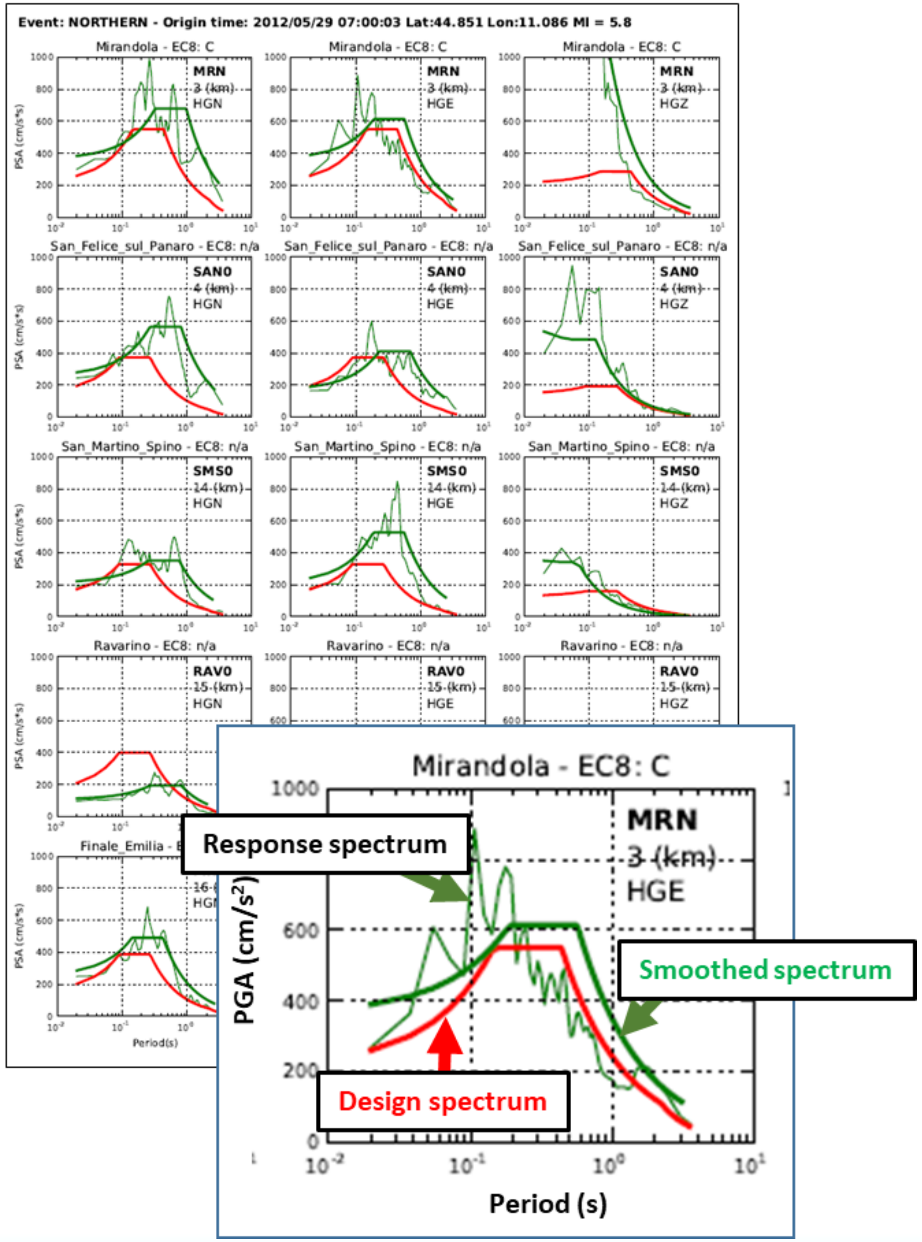
SOIL A

ACCELERATION RESPONSE SPECTRA

(5% damping)



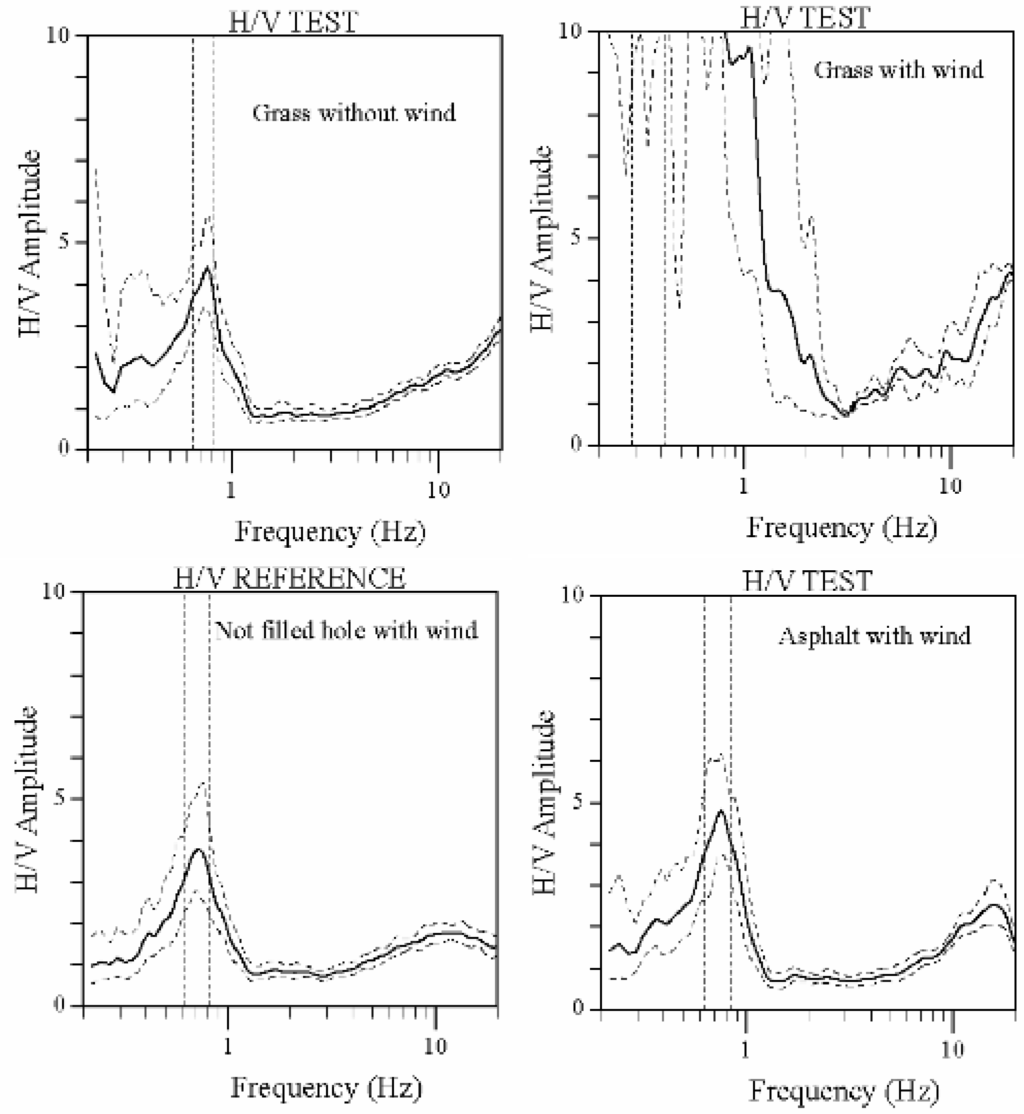
DESIGN GROUND ACCELERATION: 0.28 g


Event: NORTHERN - Origin time: 2012/05/29 07:00:03 Lat:44.851 Lon:11.086 Ml = 5.8
Mirandola - EC8: C
San_Felice_sul_Panaro - EC8: n/a
San_Martino_Spino - EC8: n/a
Ravarino - EC8: n/a
MRN
3 (km)
HGE
Response spectrum
Smoothed spectrum
Design spectrum
PGA (cm/s²)
Period (s)

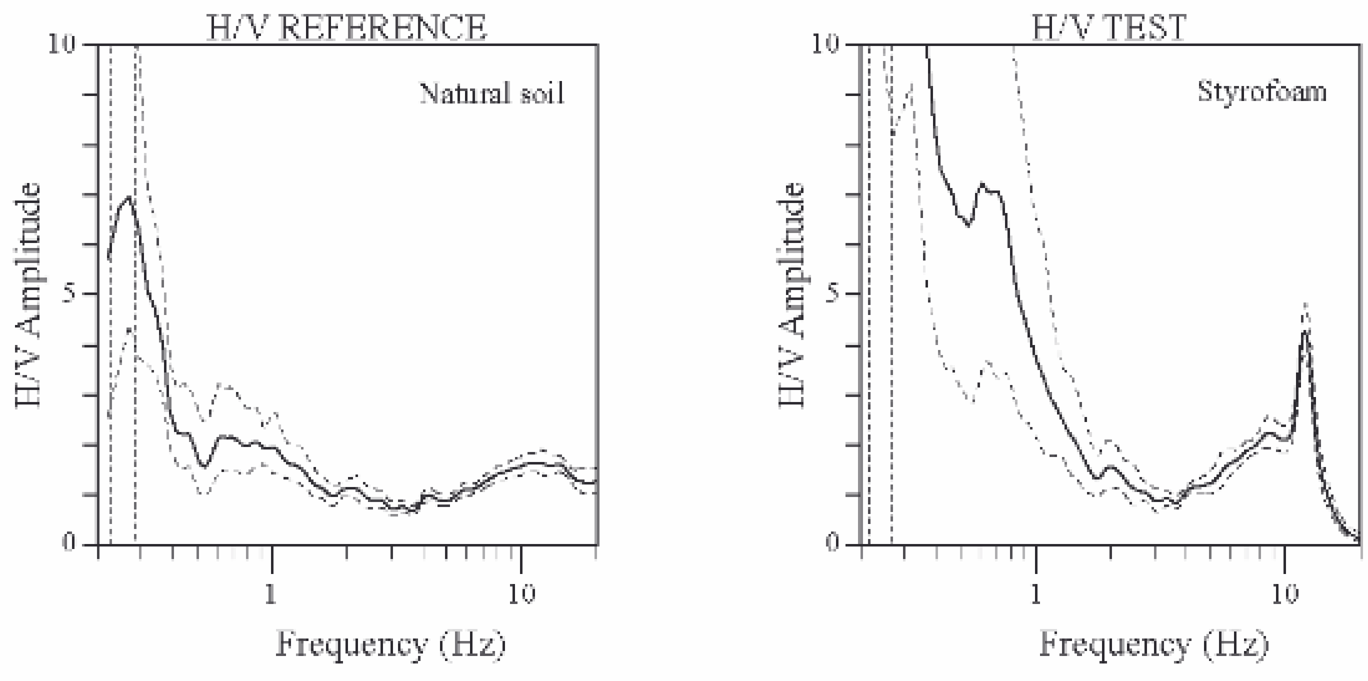
1. EXPERIMENTAL CONDITIONS + MEASUREMENT FIELD SHEET

→ This sheet is only a quick field reference. It is highly recommended that the complete guidelines be read before going out to perform the recordings. A field sheet is also provided on the next page. This page, containing two identical sheets can be printed and be taken in the field.

Type of parameter	Main recommendations	
Recording duration	Minimum expected f_0 [Hz]	Recommended minimum recording duration [min]
	0.2	30'
	0.5	20'
	1	10'
	2	5'
	5	3'
	10	2'
Measurement spacing	→ Microzonation: start with a large spacing (for example a 500 m grid) and, in case of lateral variation of the results, densify the grid point spacing, down to 250 m, for example. → Single site response: never use a single measurement point to derive an f_0 value, make at least three measurement points.	
Recording parameters	→ level the sensor as recommended by the manufacturer. → fix the gain level at the maximum possible without signal saturation.	
In situ soil-sensor coupling	→ set the sensor down directly on the ground, whenever possible. → avoid setting the sensor on "soft grounds" (mud, ploughed soil, tall grass, etc.), or soil saturated after rain.	
Artificial soil-sensor coupling	→ avoid plates from "soft" materials such as foam rubber, cardboard, etc. → on steep slopes that do not allow correct sensor levelling, install the sensor in a sand pile or in a container filled with sand. → on snow or ice, install a metallic or wooden plate or a container filled with sand to avoid sensor tilting due to local melting.	
Nearby structures	→ Avoid recording near structures such as buildings, trees, etc. in case of wind blowing (faster than approx. 5 m/s). It may strongly influence H/V results by introducing some low frequencies in the curves → Avoid measuring above underground structures such as car parks, pipes, sewer lids, etc.	
Weather conditions	→ Wind: Protect the sensor from the wind (faster than approx. 5 m/s). This only helps if there are no nearby structures. → Rain: avoid measurements under heavy rain. Slight rain has no noticeable influence. → Temperature: check sensor and recorder manufacturer's instructions. → Meteorological perturbations: indicate on the field sheet whether the measurements are performed during a low-pressure meteorological event.	
Disturbances	→ Monochromatic sources: avoid measurements near construction machines, industrial machines, pumps, generators, etc. → Transients: In case of transients (steps, cars,...), increase the recording duration to allow for enough windows for the analysis, after transient removal.	



Comparison of H/V curves obtained at the same site on grass with and without wind (top), and in a pothole, on asphalt (bottom) and again on grass with wind. This comparison shows the strong effect of wind combined with grass, while on asphalt or in a pothole, wind has no significant effect (when away from any structure)



Comparison of H/V curves obtained with and without a polystyrene plate under the sensor at the same site, a strong effect of polystyrene is evident.

DATE	HOUR	PLACE
OPERATOR	GPS TYPE and #	
LATITUDE	LONGITUDE	ALTITUDE
STATION TYPE	SENSOR TYPE	
STATION #	SENSOR #	DISK #
FILE NAME	POINT #	
GAIN	SAMPL. FREQ Hz	REC. DURATION minutes seconds

WEATHER CONDITIONS
WIND ☐ none ☐ weak (5m/s) ☐ medium ☐ strong Measurement (if any): ______
RAIN ☐ none ☐ weak ☐ medium ☐ strong Measurement (if any): ______
Temperature (approx): ______ Remarks ______

GROUND TYPE
☐ earth (☐hard ☐soft) ☐ gravel ☐ sand ☐ rock ☐ grass = (☐short ☐tall)
☐ asphalt ☐ cement ☐ concrete ☐ paved ☐ other ______
☐ dry soil ☐ wet soil Remarks ______

ARTIFICIAL GROUND-SENSOR COUPLING ☐ no ☐ yes, type ______

BUILDING DENSITY ☐ none ☐ scattered ☐ dense ☐ other, type ______

TRANSIENTS

	none	few	moderate	many	very dense	distance
cars						
trucks						
pedestrians						
other						

MONOCHROMATIC NOISE SOURCES (factories, works, pumps, rivers...)
☐ no ☐ yes, type ______

NEARBY STRUCTURES (description, height, distance) (trees, polls, buildings, bridges, underground structures....)

OBSERVATIONS

FREQUENCY: Hz
(if computed in the field)

DATE	HOUR	PLACE
OPERATOR	GPS TYPE and #	
LATITUDE	LONGITUDE	ALTITUDE
STATION TYPE	SENSOR TYPE	
STATION #	SENSOR #	DISK #
FILE NAME	POINT #	
GAIN	SAMPL. FREQ Hz	REC. DURATION minutes seconds

WEATHER CONDITIONS
WIND ☐ none ☐ weak (5m/s) ☐ medium ☐ strong Measurement (if any): ______
RAIN ☐ none ☐ weak ☐ medium ☐ strong Measurement (if any): ______
Temperature (approx): ______ Remarks ______

GROUND TYPE
☐ earth (☐hard ☐soft) ☐ gravel ☐ sand ☐ rock ☐ grass = (☐short ☐tall)
☐ asphalt ☐ cement ☐ concrete ☐ paved ☐ other ______
☐ dry soil ☐ wet soil Remarks ______

ARTIFICIAL GROUND-SENSOR COUPLING ☐ no ☐ yes, type ______

BUILDING DENSITY ☐ none ☐ scattered ☐ dense ☐ other, type ______

TRANSIENTS

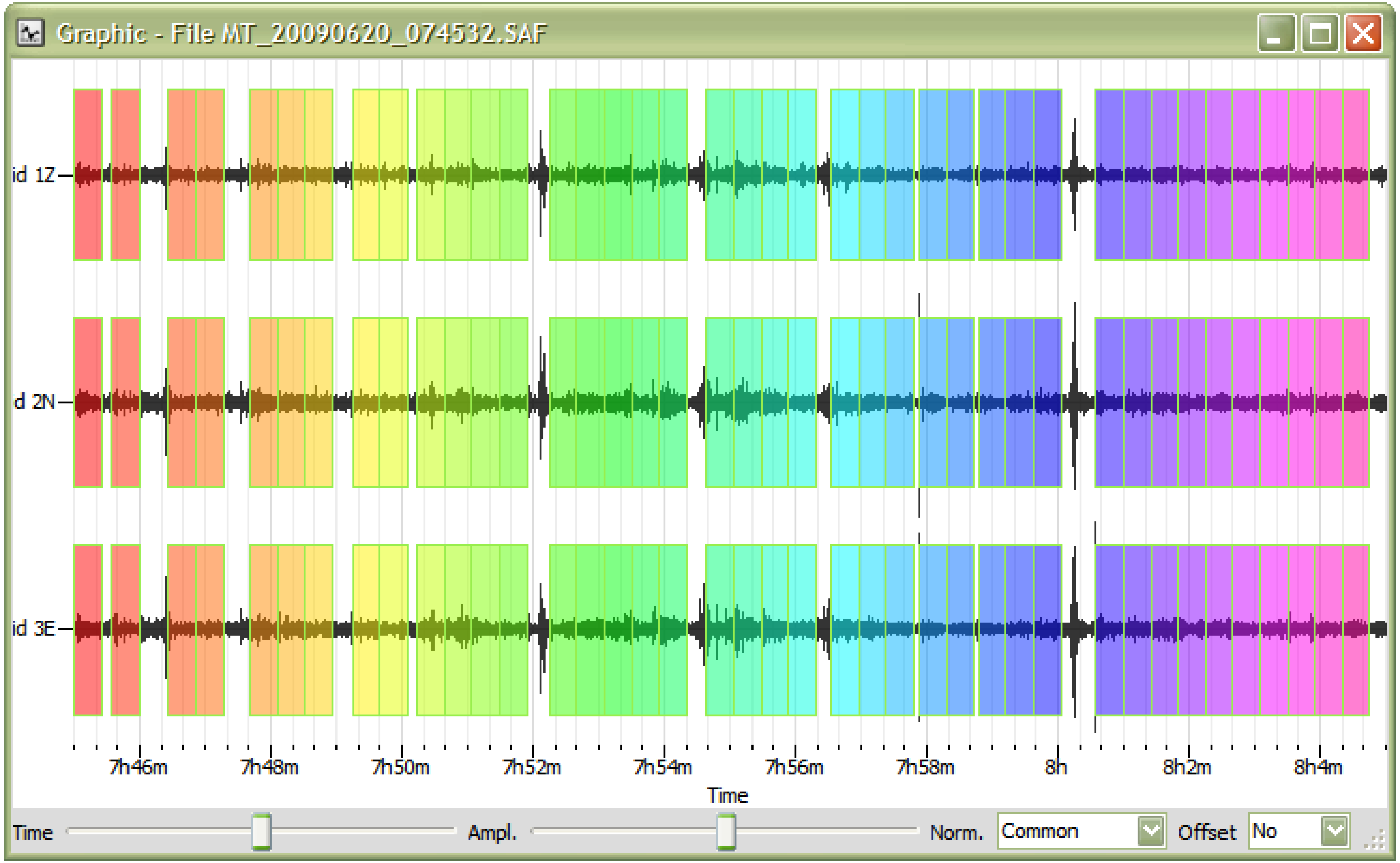
	none	few	moderate	many	very dense	distance
cars						
trucks						
pedestrians						
other						

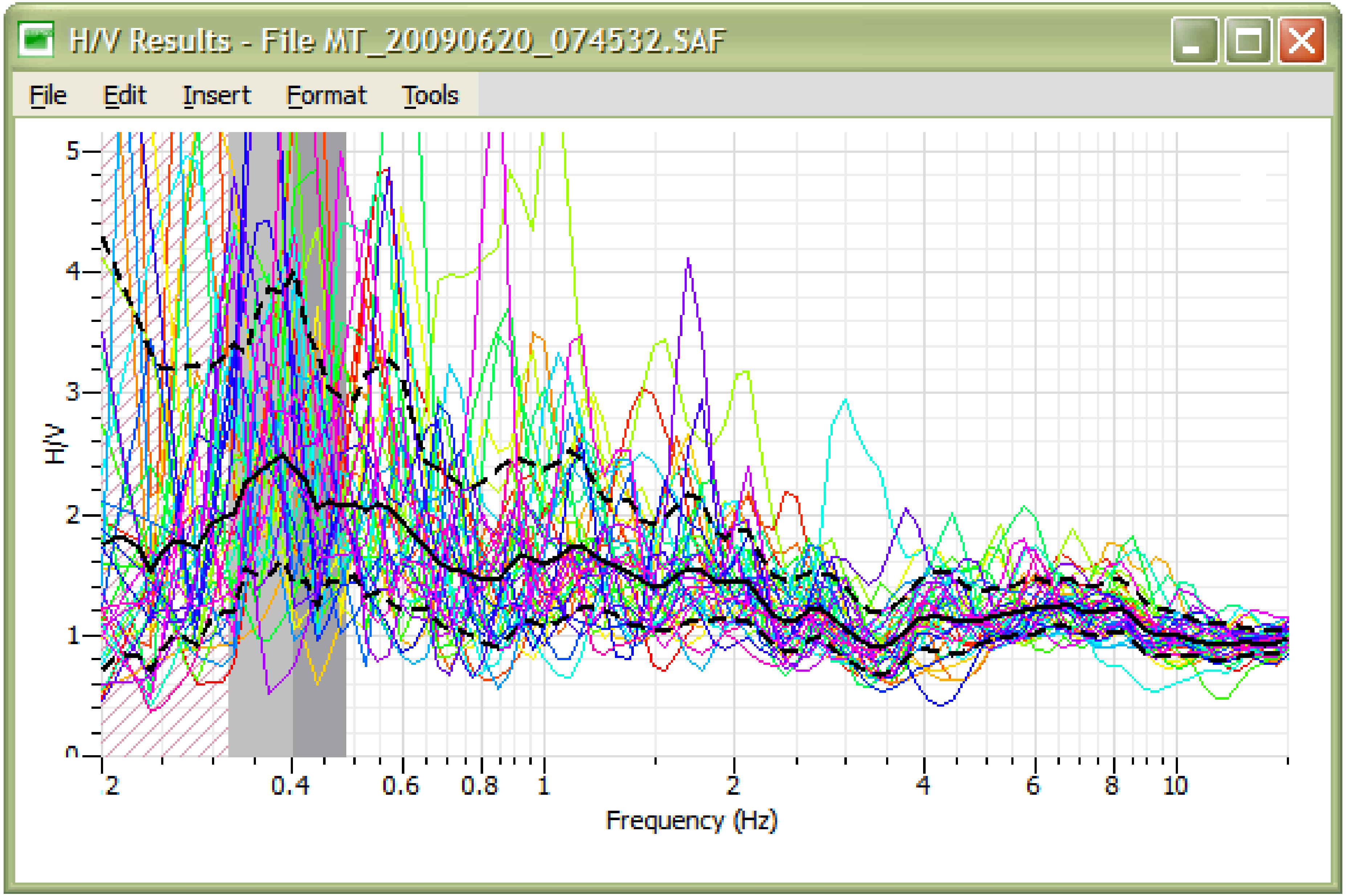
MONOCHROMATIC NOISE SOURCES (factories, works, pumps, rivers...)
☐ no ☐ yes, type ______

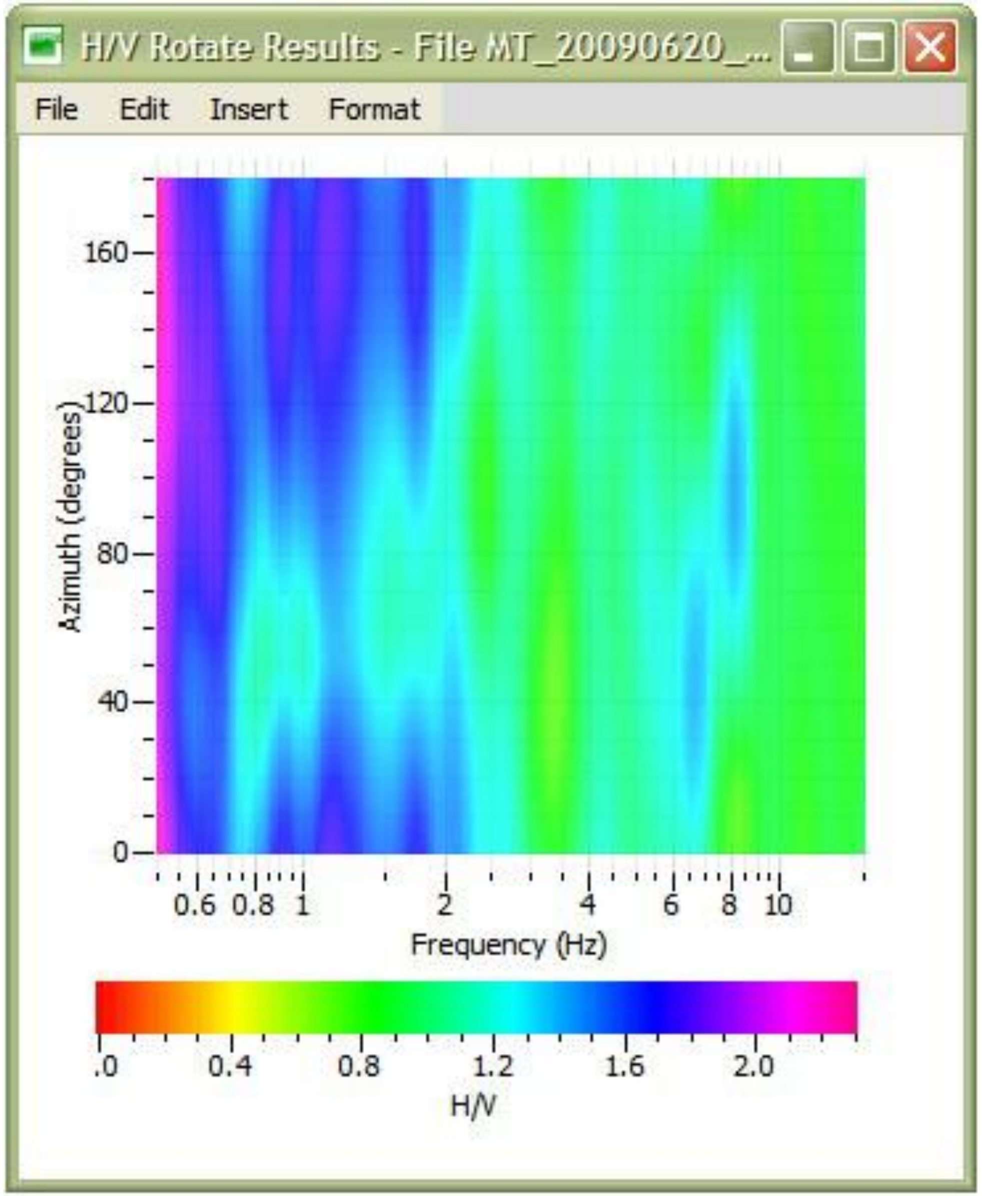
NEARBY STRUCTURES (description, height, distance) (trees, polls, buildings, bridges, underground structures....)

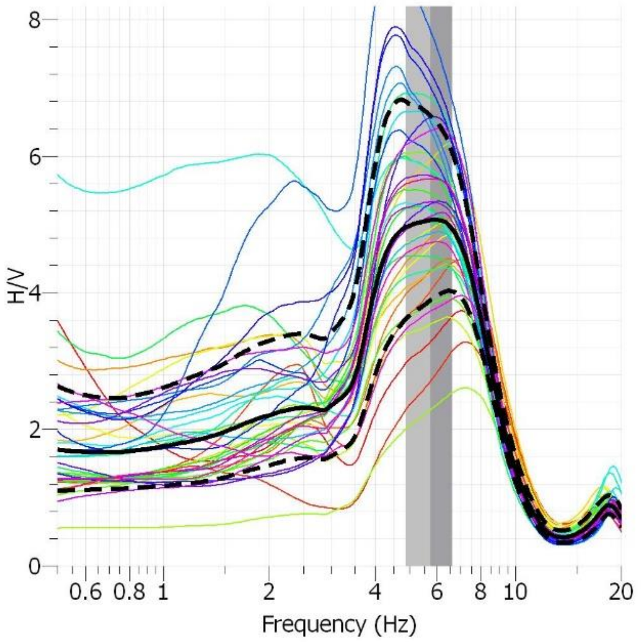
OBSERVATIONS

FREQUENCY: Hz
(if computed in the field)


Graphic - File MT_20090620_074532.SAF
id 1Z
d 2N
id 3E
7h46m
7h48m
7h50m
7h52m
7h54m
7h56m
7h58m
8h
8h2m
8h4m
Time
Time
Ampl.
Norm.
Common
Offset
No


H/V Results - File MT_20090620_074532.SAF
File Edit Insert Format Tools
H/V
Frequency (Hz)
0 1 2 3 4 5
2 0.4 0.6 0.8 1 2 4 6 8 10


H/V Rotate Results - File MT_20090620_...
File
Edit
Insert
Format
Azimuth (degrees)
160
120
80
40
0
0.6
0.8
1
2
4
6
8
10
Frequency (Hz)
.0
0.4
0.8
1.2
1.6
2.0
H/V

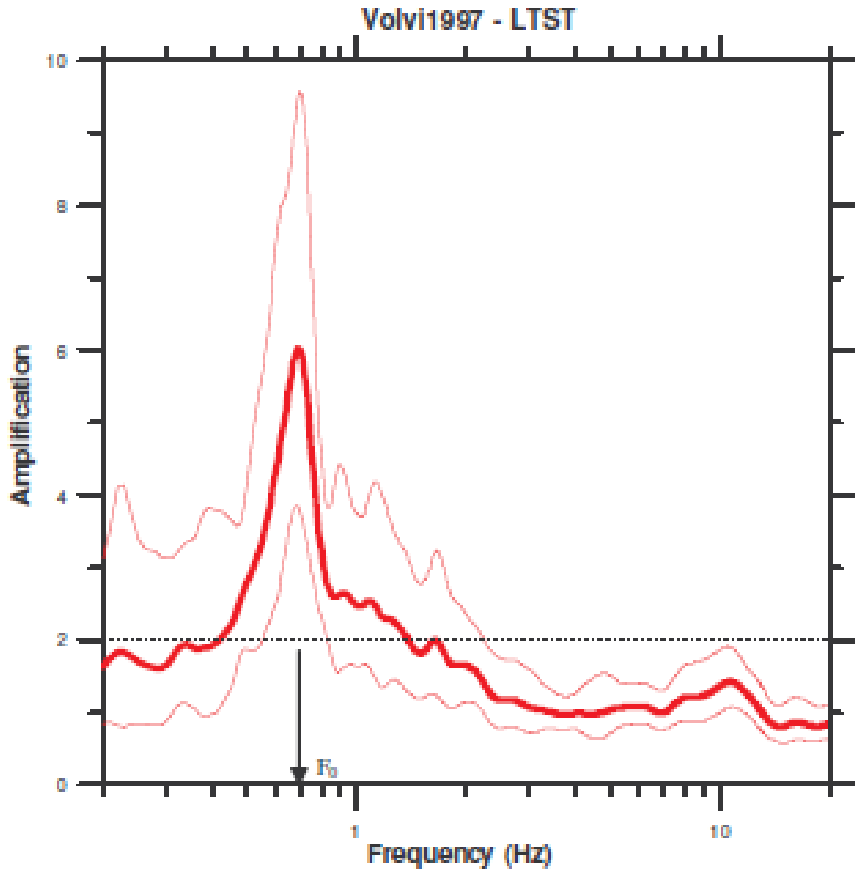


Criteri per una H/V affidabile (devono essere rispettati tutti e tre i parametri)
$f_0>10/L_w$
$n_c(f_0)>200$
$\sigma_A<2$ per $0.5f_0<f<2f_0$ se $f_0>0.5$ Hz oppure $\sigma_A<3$ per $0.5f_0<f<2f_0$ se $f_0<0.5$ Hz

Criteri per un picco H/V chiaro (almeno 5 su 6 devono essere rispettati)
Esiste f- in $[f_0/4, f_0]$ | $A_{H/V}(f-)<A_0/2$
Esiste f+ in $[f_0, 4f_0]$ | $A_{H/V}(f+)<A_0/2$
$A_0>2$
$f_{picco}[A_{H/V}(f)\pm\sigma_A(f)]=f_0\pm5\%$
$\sigma_f<\sigma(f_0)$
$\sigma_A(f_0)<\theta(f_0)$

Lw=Lunghezza finestra.
nw=Numero di finestre selezionate per la media della curva H/V.
nc=Lw*nw*f0=Numero di cicli significativi.
f=Frequenza corrente.
f0=Picco di frequenza H/V.
σ f=Deviazione standard del picco di frequenza H/V (f0 ±σ f).
σ(f0)=Valore di soglia per la condizione di stabilità σ f<σ(f0).
A0=Ampiezza del picco H/V alla frequenza f0.
AH/V(f)=Ampiezza della curva H/V alla frequenza f0.
f-=Frequenza tra f0 /4 e f0 per cui AH/V(f-)<A0 /2.
f+=Frequenza tra f0 e 4f0 per cui (f+)<A0 /2.
σ A(f0)=Deviazione standard di AH/V(f), σ A(f) è il valore per il quale la AH/V(f) va moltiplicata o divisa.
σ Log H/V(f)=Dev. Standard della curva Log AH/V(f), σ Log H/V(f)è il valore assoluto da sottrarre o addizionare alla curva media Log AH/V(f).
θ(f0)=Valore di soglia per la condizione di stabilità σ f<θ(f0).

Valori di soglia per le condizioni di stabilità					
Range di frequenza [Hz]	<0,2	0,2-0,5	0,5-1,0	1,0-2,0	>2,0
$\sigma(f_0)$ [Hz]	$0{,}25f_0$	$0{,}20f_0$	$0{,}15f_0$	$0{,}10f_0$	$0{,}05f_0$
$\theta(f_0)$ per $\sigma_A(f_0)$	3	2,5	2	1,78	1,58
Log $\theta(f_0)$ per $\sigma_{Log\,H/V}(f_0)$	0,48	0,4	0,3	0,25	0,2



Basin geometry: Elongated alluvial valley, width~5km, length~40km, Depth~200m

Site Information
LTST site depth to bedrock: 196m
Type of bedrock: Gneiss
Average shear wave velocity of deposits: 570m/s

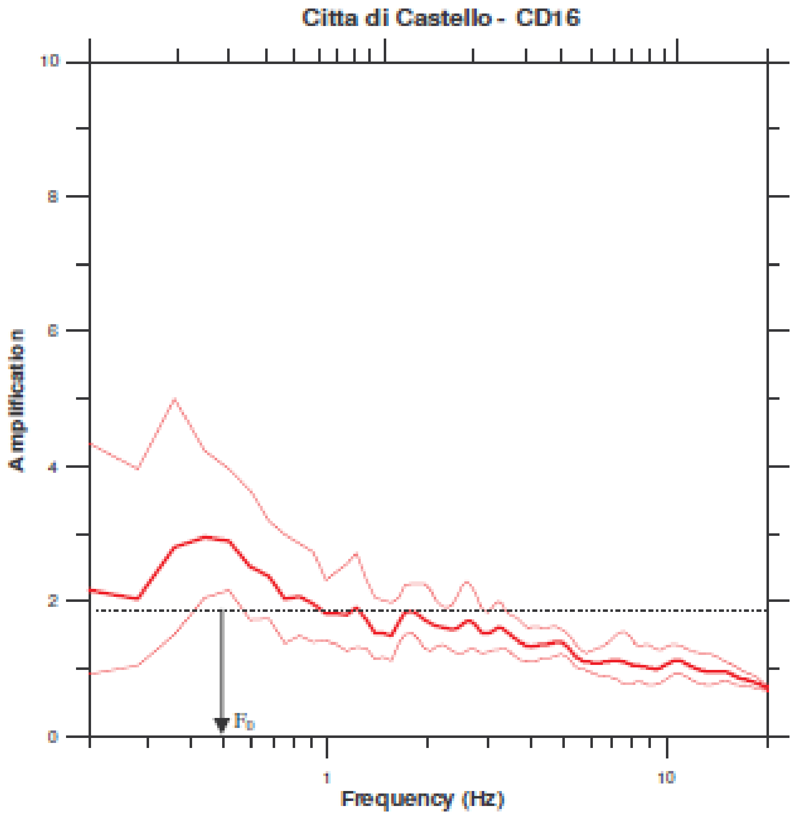
Comments
Criteria for a reliable H/V curve are fulfilled, that is:

$f_0 > 10 / l_w$
$n_c(f_0) > 200$
$\sigma_A(f) < \log_{10}(2)$

Criteria for an ideal H/V peak are also fulfilled:

$A_0 (=6) > 2$
$\exists f^- \in [f_0/4, f_0] \mid A_{H/V}(f^-) < A_0/2$
$\exists f^+ \in [f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$
$\sigma_f (=14\%) < \varepsilon(f_0) (=15\%)$
$\sigma_A(f_0) (=1.6) < \theta(f_0) (=2)$

Interpretation : All criteria are fulfilled, the fundamental frequency of the site may be reliably estimated at 0.7 Hz.



Basin geometry: Elliptical alluvium valley, width~10km, length~25km, depth~0.1km

Site Information
CD16 site is situated on soft alluvium sediments and silty clay.
Type of bedrock: Sandstone (Middle Miocene).

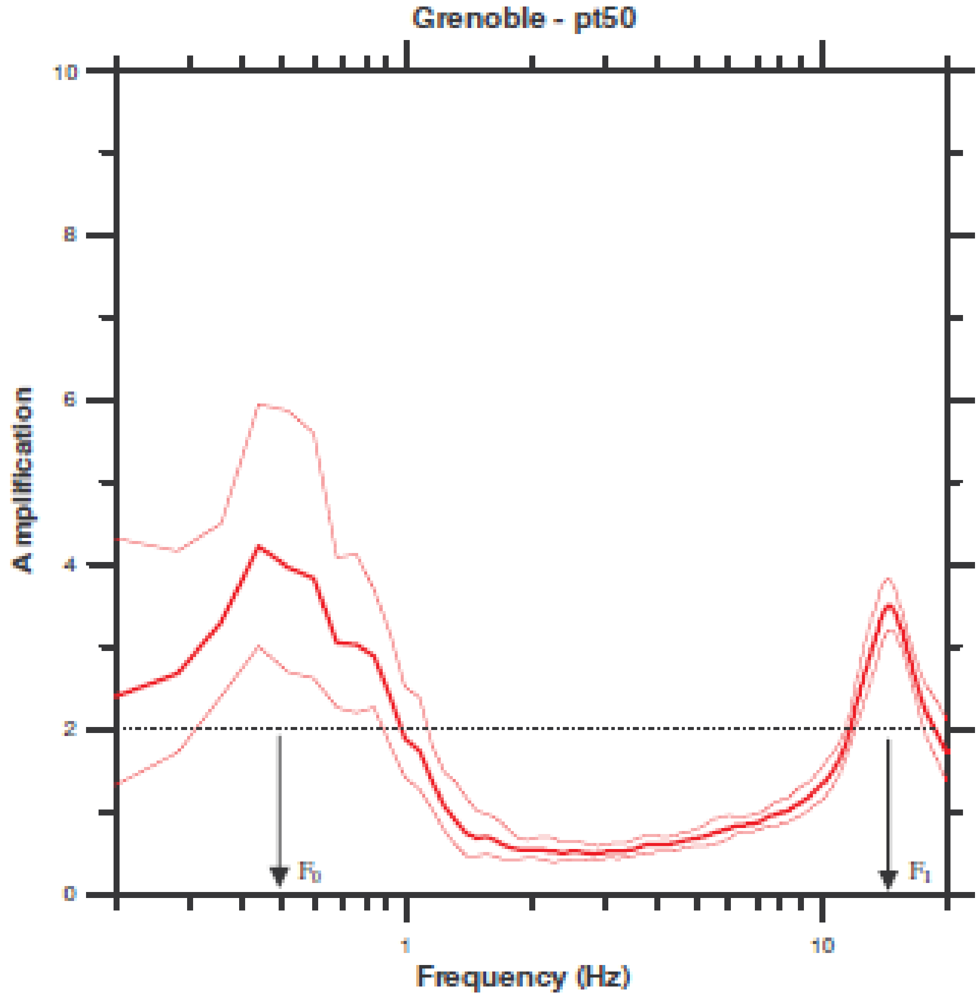
Comments
Criteria for a reliable H/V curve are fulfilled, that is:

$f_0 > 10 / l_w$
$n_c (f_0) > 200$
$\sigma_A(f) < \log_{10}(2)$

In addition:

Although $A_0(=2.9) > 2$, the peak cannot be qualified "clear" since the amplitude is not decreasing rapidly on each side.
None $f_1 \in [f_0/4, f_0] \mid A_{H/V}(f_1) < A_0/2$
None $f_2 \in [f_0, 4f_0] \mid A_{H/V}(f_2) < A_0/2$

Interpretation : further tests should be performed as listed in section II-3.3.2-b



Basin geometry: Y-shaped sedimentary valley, Depth~800m

Site Information
PT50 site is situated on late quaternary post-glacial deposits.
Type of bedrock: Jurassic marls and marly limestone.

Comments
Criteria for a reliable H/V curve are fulfilled, that is:

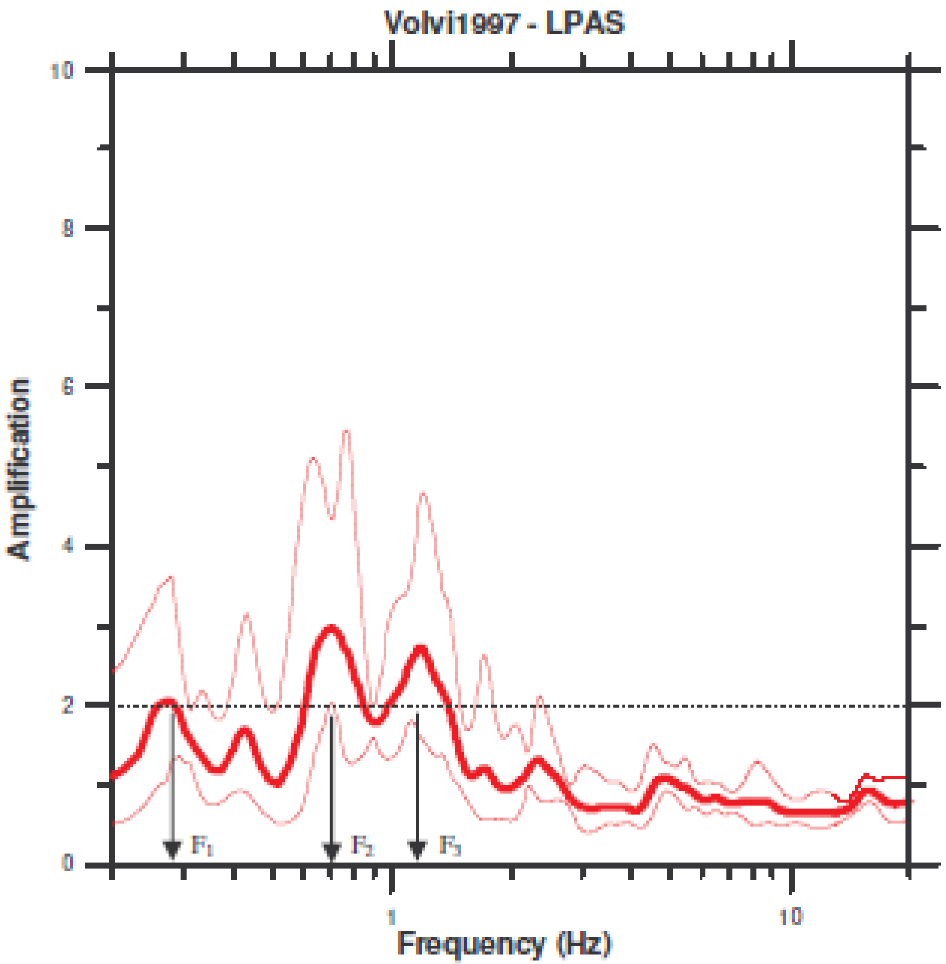
$f_0 > 10 / l_w$
$n_c (f_0) > 200$
$\sigma_A(f) < \log_{10}(2)$

Interpretation :
For the low frequency peak, $A_0(=4.0) > 2$ and $\exists f_2 \in [f_0, 4f_0] \mid A_{H/V}(f_2) < A_0/2$
Although, strictly speaking, one cannot find $f_1 \in [f_0/4, f_0] \mid A_{H/V}(f_1) < A_0/2$, the general trend of the curve, together with the known geology of the site, allow the meaning of the low frequency peak to be assigned with confidence; another processing with more narrow band smoothing would satisfy the criteria

For the second peak, all the criteria are fulfilled:

$A_1(=3.5)>2$
$\exists f_1 \in [f_1/4, f_1] \mid A_{H/V}(f_1) < A_1/2$
$\exists f_2 \in [f_1, 4f_1] \mid A_{H/V}(f_2) < A_1/2$

This second peak around 13 Hz is certainly associated with a very shallow structure.



Basin geometry: Elongated alluvial valley, width~5km, length~40km, Depth~200m

Site Information
LTST site depth to bedrock: ~180m
Type of bedrock: Gneiss
Average shear wave velocity of deposits: 570m/s

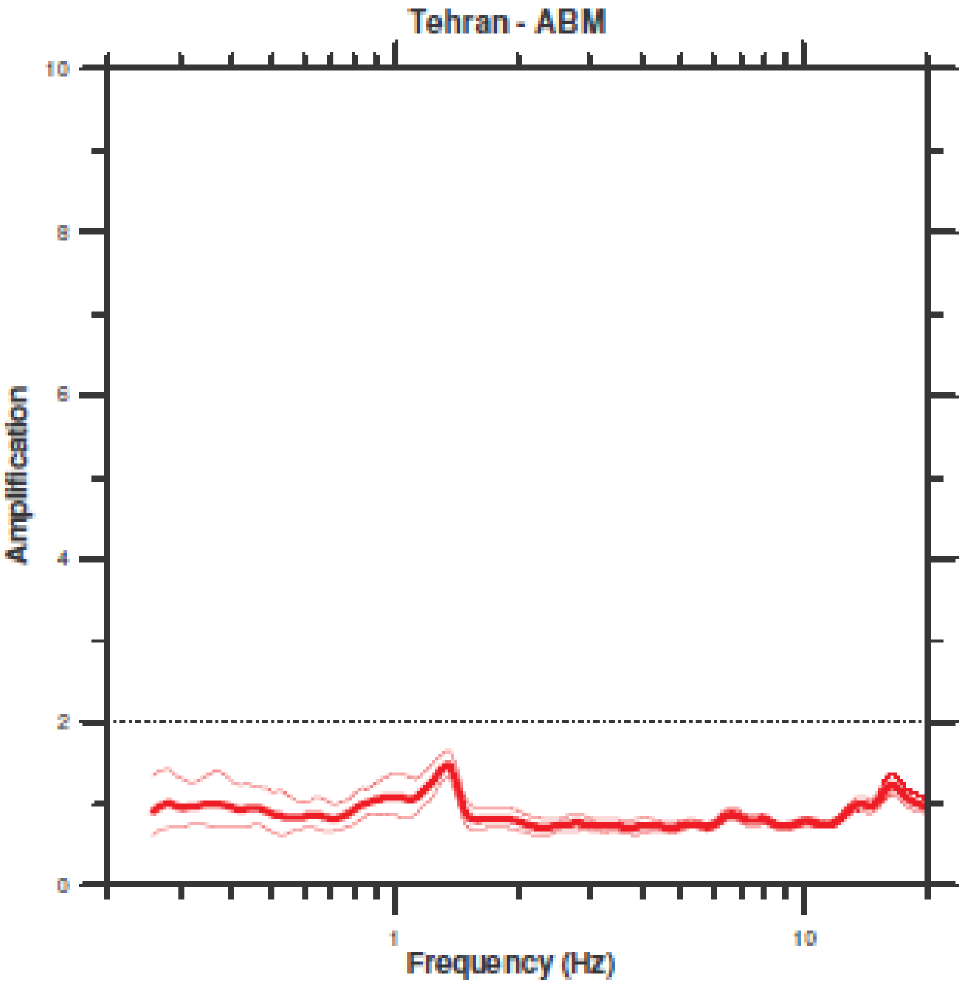
Comments
Criteria for a reliable H/V curve are fulfilled, that is:

$f_0 > 10 / l_w$

$n_c (f_0) > 200$

$\sigma_A(f) < \log_{10}(2)$

Interpretation : All three peaks fulfil the criterion for amplitude, A_i>2. However, only the peaks F_2 and F_3 fulfil all "clarity" criteria (3.3.1). The availability of other information (geology, deposit thickness, geophysics) in that area allows us to identify f_2 as the fundamental frequency of the site. The location of this site close to a valley edge may explain the presence of these two peaks with rather low amplitude, while another nearby site (LTST, see above the "clear peak" example") exhibits a clear peak with larger amplitude: the latter is located in the central, part of the graben.



Basin geometry: Unknown

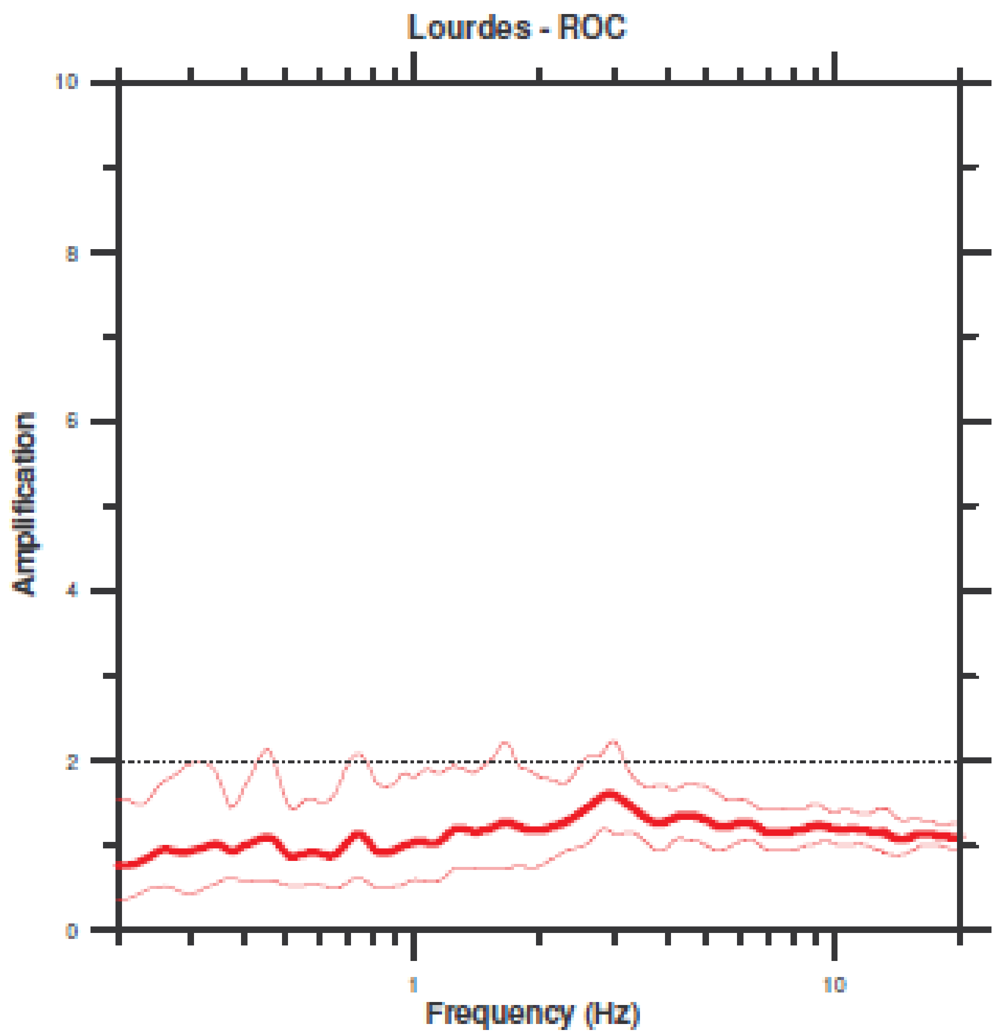
Site Information
ABM site is characterised by stiff soil (coarse grained alluvium) overlying bedrock at an unknown depth.

Comments
Criteria for a reliable H/V curve are fulfilled, that is:

$f_0 > 10 / l_w$
$n_c(f_0) > 200$
$\sigma_A(f) < \log_{10}(2)$

Significant low frequency amplification (F<1.0 Hz) was found for the ABM sedimentary site using earthquake data, which does not appear in the H/V ratio. This site is one of the few examples of non-rock sites exhibiting a flat H/V curve though also exhibiting a significant low frequency amplification (less that 5% of the total number of sites studied, as can be seen on Figure 8, section 3.1)

Note: the peak around 1.3 Hz was shown to have an industrial origin.



Basin geometry: Confluence of two valleys

Site Information
ROC site is situated on rock outcrop at the confluence of two valleys (reference site). (Dubos et al., 2003; Dubos, 2003)

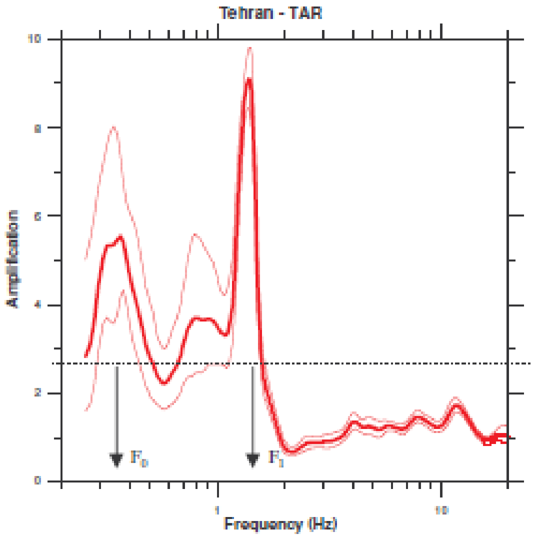
Comments
Criteria for a reliable H/V curve are fulfilled, that is:

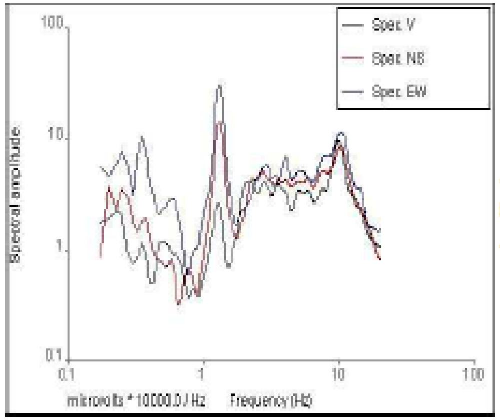
$f_0 > 10 / l_w$

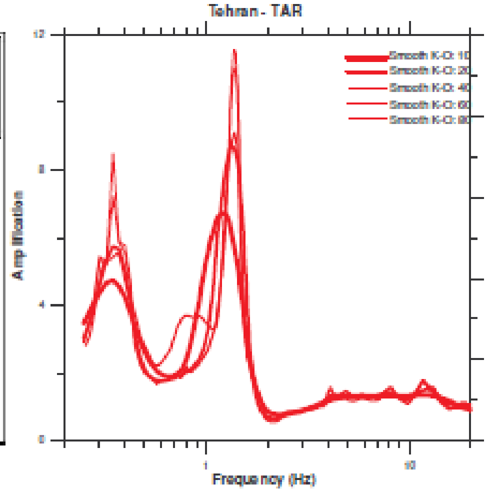
$n_c(f_0) > 200$

$\sigma_A(f) < \log_{10}(2)$

The H/V ratio is flat over the whole frequency range examined. As the available geological information unambiguously indicates that it is a hard rock site, this flat H/V curve may be interpreted as indicative of a good, non weathered reference site free of any amplification even at high frequencies.







Site Information
TAR site is overlain with stiff soil (coarse grained alluvium).

Comments
Criteria for a reliable H/V curve are fulfilled, that is:

$f_0 > 10 / l_w$

$n_c (f_0) > 200$

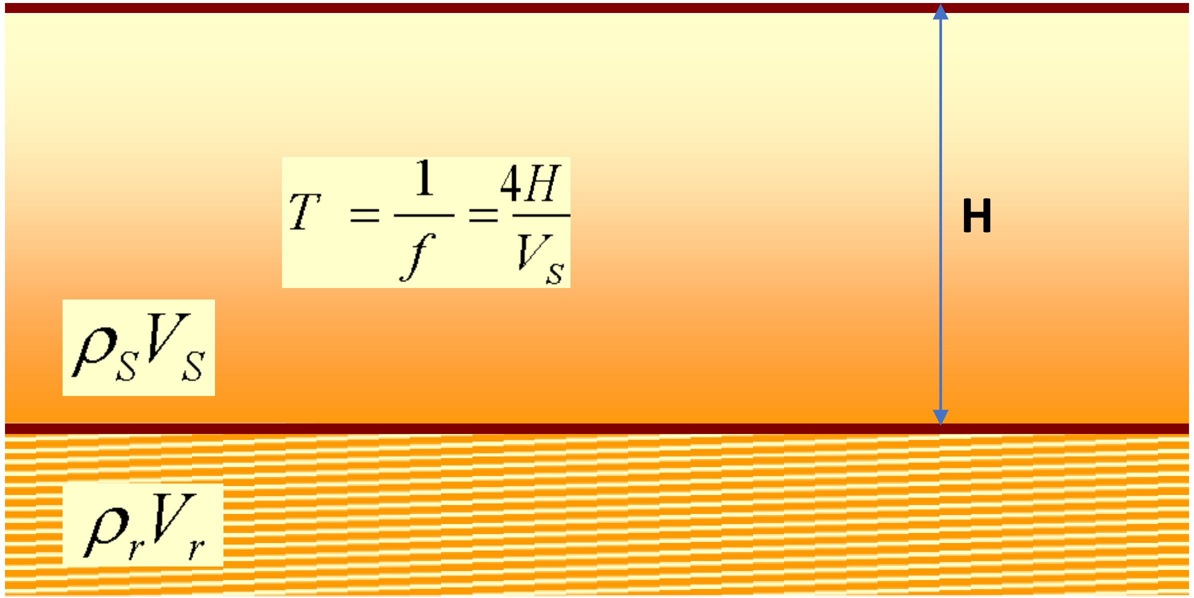
$\sigma_A(f) < \log_{10}(2)$

The F_1 local narrow peak has an industrial origin. This (H/V) spectral ratio peak is due to manmade noise/machinery; the reprocessing with different smoothing parameters (bottom right) shows it becomes narrower and narrower, with a larger and larger amplitude when the b-value (Konno-Ohmachi smoothing approach) is increasing: this behaviour is typical of industrial origin. Another confirmation is obtained form the fact this narrow peak occurs at the same frequency in the Fourier spectra of all three components (Figure on bottom left).

Basin geometry: Unknown

1D Amplification

Elastic layer on deformable basement



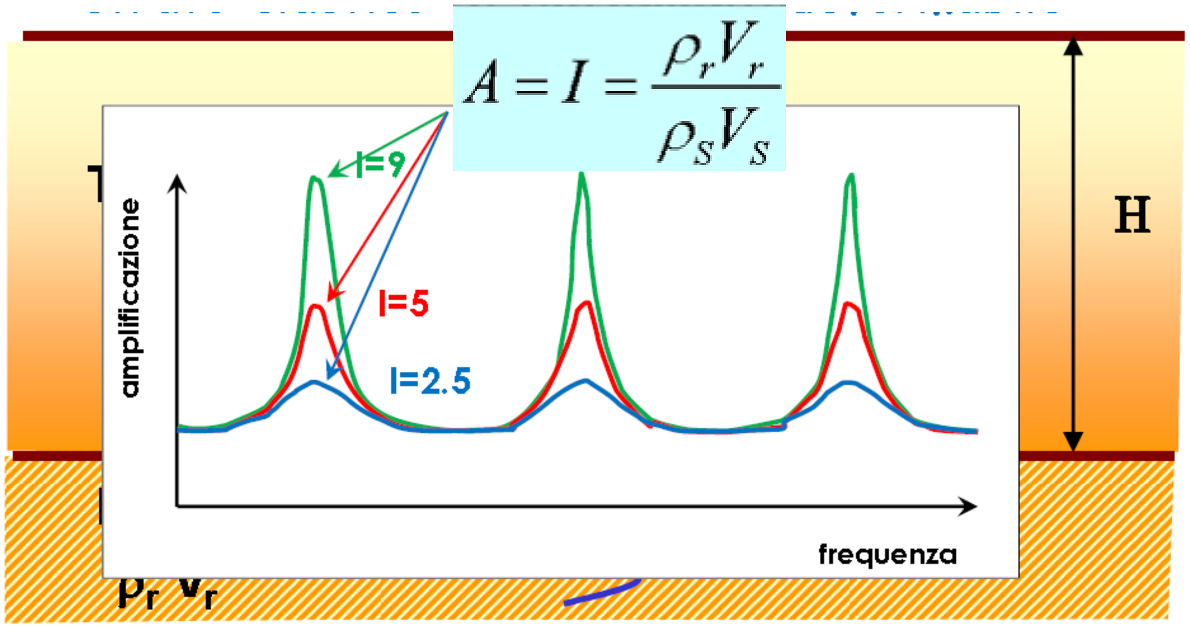
$$T = \frac{1}{f} = \frac{4H}{V_S}$$

$\rho_S V_S$

$\rho_r V_r$

1D Amplification

Elastic layer on deformable basement



$$I = \frac{\rho_r V_r}{\rho_S V_S}$$

Rock-to-soil impedance ratio

$$T_n = \frac{1}{f_n} = \frac{4H}{V_S(2n+1)}$$

natural periods

Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

1D Amplification

The two control variables

$$I = \frac{\rho_r V_r}{\rho_S V_S}$$

$$T_0 = \frac{1}{f_0} = \frac{4H}{V_S}$$

Studies by Borcherdt (1992, 1994, 2002) shown for sites:

- of comparable basement thickness H
- of comparable velocity V_r

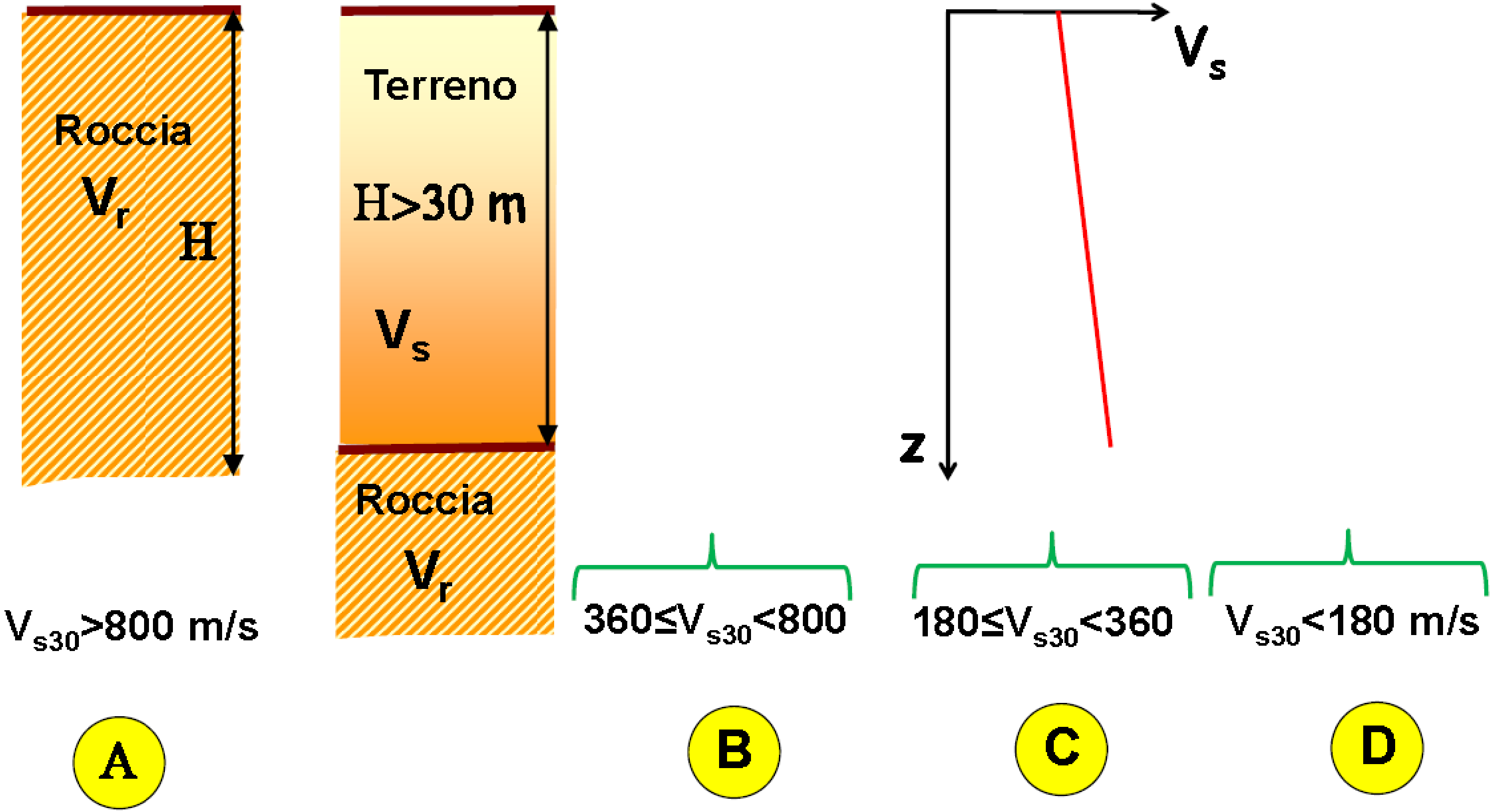
the average amplification increases as V_s

Under these conditions V_s can be an effective parameter for seismic characterization.

$$V_{s30} = \frac{30}{\sum_{i=1}^{n} \frac{h_i}{V_{si}}} \Rightarrow \sum_{i=1}^{n} t_i \Rightarrow$$

Subsurface classes

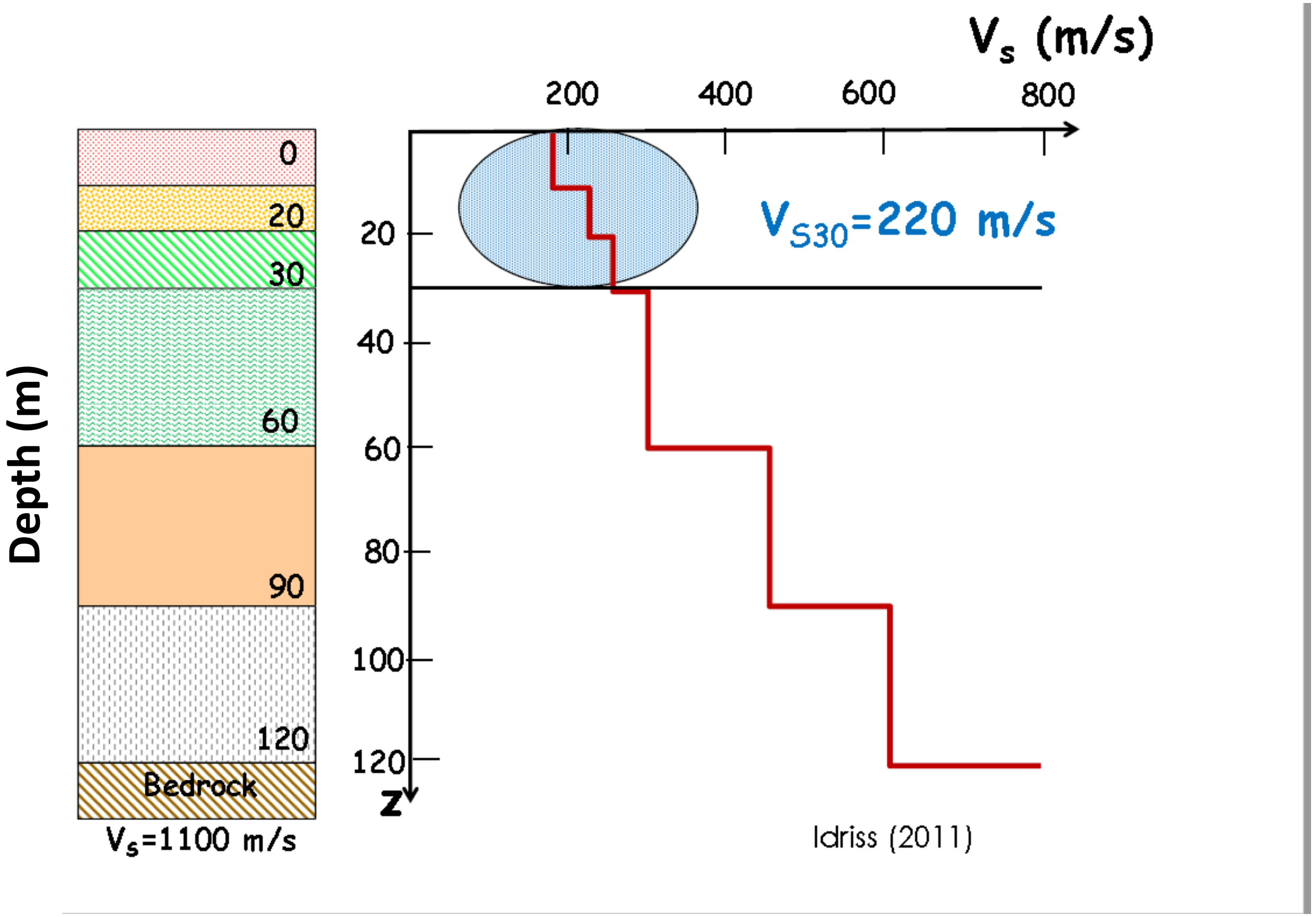
For subsurface classes A to E, $V_{s,30}$ is calculated:



Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

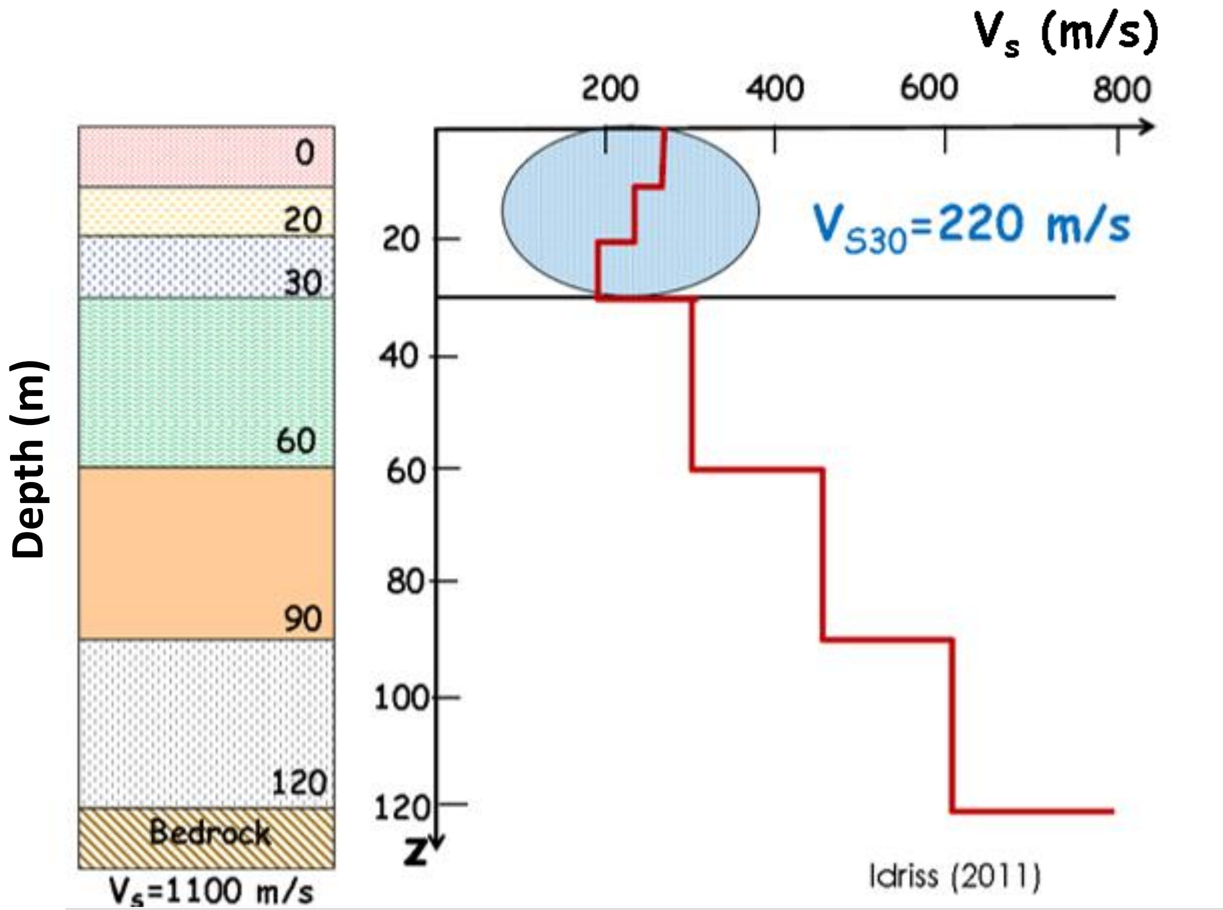
Sites with the same vs30 can have significantly different responses



Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

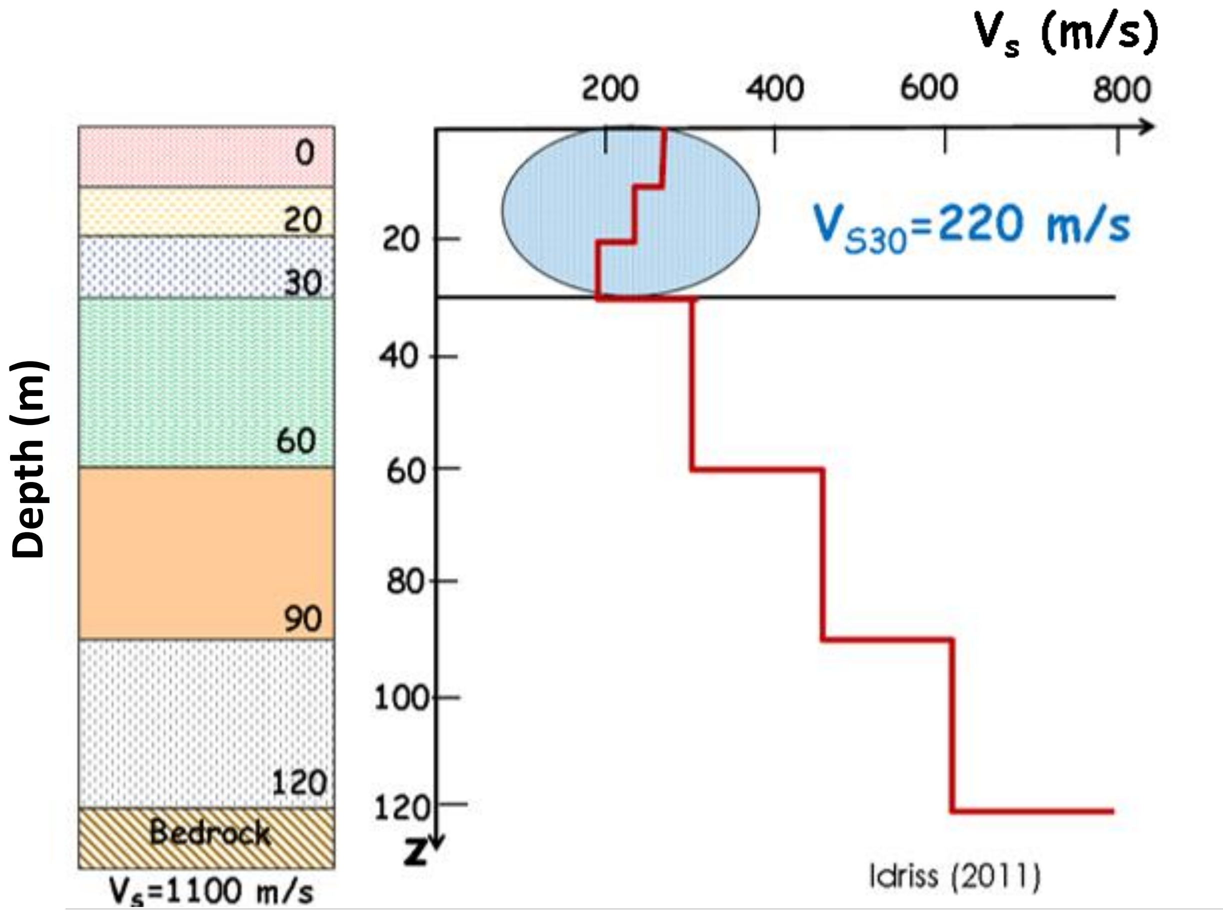
Sites with the same vs30 can have significantly different responses



Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

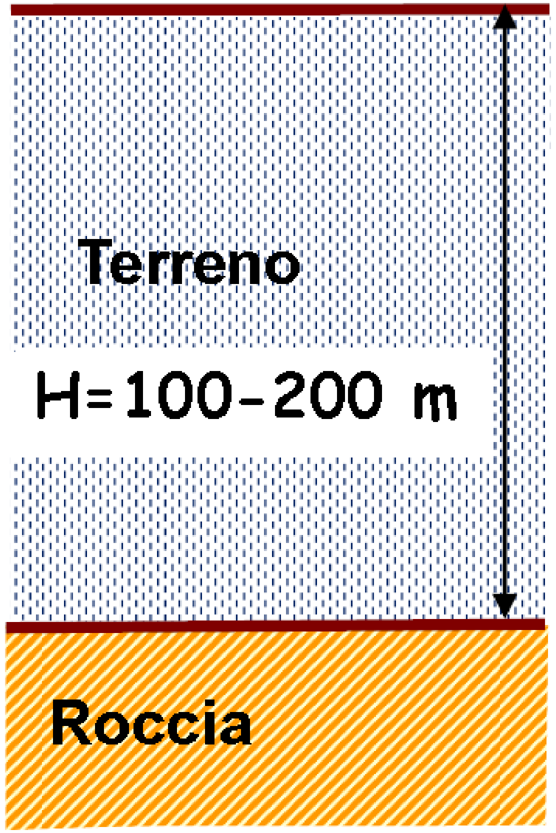
Sites with the same vs30 can have significantly different responses

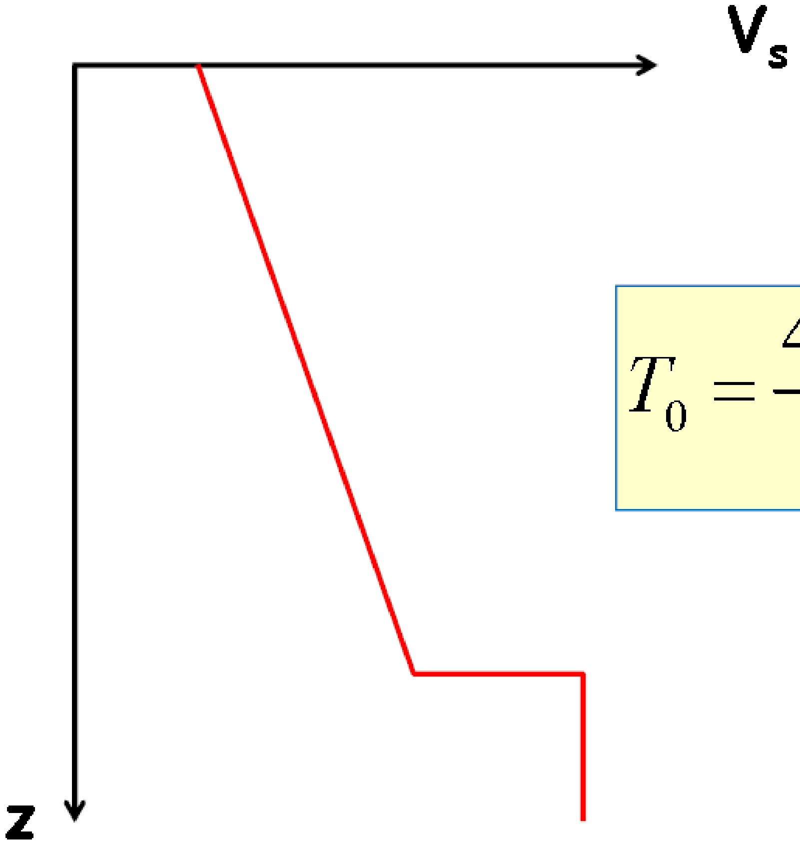


Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

Deposits of soils of high thickness



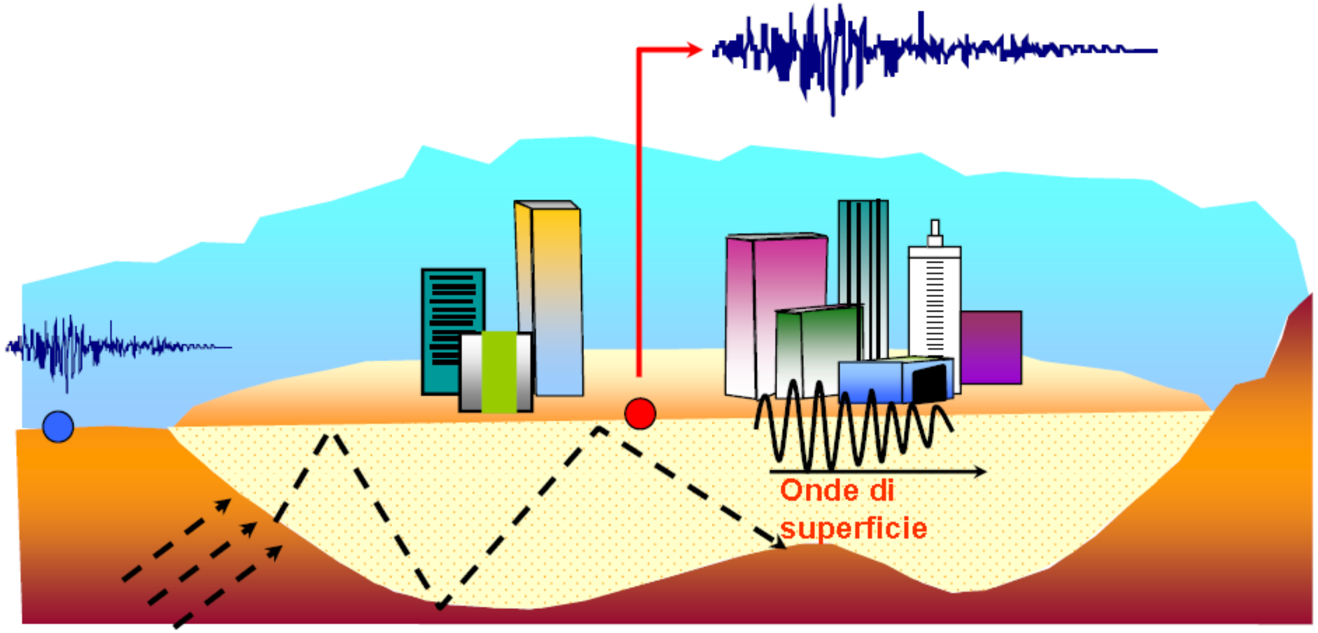


$$T_0 = \frac{4H}{V_s}$$

Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

2D Amplification



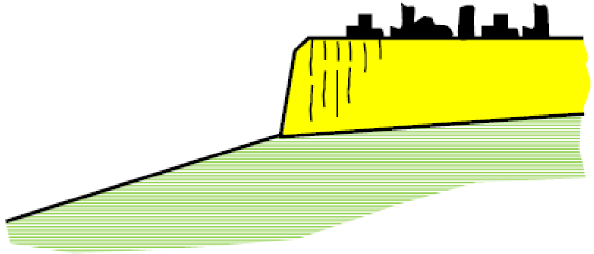
Compared with 1D conditions:

- increased amplification
- increase in duration
- broadband amplification
- spatial variation of motion

Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

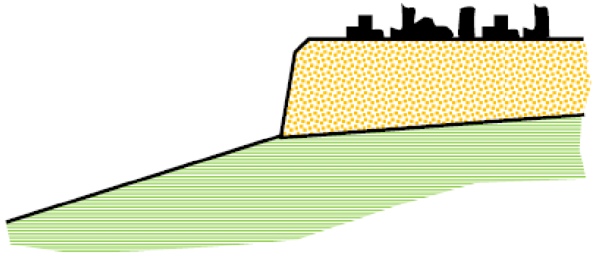
Limits of Vs30

Cliff-type configurations



Rock pastrons on clay substrate

- Orvieto (TR) **(lithoid tuff on marine clays)**
- Agrigento **(calcarenites on marine clays)**
- Gerace (RC) **(calcarenites on varicolored clays)**



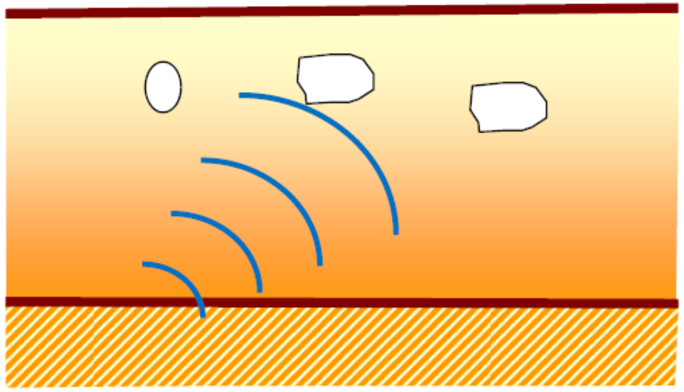
Banks of sandy and gravelly soils on clay substrate

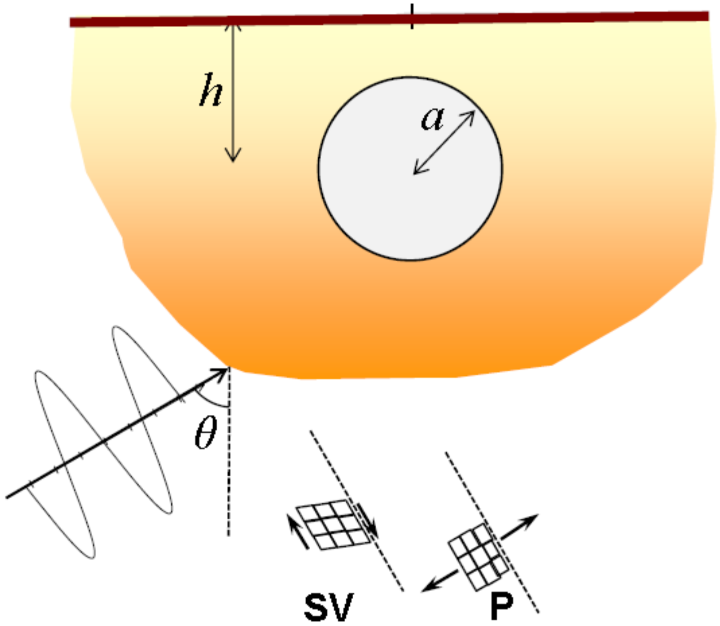
- Bisaccia (AV) **(conclomerates on Pliocene flake clays).**

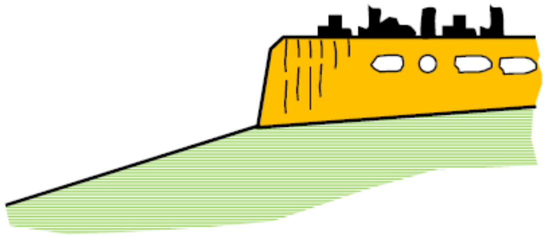
Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

Limits of Vs30

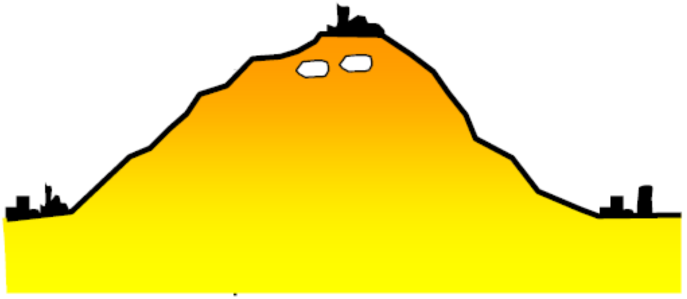
Presence of cavities







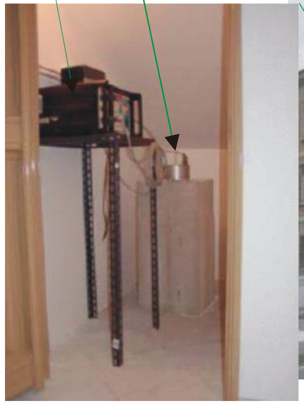
➢ Orvieto (TR)

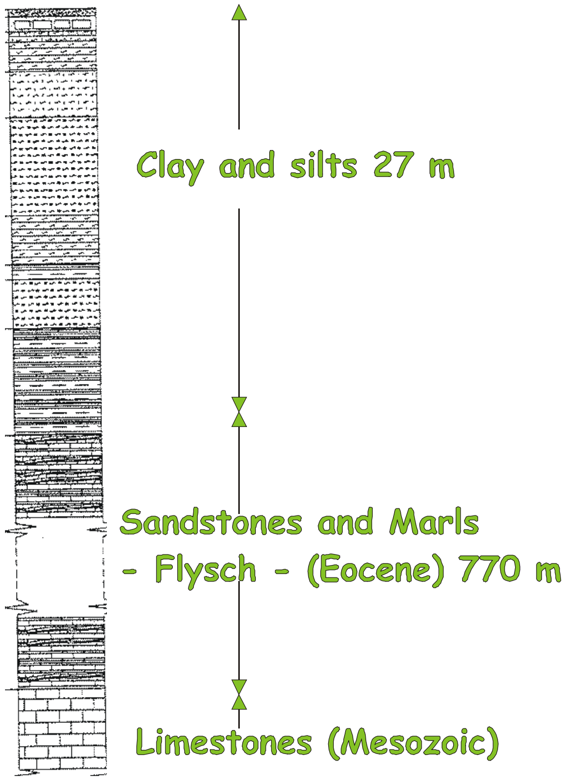


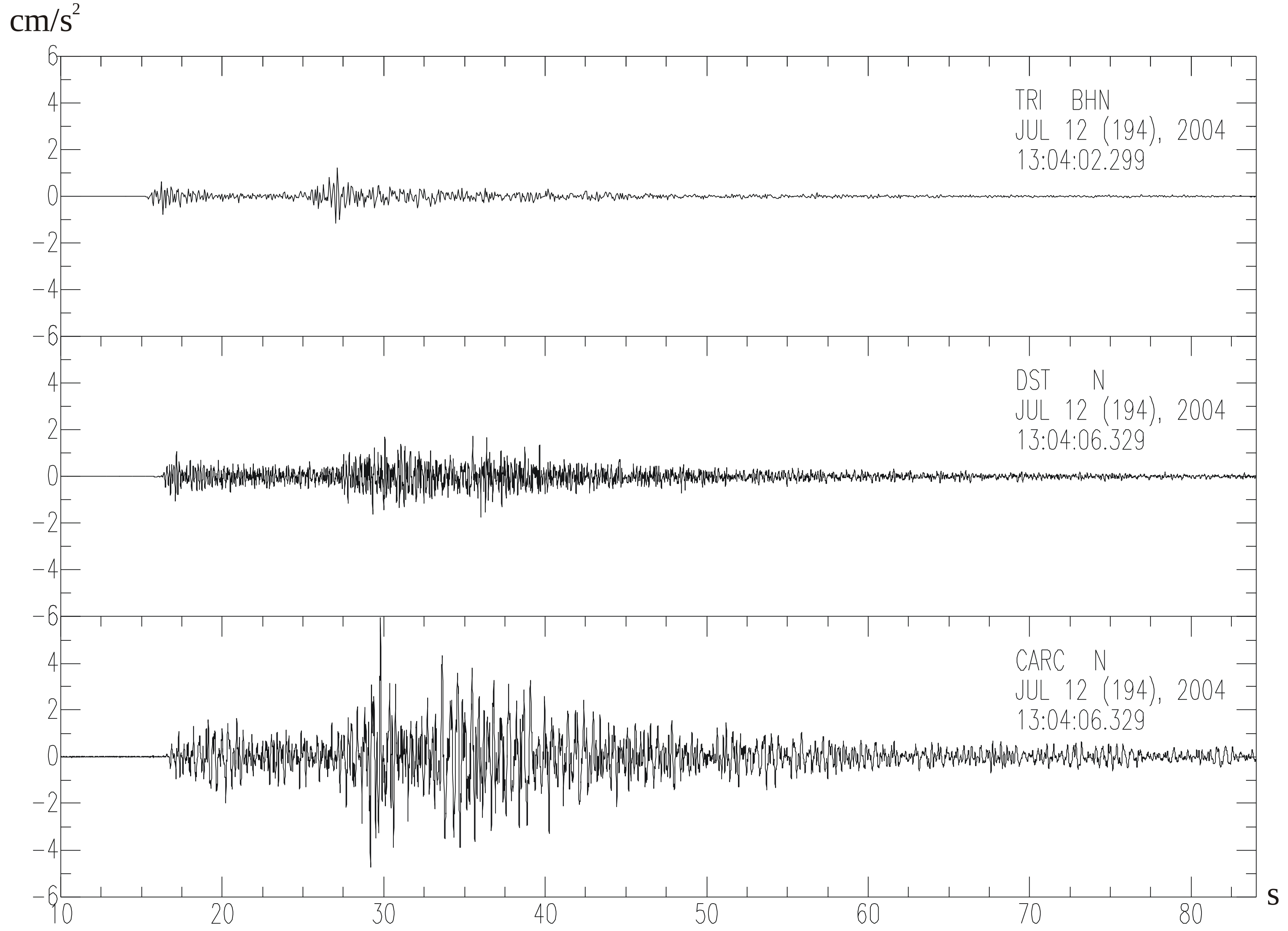
➢ Castelnuovo (AQ)

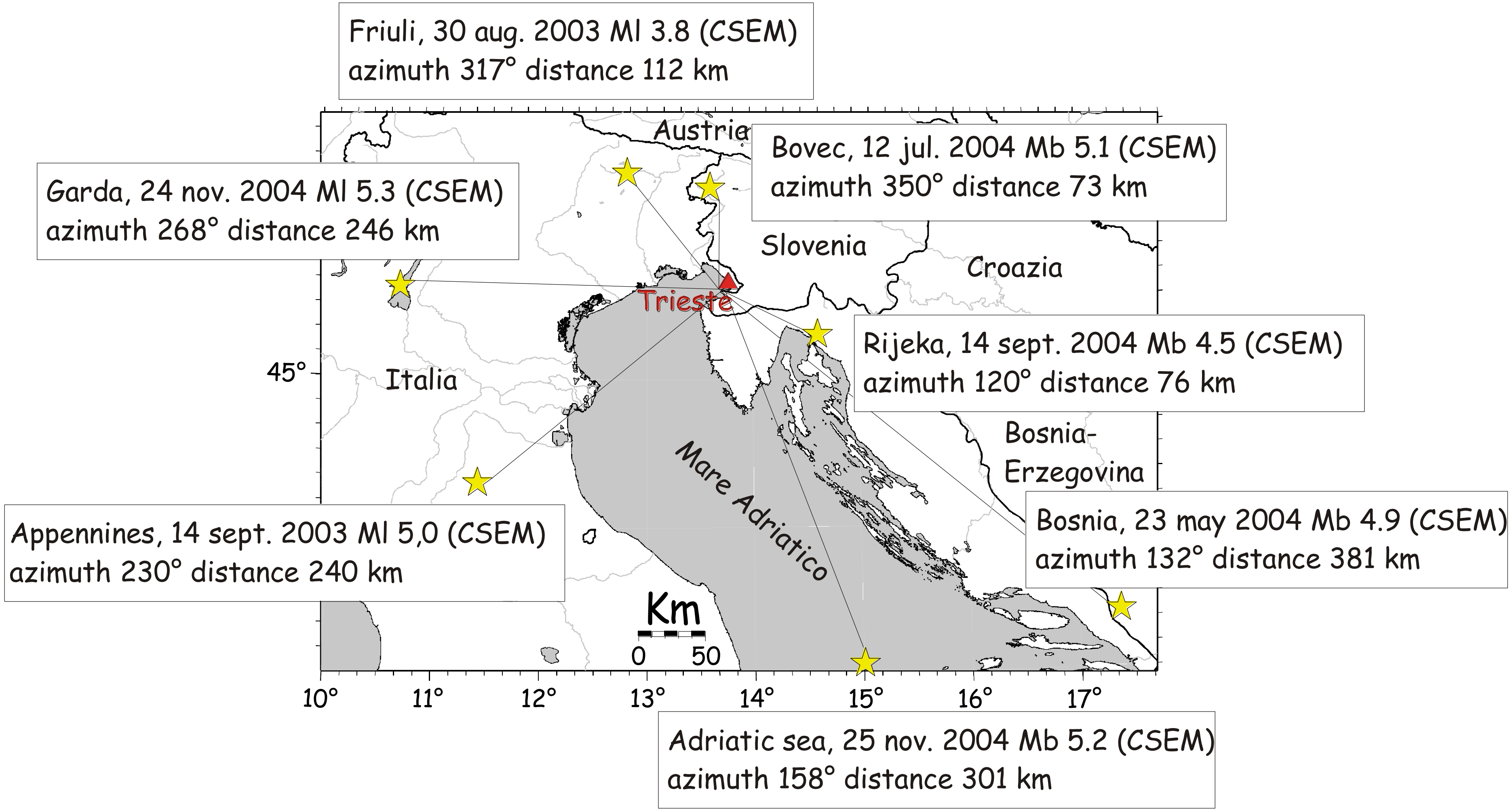
Da: "Le categorire di sottosuolo delle NTC08: limiti applicabilità V_{s30}" - Giuseppe Lanza

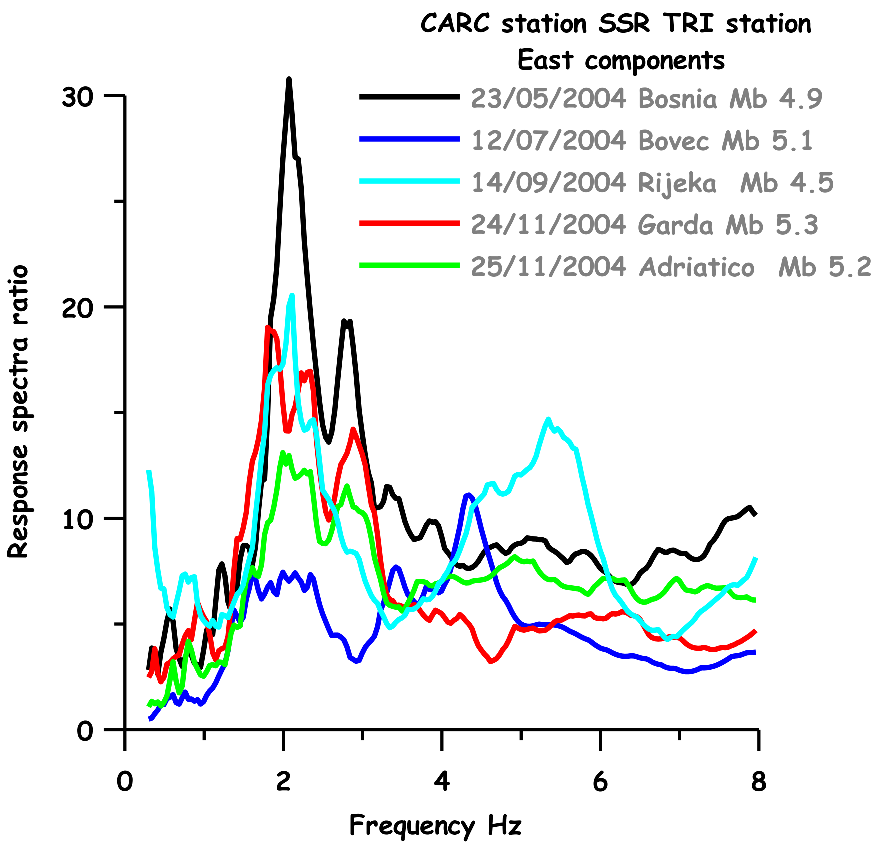
The station CARC

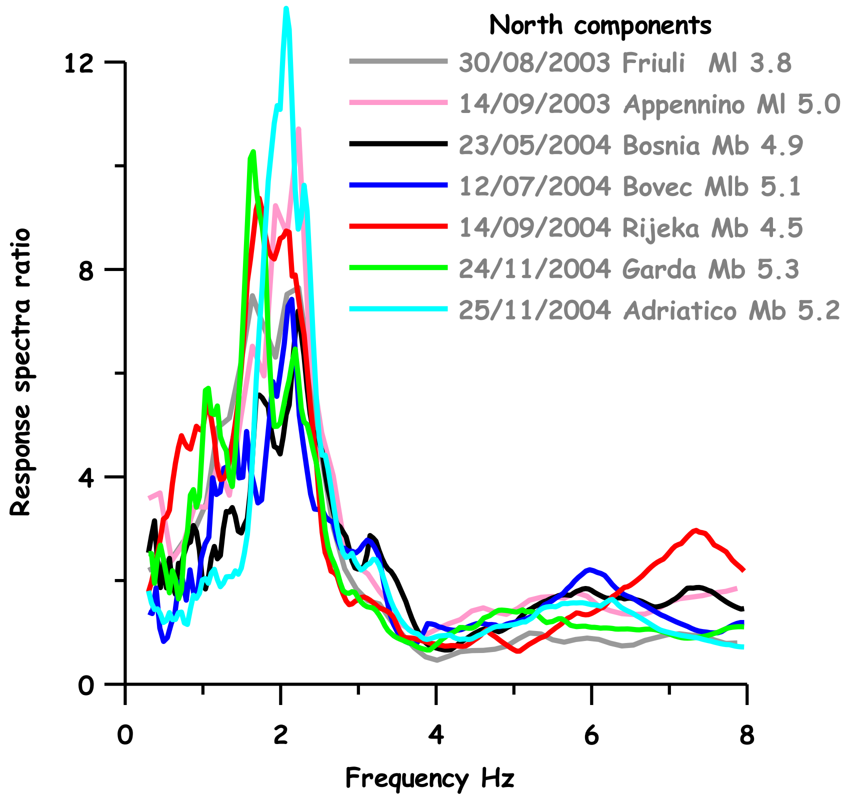


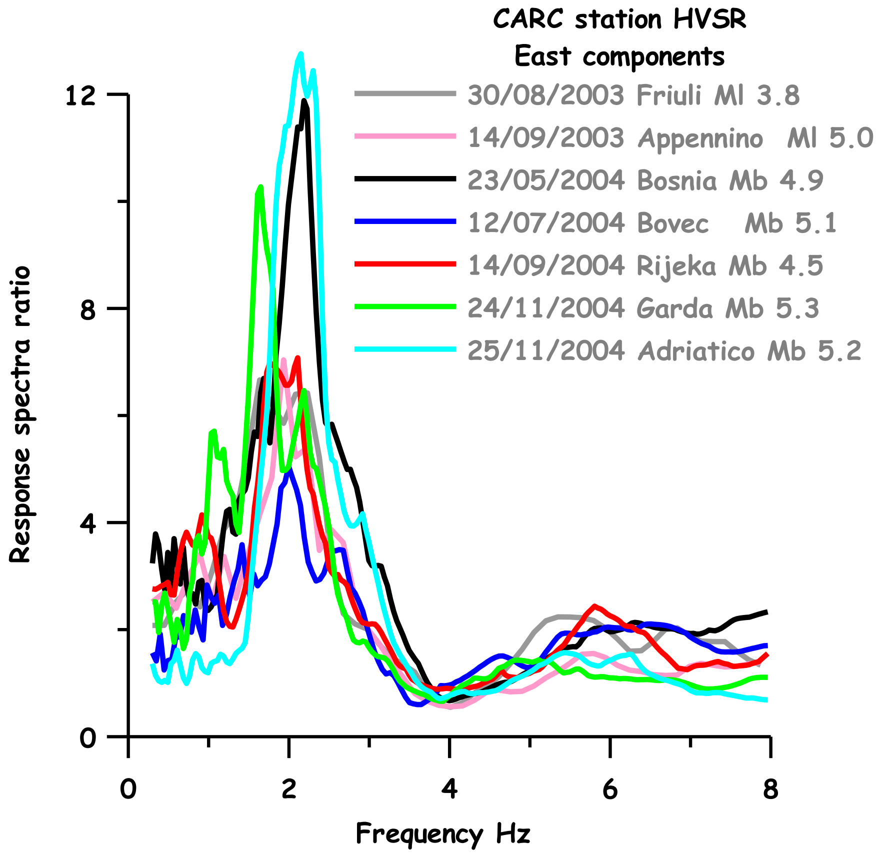


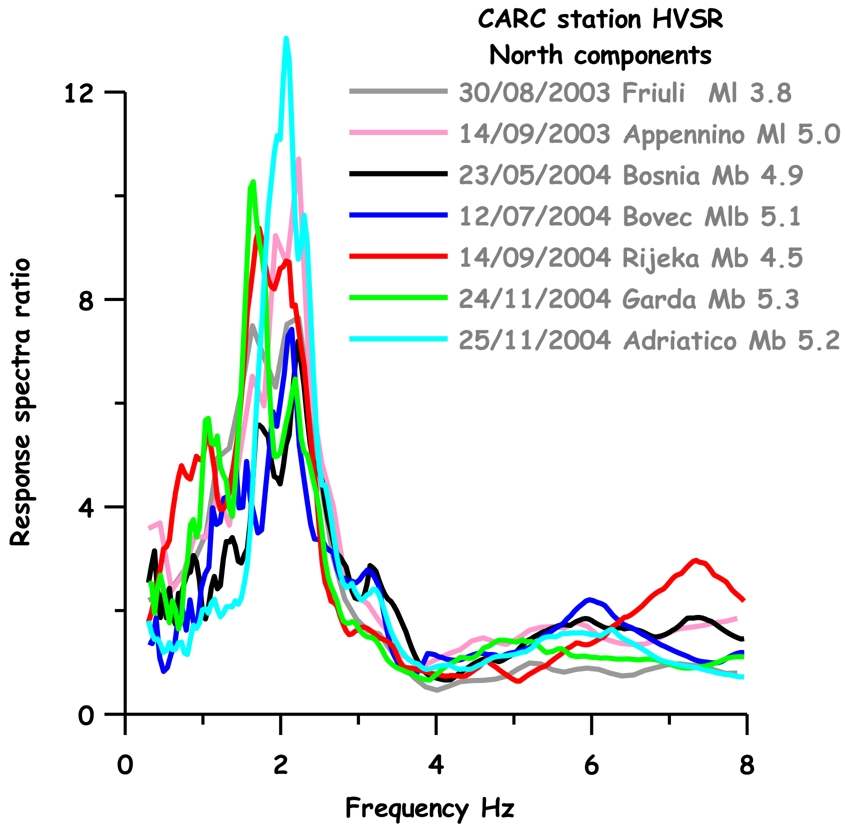

cm/s²
TRI BHN
JUL 12 (194), 2004
13:04:02.299
DST N
JUL 12 (194), 2004
13:04:06.329
CARC N
JUL 12 (194), 2004
13:04:06.329
6
4
2
0
−2
−4
−6
10
20
30
40
50
60
70
80
s

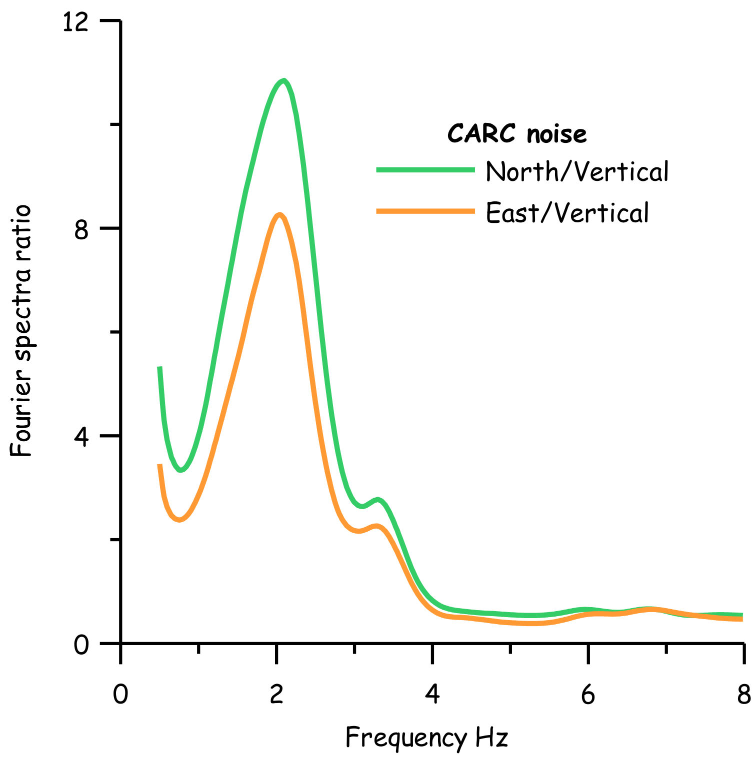

Friuli, 30 aug. 2003 Ml 3.8 (CSEM)
azimuth 317° distance 112 km
Austria
Bovec, 12 jul. 2004 Mb 5.1 (CSEM)
azimuth 350° distance 73 km
Garda, 24 nov. 2004 Ml 5.3 (CSEM)
azimuth 268° distance 246 km
Slovenia
Croazia
Trieste
Rijeka, 14 sept. 2004 Mb 4.5 (CSEM)
azimuth 120° distance 76 km
45°
Italia
Bosnia-
Erzegovina
Mare Adriatico
Bosnia, 23 may 2004 Mb 4.9 (CSEM)
azimuth 132° distance 381 km
Appennines, 14 sept. 2003 Ml 5,0 (CSEM)
azimuth 230° distance 240 km
Km
0
50
10°
11°
12°
13°
14°
15°
16°
17°
Adriatic sea, 25 nov. 2004 Mb 5.2 (CSEM)
azimuth 158° distance 301 km


CARC station SSR TRI station
East components
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz
0
10
20
30
2
4
6
8

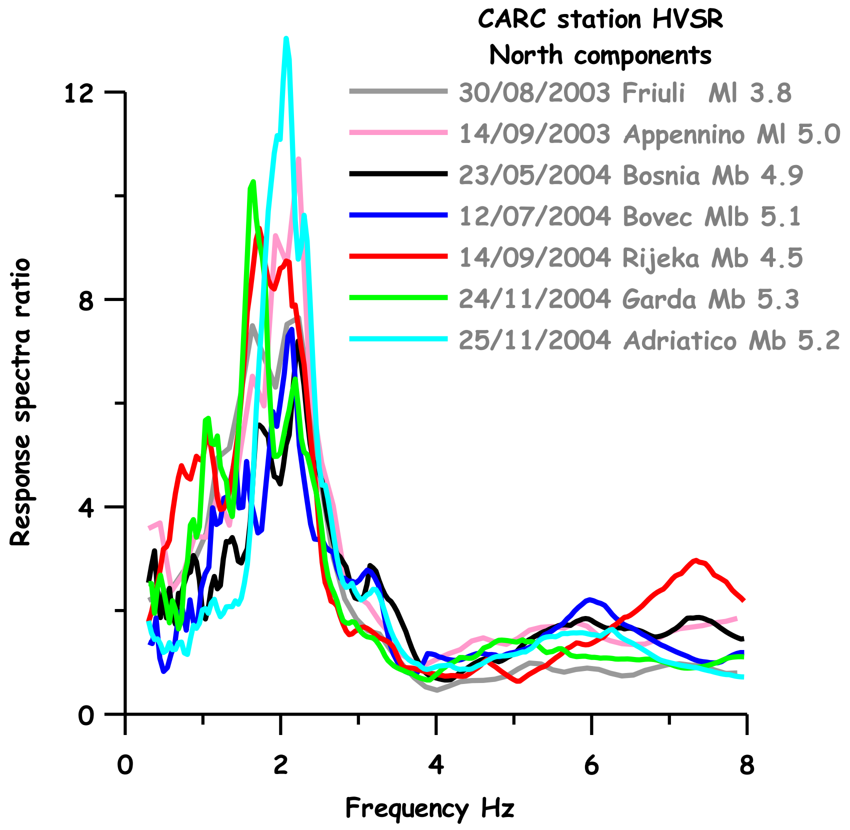

CARC station HVSR
North components
30/08/2003 Friuli Ml 3.8
14/09/2003 Appennino Ml 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mlb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz
0
4
8
12
2
4
6
8


CARC station HVSR
East components
30/08/2003 Friuli Ml 3.8
14/09/2003 Appennino Ml 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8

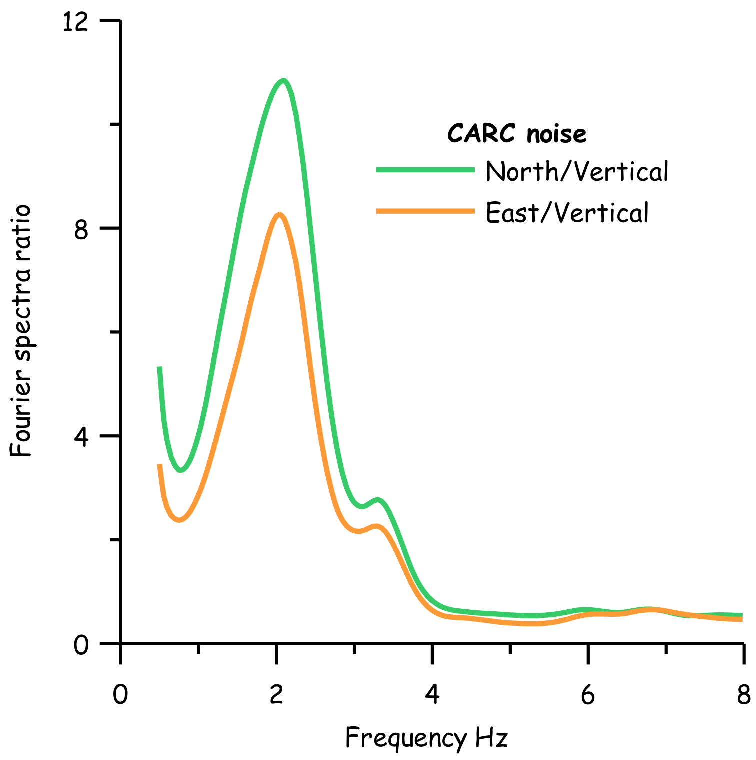

CARC station HVSR
North components
30/08/2003 Friuli Ml 3.8
14/09/2003 Appennino Ml 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mlb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8

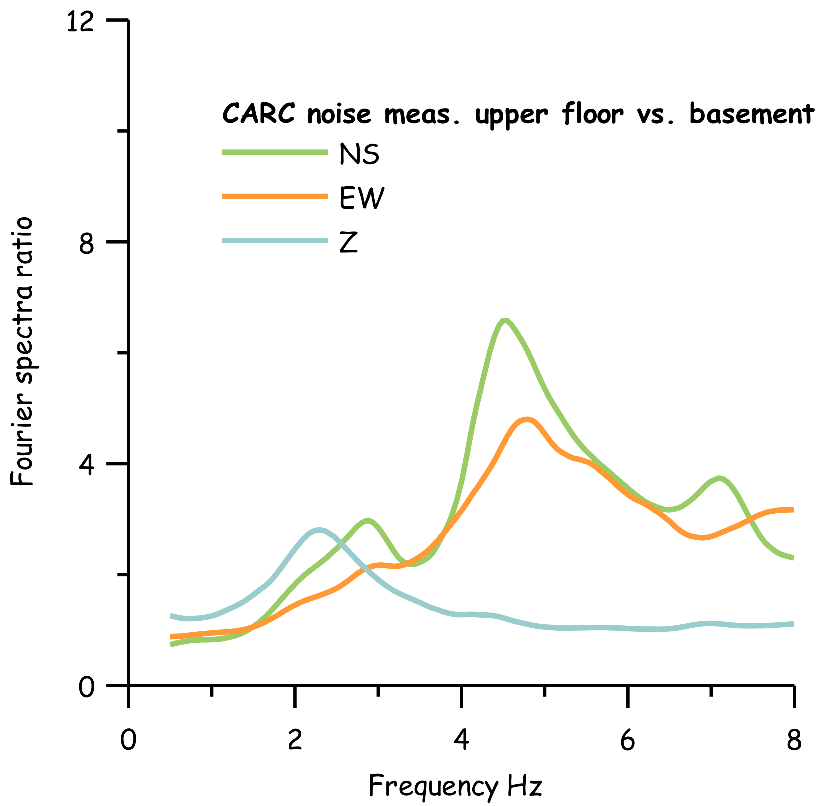


CARC noise
North/Vertical
East/Vertical
Fourier spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8



CARC station HVSR
North components
30/08/2003 Friuli Ml 3.8
14/09/2003 Appennino Ml 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mlb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8


CARC noise
North/Vertical
East/Vertical
Fourier spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8


CARC noise meas. upper floor vs. basement
NS
EW
Z
Fourier spectra ratio
Frequency Hz
0
4
8
12
0
2
4
6
8

For 1D structures, with only one layer on a half-space, the fundamental frequency for the layer is given by:

$$f_0 = \frac{\beta_1}{4h}$$

β_1 S-wave velocity in the surface layer

h Layer thickness

Where n is the integer indicating the order of the harmonic.

The upper harmonics are given by:

$$f_n = (2n+1)f_0$$

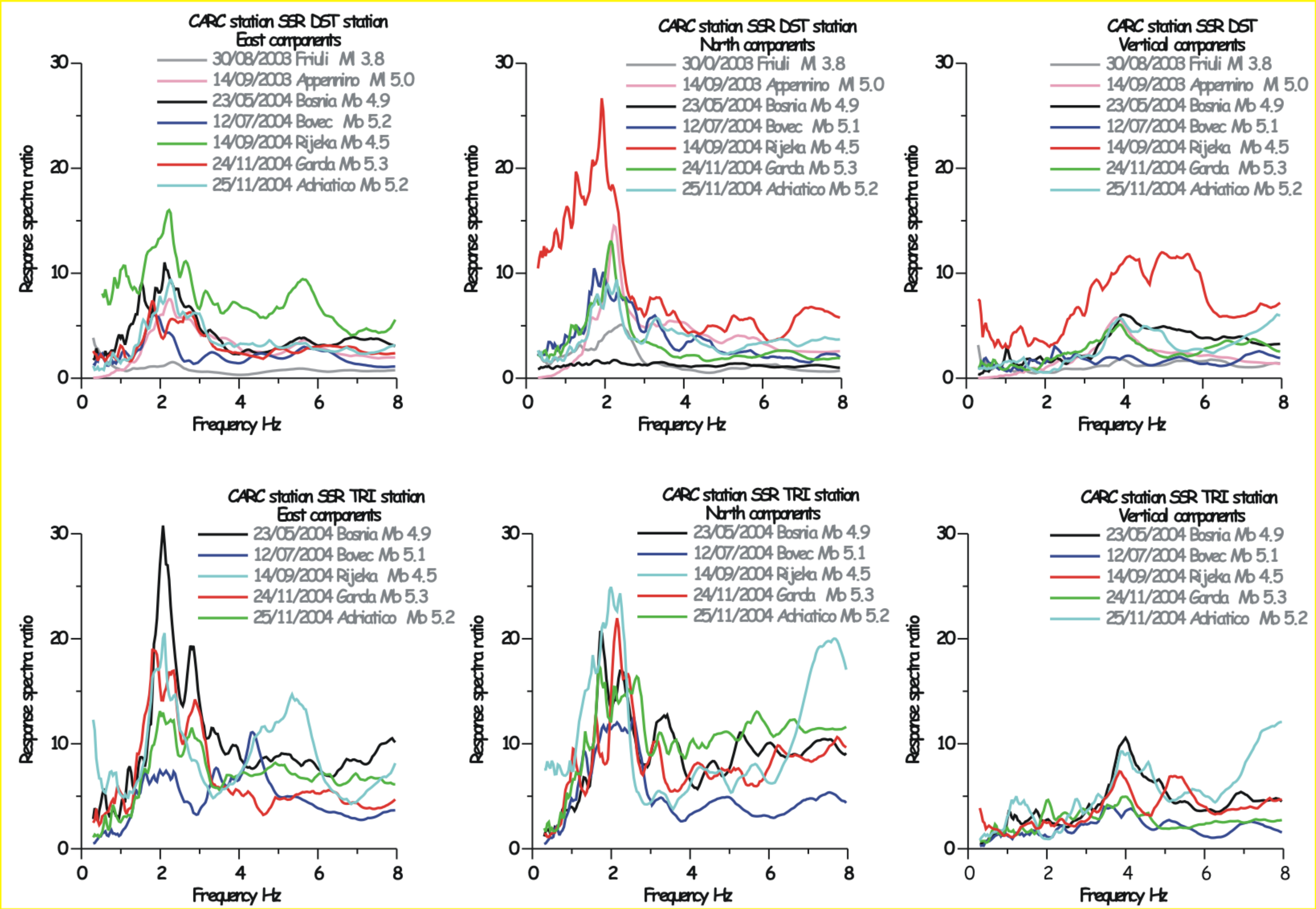
Where n is the integer indicating the order of the harmonic.

simple 1D model

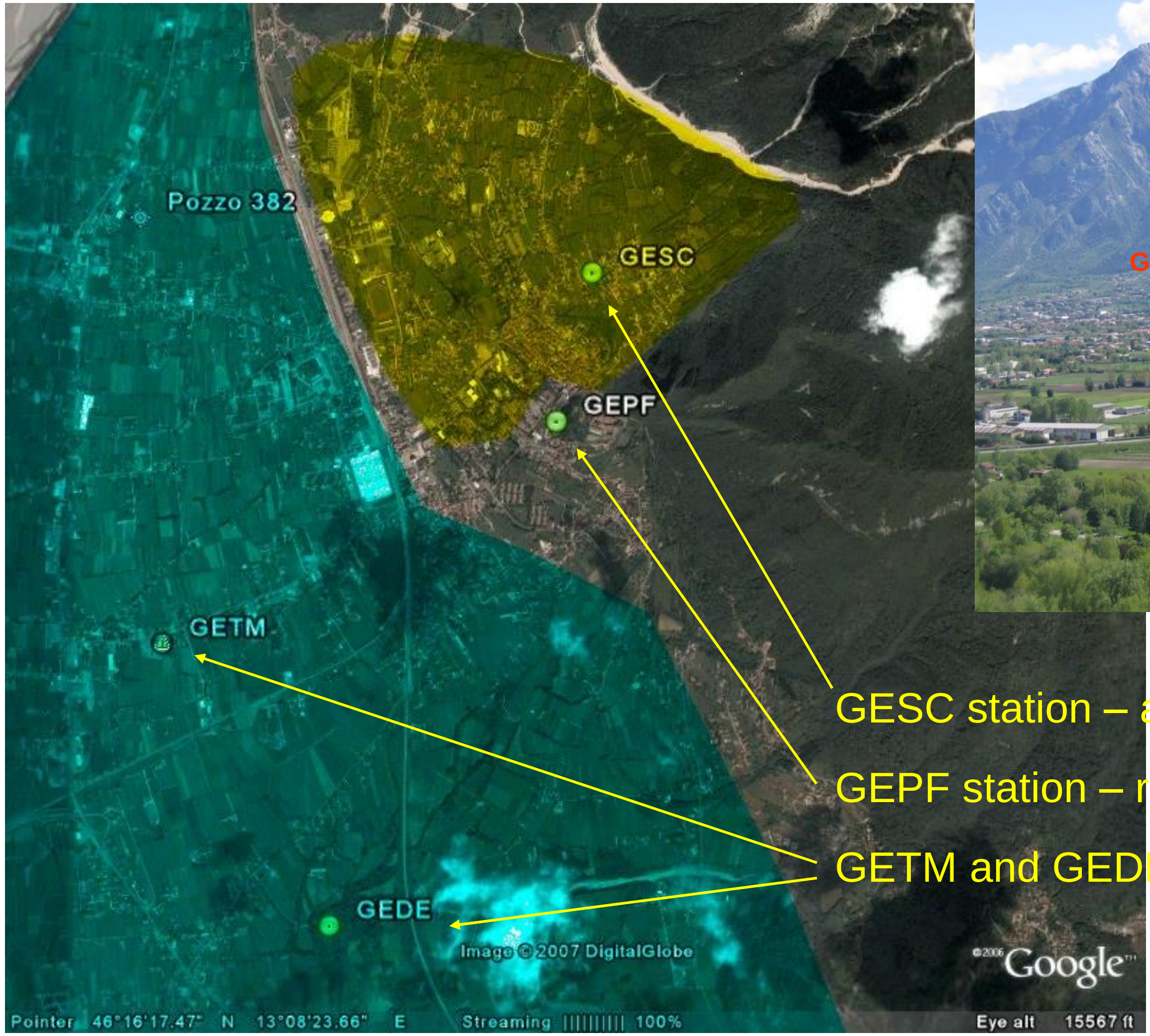
$f=v/4H$, f frequency Hz, V s-waves velocity m/s^2, H sediments thickness m [Bard and Bouchon, 1985]

Uniform Building Code (1985)

$T=0.09H*[D]^{-1/2}$ T period s, H height m and D building basement dimension


CARC station SSR DST station
East components
30/08/2003 Friuli M 3.8
14/09/2003 Appennino M 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.2
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
CARC station SSR DST station
North components
30/0/2003 Friuli M 3.8
14/09/2003 Appennino M 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
CARC station SSR DST
Vertical components
30/08/2003 Friuli M 3.8
14/09/2003 Appennino M 5.0
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
CARC station SSR TRI station
East components
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
CARC station SSR TRI station
North components
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
CARC station SSR TRI station
Vertical components
23/05/2004 Bosnia Mb 4.9
12/07/2004 Bovec Mb 5.1
14/09/2004 Rijeka Mb 4.5
24/11/2004 Garda Mb 5.3
25/11/2004 Adriatico Mb 5.2
Response spectra ratio
Frequency Hz

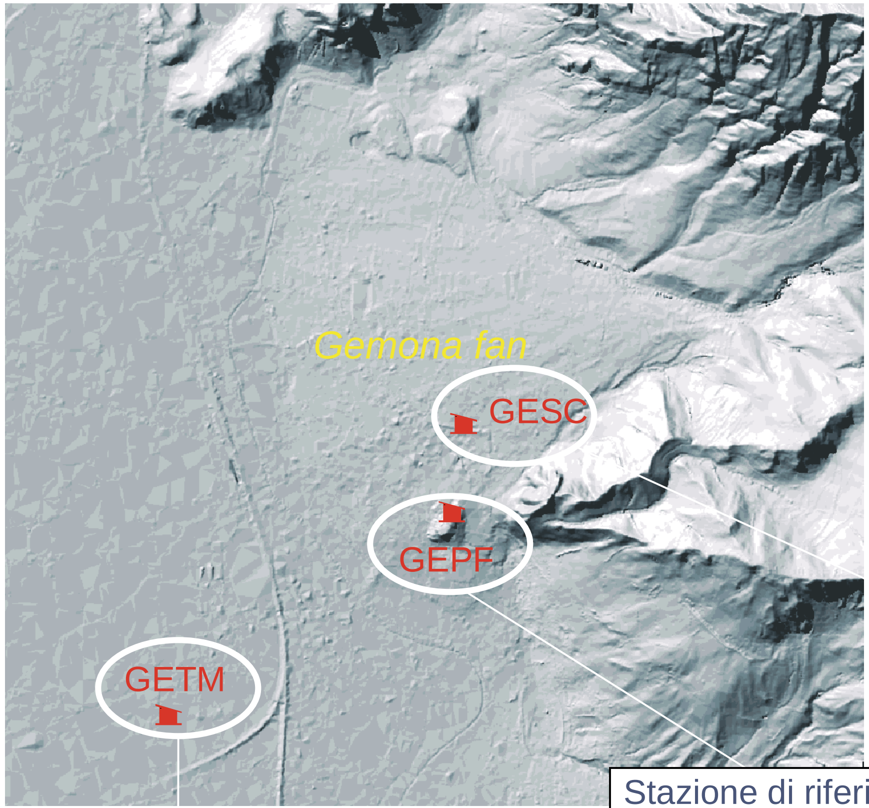
Gemona del Friuli



GESC station – alluvial fan

GEPF station – reference station

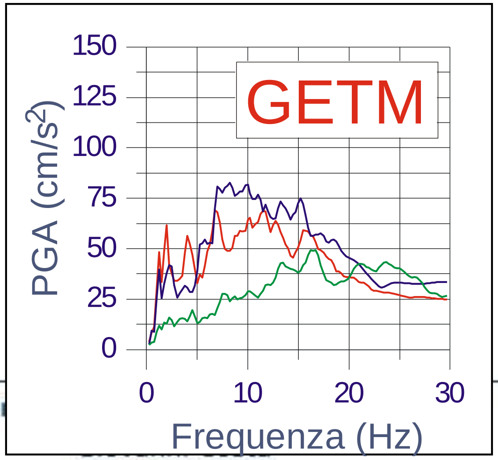
GETM and GEDE stations – sedimentary basin



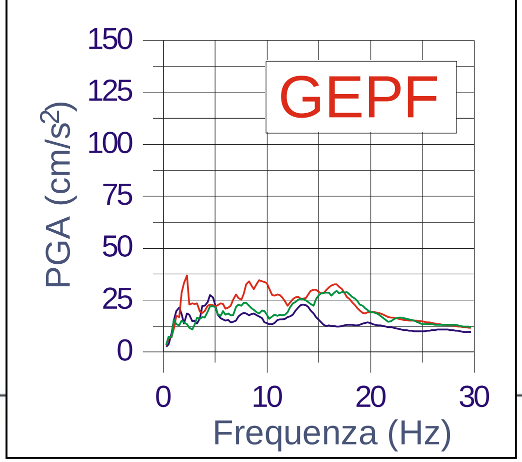
GETM

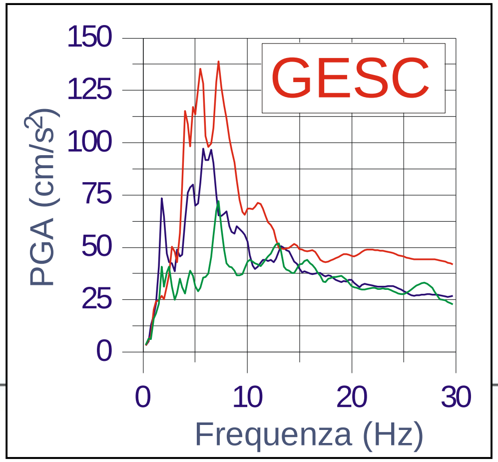
GESC

GEPF

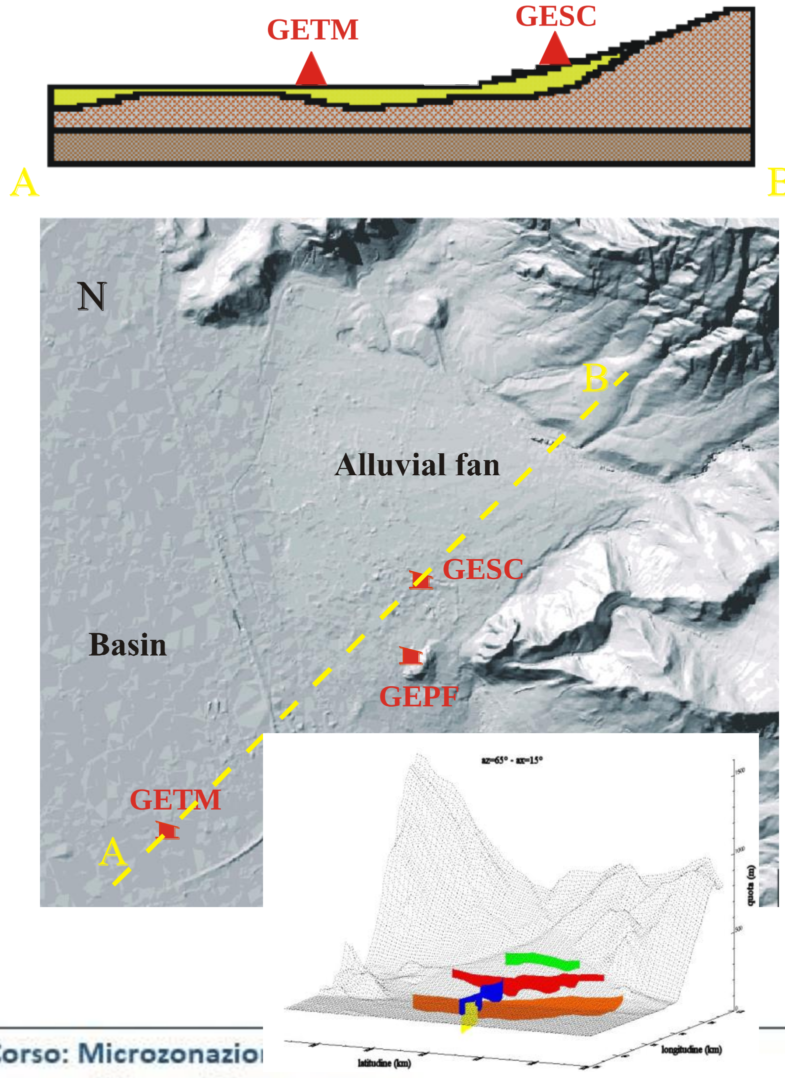


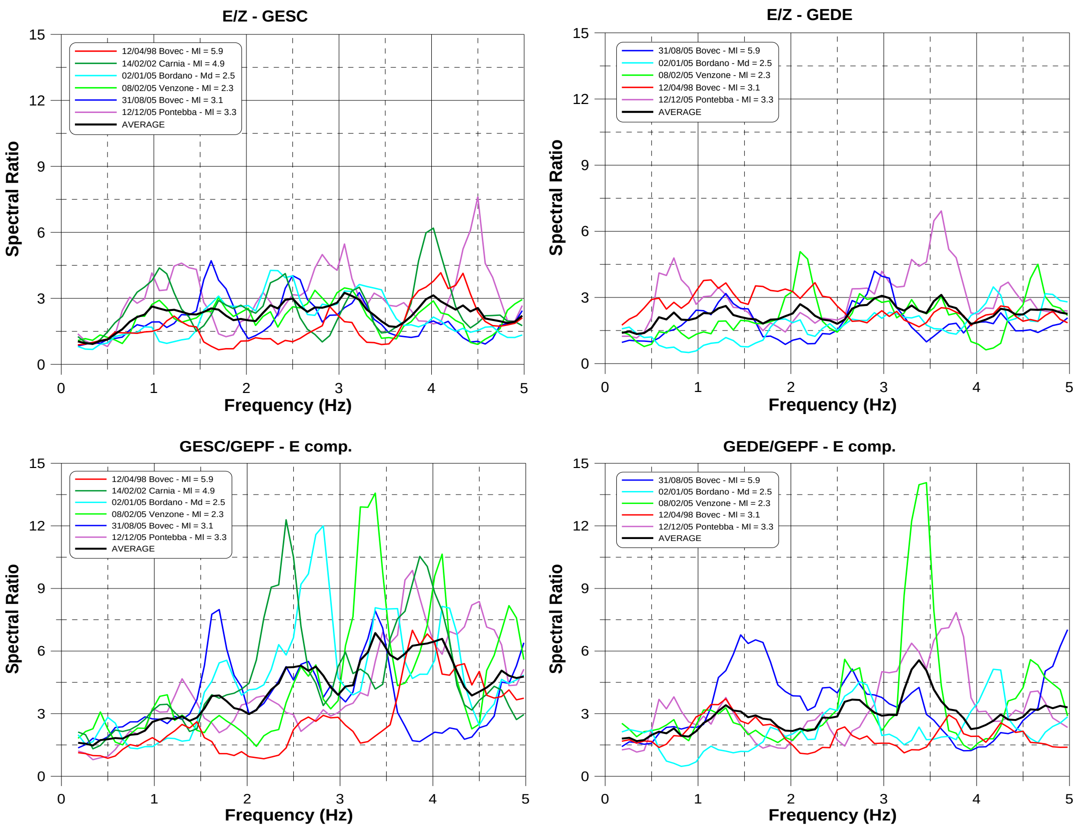
Stazione di riferimento su roccia



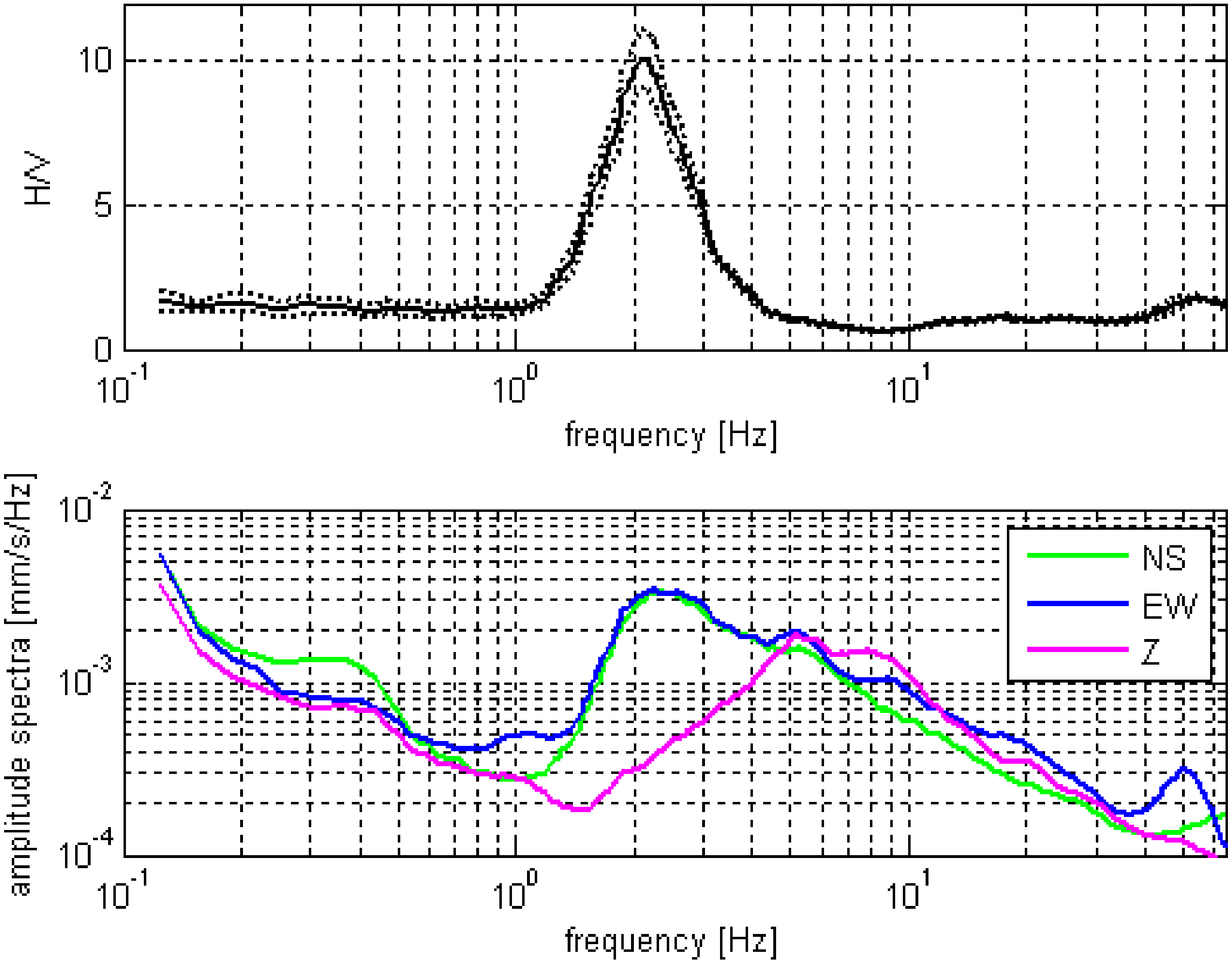


GESC GETM

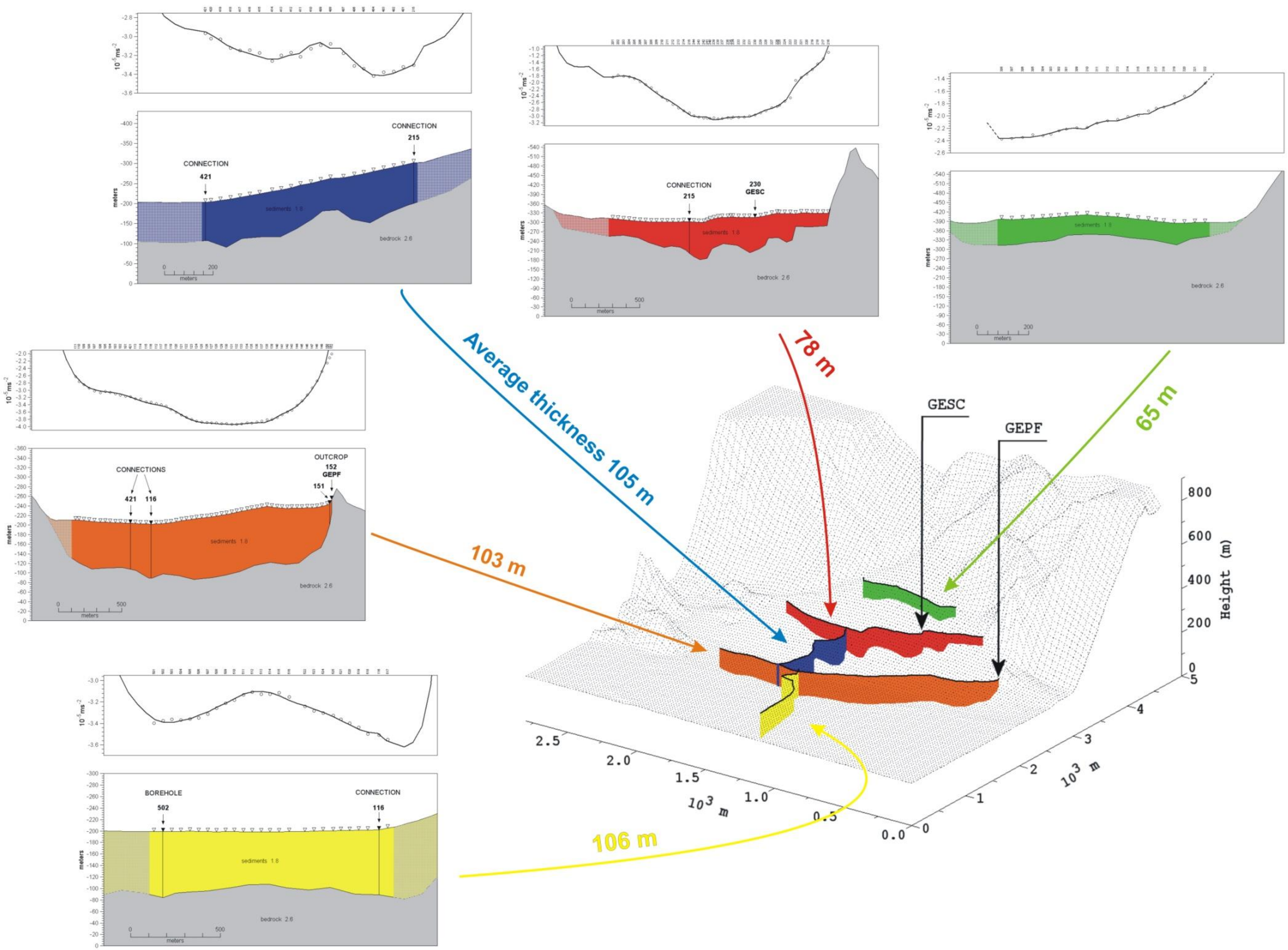




Progetto INTERREG IIIB Spazio Alpino
"Sismovalp: Seismic risk in alpine valleys"

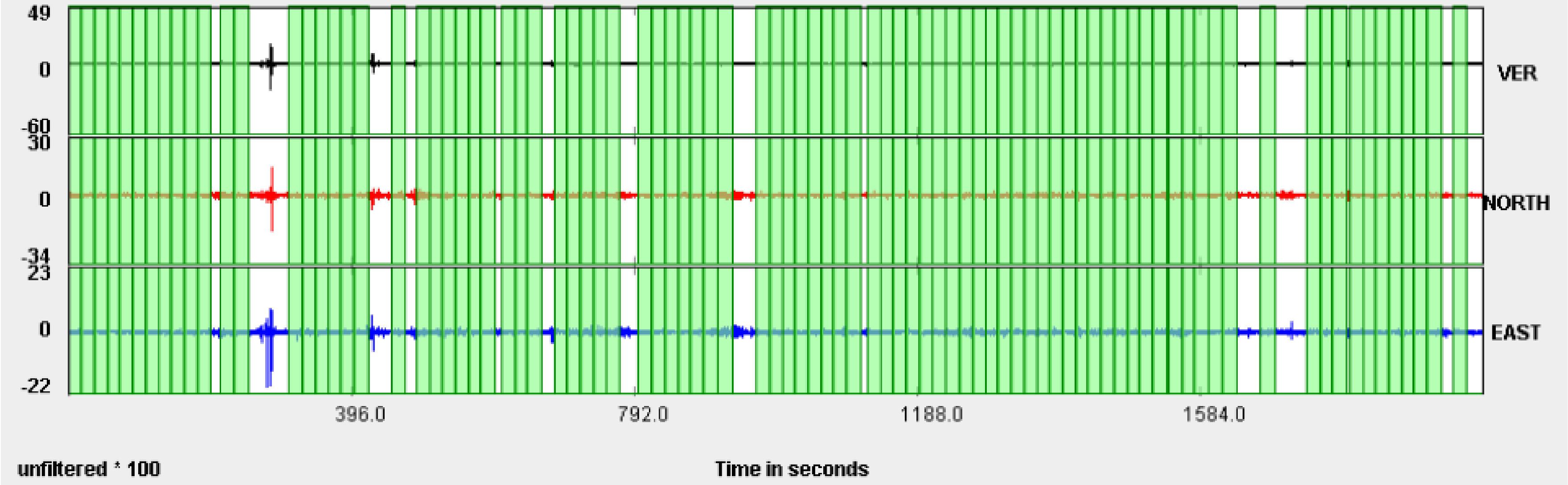


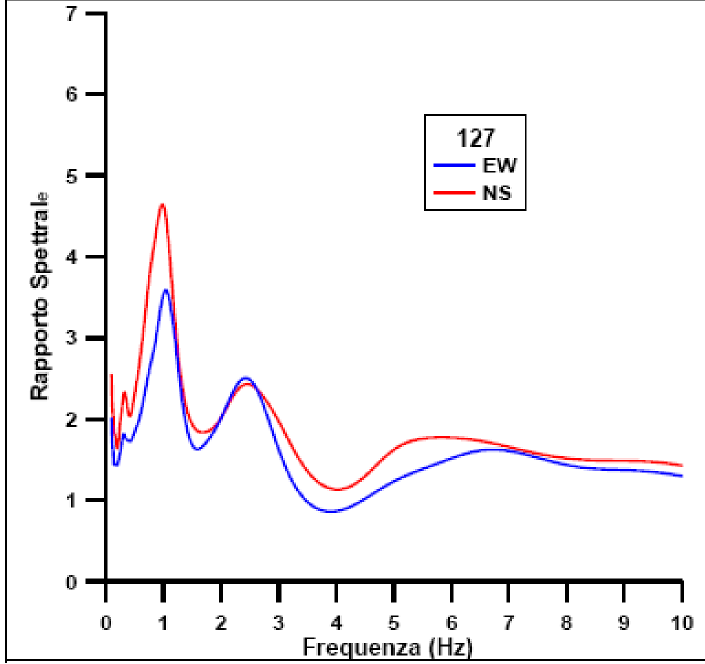
H/V
10
5
0
10^{-1}
10^{0}
10^{1}
frequency [Hz]
amplitude spectra [mm/s/Hz]
10^{-2}
10^{-3}
10^{-4}
NS
EW
Z
10^{-1}
10^{0}
10^{1}
frequency [Hz]

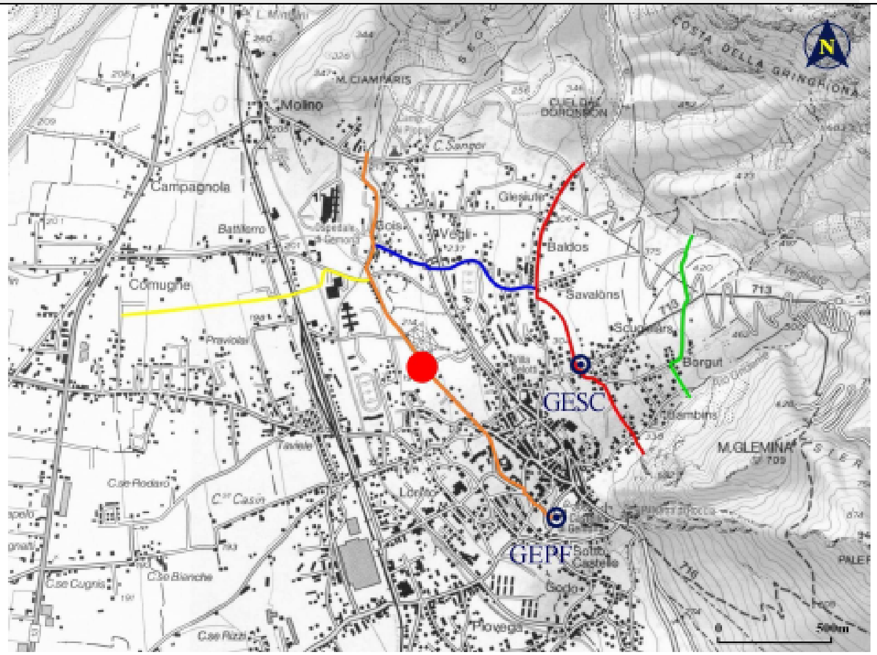


CONNECTION
421
CONNECTION
215
sediments 1.8
bedrock 2.6
meters
CONNECTION
215
230
GESC
sediments 1.8
bedrock 2.6
sediments 1.8
bedrock 2.6
CONNECTIONS
421
116
OUTCROP
152
GEPF
151
sediments 1.8
bedrock 2.6
BOREHOLE
502
CONNECTION
116
sediments 1.8
bedrock 2.6
Average thickness 105 m
78 m
65 m
103 m
106 m
GESC
GEPF
Height (m)
10^3 m
10^3 m

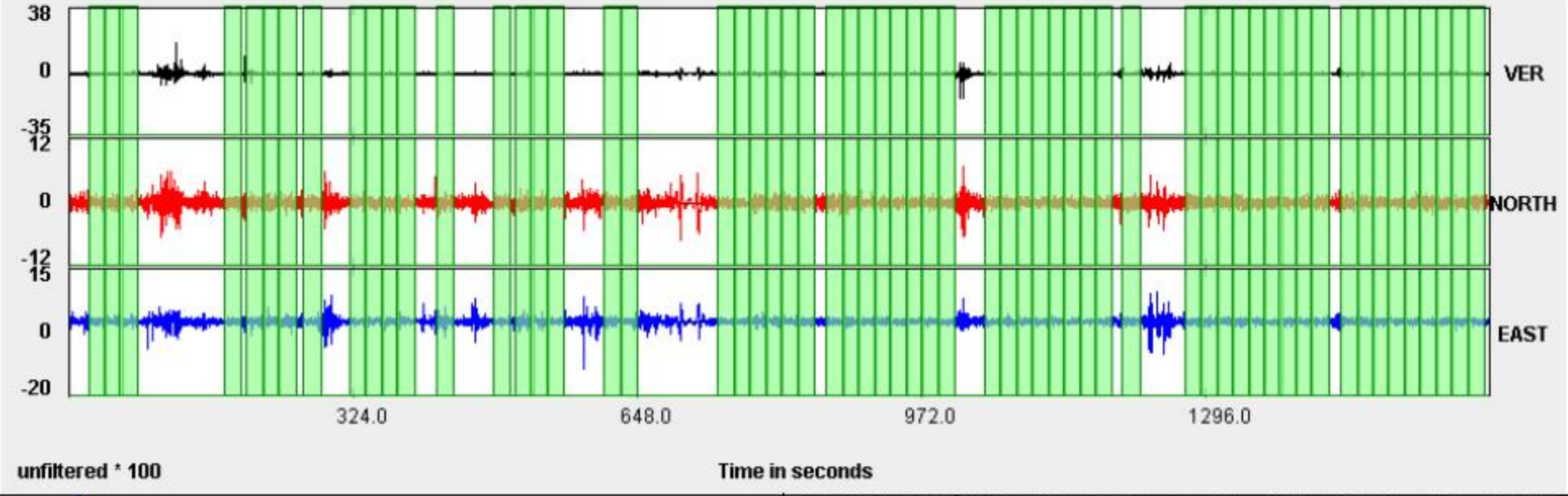
PUNTO 127

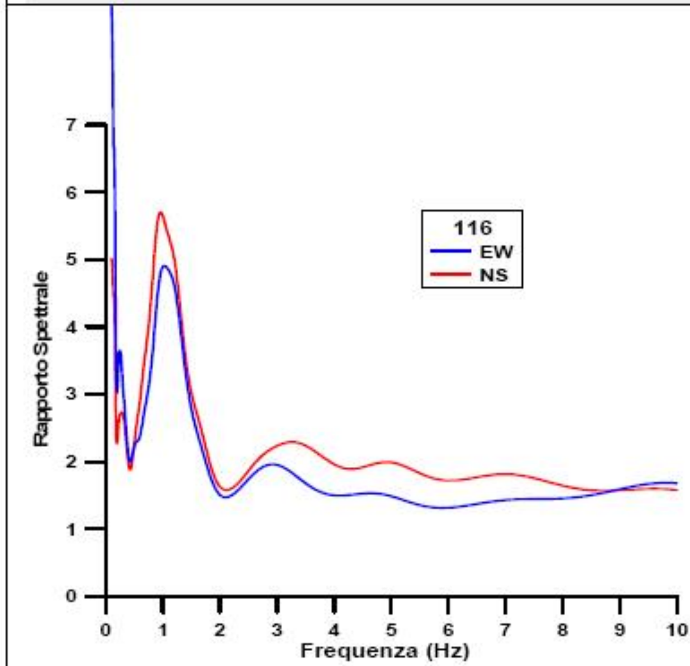

49
0
-60
VER
30
0
-34
NORTH
23
0
-22
EAST
396.0
792.0
1188.0
1584.0
unfiltered * 100
Time in seconds

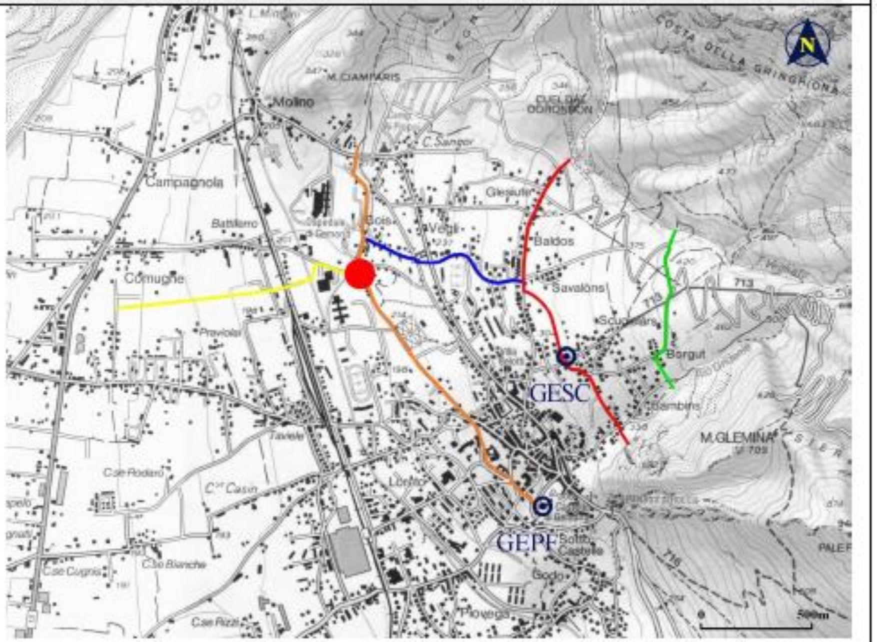

127
EW
NS
Rapporto Spettrale
Frequenza (Hz)
0
1
2
3
4
5
6
7
8
9
10


GESC
GEPF
Campagnola
Comugne
Molino
Savalons
Baldos
Borgut
M.GLEMINA

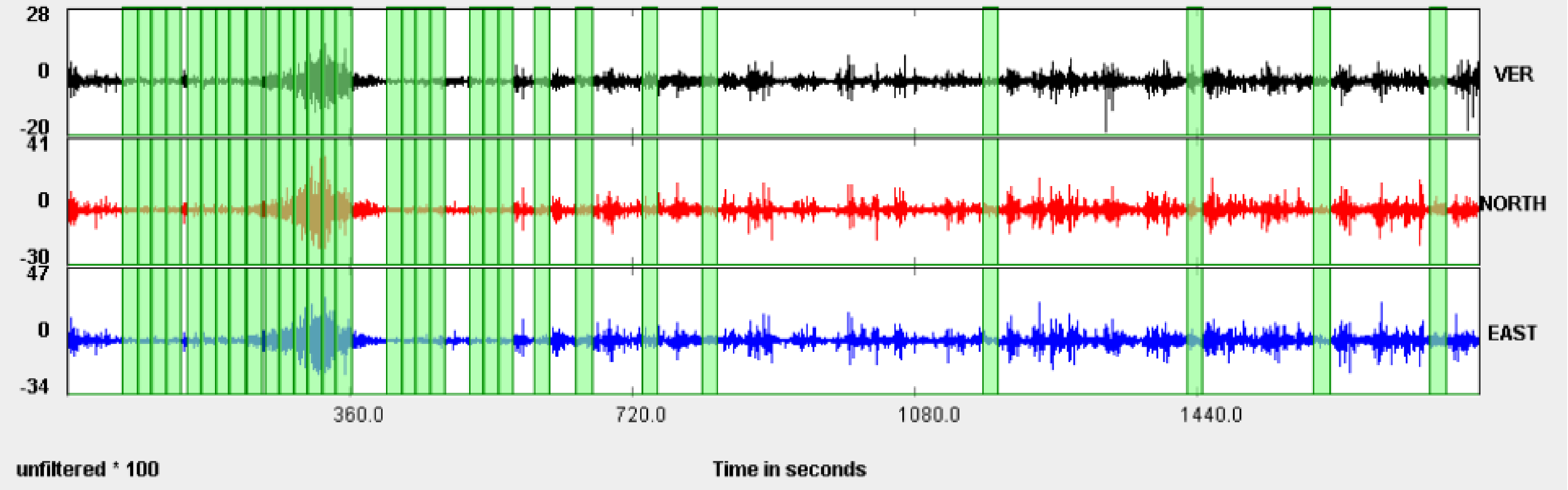
PUNTO 116


38
0
-35
12
0
-12
15
0
-20
VER
NORTH
EAST
324.0
648.0
972.0
1296.0
unfiltered * 100
Time in seconds

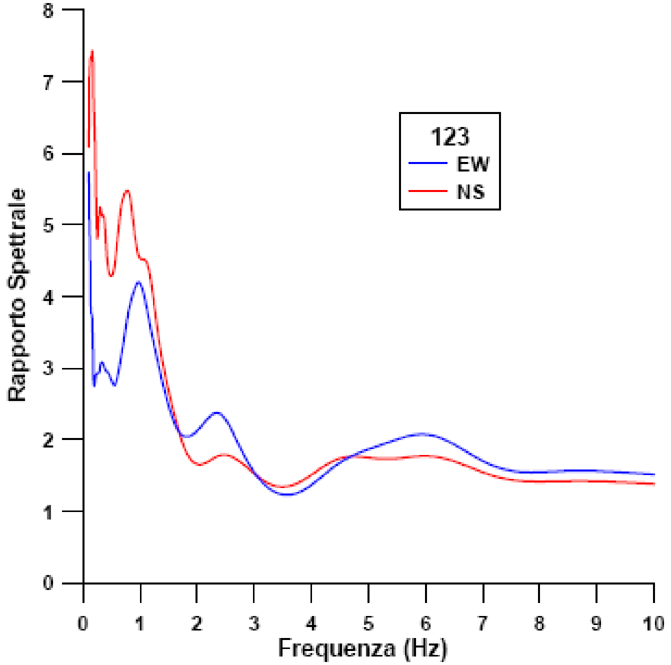

116
EW
NS
Rapporto Spettrale
Frequenza (Hz)
0
1
2
3
4
5
6
7
8
9
10


N
Molino
M.CIAMPARIS
Campagnola
Comugne
Baldos
Savalons
Borgut
GESC
GEPF
M.GLEMINA

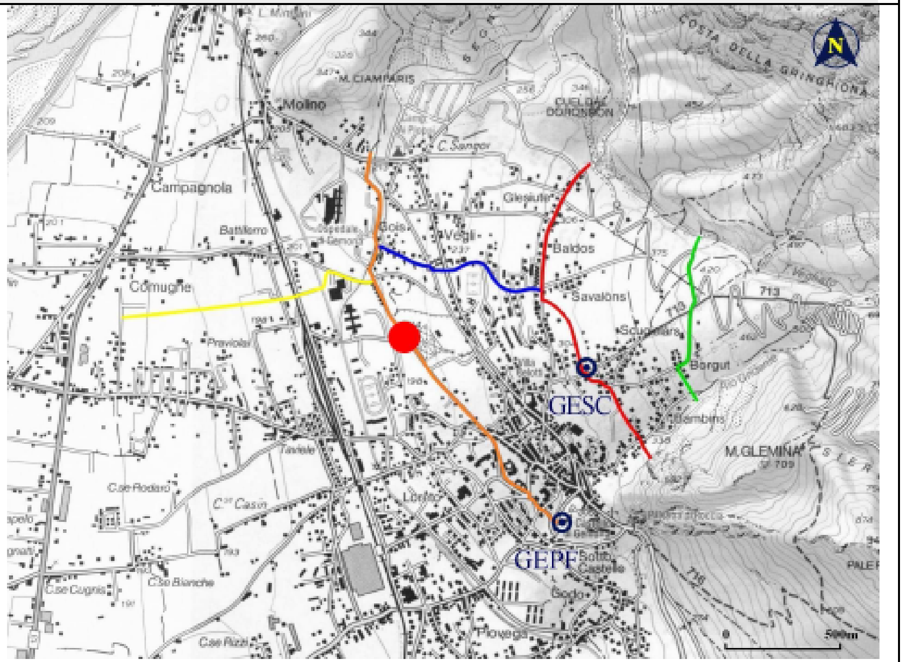
PUNTO 123



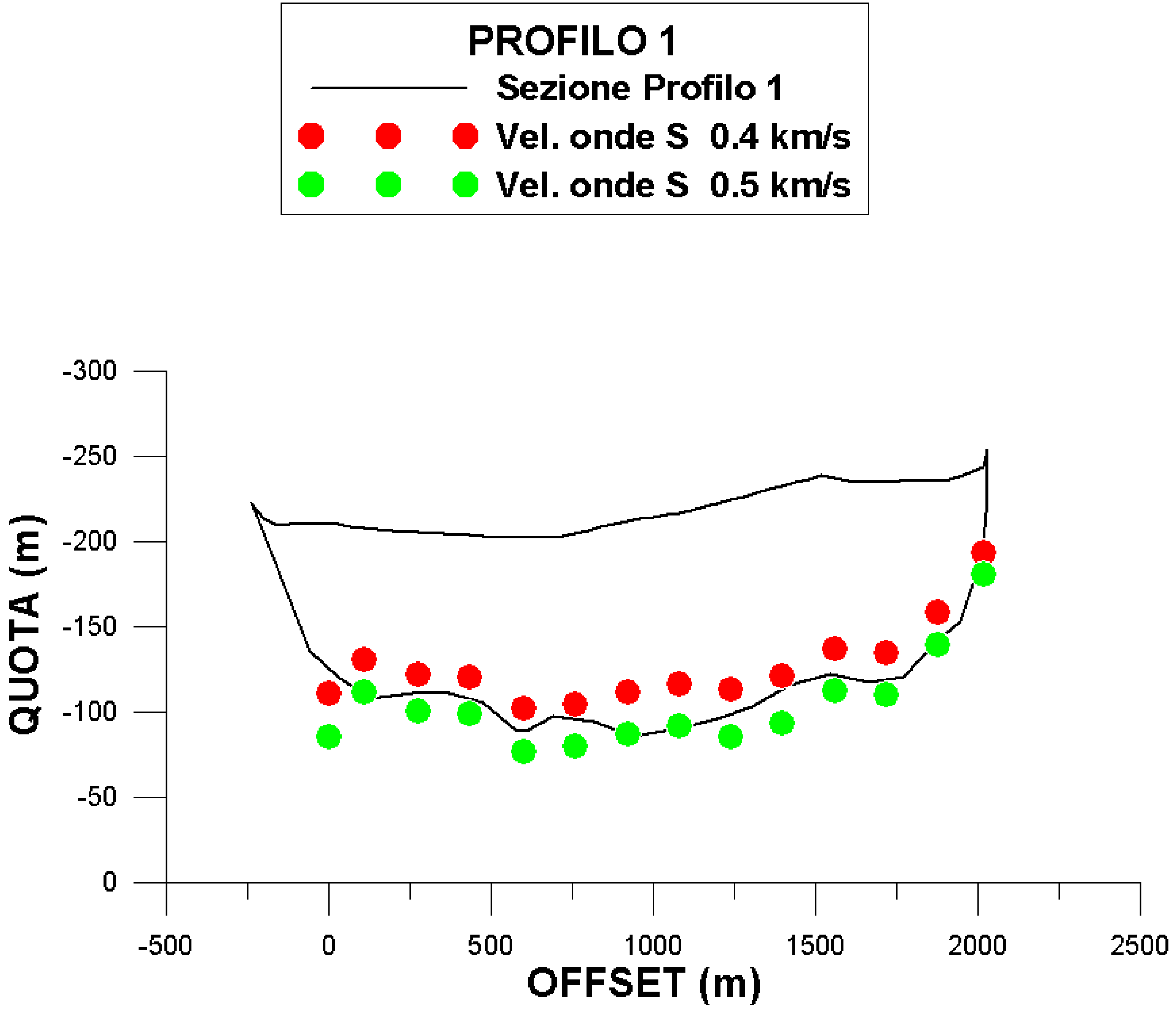
28
0
-20
VER
41
0
-30
NORTH
47
0
-34
EAST
360.0
720.0
1080.0
1440.0
unfiltered * 100
Time in seconds

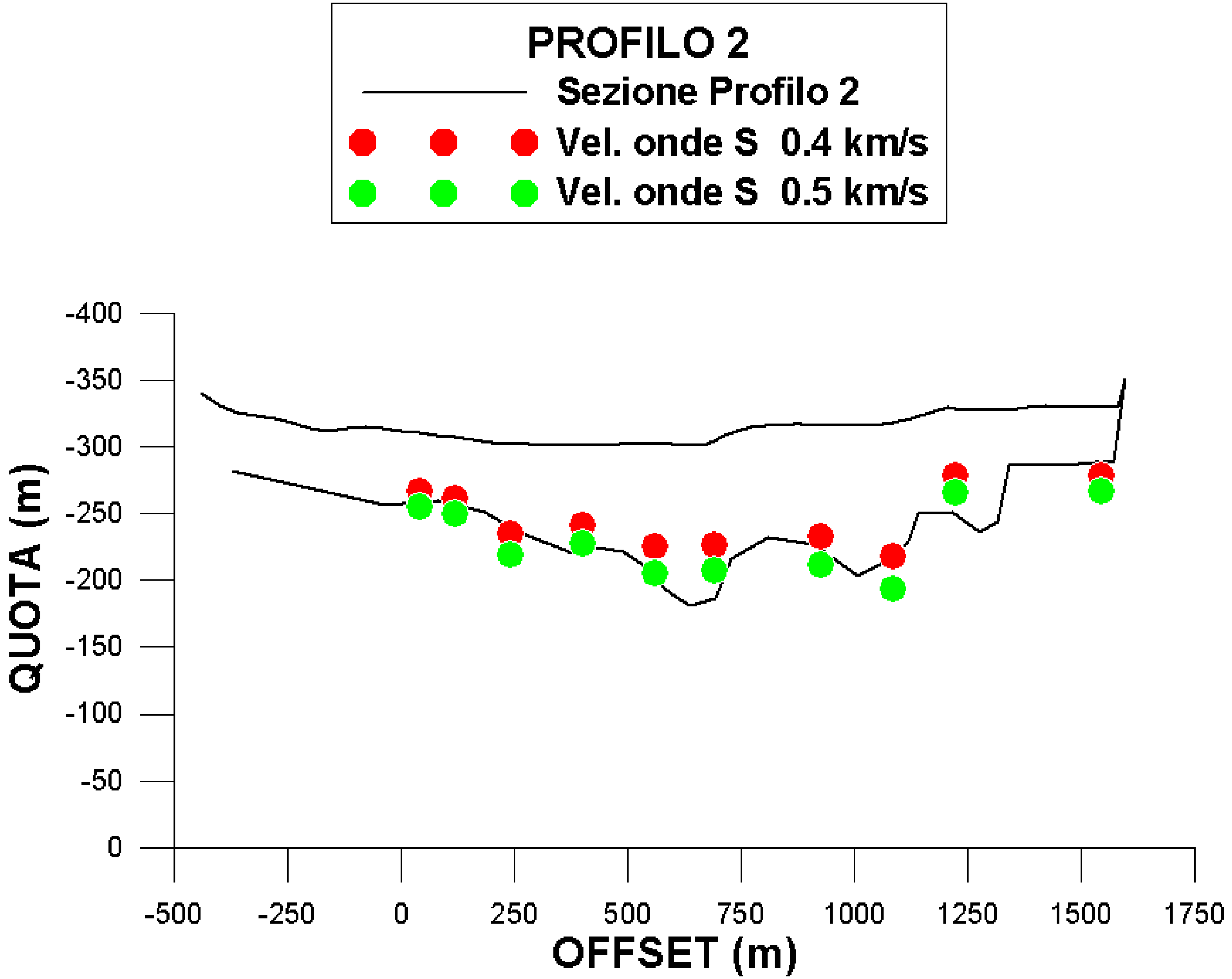


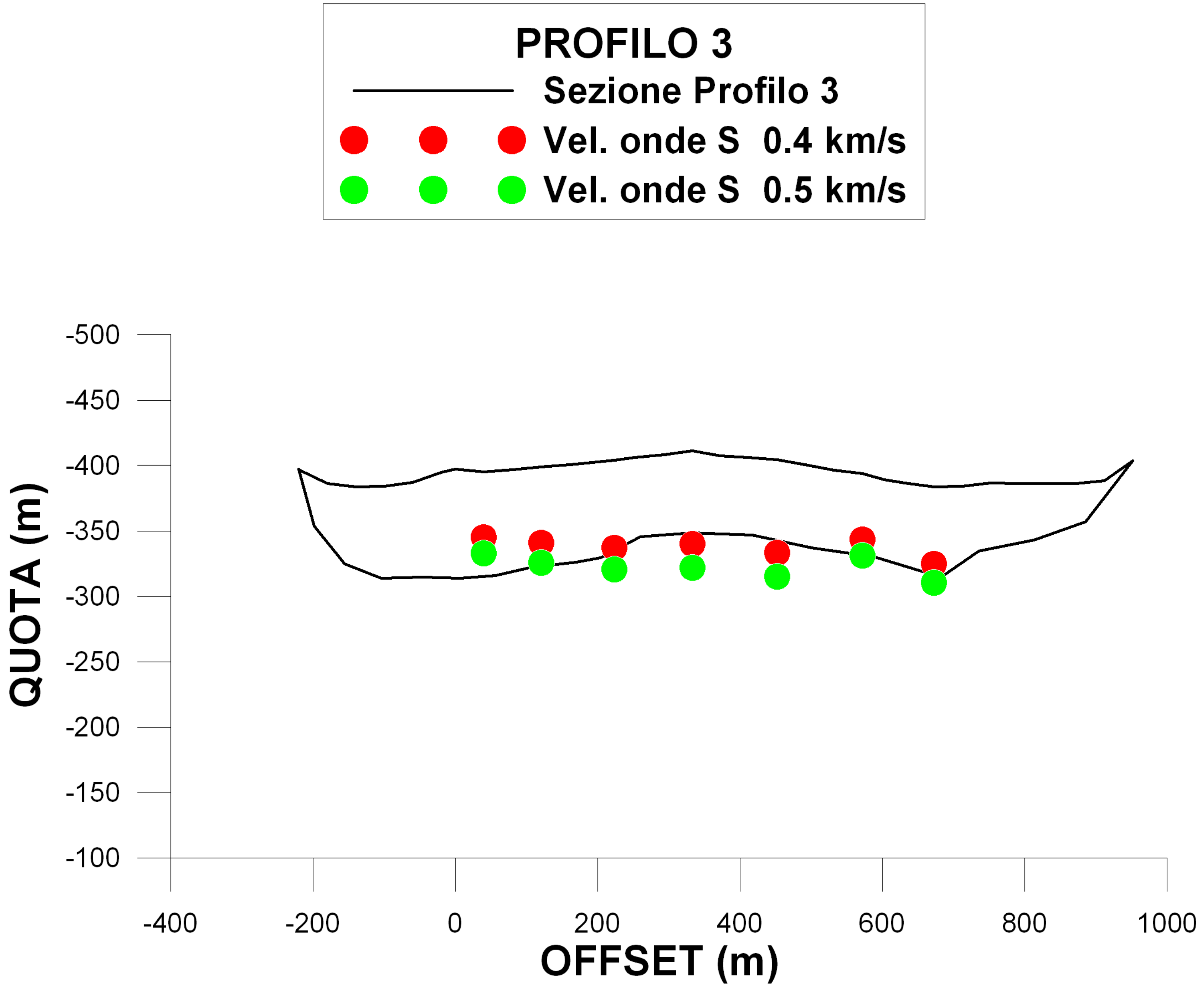
Rapporto Spettrale
Frequenza (Hz)
123
EW
NS
0
1
2
3
4
5
6
7
8
9
10

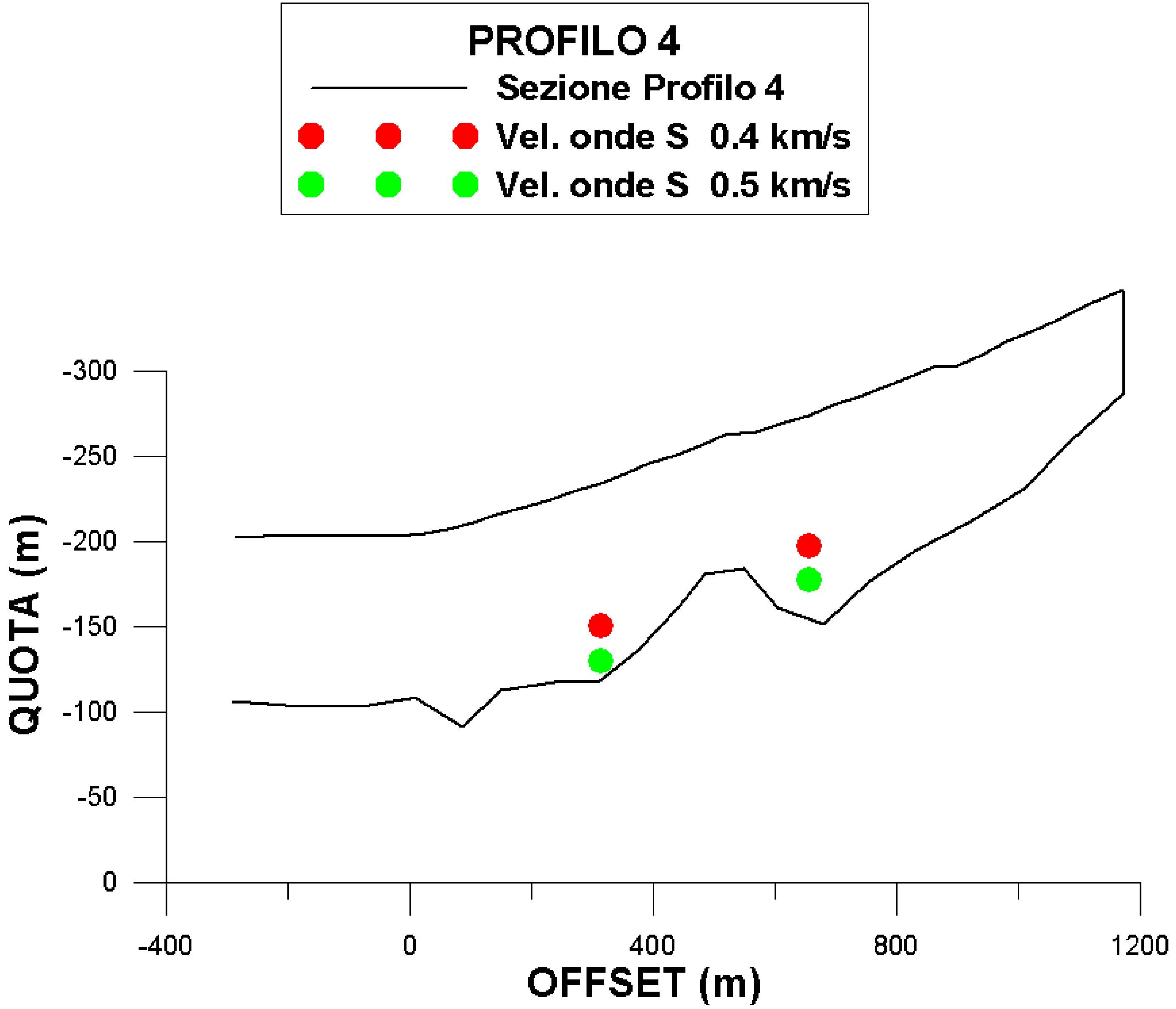


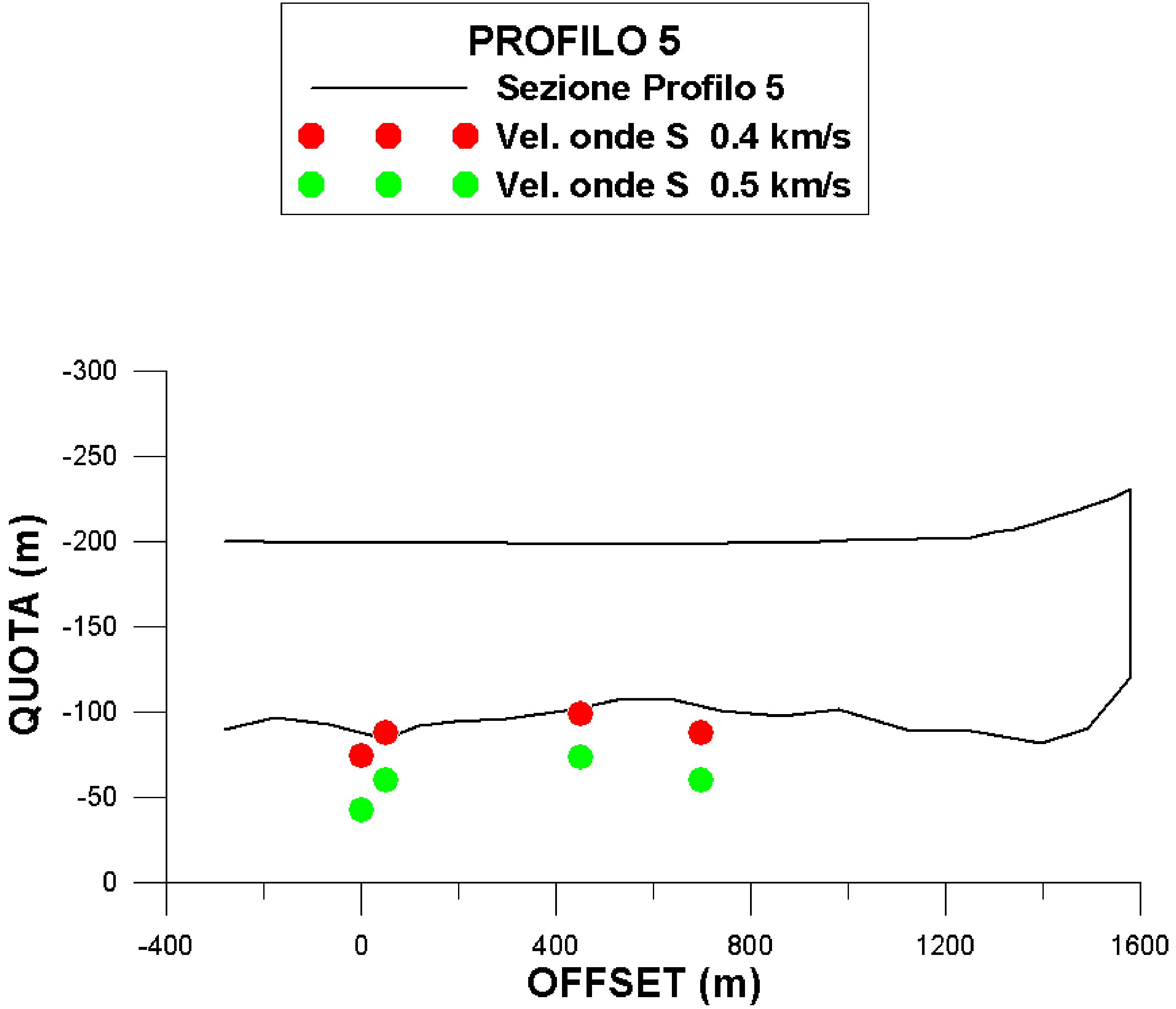
GESC
GEPF
Campagnola
Comugne
Baldos
Savalons
Borgut
M.GLEMINA
COSTA DELLA GRINGHIONA


PROFILO 1
Sezione Profilo 1
Vel. onde S 0.4 km/s
Vel. onde S 0.5 km/s
QUOTA (m)
-300
-250
-200
-150
-100
-50
0
-500
0
500
1000
1500
2000
2500
OFFSET (m)


PROFILO 2
Sezione Profilo 2
Vel. onde S 0.4 km/s
Vel. onde S 0.5 km/s
-400
-350
-300
-250
-200
-150
-100
-50
0
QUOTA (m)
-500
-250
0
250
500
750
1000
1250
1500
1750
OFFSET (m)


PROFILO 3
Sezione Profilo 3
Vel. onde S 0.4 km/s
Vel. onde S 0.5 km/s
-500
-450
-400
-350
-300
-250
-200
-150
-100
QUOTA (m)
-400
-200
0
200
400
600
800
1000
OFFSET (m)


PROFILO 4
Sezione Profilo 4
Vel. onde S 0.4 km/s
Vel. onde S 0.5 km/s
QUOTA (m)
-300
-250
-200
-150
-100
-50
0
-400
0
400
800
1200
OFFSET (m)


PROFILO 5
Sezione Profilo 5
Vel. onde S 0.4 km/s
Vel. onde S 0.5 km/s
-300
-250
-200
-150
-100
-50
0
QUOTA (m)
-400
0
400
800
1200
1600
OFFSET (m)