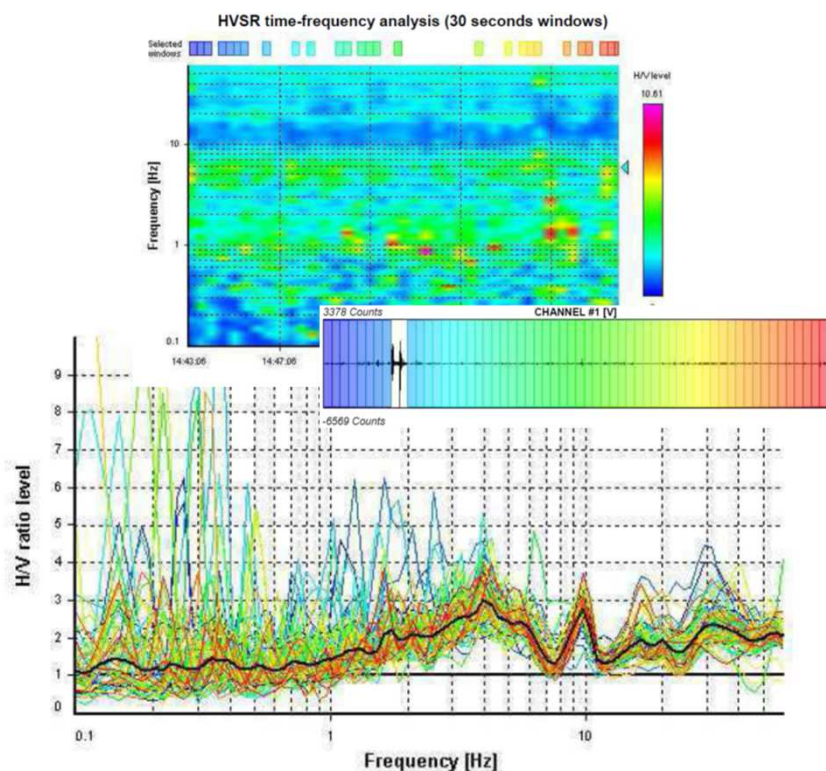


ALLEGATO 4

Indagini sismiche passive a stazione singola (metodologia HVSR) a supporto della Microzonazione sismica del Comune di Frassinoro

Abitati di Fontanaluccia e di Piandelagotti

COMUNE DI FRASSINORO
PROVINCIA DI MODENA



Modena, 22/09/2017

Studio Tecnico Associato **FOR.GEO**

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**Indagini sismiche passive a stazione singola (metodologia HVSR) a
supporto della Microzonazione sismica del Comune di Frassinoro
Abitati di Fontanaluccia e di Piandelagotti
COMUNE DI FRASSINORO
(PROVINCIA DI MODENA)**

Introduzione

Su incarico del Dott. Geol. Fabio Parmegiani e del Dott. Geol. Paolo Pallante, dello Studio For.Geo di Modena, sono state eseguiti:

- il giorno 30.03.2017, 6 rilievi di rumore ambientale (microtremori) a stazione singola elaborati poi secondo la metodologia HVSR (*Horizontal to Vertical Spectral Ratio*) detta anche di Nakamura, nella Frazione di Fontanaluccia d Frassinoro;
- il giorno 21.04.2017, 7 rilievi di rumore ambientale (microtremori) a stazione singola elaborati poi secondo la metodologia HVSR (*Horizontal to Vertical Spectral Ratio*) detta anche di Nakamura, nella frazione di Piandelagotti di Frassinoro;

I rilievi (ubicati come da figura 1) hanno come scopo la determinazione della eventuale frequenza di risonanza di sito e, qualora possibile, la modellazione di un profilo verticale di velocità approssimato per la stima del parametro Vs30 (o eventualmente VSh) da utilizzare a supporto degli studi per la Microzonazione sismica di primo, secondo e terzo livello della frazione di Fontanaluccia e di terzo livello della frazione di Piandelagotti.

Strumentazione, geometria e parametri di acquisizione

Sono state eseguite registrazioni di rumore ambientale a stazione singola, della durata di 20 minuti ciascuna, con frequenza di campionamento di 300 Hz, ubicate come da Figura 1. È stato utilizzato un sismografo munito di terna triassiale di geofoni con frequenza di taglio di 4,5 Hz, modello Geobox della ditta Sara Electronics Instruments di Perugia.

Per l'elaborazione dei dati sono stati utilizzati il software GeoexplorerHVSR della Sara Electronics Instruments di Perugia e il software di libero utilizzo Geopsy (www.geopsy.org).

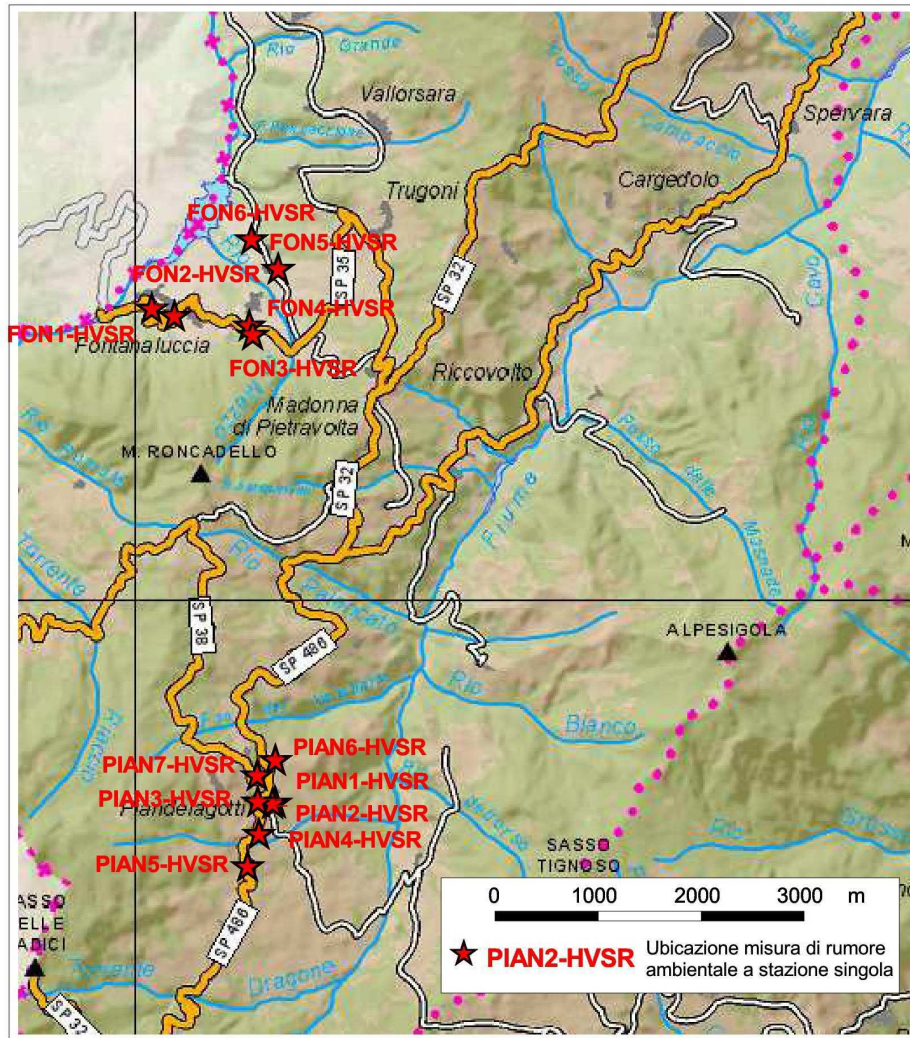


Figura 1 - Inquadramento territoriale con ubicazione delle indagini di sismica passiva (metodologia HVSr). (Base topografica: estratto da Carta del territorio 1:100.000 realizzata a cura della Provincia di Modena).

Conclusioni

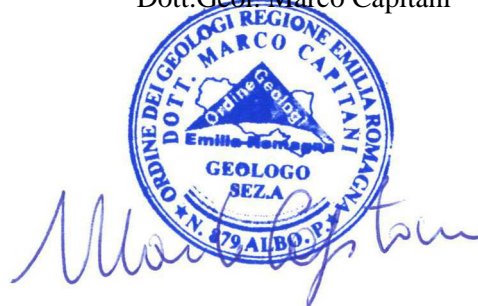
Sono state descritte le modalità di esecuzione, la strumentazione di acquisizione e i risultati delle elaborazioni di 13 misure di rumore ambientale a stazione singola elaborate secondo la metodologia HVSr (*Horizontal to Vertical Spectral Ratio*) ubicate come da figura 1 e identificate con le sigle FON1-HVSR, FON2-HVSR, FON3-HVSR, FON4-HVSR, FON5-HVSR e FON6-HVSR, per le acquisizioni eseguite a Fontanaluccia, e con le sigle PIAN1-HVSR, PIAN2-HVSR, PIAN3-HVSR, PIAN4-HVSR, PIAN5-HVSR, PIAN6-HVSR e PIAN7-HVSR, per quelle eseguite a Plandelagotti, realizzate, su incarico dei Dott. Geol. Paolo Pallante e Dott. Geol. Fabio Parmegiani, a supporto dello Studio di Microzonazione Sismica del Comune di Frassinoro (Provincia di Modena).

Nell'allegato alla presente relazione sono descritti e riportati con appositi elaborati grafici, per

ciascuna acquisizione, l'ubicazione, i dati e la loro relativa interpretazione, eseguita tenendo conto anche dei dati geologici disponibili (cartografici e geognostici), sia da bibliografia che rilevati in loco.

Vignola, maggio 2017

Dott. Geol. Marco Capitani

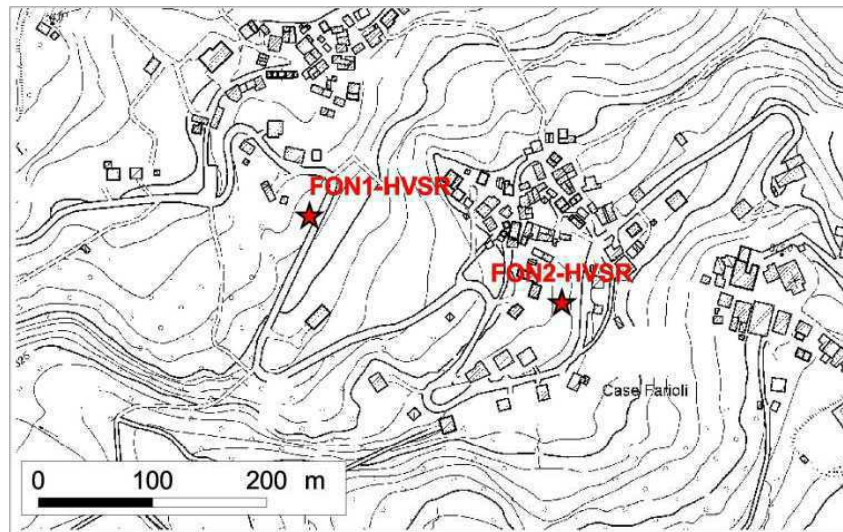


ALLEGATO N. 1

INDAGINI HVSR A FONTANALUCCIA E A PIANDELAGOTTI

(ubicazioni, spettri delle componenti, finestatura (*windowing*), grafici della persistenza temporale e della direzionalità, criteri SESAME, modelli di velocità).

FON1-HVSR



PLACE INFORMATION

Place ID: FON1-HVSR

Address:

Latitude: 4911362

Longitude: 141198

Coordinate system: WGS84

Elevation: 795 m s.l.m.

Weather: Soleggiato

Notes: Non si esegue il *modeling* interpretativo del profilo di velocità, in quanto la curva non presenta picchi stratigrafici affidabili per il contesto geologico in esame. (Il picco a bassa frequenza, eventualmente indicativo di un contrasto d'impedenza profondo, non soddisfa tutti i criteri SESAME, non è stabile lungo tutta la durata della registrazione e, considerate le velocità delle coperture, risulterebbe piuttosto profondo, tenuto anche conto del contesto non di pianura né di bacino, ma piuttosto di versante montano che potrebbe non essere inquadrabile in un contesto 1D).

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

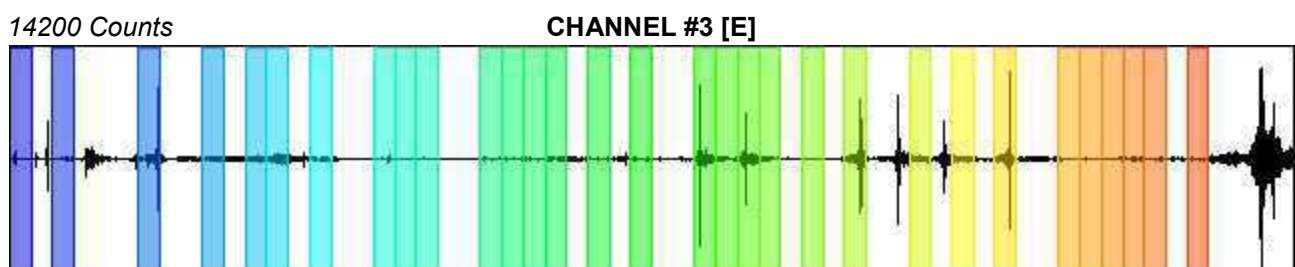
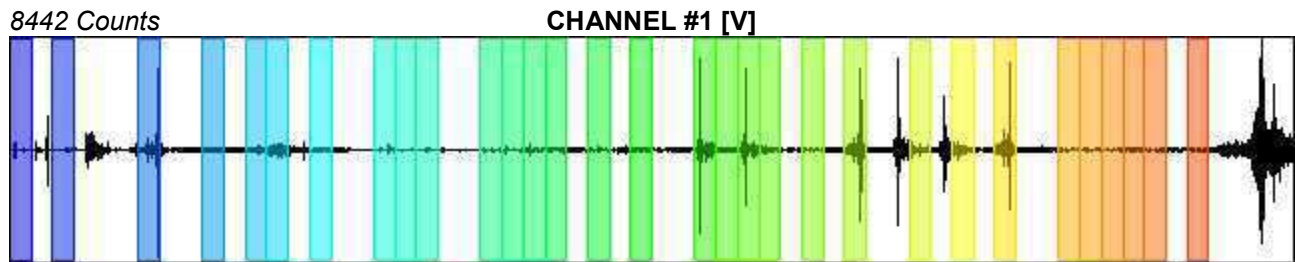
Recording start time: 2017/03/30 11:12:53

Recording length: 20 min

Windows count: 31

Average windows length: 20

Signal coverage: 51.68%



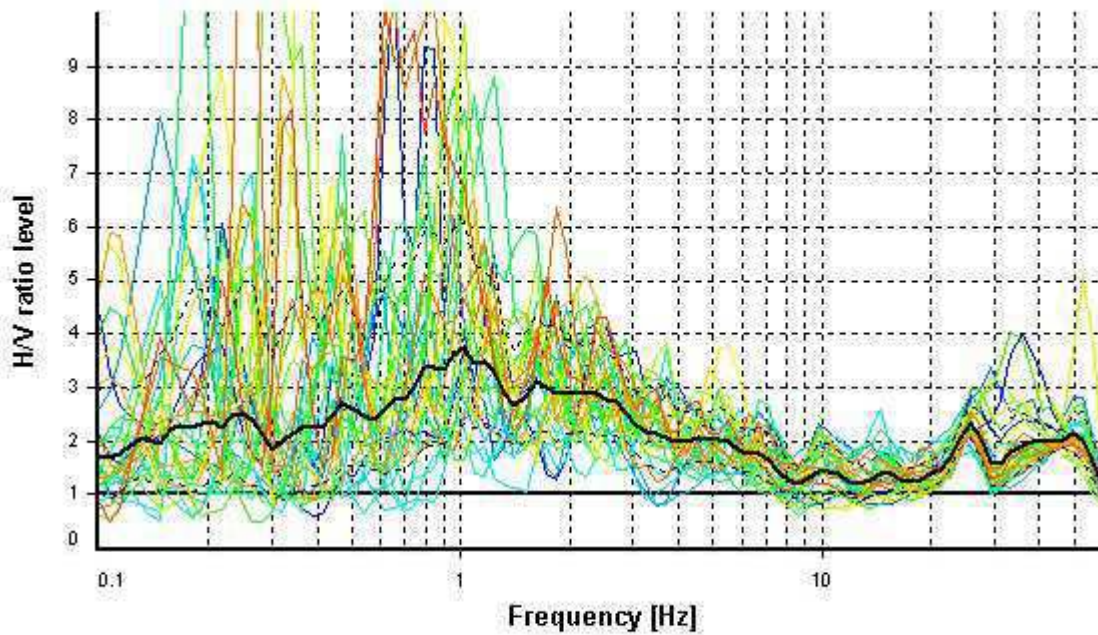
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

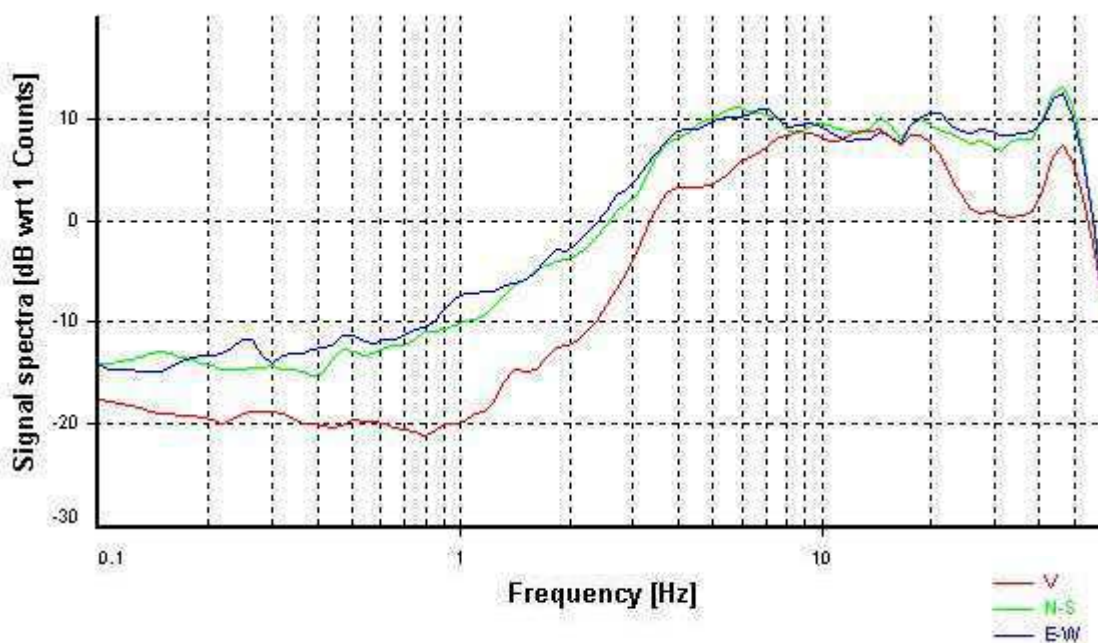
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

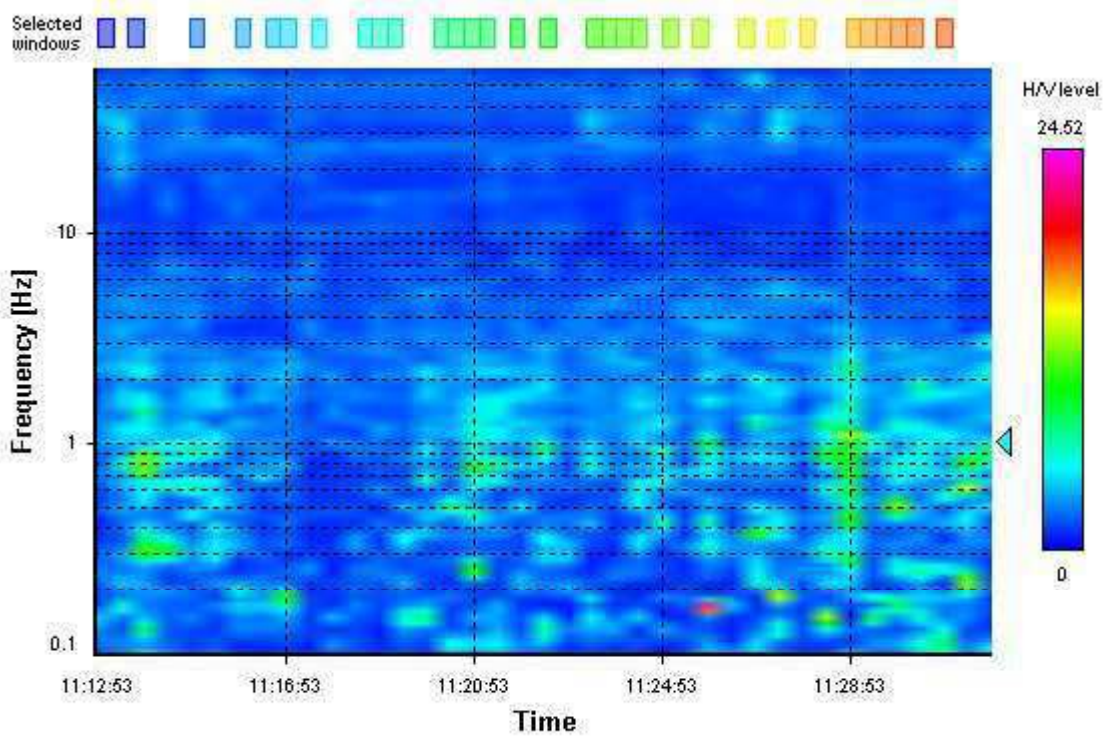
HVSR average



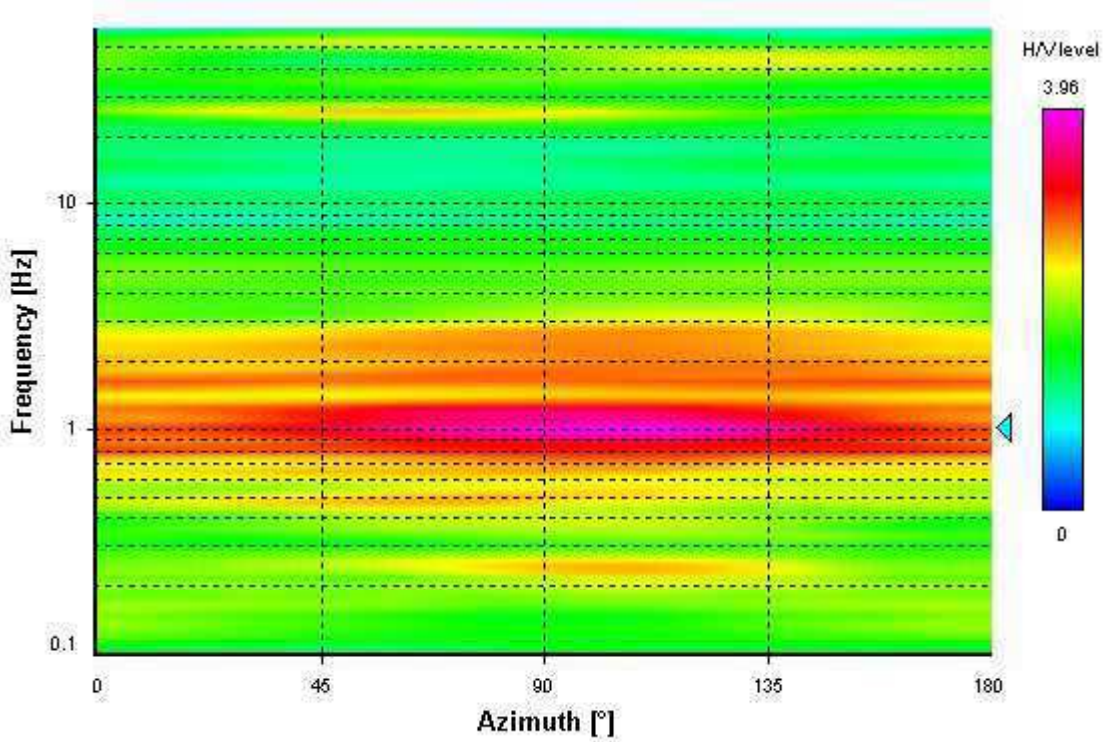
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



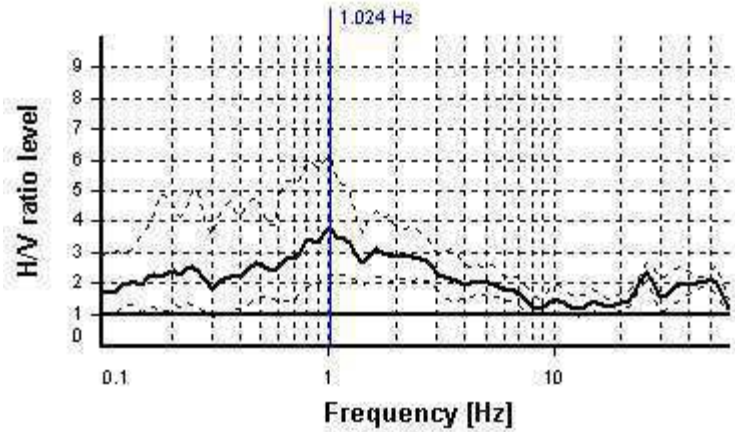
SESAME CRITERIA

Selected f_0 frequency

1.024 Hz

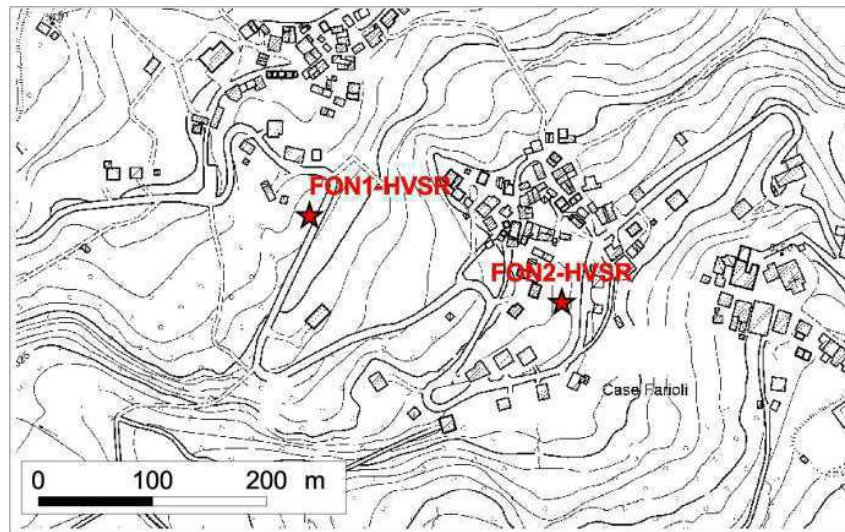
A_0 amplitude = 3.751

Average $f_0 = 0.995 \pm 0.203$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	31 valid windows (length > 9.77 s) out of 31	OK
$n_o(f_0) > 200$	634.79 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0.29996 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0 Hz	NO
$A_0 > 2$	3.75 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.20322 >= 0.10239	NO
$\sigma_A(f_0) < \theta(f_0)$	1.62814 < 1.78	OK
Overall criteria fulfillment		NO

FON2-HVSR



PLACE INFORMATION

Place ID: FON2-HVSR

Address: -

Latitude: 4911248

Longitude: 141328

Coordinate system: WGS84

*Elevation :*823 m s.l.m.

Weather: Soleggiato

Notes: Si omette il *modeling* interpretativo del profilo di velocità in quanto la curva non presenta picchi stratigrafici affidabili per il contesto geologico in esame (picchi direzionali, non temporalmente stabili, che non soddisfano i criteri SESAME, in contesto di versante)..

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

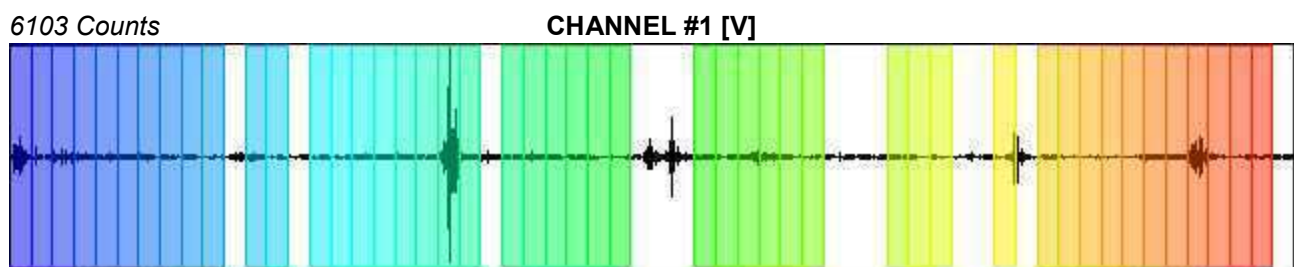
Recording start time: 2017/03/30 12:46:49

Recording length: 20 min

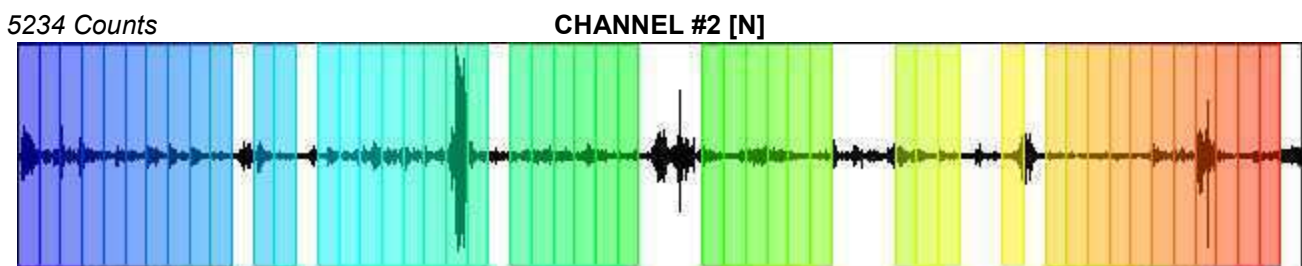
Windows count: 47

Average windows length: 20

Signal coverage: 78.33%



-5831 Counts



-4508 Counts



-5666 Counts

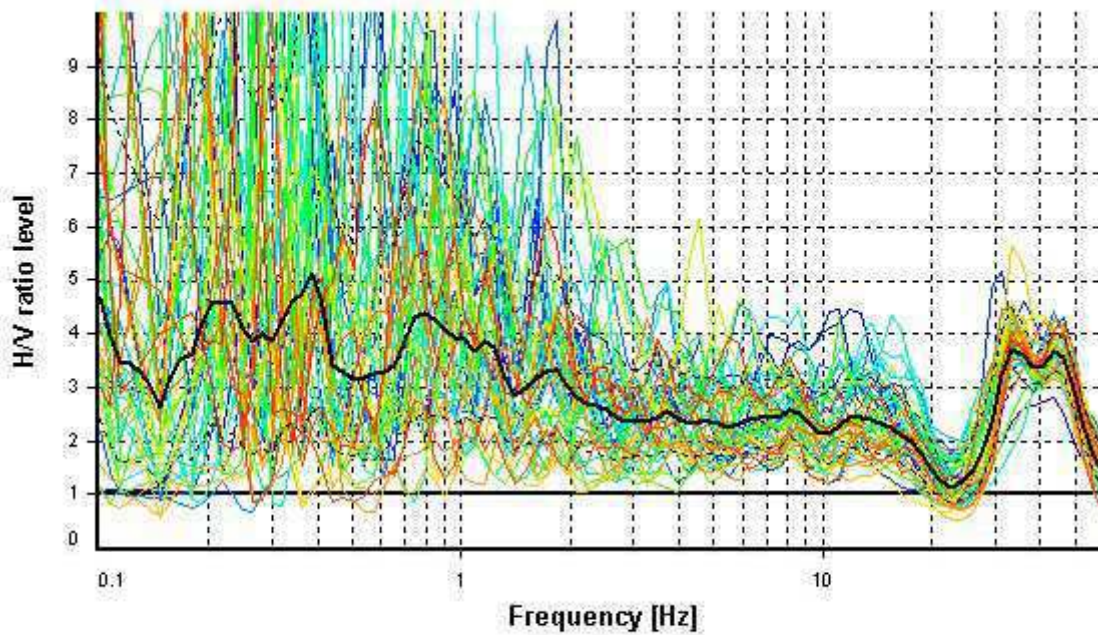
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

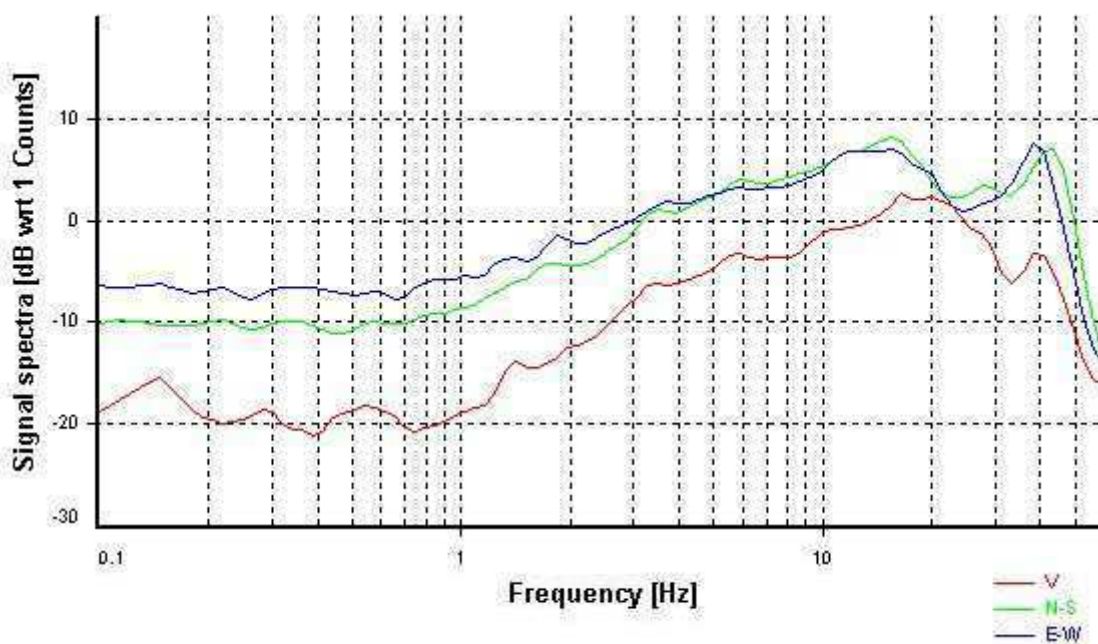
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

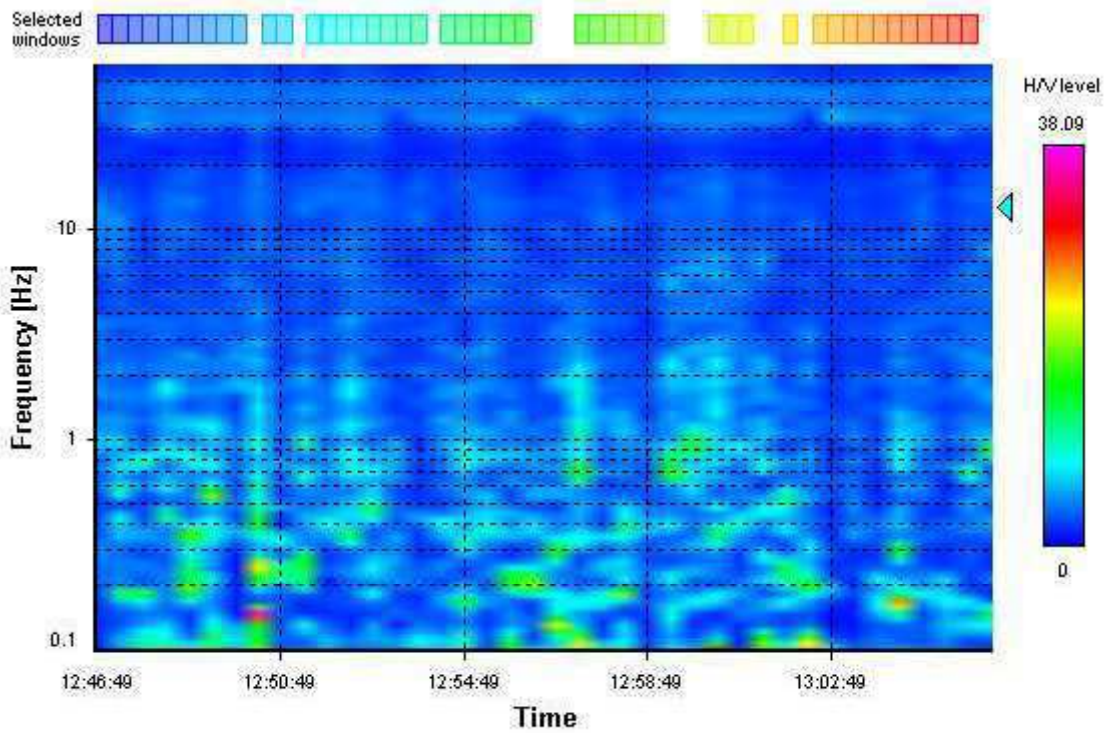
HVSR average



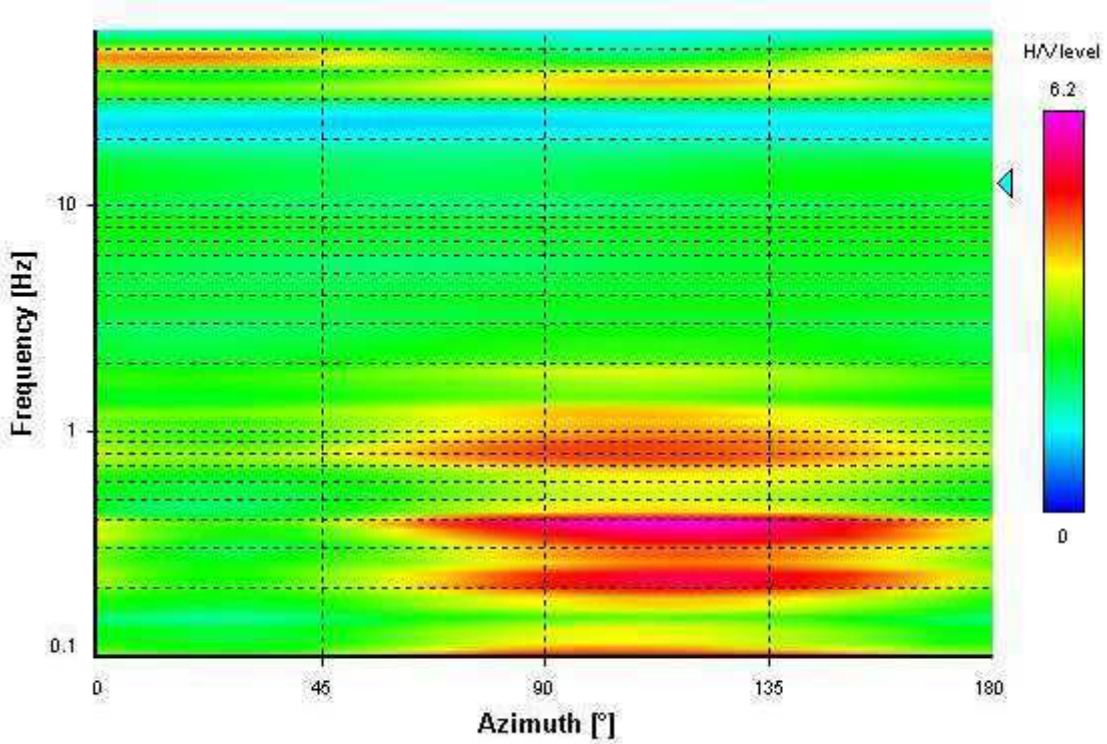
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



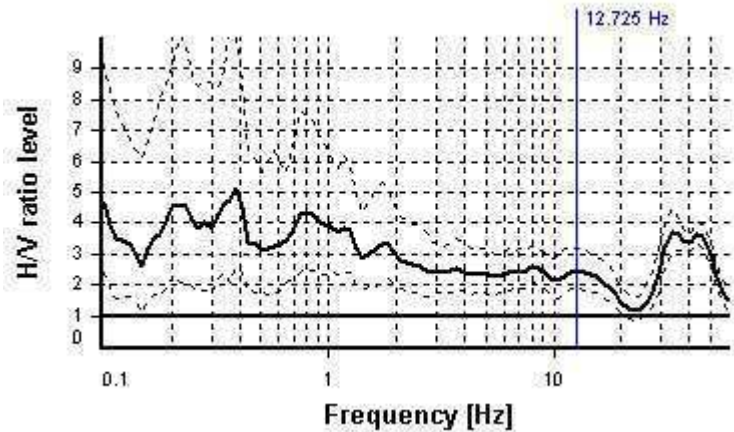
SESAME CRITERIA

Selected f_0 frequency

12.725 Hz

A_0 amplitude = 2.430

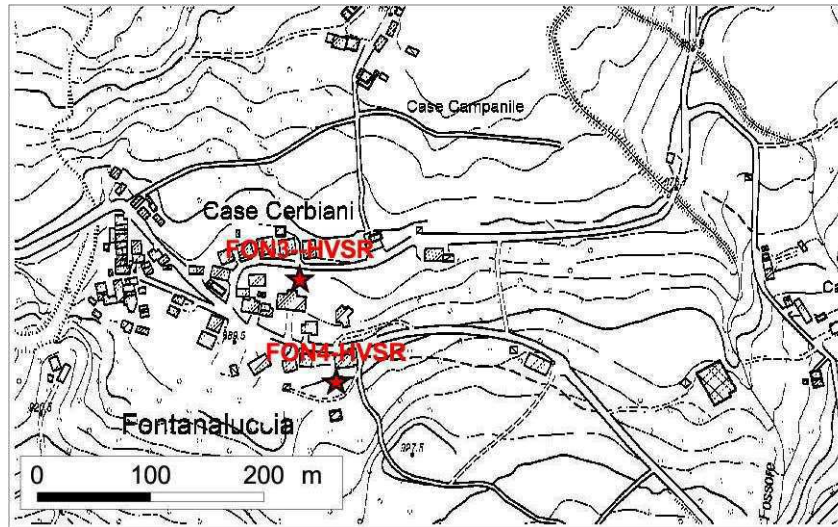
Average f_0 = 12.405 \pm 1.995



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	47 valid windows (length > 0.79 s) out of 47	OK
$n_c(f_0) > 200$	11961.56 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	22.76246 Hz	OK
$A_0 > 2$	2.43 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	6.67% > 5%	NO
$\sigma_f < \varepsilon(f_0)$	1.99492 \geq 0.63625	NO
$\sigma_A(f_0) < \theta(f_0)$	1.29829 < 1.58	OK
Overall criteria fulfillment		NO

EXPERIMENTAL HVSR

FON3-HVSR



PLACE INFORMATION

Place ID: FON3-HVSR

Address: -

Latitude: 4911117

Longitude: 142129

Coordinate system: WGS84

Elevation: 885 m s.l.m.

Weather: Soleggiato

Notes: Curva poco attendibile. Picchi a bassa frequenza poco attendibili considerato il contesto geologico di versante montuoso (evidente direzionalità, scarsa persistenza temporale, criteri SESAME non soddisfatti, in alcuni casi con andamento delle componenti spettrali orizzontali simile a quello della componente verticale).

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

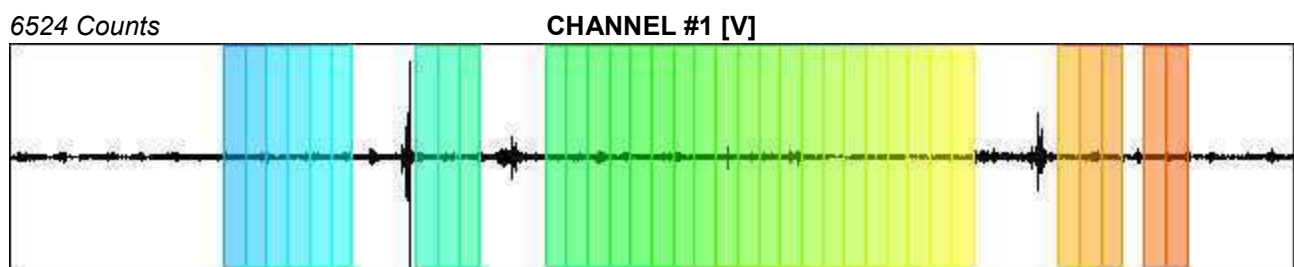
Recording start time: 2017/03/30 15:18:06

Recording length: 20 min

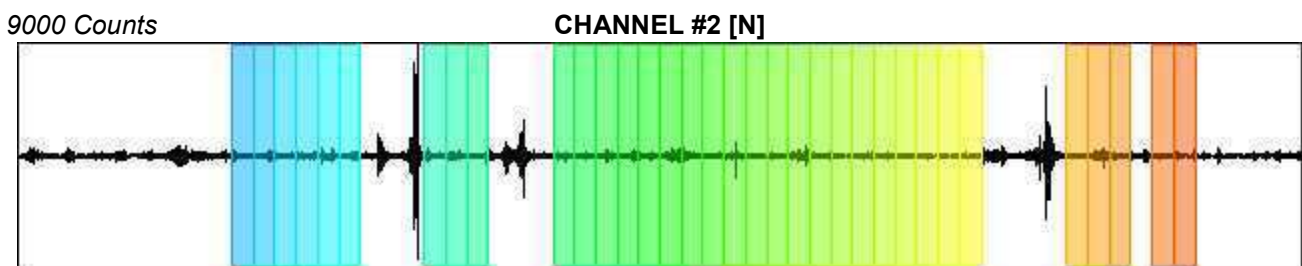
Windows count: 34

Average windows length: 20

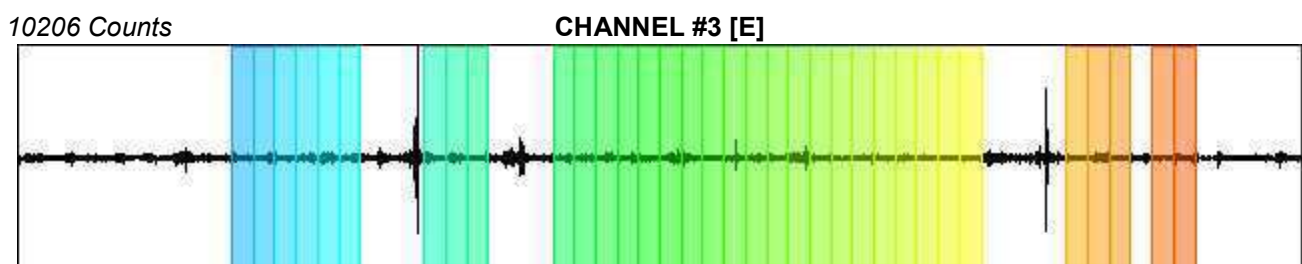
Signal coverage: 56.67%



-7662 Counts



-8289 Counts



-6929 Counts

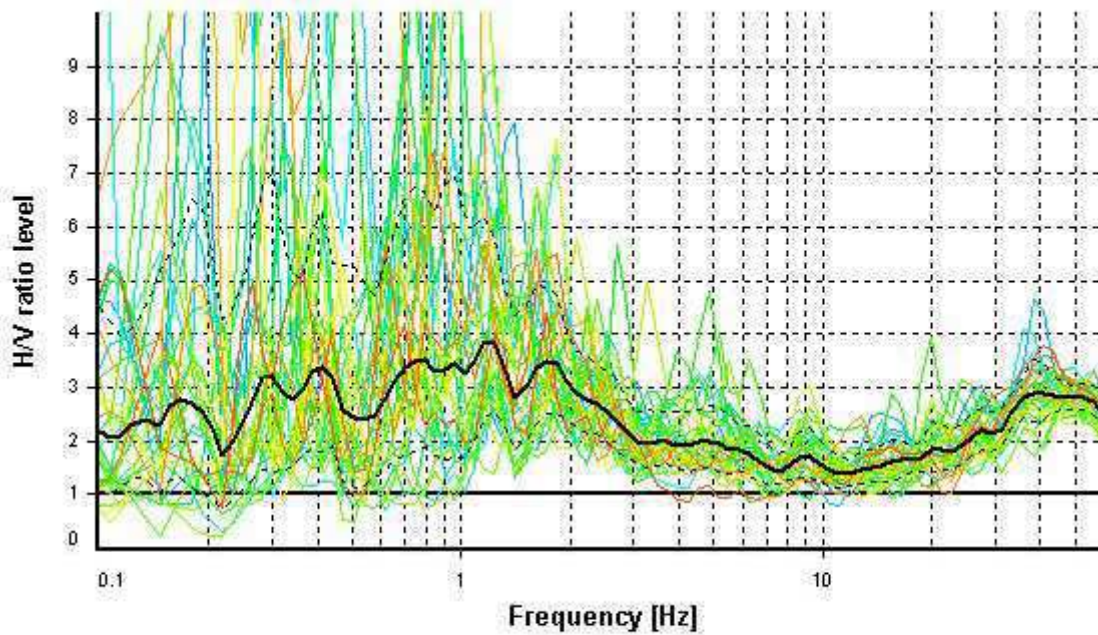
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

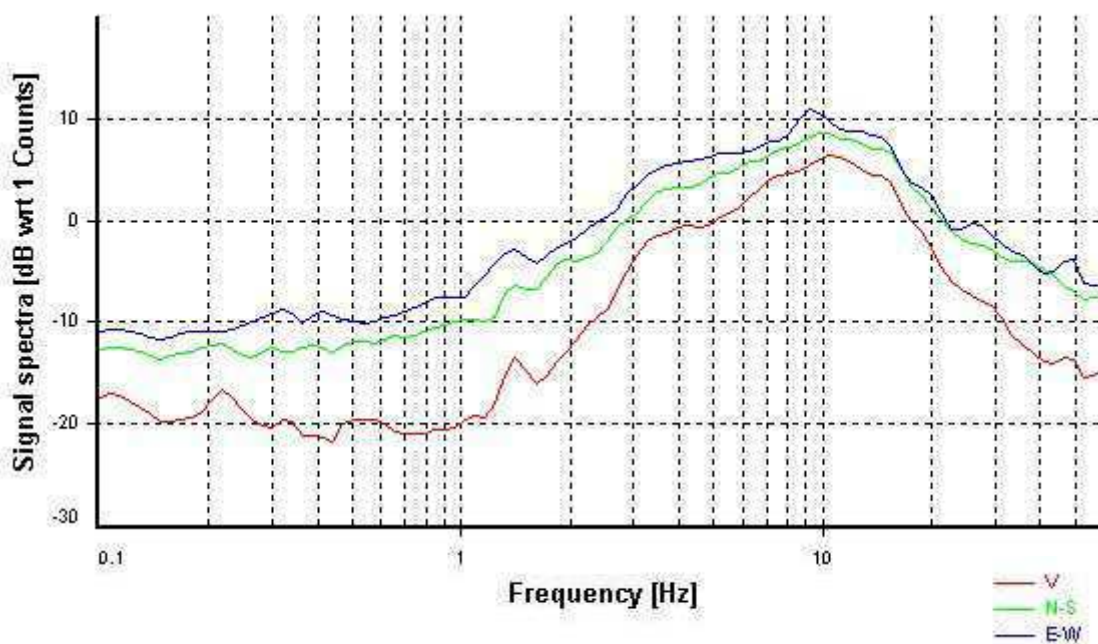
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

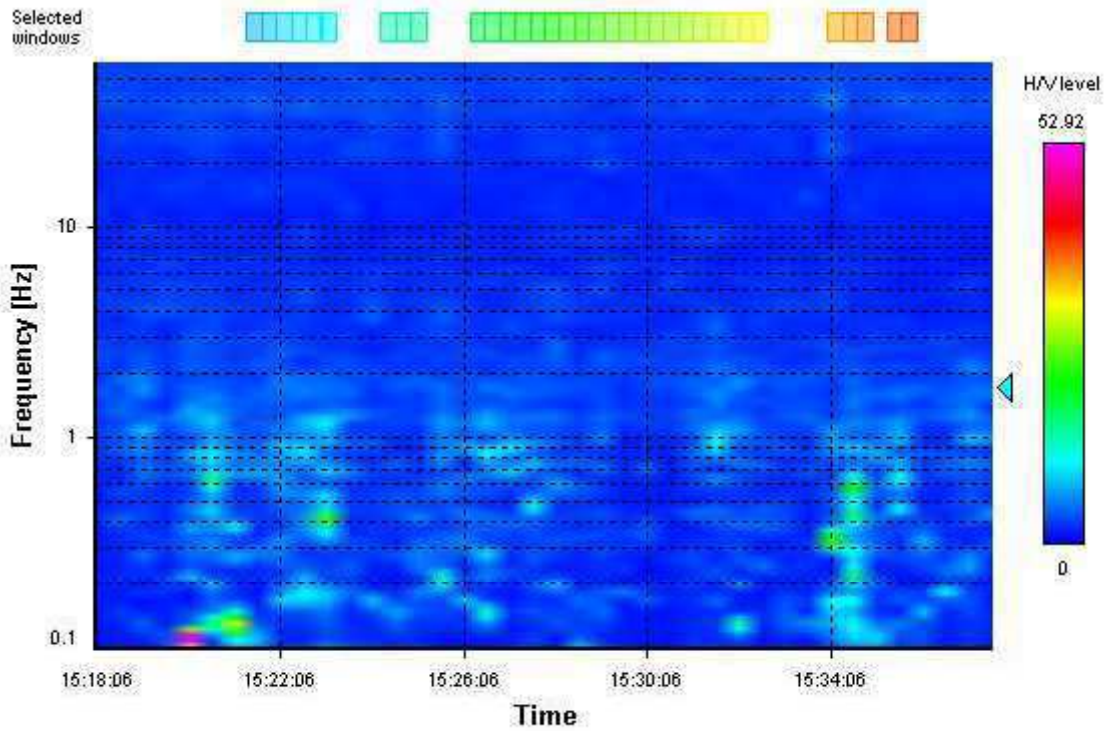
HVSR average



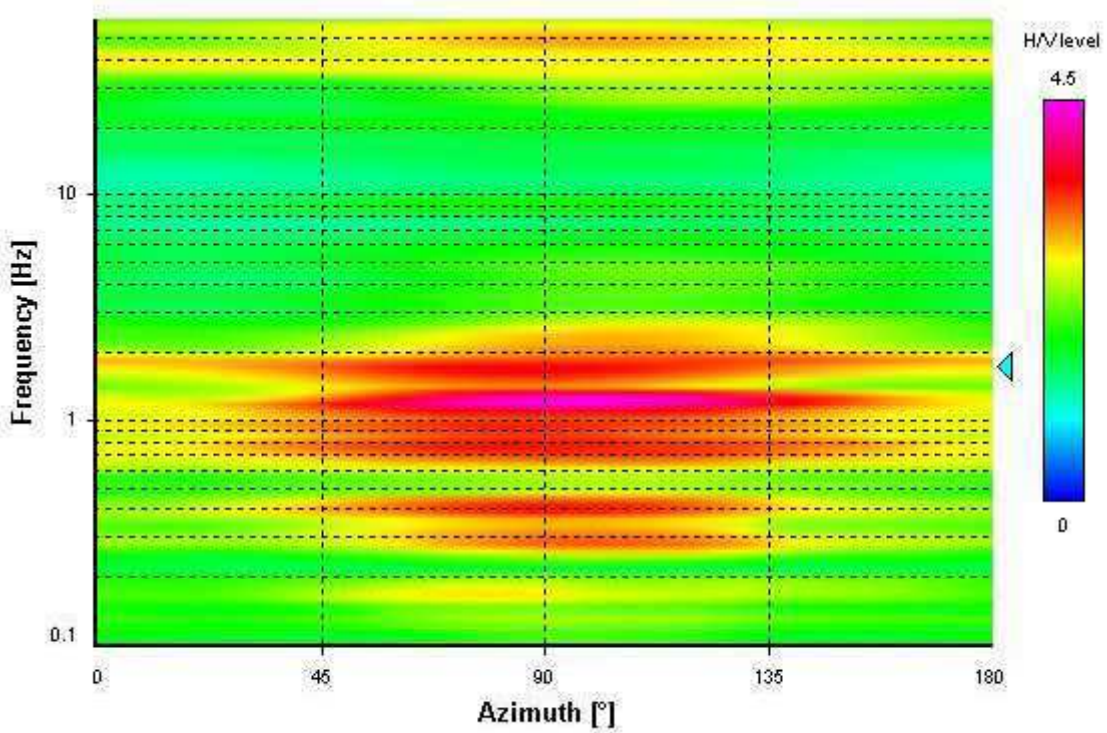
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



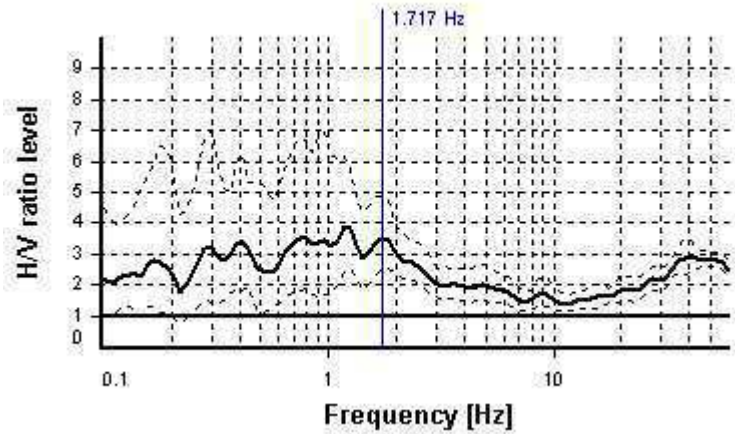
SESAME CRITERIA

Selected f_0 frequency

1.717 Hz

A_0 amplitude = 3.496

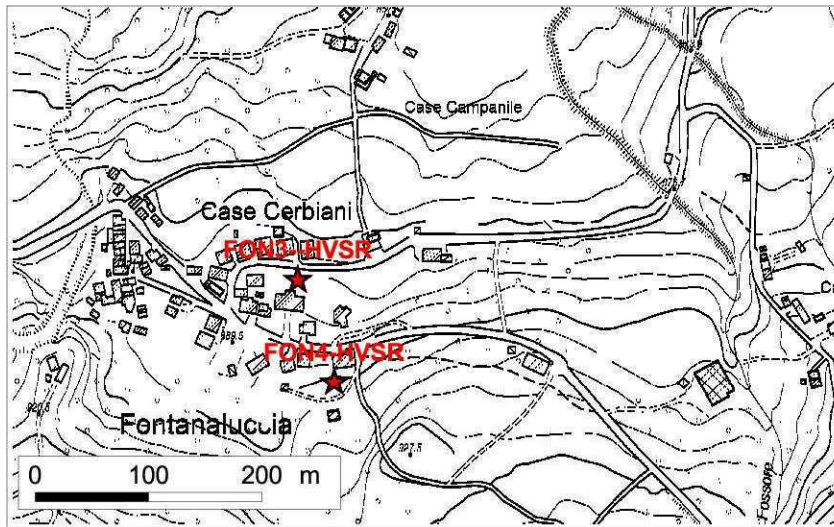
Average $f_0 = 1.577 \pm 0.334$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	34 valid windows (length > 5.82 s) out of 34	OK
$n_c(f_0) > 200$	1167.46 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 2 times in 21	NO
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	6.66866 Hz	OK
$A_0 > 2$	3.5 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	32.14% > 5%	NO
$\sigma_f < \varepsilon(f_0)$	0.33415 \geq 0.17169	NO
$\sigma_A(f_0) < \theta(f_0)$	1.38889 < 1.78	OK
Overall criteria fulfillment		NO

EXPERIMENTAL HVSR

FON4-HVSR



PLACE INFORMATION

Place ID: FON4-HVSR

Address:

Latitude: 4911022

*Longitude:*142155

Coordinate system: WGS84

Elevation: 905

Weather: soleggiato

Notes: Picco a 0.4 Hz poco affidabile: non si procede al modeling interpretativo del profilo di velocità (evidente direzionalità, non persistenza temporale, criteri SESAME non soddisfatti).

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

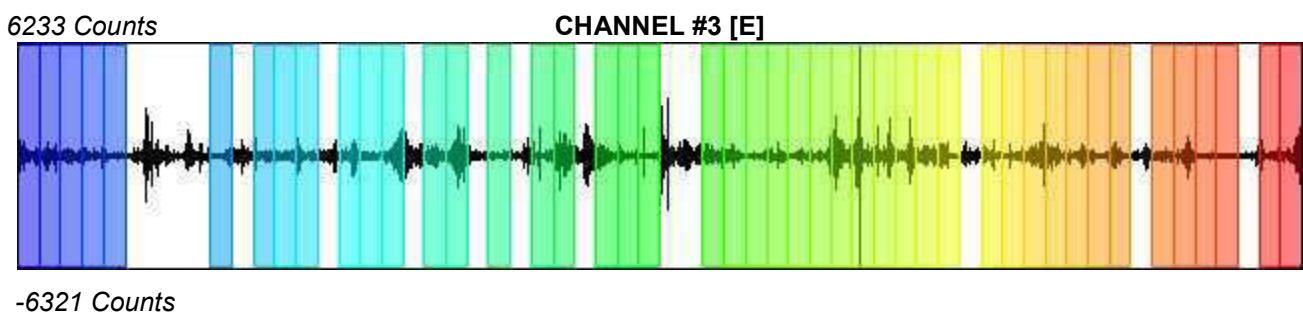
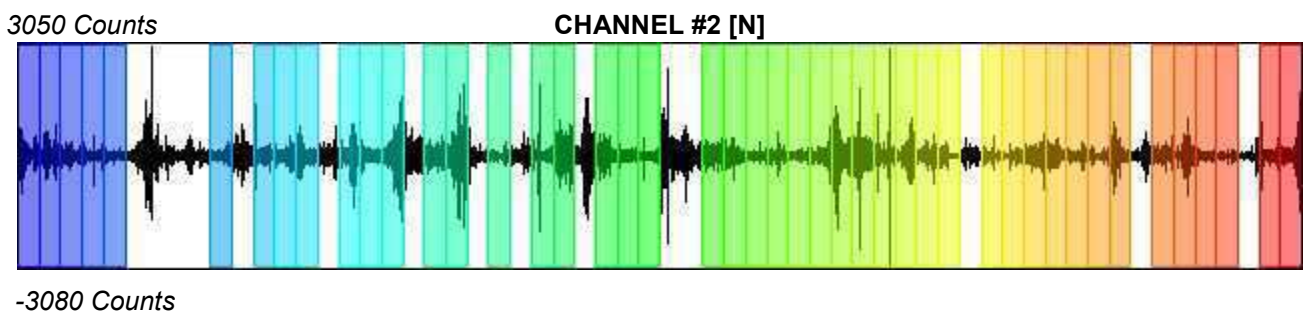
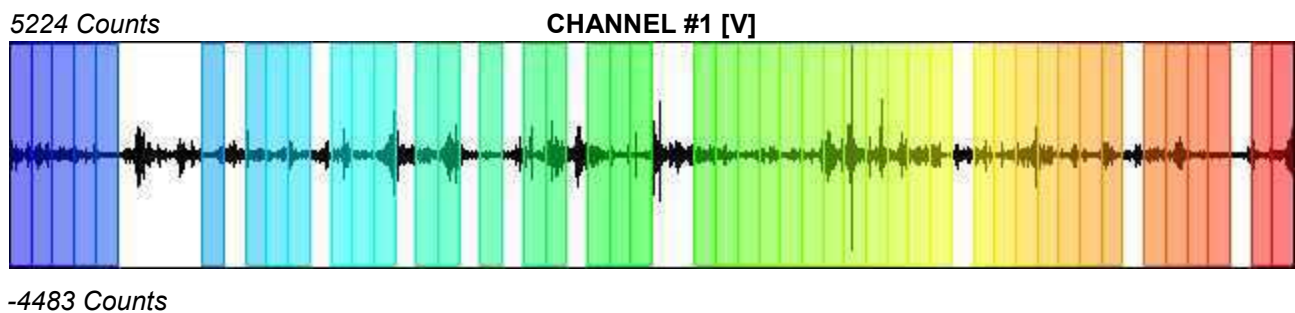
Recording start time: 2017/03/30 16:26:36

Recording length: 20 min

Windows count: 45

Average windows length: 20

Signal coverage: 75%



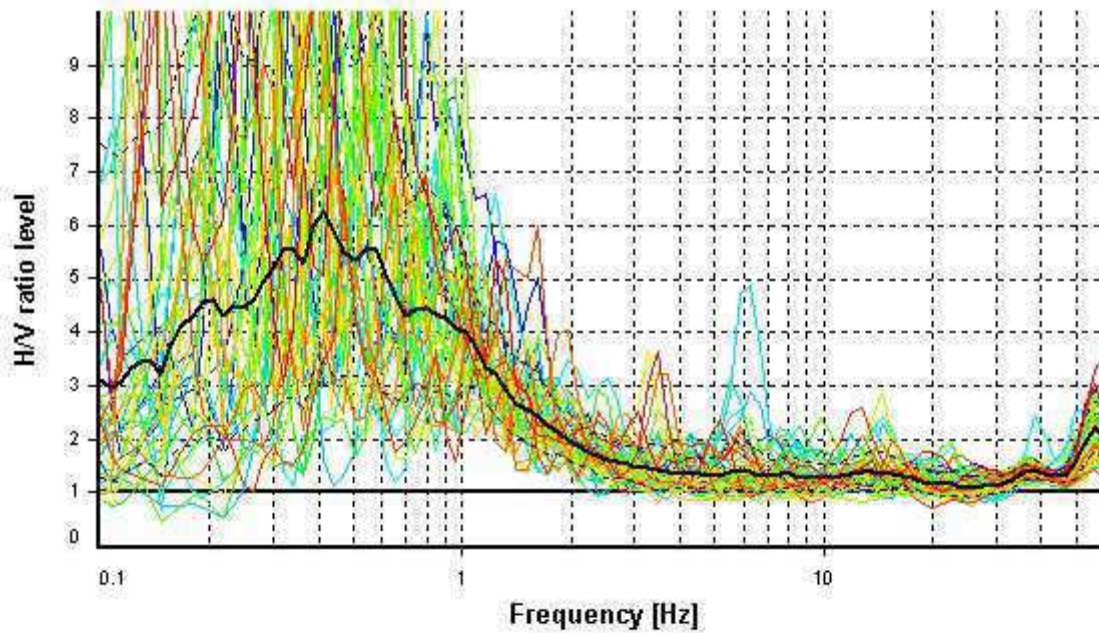
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

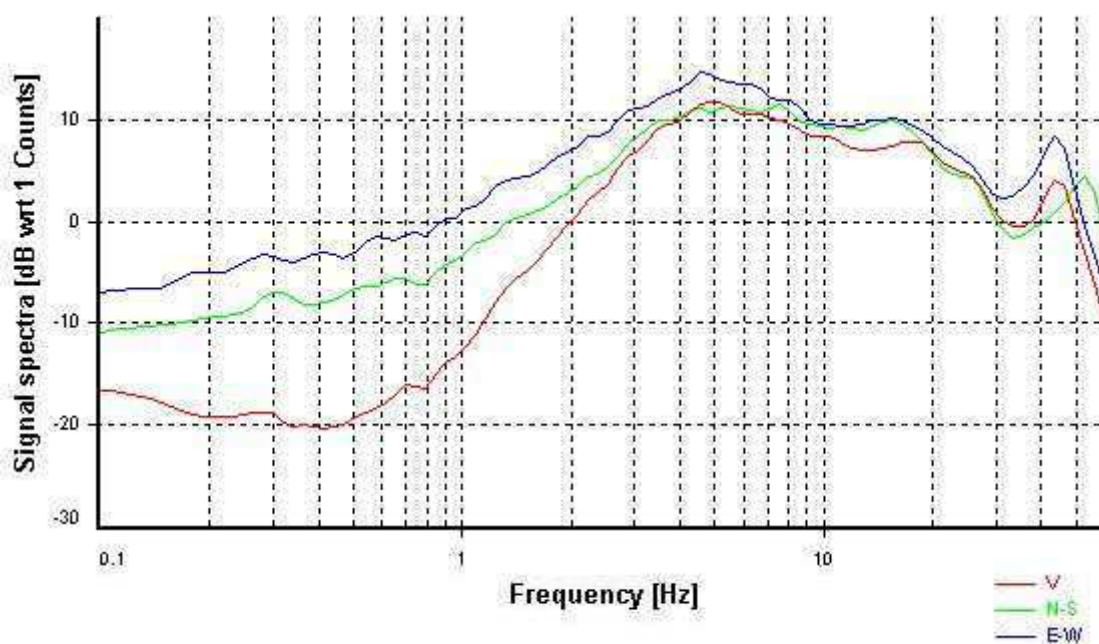
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

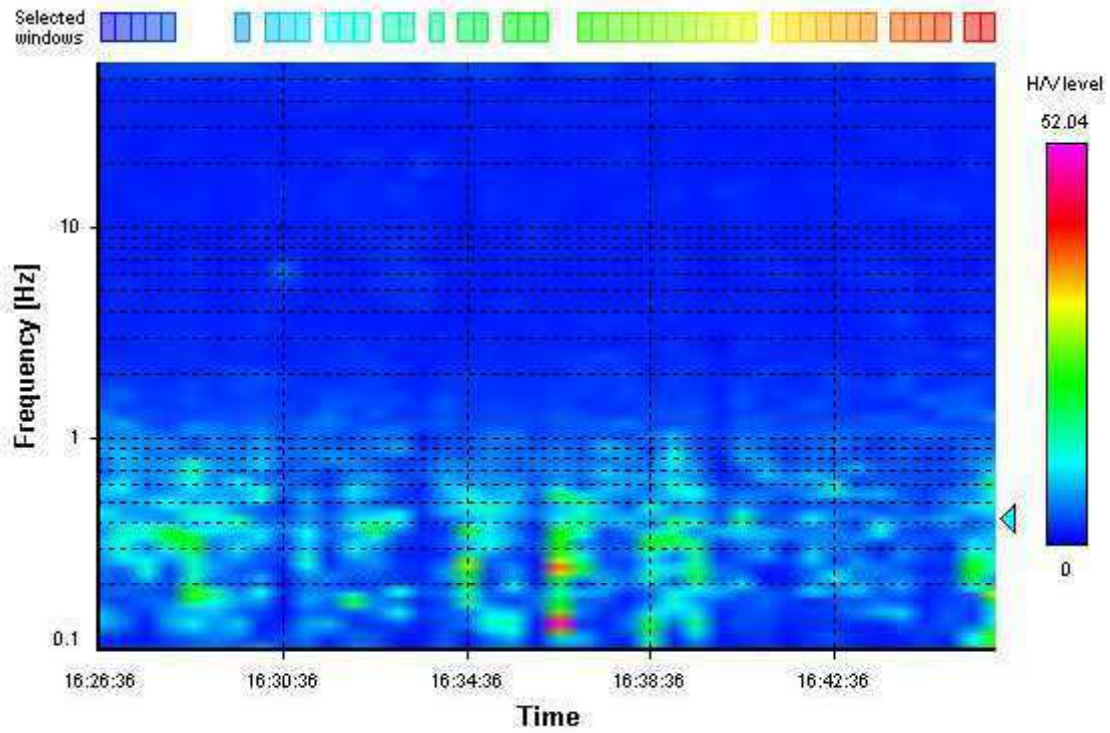
HVSR average



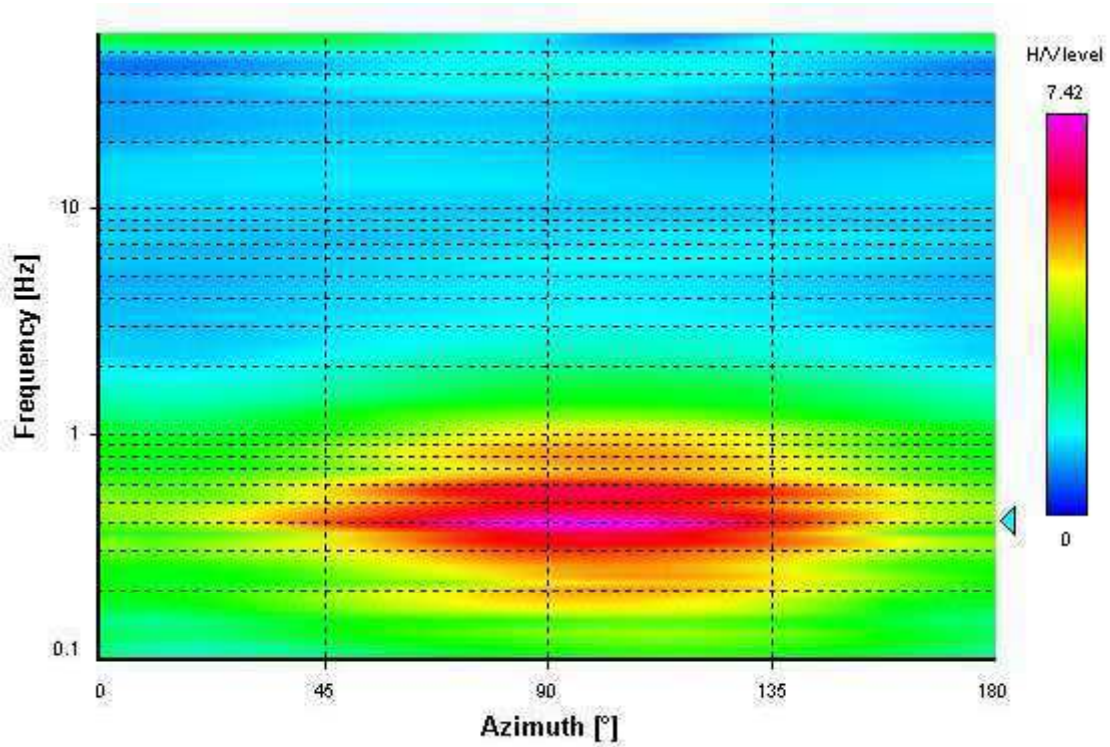
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



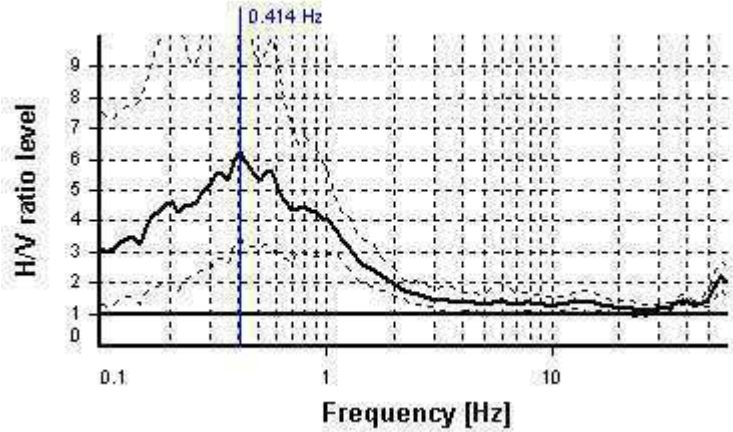
SESAME CRITERIA

frequency
Selected f_0

0.414 Hz

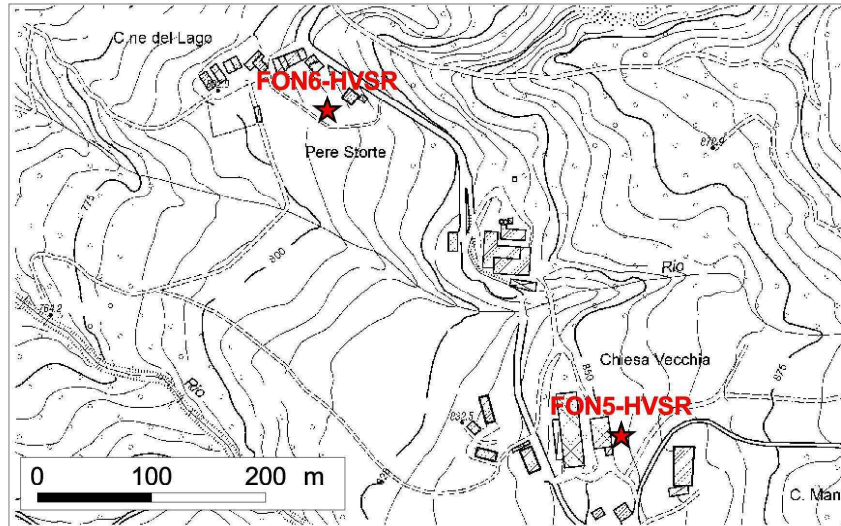
A_0 amplitude = 6.243

Average $f_0 = 0.429 \pm 0.107$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	0 valid windows (length > 24.13 s) out of 45	NO
$n_c(f_0) > 200$	0 \leq 200	NO
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0.1138 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.32582 Hz	OK
$A_0 > 2$	6.24 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% \leq 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.10726 \geq 0.08287	NO
$\sigma_A(f_0) < \theta(f_0)$	1.80374 < 2.5	OK
Overall criteria fulfillment		NO

FON5-HVSR



PLACE INFORMATION

Place ID: FON5-HVSR

Address: -

Latitude: 4911646

Longitude: 142447

Coordinate system: WGS84

Elevation 852 m s.l.m.

Weather: soleggiato con brezza

Notes: Picco poco affidabile e direzionale a bassa frequenza (non si procede al modeling interpretativo del profilo di velocità)

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

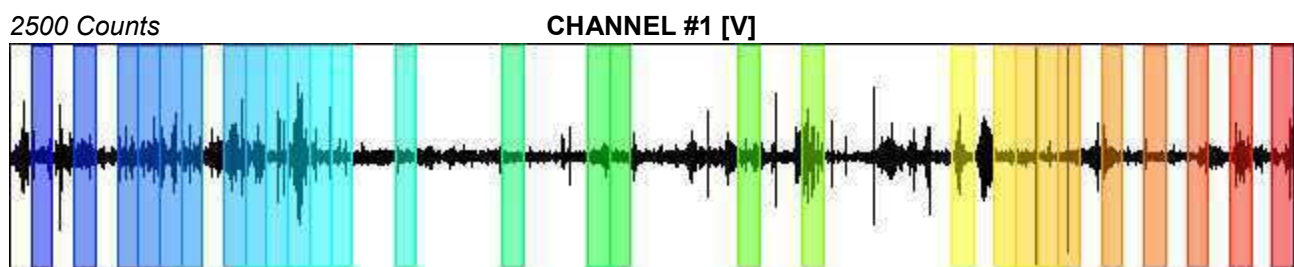
Recording start time: 2017/03/30 17:48:00

Recording length: 20 min

Windows count: 28

Average windows length: 20

Signal coverage: 46.67%



-2403 Counts



-3317 Counts



-5099 Counts

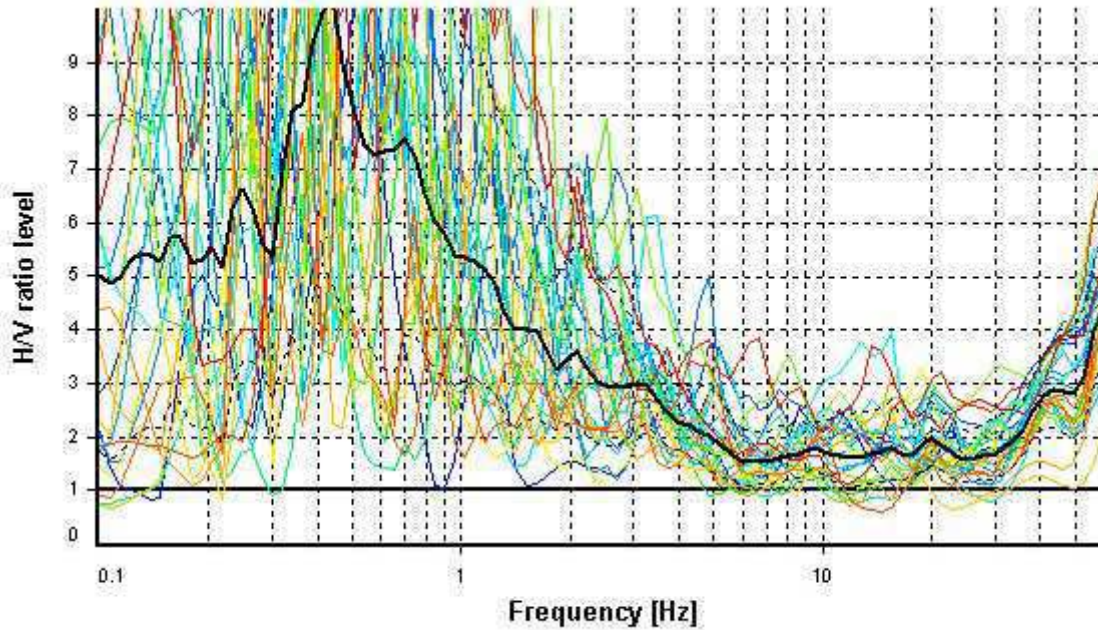
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

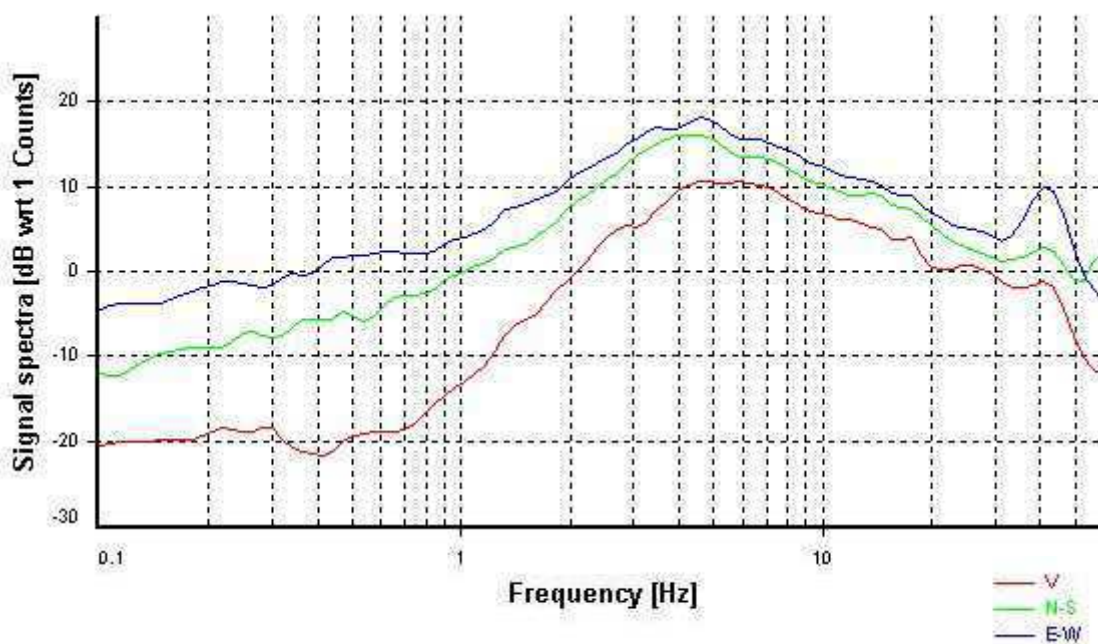
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

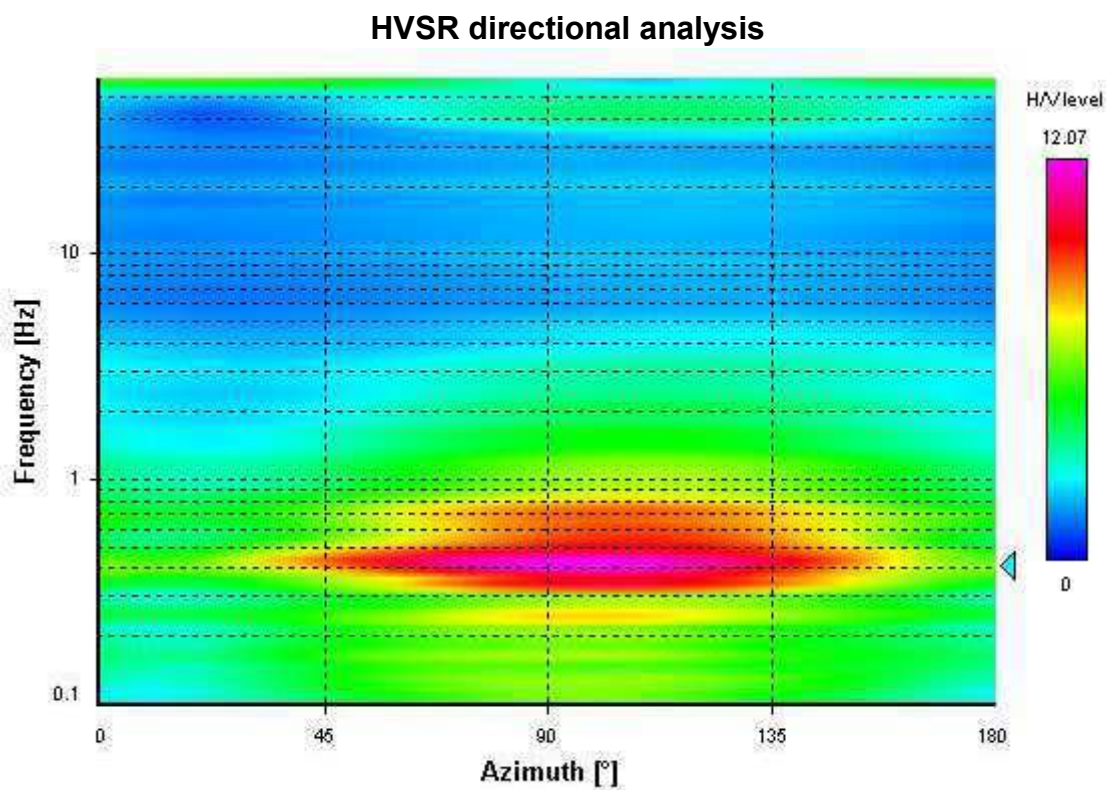
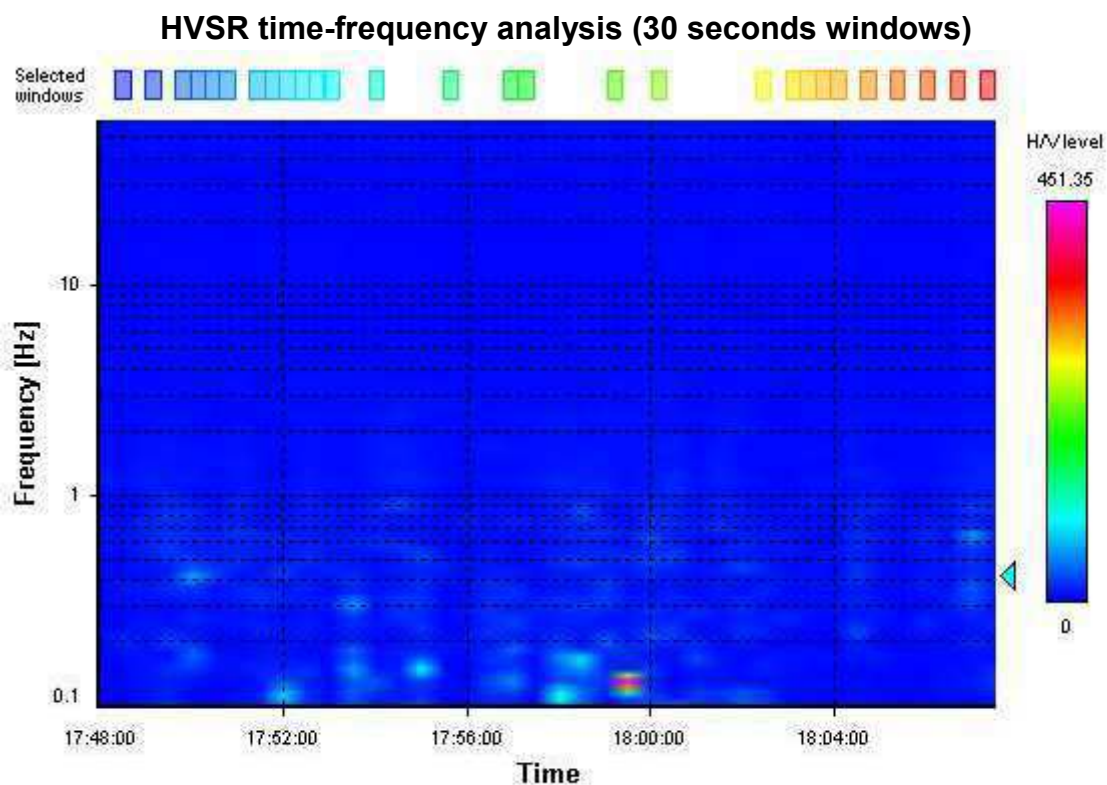
Instrumental correction: Disabled

HVSR average



Signal spectra average





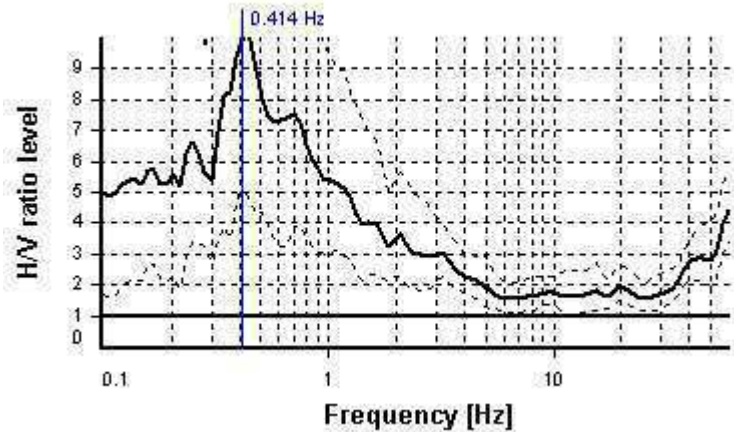
SESAME CRITERIA

Selected f_0 frequency

0.414 Hz

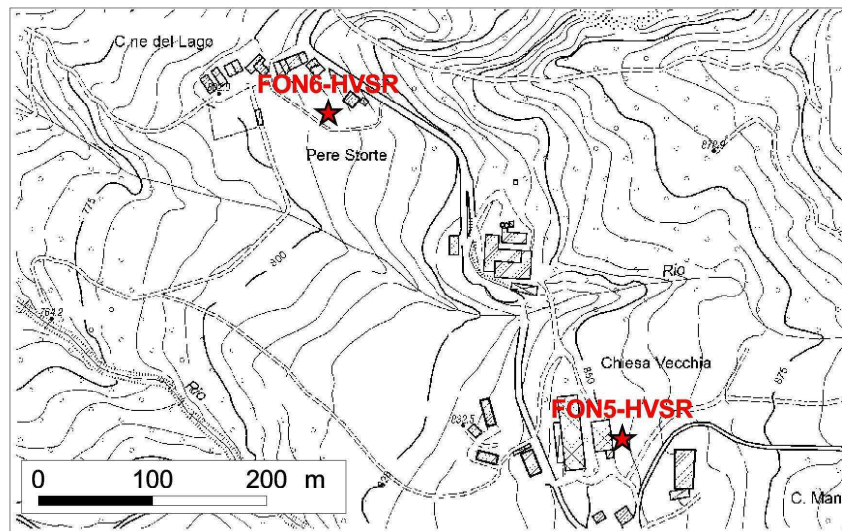
A_0 amplitude = 9.921

Average $f_0 = 0.467 \pm 0.080$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	0 valid windows (length > 24.13 s) out of 28	NO
$n_c(f_0) > 200$	0 \leq 200	NO
$\sigma_A(f) < 3$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0.10667 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	1.24286 Hz	OK
$A_0 > 2$	9.92 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	6.67% > 5%	NO
$\sigma_f < \varepsilon(f_0)$	0.08042 < 0.08287	OK
$\sigma_A(f_0) < \theta(f_0)$	1.89494 < 2.5	OK
Overall criteria fulfillment		NO

FON6-HVSR



PLACE INFORMATION

Place ID: FON6-HVSR

Address:

Latitude: 4911962

*Longitude:*142011

Coordinate system: WGS84

Elevation: 810 m s.l.m.

Weather: Soleggiato con brezza

Notes:

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

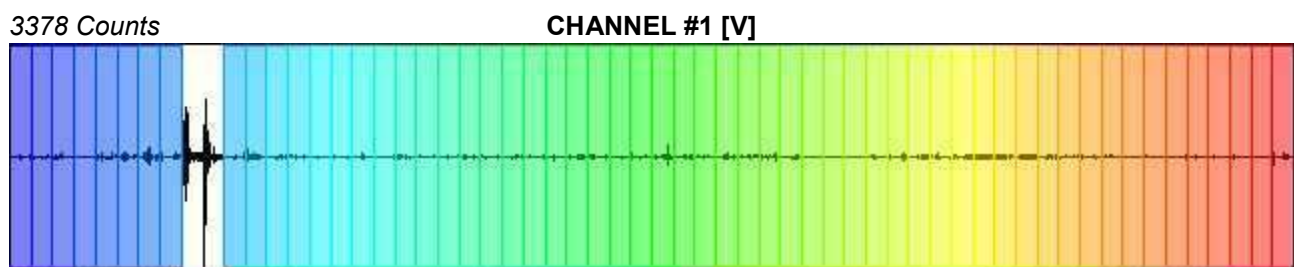
Recording start time: 2017/03/30 18:35:20

Recording length: 20 min

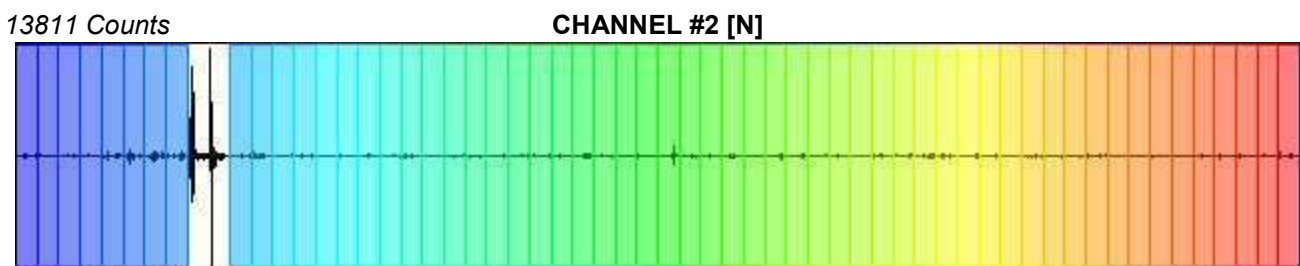
Windows count: 58

Average windows length: 20

Signal coverage: 96.67%



-6569 Counts



-14455 Counts



-10220 Counts

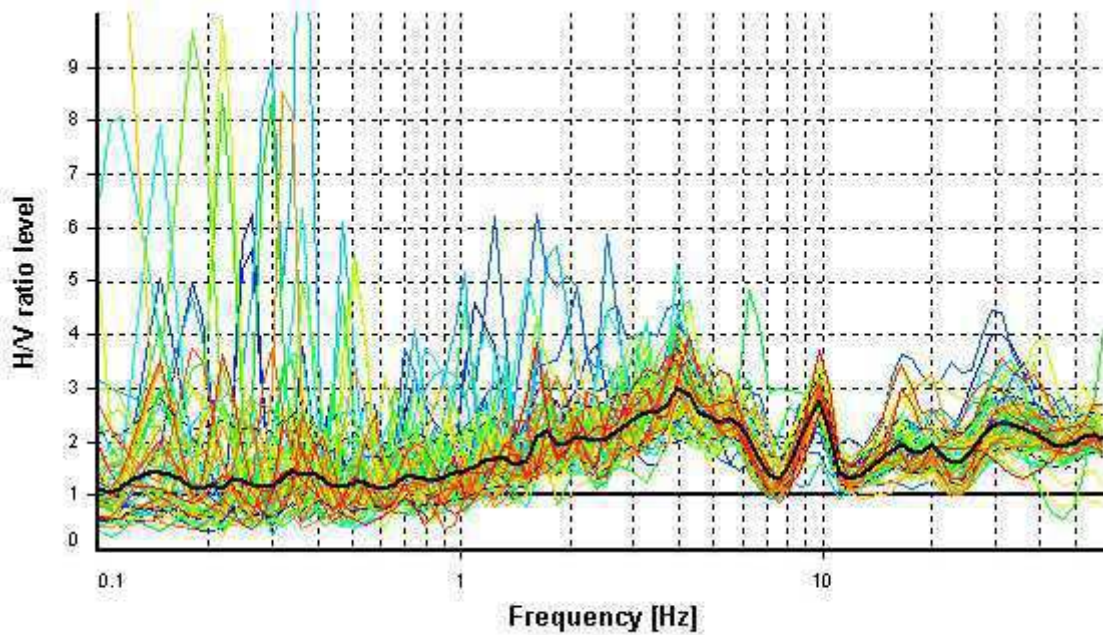
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

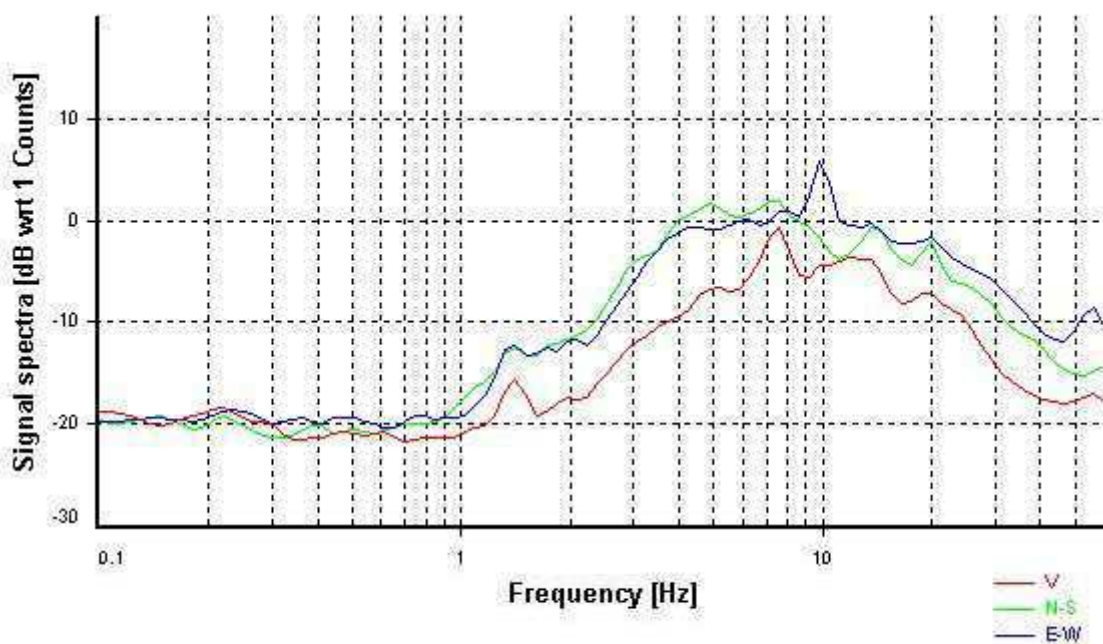
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

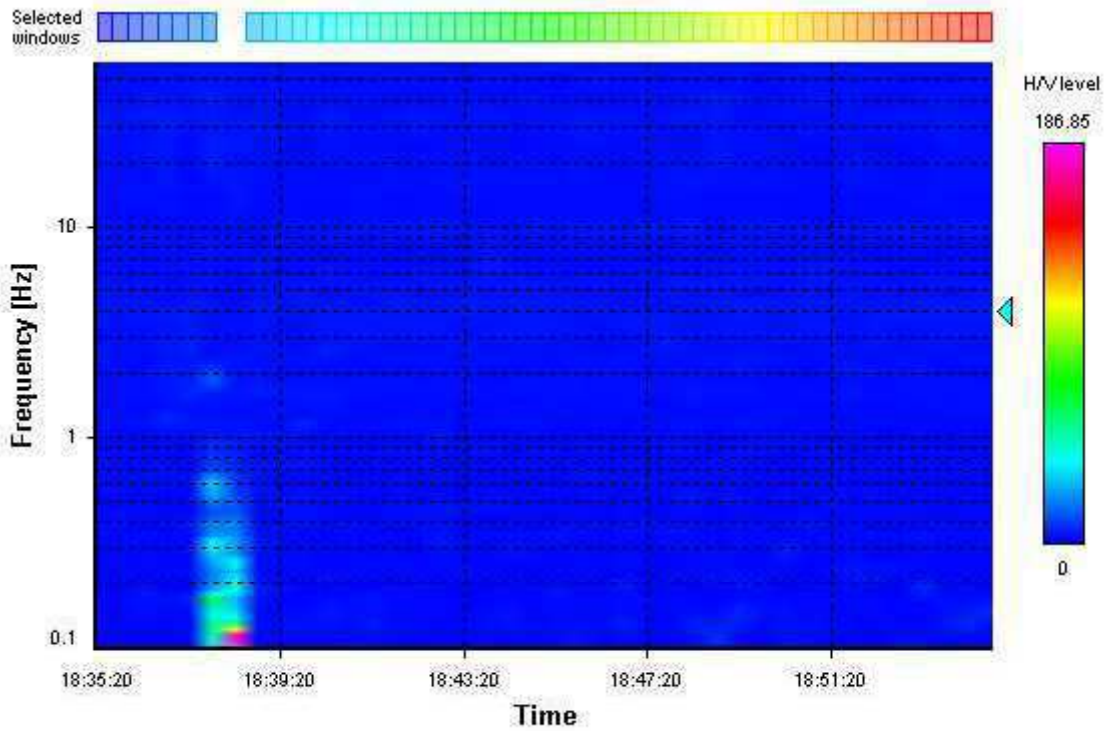
HVSR average



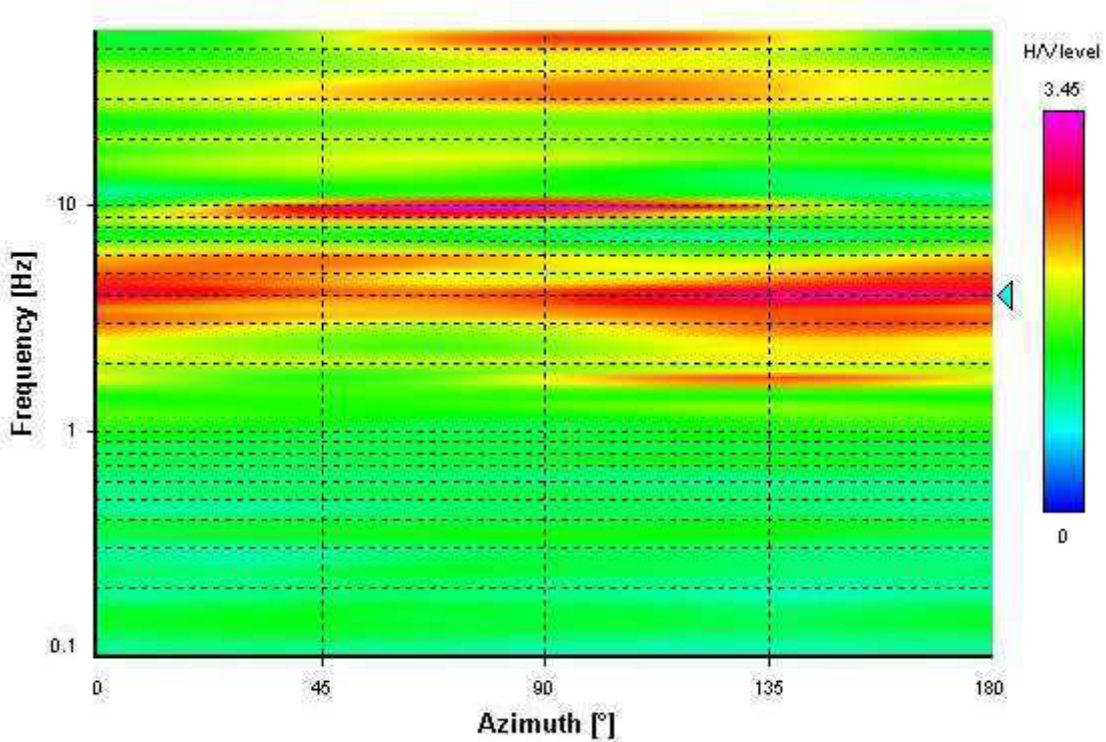
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



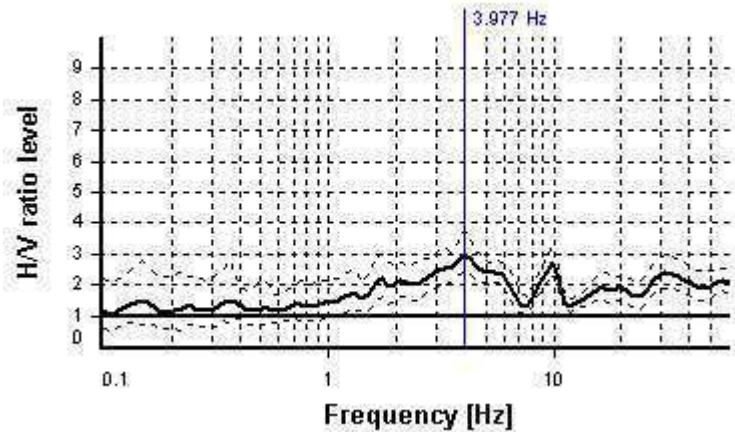
SESAME CRITERIA

Selected f_0 frequency

3.977 Hz

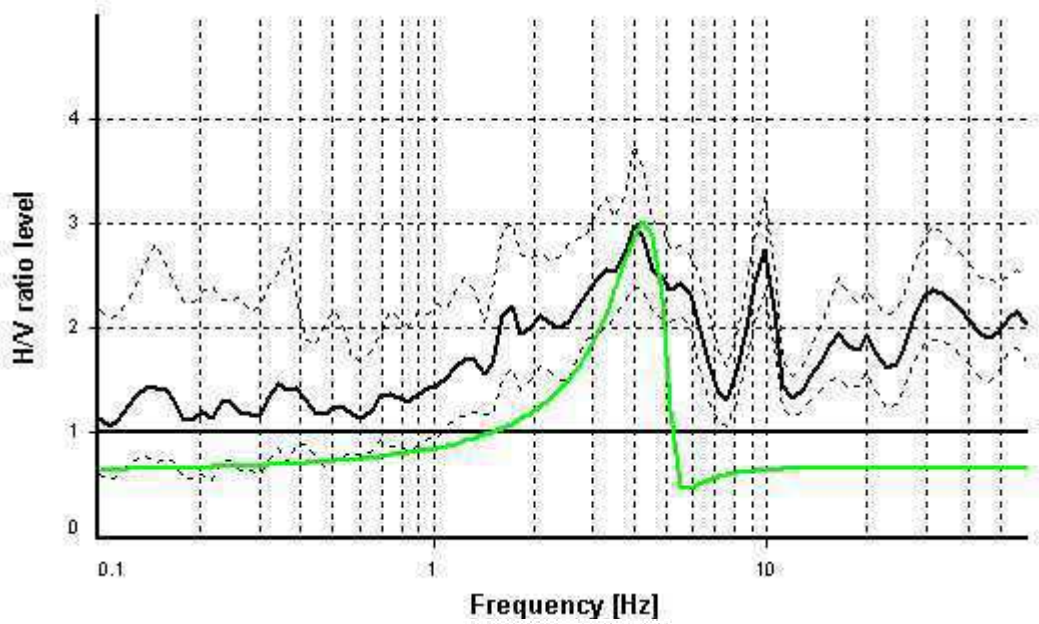
A_0 amplitude = 2.986

Average $f_0 = 3.904 \pm 0.645$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	58 valid windows (length > 2.51 s) out of 58	OK
$n_c(f_0) > 200$	4613.17 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	1.02385 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	7.11379 Hz	OK
$A_0 > 2$	2.99 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.64512 >= 0.19884	NO
$\sigma_A(f_0) < \theta(f_0)$	1.25474 < 1.58	OK
Overall criteria fulfillment		OK

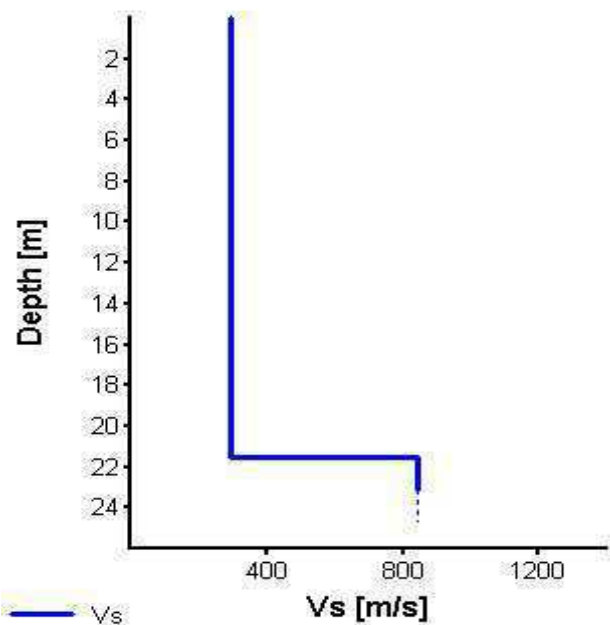
Synthetic HVSr modelling



EXPERIMENTAL
HVSr

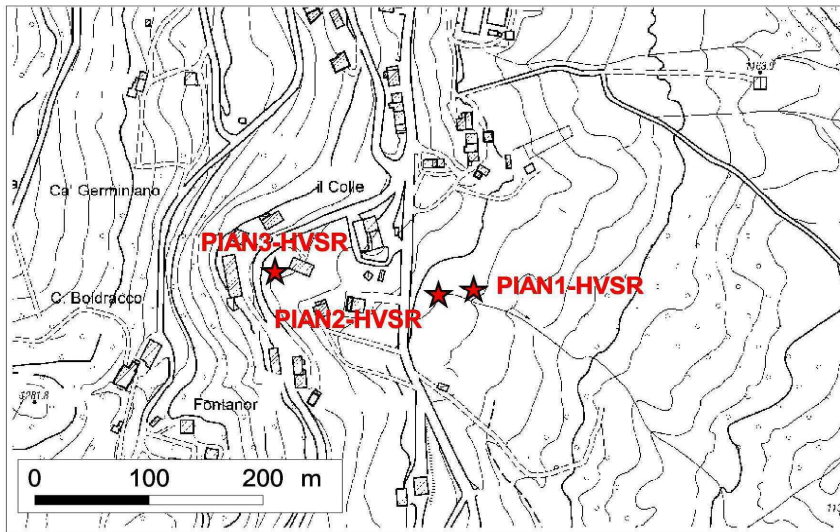
SYNTHETIC
HVSr

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
21.5	21.5	539	290	1800
-	> 21.5	1818	840	2200



Vs 30 = 356 m/s (Offset = 0 m)

PIAN1-HVSR



PLACE INFORMATION

*Place ID:*PIAN1-HVSR

Address:

Latitude: 4906466

*Longitude:*142057

Coordinate system:

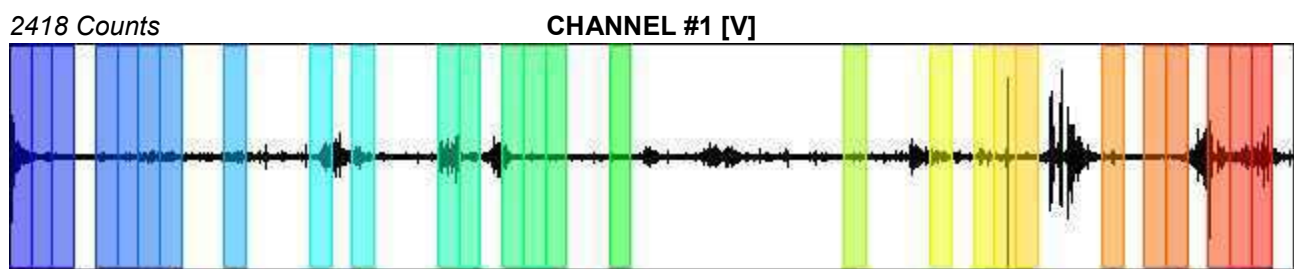
Elevation: 1193 m s.l.m.

*Weather:*soleggiato con qualche nuvola

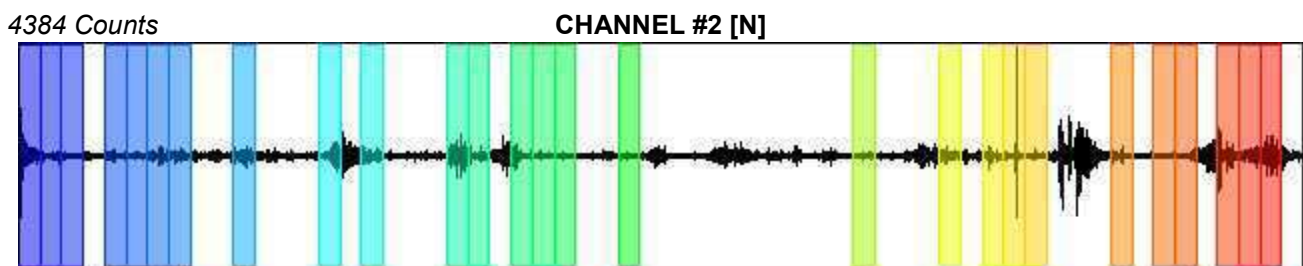
Notes: Presente un picco a circa 1 Hz, poco affidabile e direzionale, altro picco più affidabile a circa 5.8 Hz

SIGNAL AND WINDOWING

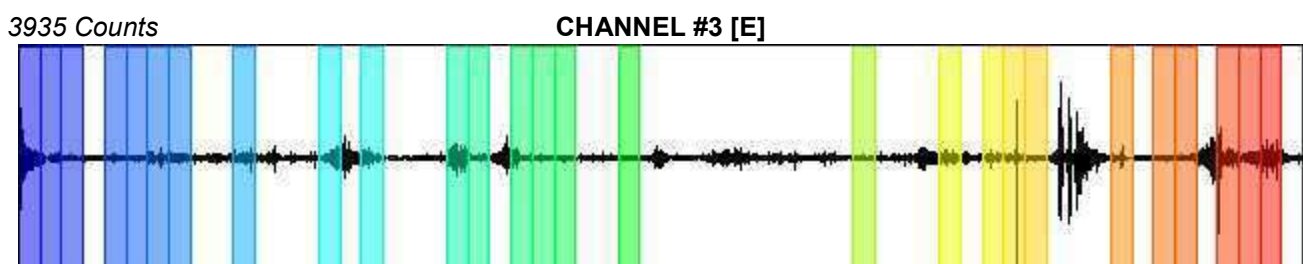
Sampling frequency: 300 Hz
Recording start time: 2017/04/21 14:43:06
Recording length: 19.99 min
Windows count: 27
Average windows length: 20
Signal coverage: 45.01%



-3097 Counts



-2404 Counts



-5805 Counts

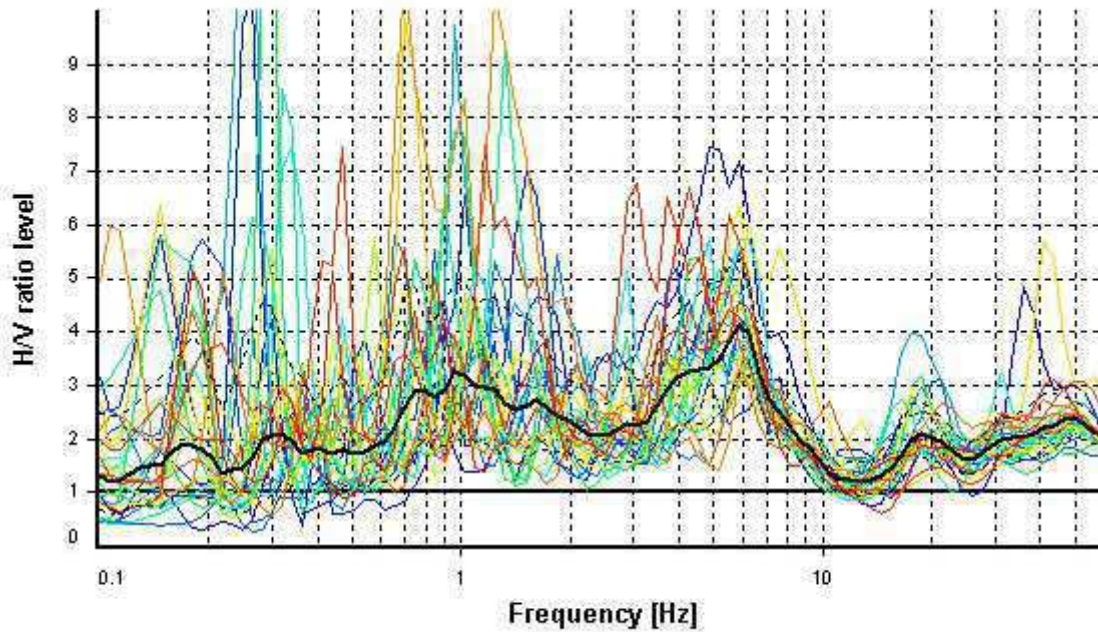
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

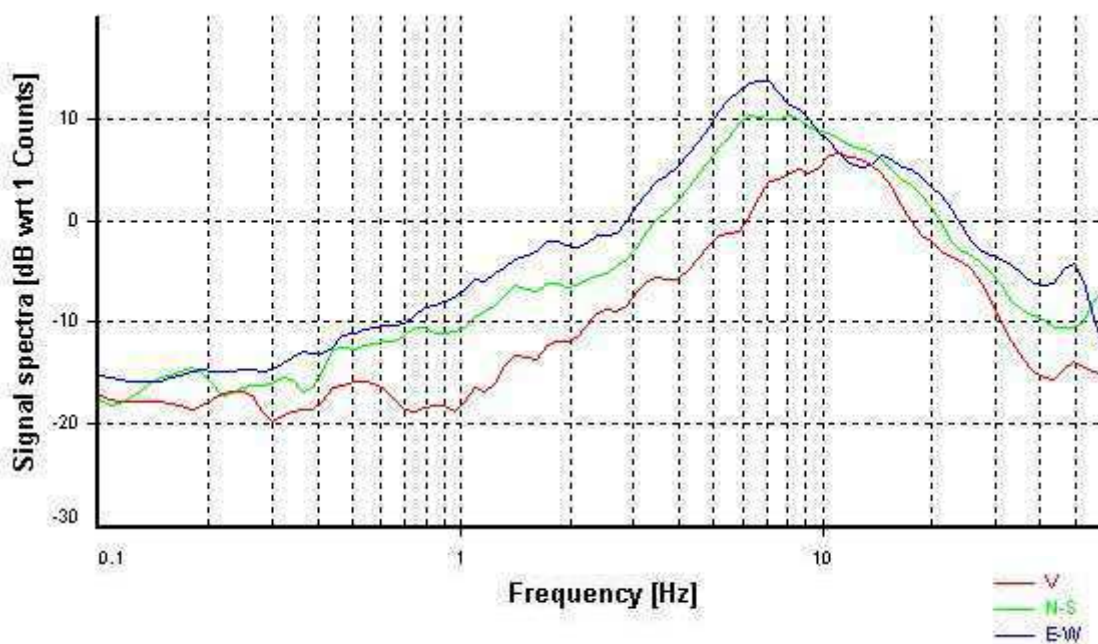
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

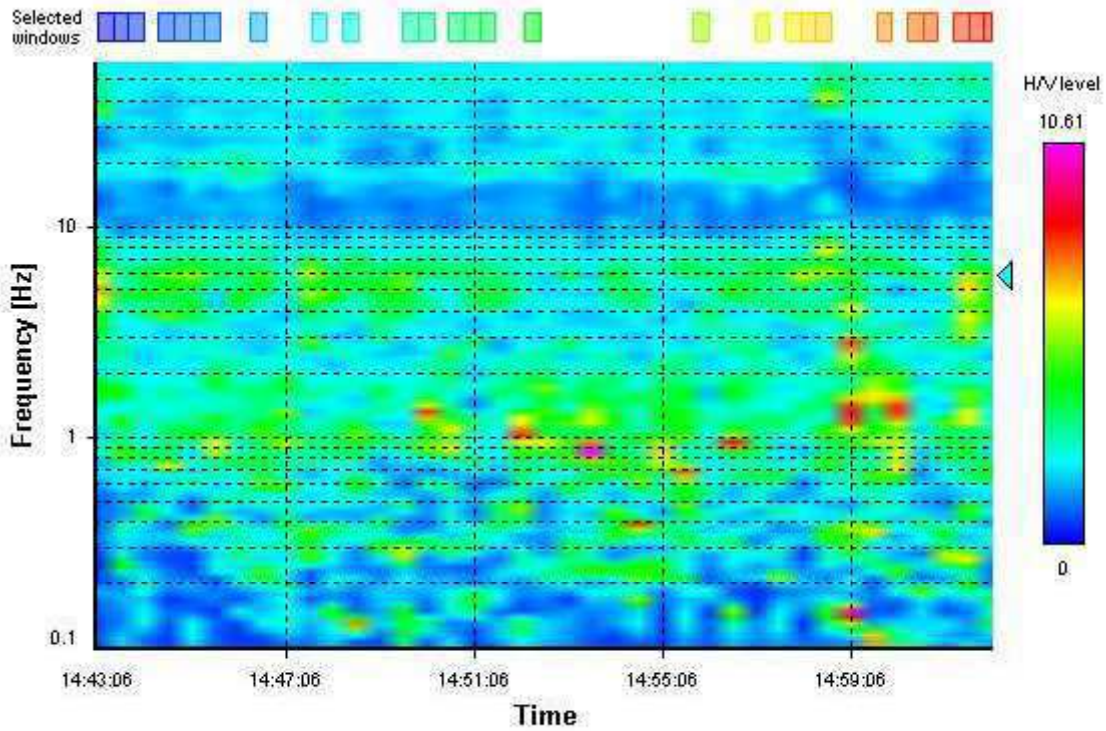
HVSR average



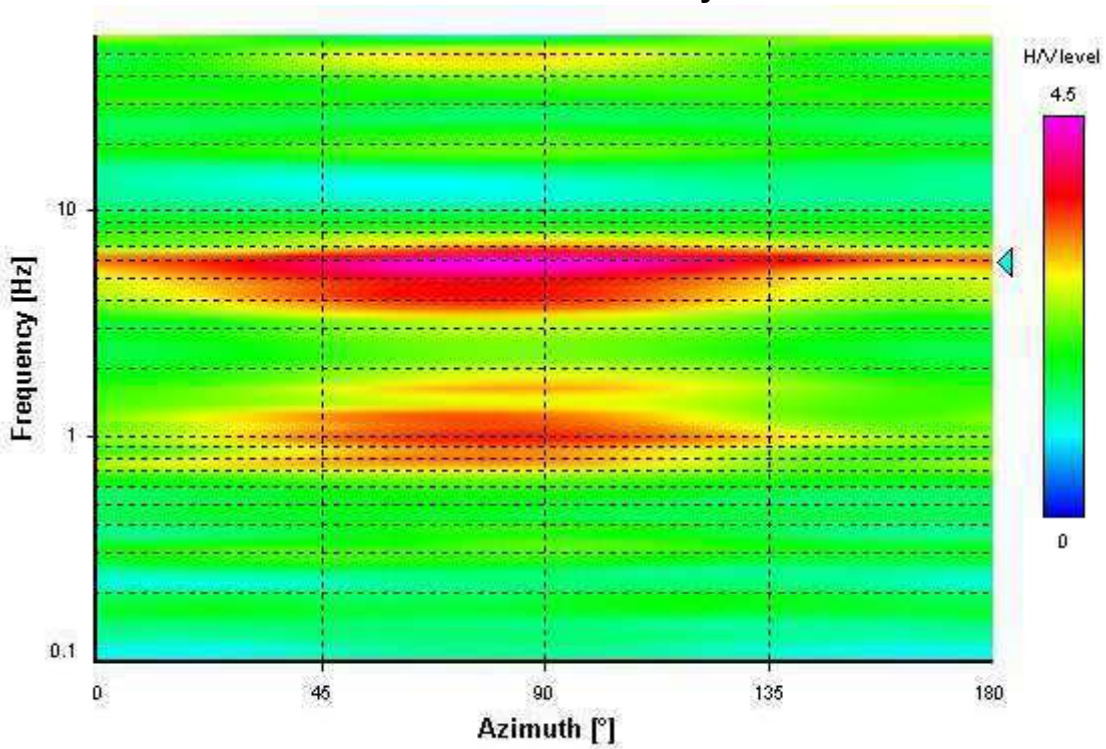
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



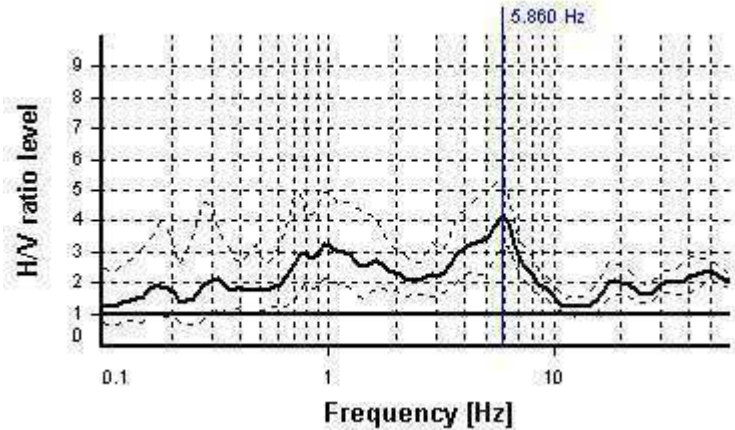
SESAME CRITERIA

Selected f_0 frequency

5.860 Hz

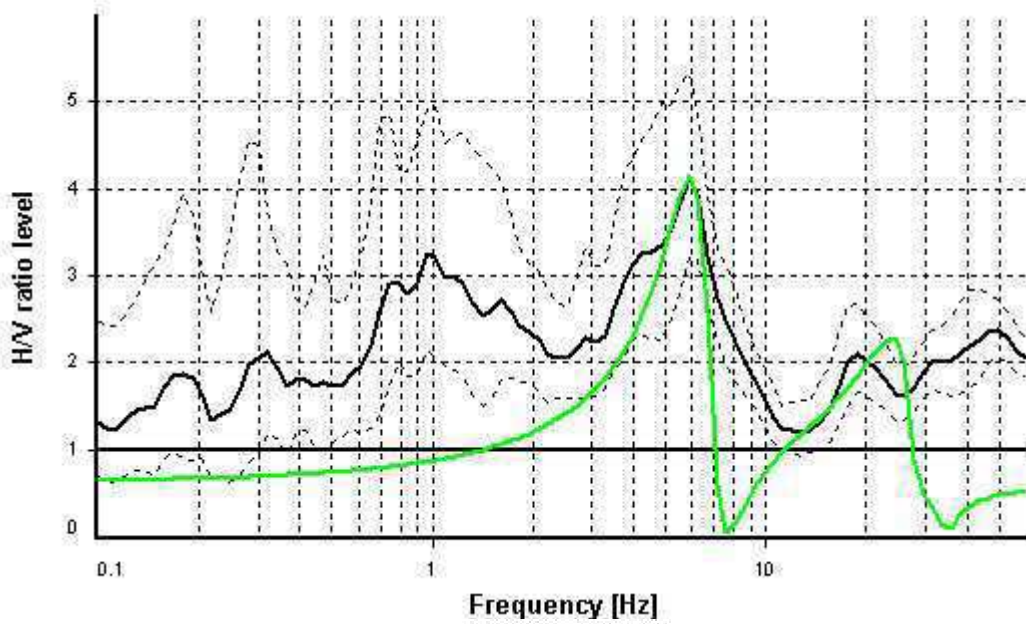
A_0 amplitude = 4.137

Average $f_0 = 5.527 \pm 0.715$



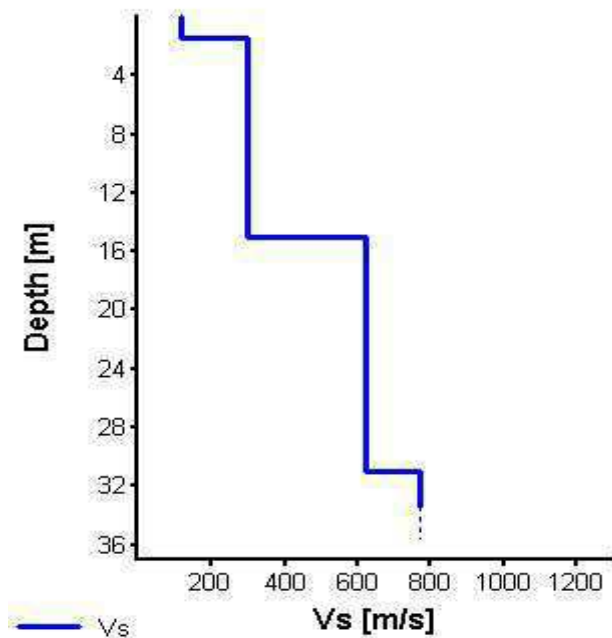
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	27 valid windows (length > 1.71 s) out of 27	OK
$n_c(f_0) > 200$	3164.52 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	2.52992 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	8.63549 Hz	OK
$A_0 > 2$	4.14 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% \leq 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.71498 \geq 0.29301	NO
$\sigma_A(f_0) < \theta(f_0)$	1.29091 < 1.58	OK
Overall criteria fulfillment		OK

**Synthetic
HVSR
modelling**



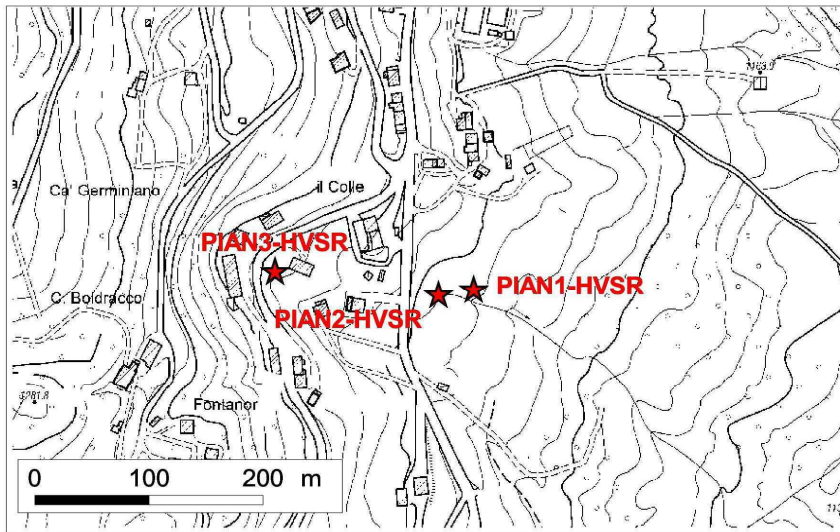
EXPERIMENTAL
HVSR
SYNTHETIC
HVSR

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
1.5	1.5	663	115	1800
13.5	15	943	300	1800
16	31	1409	620	1900
-	> 31	1682	770	2100



Vs 30 = 365 m/s (Offset = 0 m)

PIAN2-HVSR



PLACE INFORMATION

*Place ID:*PIAN2-HVSR

Address:

Latitude: 4906474

*Longitude:*142004

Coordinate system: WGS84

Elevation: 1198 m s.l.m.

Weather: soleggiato con qualche nuvola

Notes: Alcuni picchi non chiari, poco affidabili e direzionali tra 1 Hz e 2 Hz

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

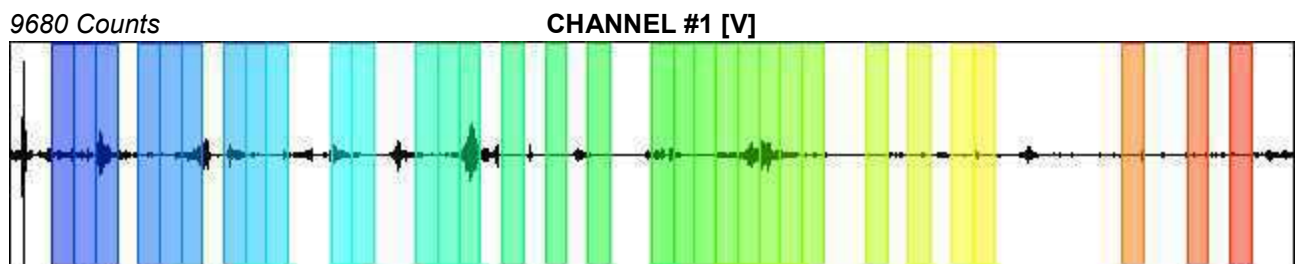
Recording start time: 2017/04/21 15:48:58

Recording length: 20 min

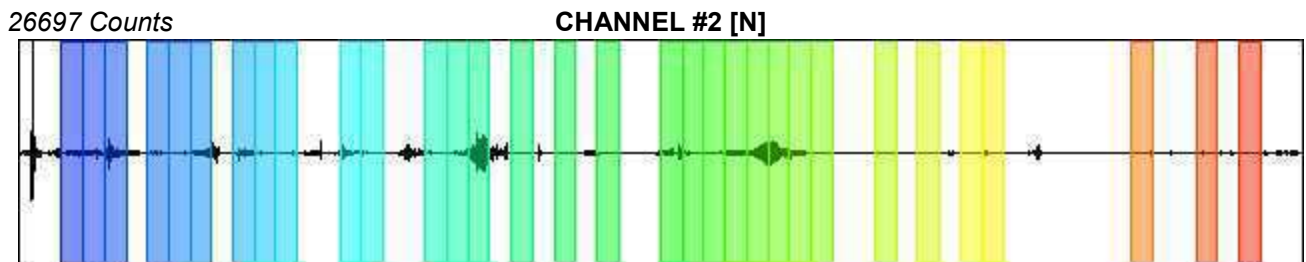
Windows count: 32

Average windows length: 20

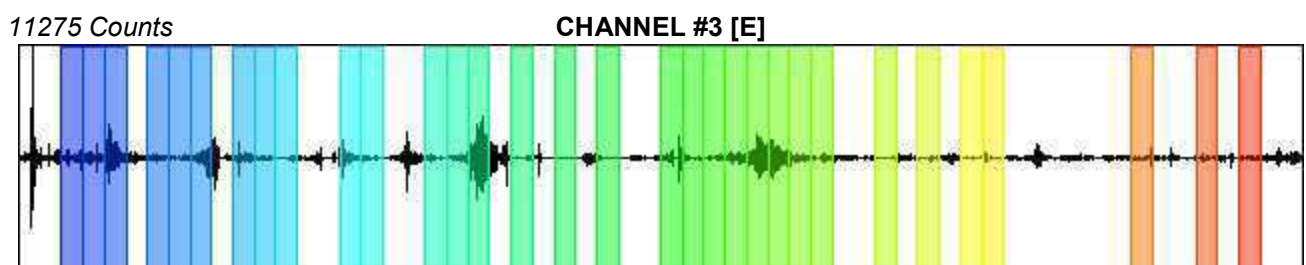
Signal coverage: 53.33%



-11440 Counts



-11655 Counts



-7009 Counts

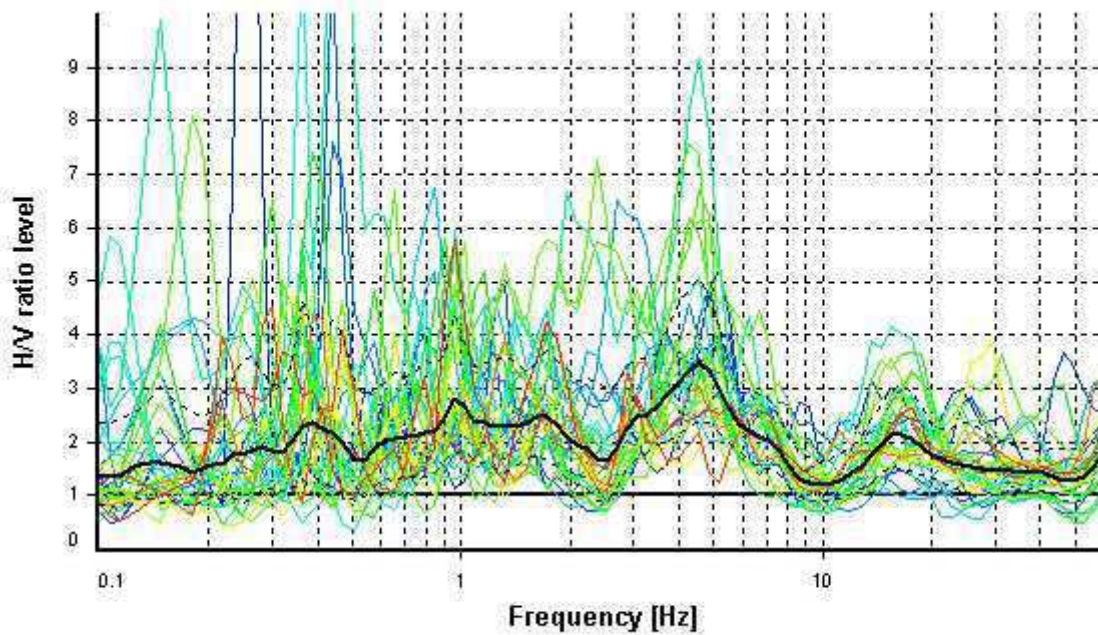
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

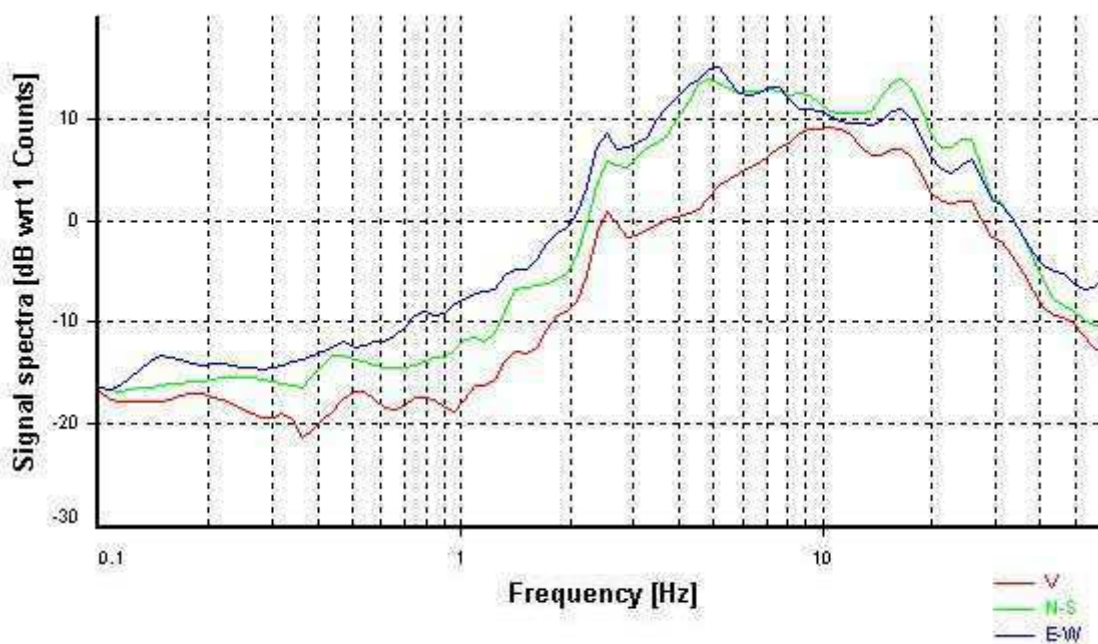
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

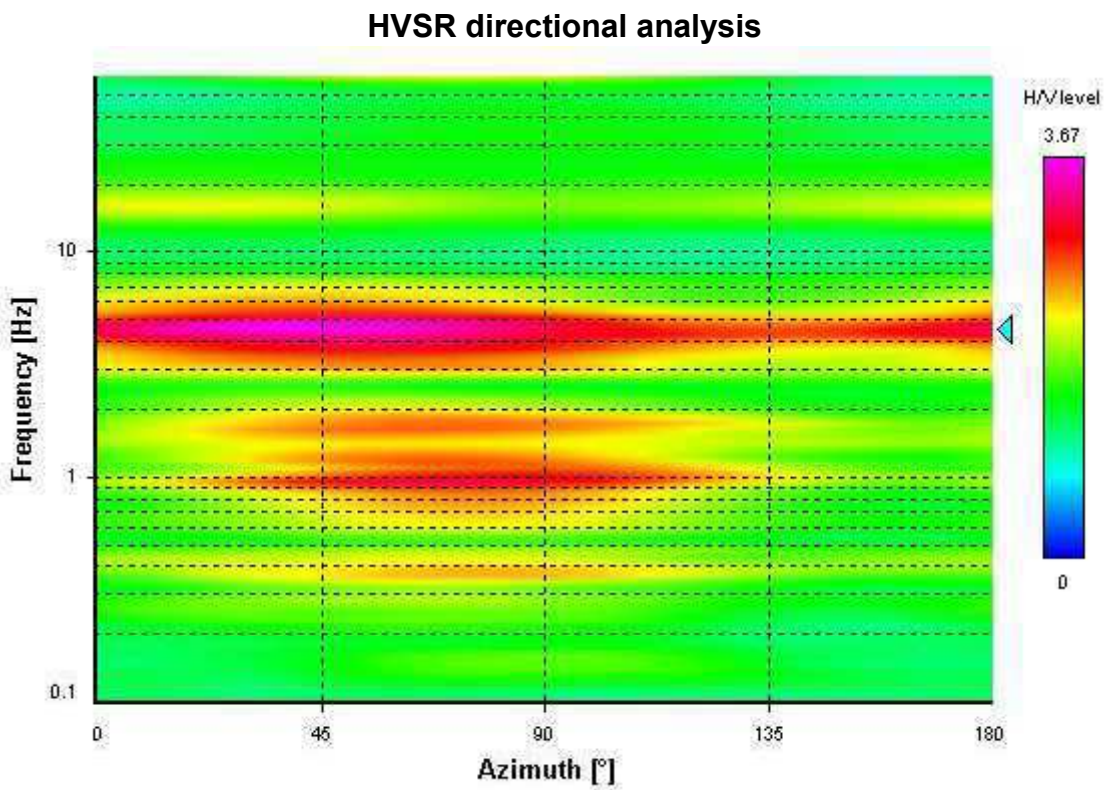
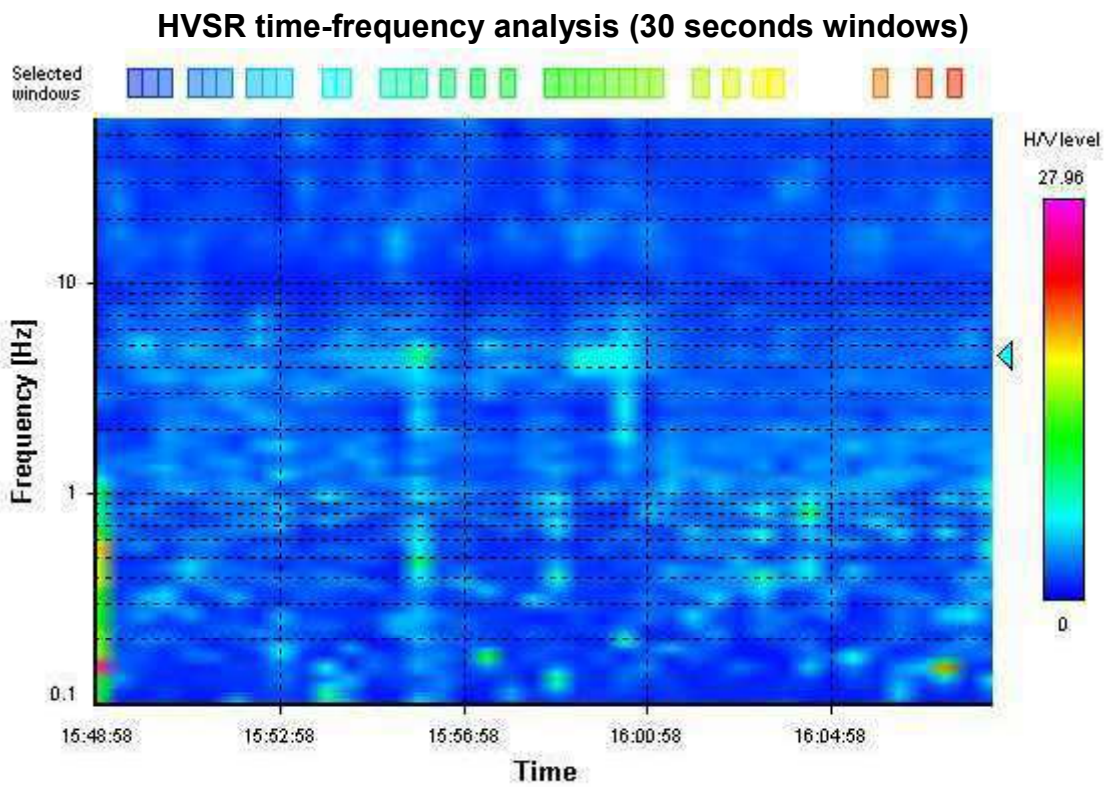
Instrumental correction: Disabled

HVSR average



Signal spectra average





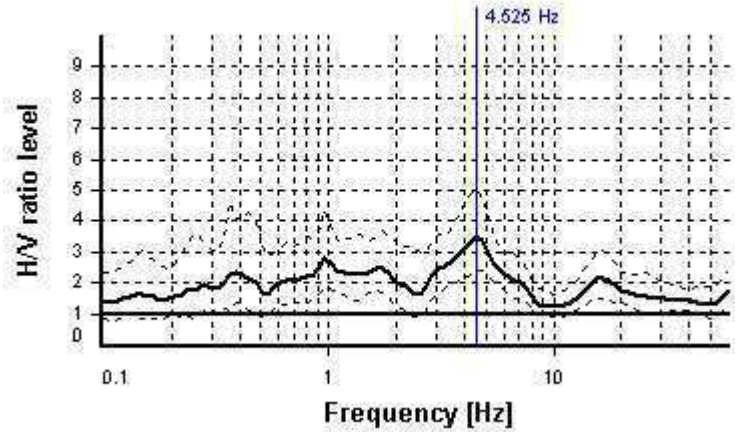
SESAME CRITERIA

Selected f_0 frequency

4.525 Hz

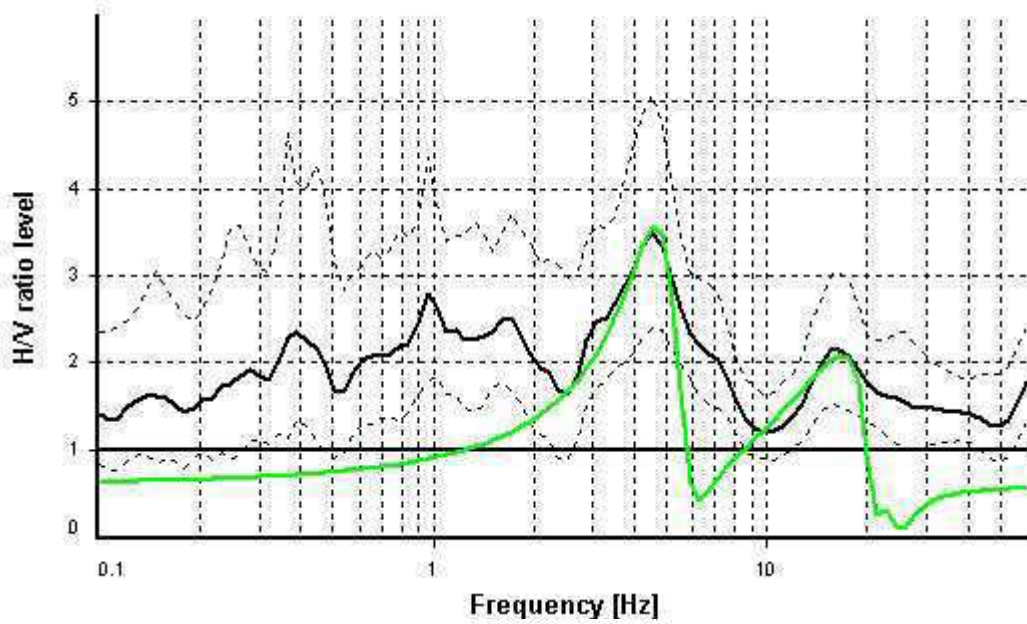
A_0 amplitude = 3.485

Average $f_0 = 4.260 \pm 0.707$



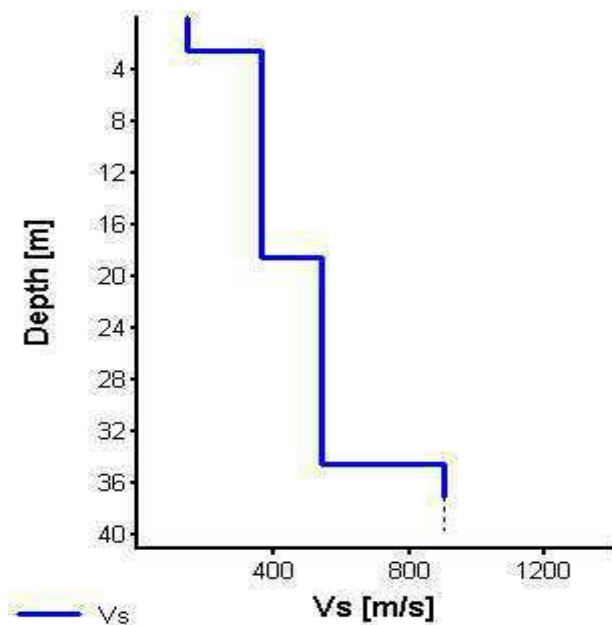
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	32 valid windows (length > 2.21 s) out of 32	OK
$n_c(f_0) > 200$	2896.32 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	2.52992 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	8.09515 Hz	OK
$A_0 > 2$	3.49 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.70701 >= 0.22627	NO
$\sigma_A(f_0) < \theta(f_0)$	1.45584 < 1.58	OK
Overall criteria fulfillment		OK

Synthetic HVSr modelling



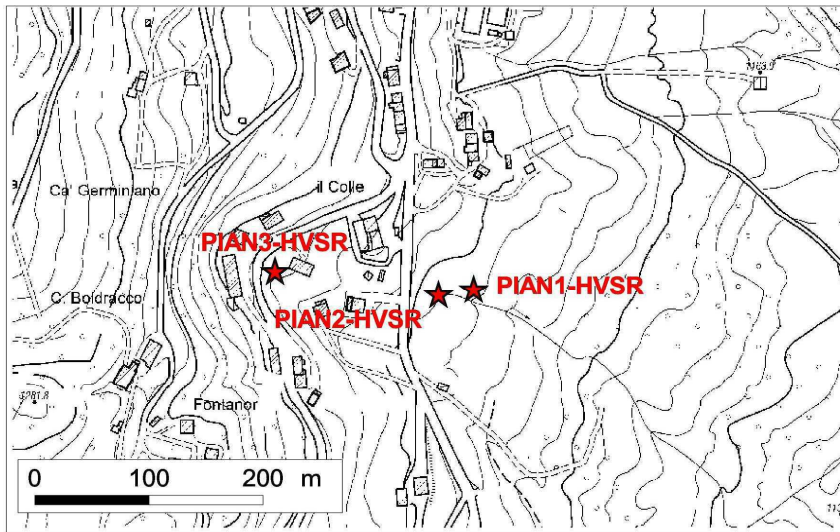
EXPERIMENTAL
HVSr
SYNTHETIC
HVSr

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
2.5	2.5	663	140	1800
16	18.5	943	360	1800
16	34.5	1409	540	1900
-	> 34.5	2209	900	2200



Vs 30 = 359 m/s (Offset = 0 m)

PIAN3-HVSR



PLACE INFORMATION

Place ID:PIAN3-HVSR

Address:

Latitude: 4906506

Longitude:141873

Coordinate system: WGS84

Elevation: 1216 m s.l.m.

Weather:soleggiato con qualche nuvola

Notes: Picco che presenta una certa direzionalità. Plateau, direzionale, tra 0.8Hz e 2 Hz

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

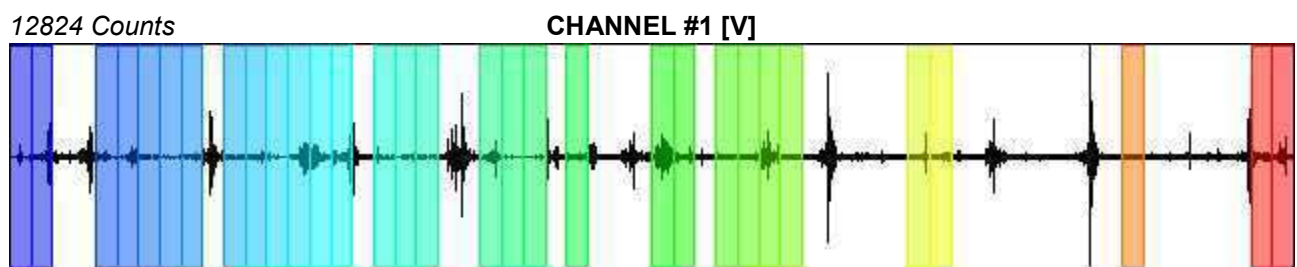
Recording start time: 2017/04/21 16:30:12

Recording length: 20 min

Windows count: 31

Average windows length: 20

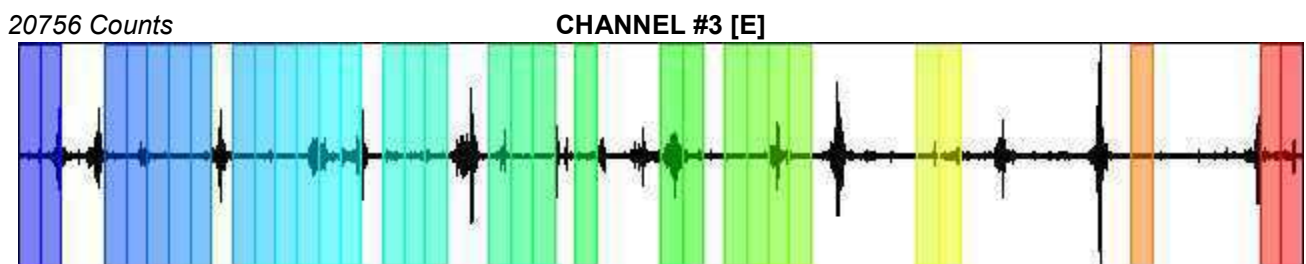
Signal coverage: 51.67%



-12683 Counts



-14338 Counts



-20520 Counts

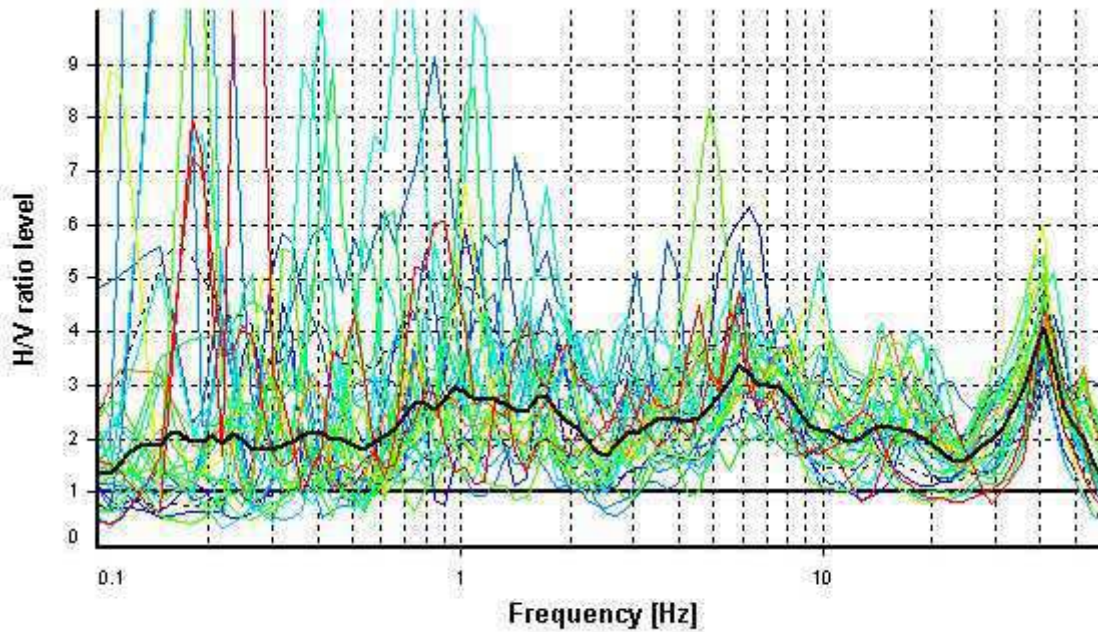
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

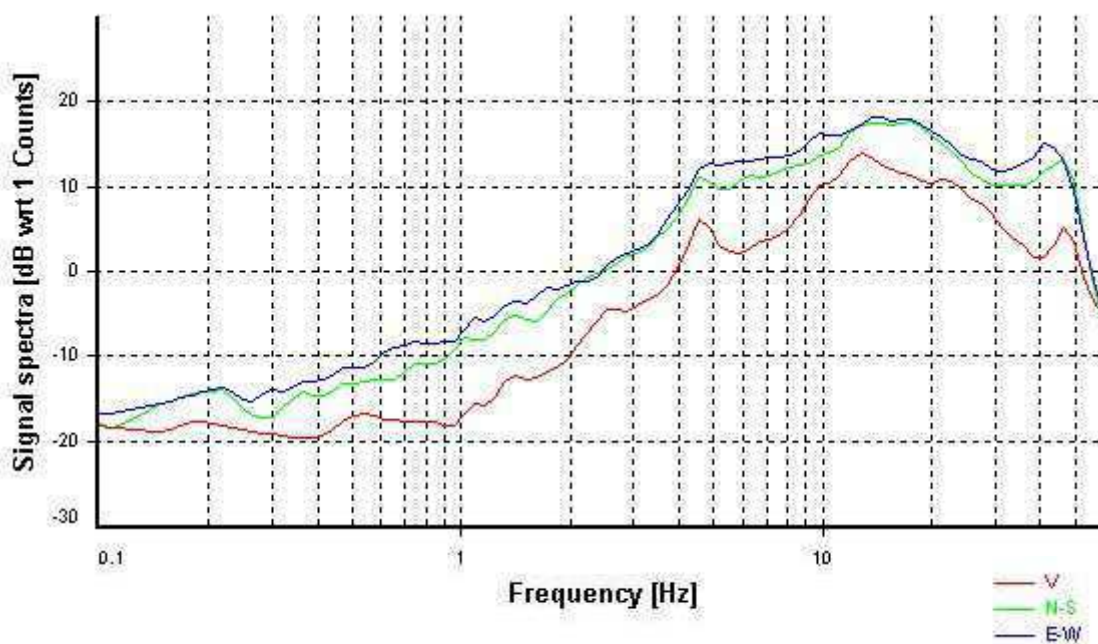
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

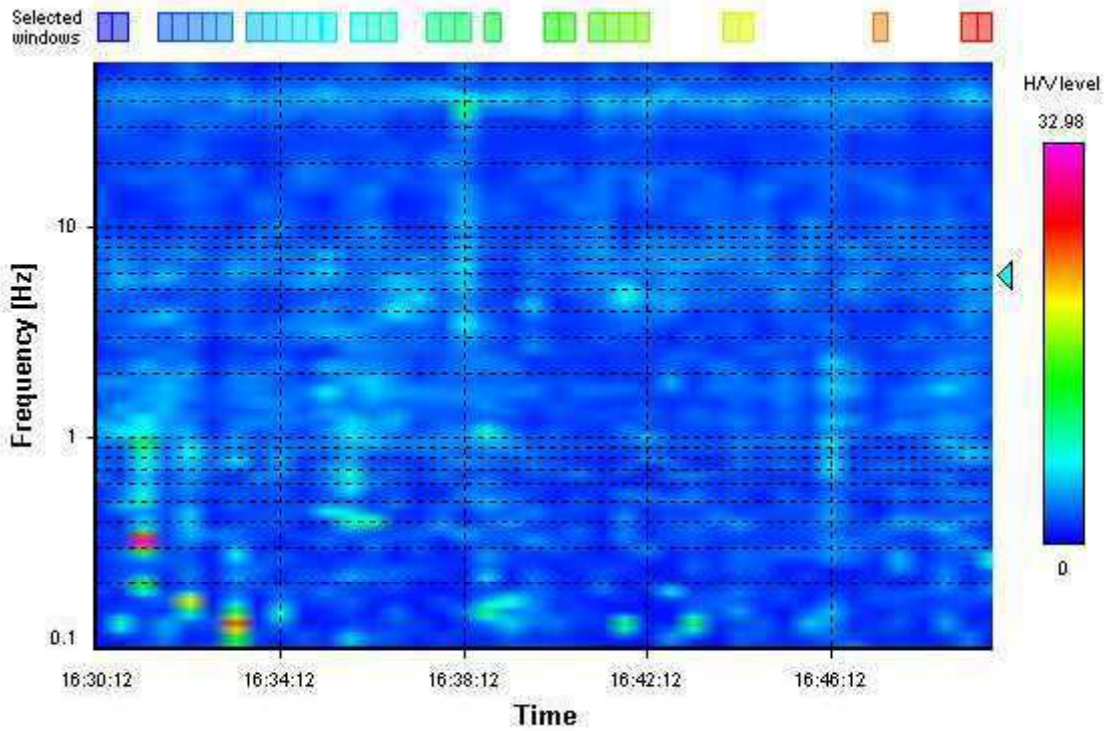
HVSR average



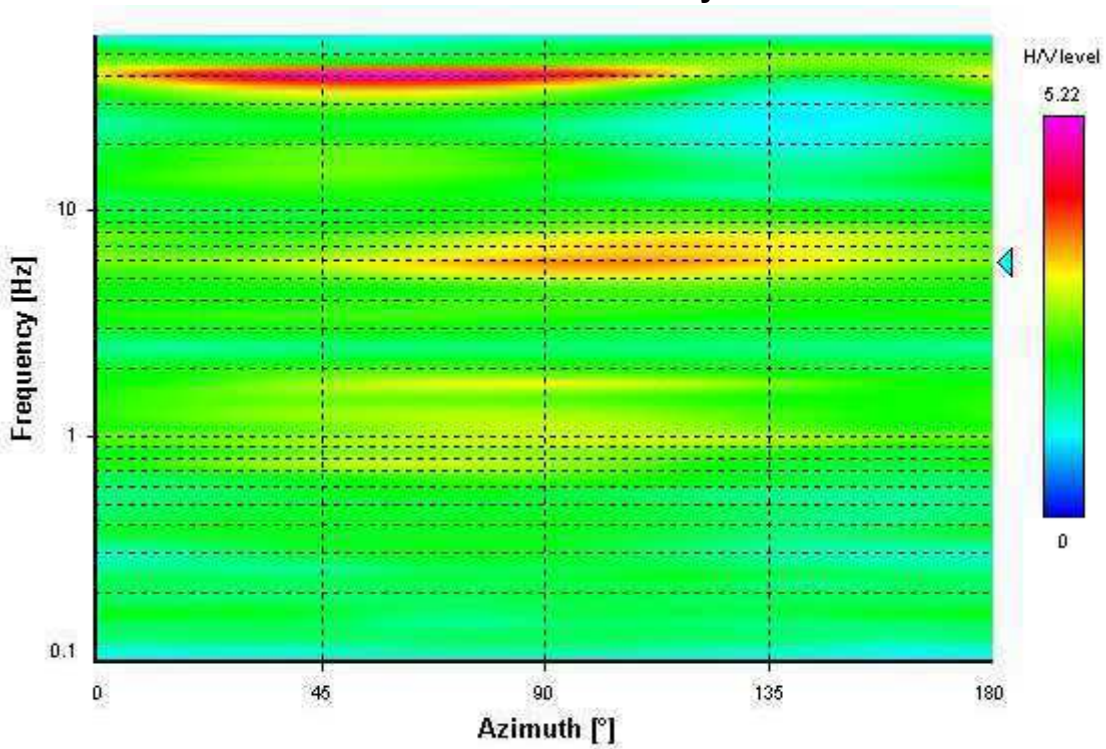
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



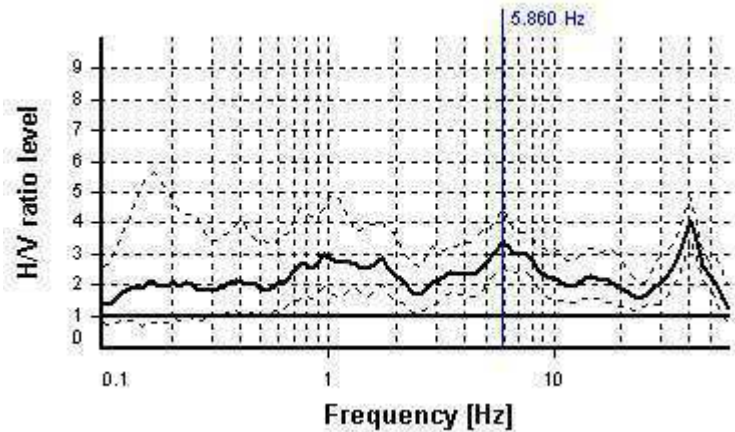
SESAME CRITERIA

Selected f_0 frequency

5.860 Hz

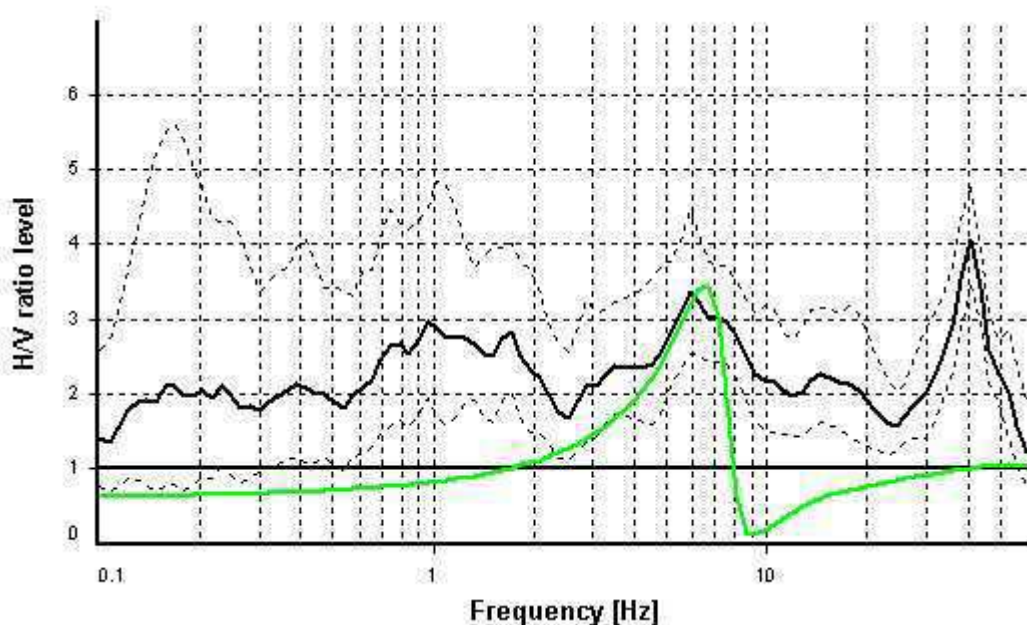
A_0 amplitude = 3.363

Average $f_0 = 6.377 \pm 1.279$



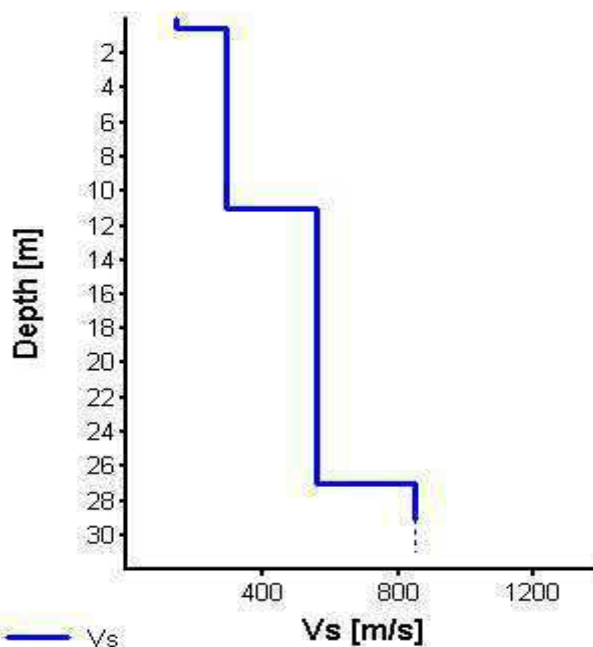
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	31 valid windows (length > 1.71 s) out of 31	OK
$n_c(f_0) > 200$	3633.34 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	2.52992 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	22.76246 Hz	OK
$A_0 > 2$	3.36 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% \leq 5%	OK
$\sigma_f < \varepsilon(f_0)$	1.27854 \geq 0.29301	NO
$\sigma_A(f_0) < \theta(f_0)$	1.32815 < 1.58	OK
Overall criteria fulfillment		OK

Synthetic HVS modelling



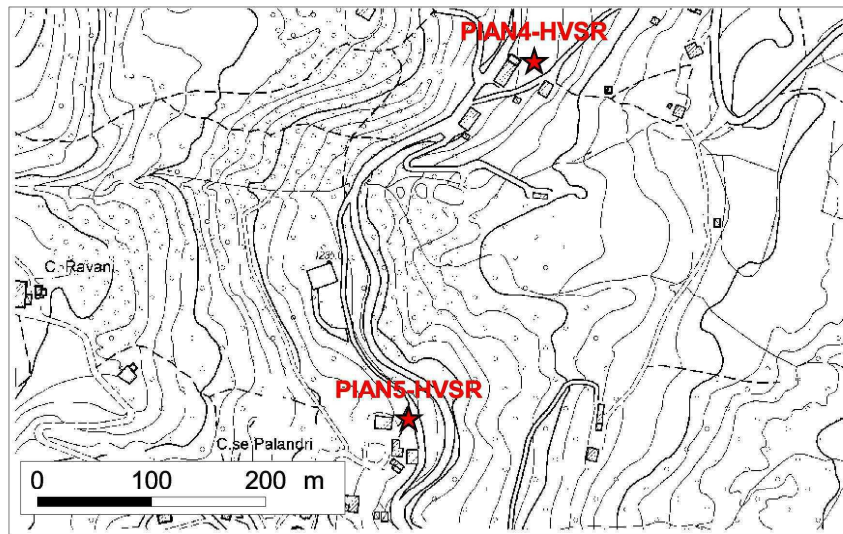
EXPERIMENTAL
HVS
SYNTHETIC
HVS

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
0.5	0.5	663	140	1800
10.5	11	943	290	1800
16	27	1409	560	1900
-	> 27	2209	850	2200



Vs 30 = 417 m/s (Offset = 0 m)

PIAN4-HVSR



PLACE INFORMATION

Place ID: PIAN4-HVSR

Address:

Latitude: 4906183

Longitude: 141861

Coordinate system: WGS84

Elevation: 1218 m s.l.m.

Weather: soleggiato con qualche nuvola

Notes: Curva con molti massimi e minimi, poco affidabili (direzionalità, persistenza temporale, andamento relativo delle componenti spettrali, criteri SESAME)

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

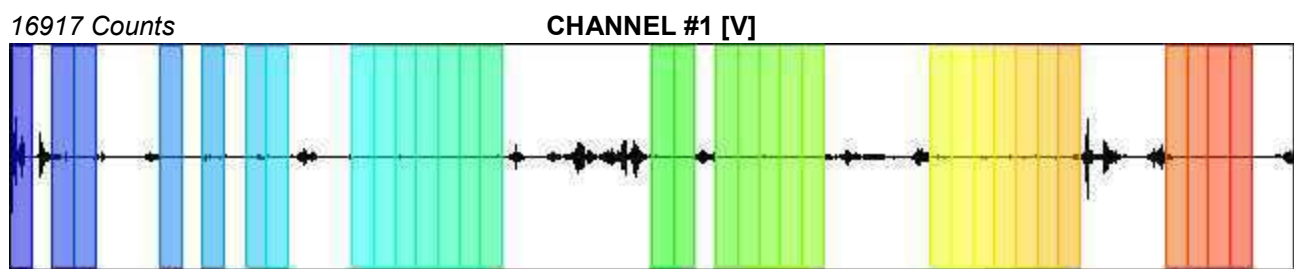
Recording start time: 2017/04/21 17:12:32

Recording length: 20 min

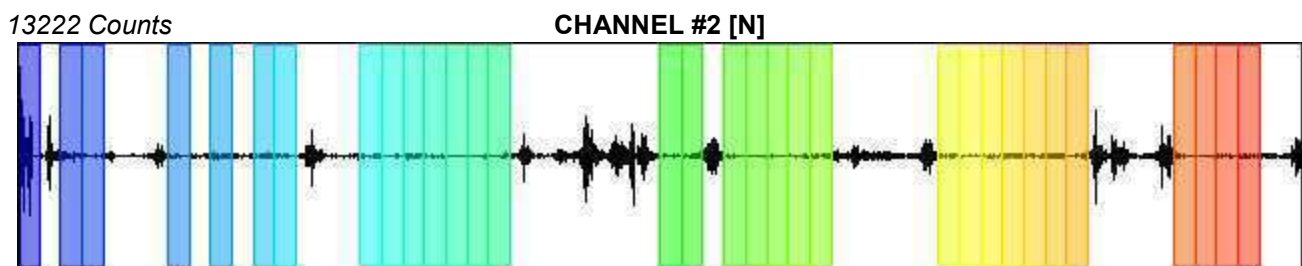
Windows count: 32

Average windows length: 20

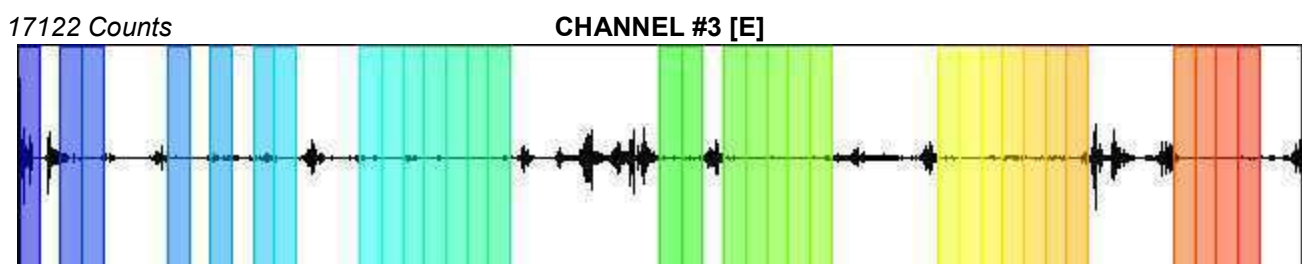
Signal coverage: 53.33%



-8354 Counts



-16306 Counts



-23963 Counts

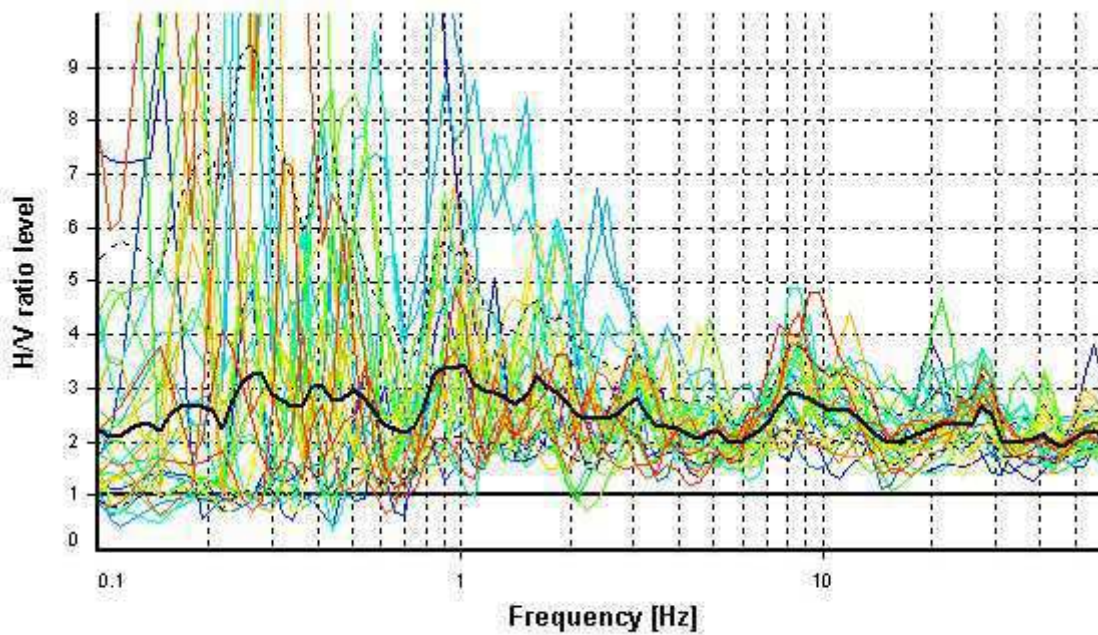
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

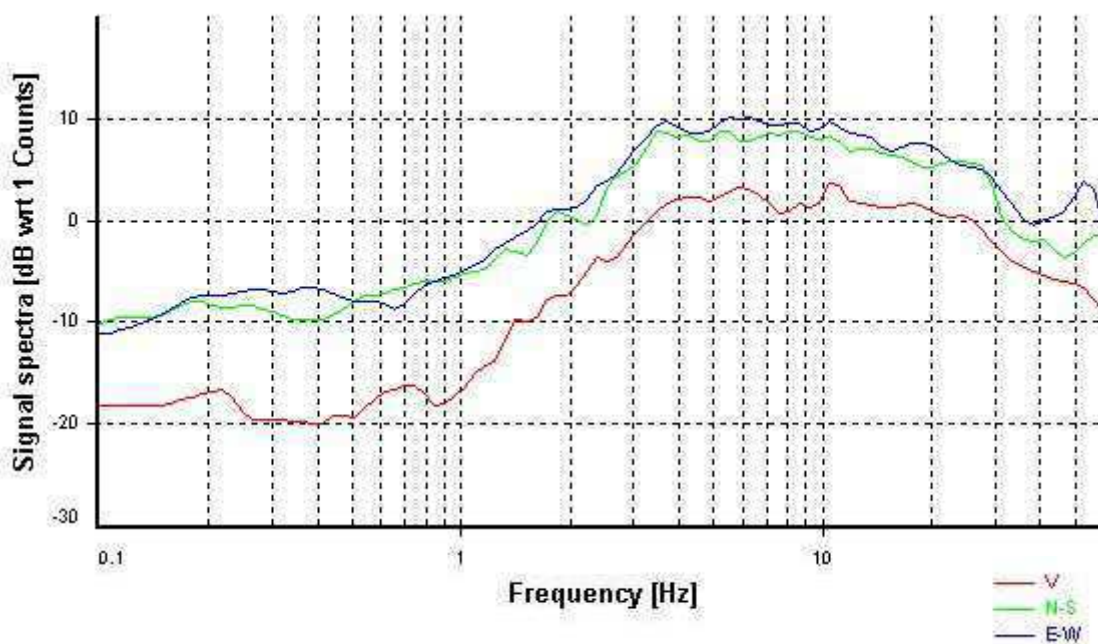
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

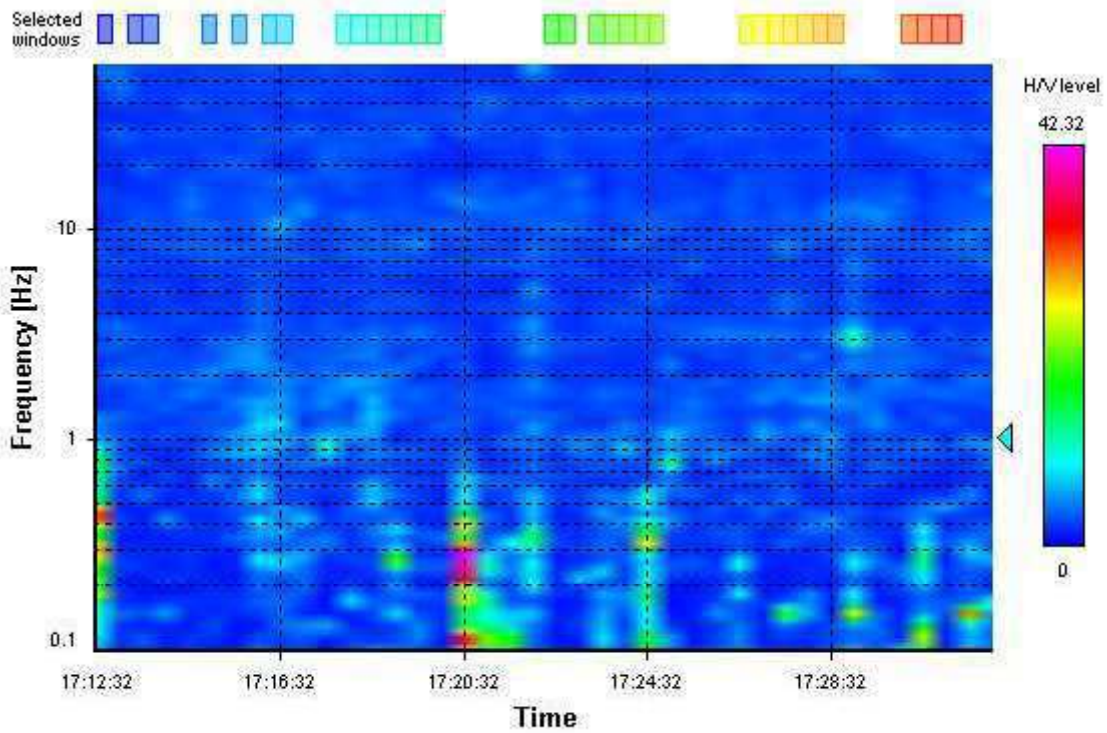
HVSR average



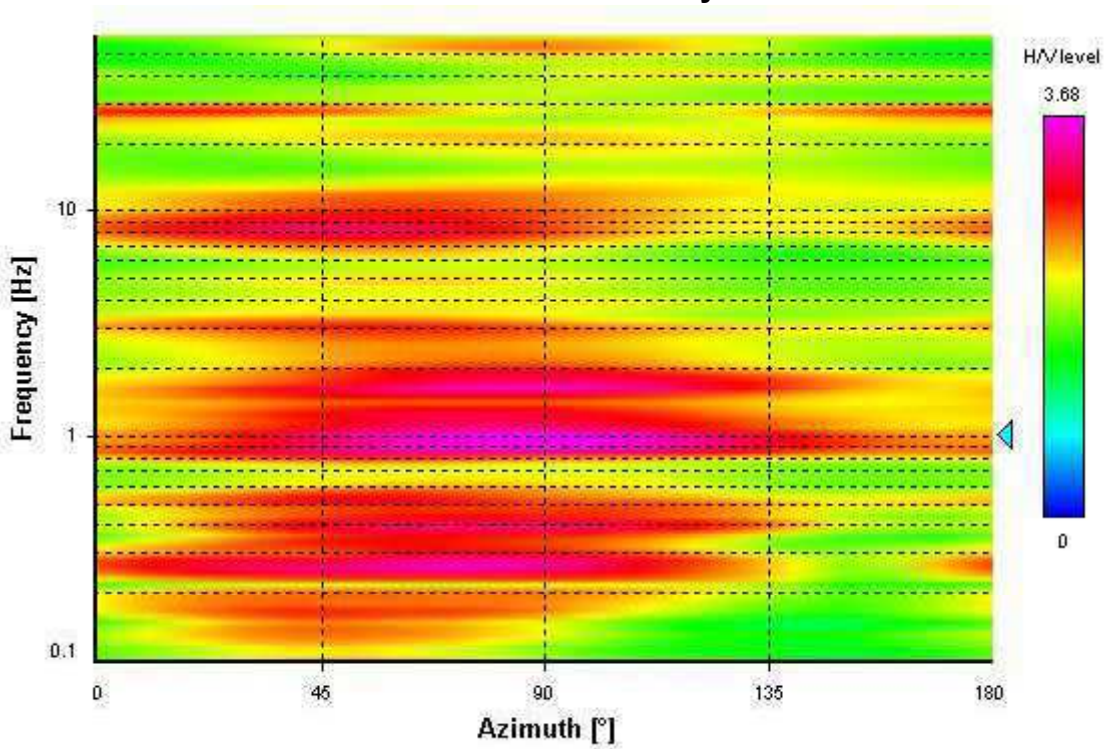
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



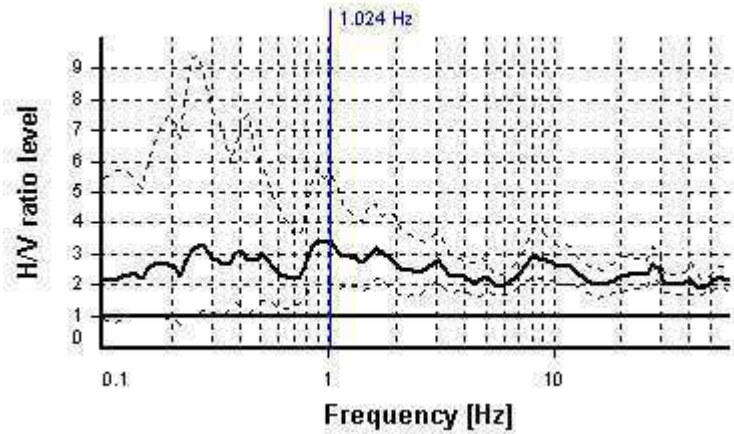
SESAME CRITERIA

Selected f_0 frequency

1.024 Hz

A_0 amplitude = 3.434

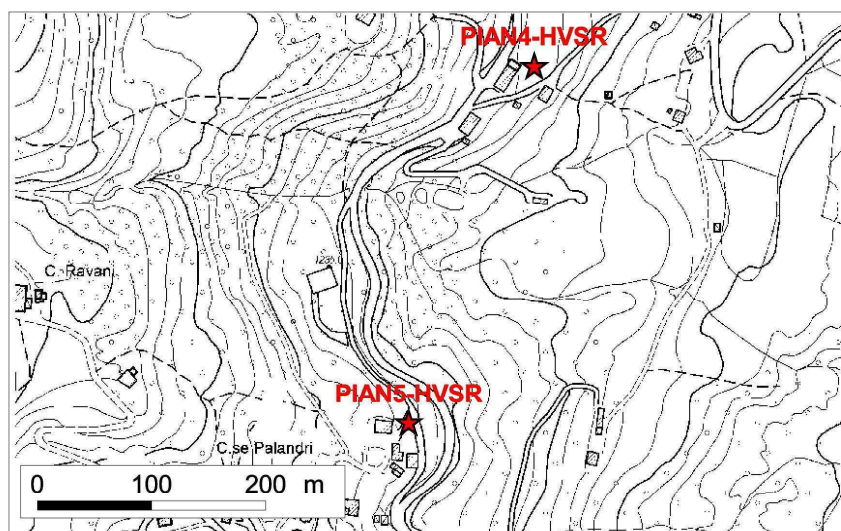
Average $f_0 = 1.077 \pm 0.242$



HVSR curve reliability criteria		
$f_0 > 10 / L_w$	32 valid windows (length > 9.77 s) out of 32	OK
$n_c(f_0) > 200$	655.26 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	0 Hz	NO
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	0 Hz	NO
$A_0 > 2$	3.43 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	12.12% > 5%	NO
$\sigma_f < \varepsilon(f_0)$	0.24237 >= 0.10239	NO
$\sigma_A(f_0) < \theta(f_0)$	1.63849 < 1.78	OK
Overall criteria fulfillment		NO

EXPERIMENTAL HVSR

PIAN5-HVSR



PLACE INFORMATION

Place ID:PIAN5-HVSR-

Address:

Latitude: 4905881

Longitude:141734

Coordinate system: WGS84

Elevation: 1237 m s.l.m.

Weather:soleggiato con qualche nuvola

Notes:

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

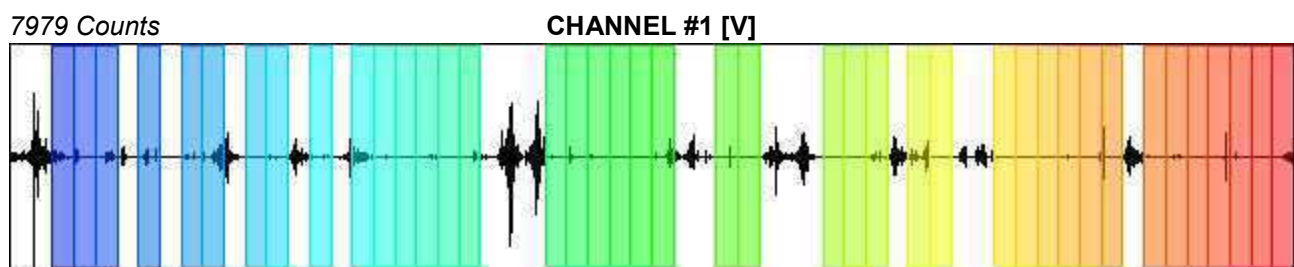
Recording start time: 2017/04/21 18:09:53

Recording length: 20 min

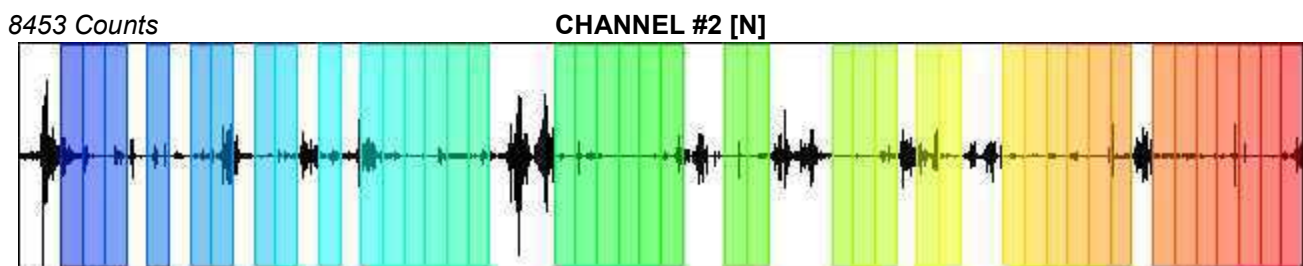
Windows count: 41

Average windows length: 20

Signal coverage: 68.33%



-14012 Counts



-12578 Counts



-13854 Counts

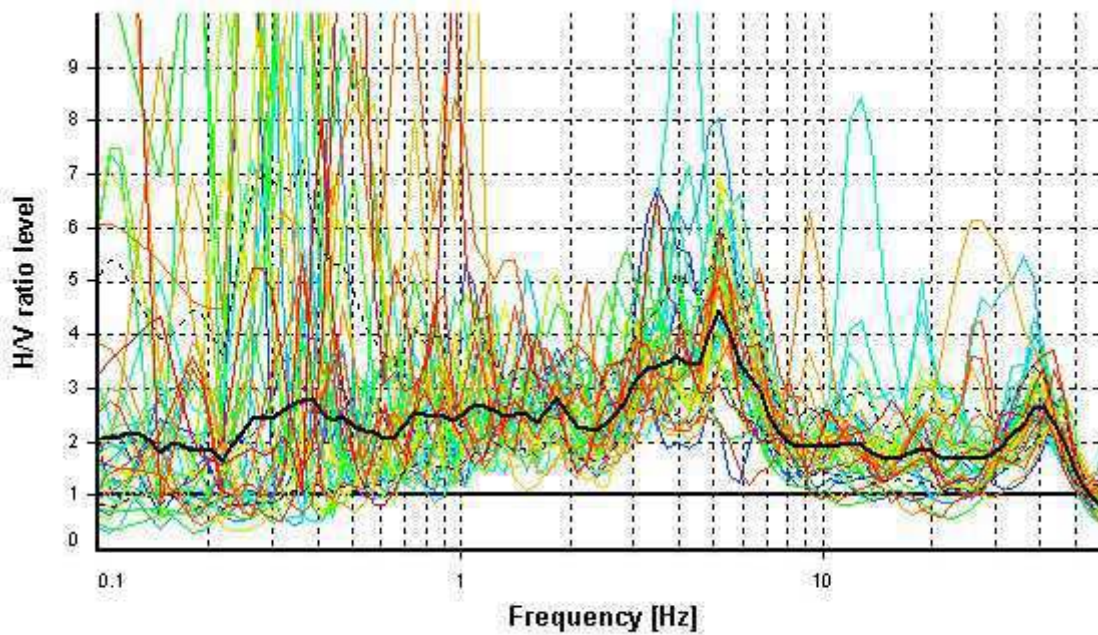
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

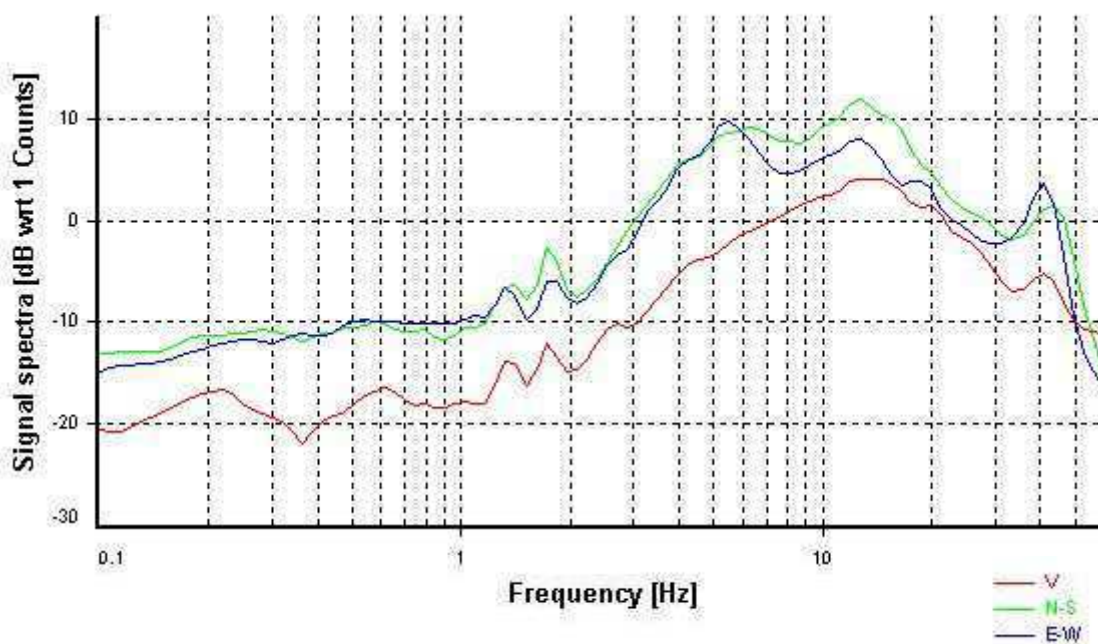
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

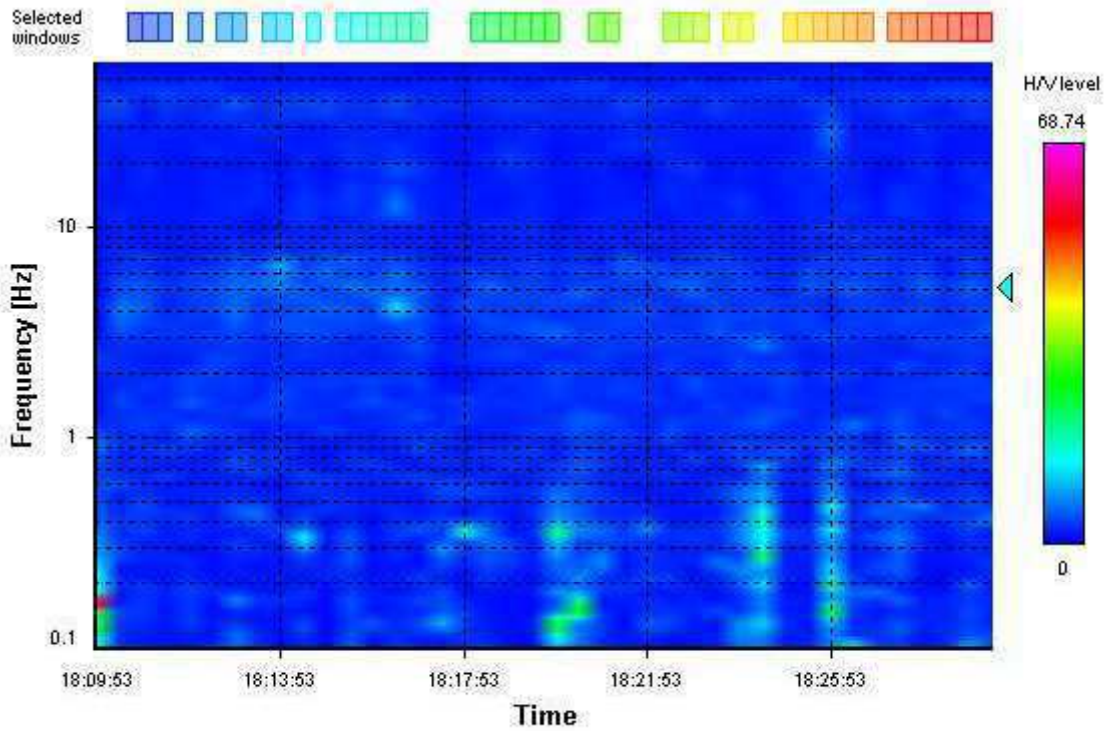
HVSR average



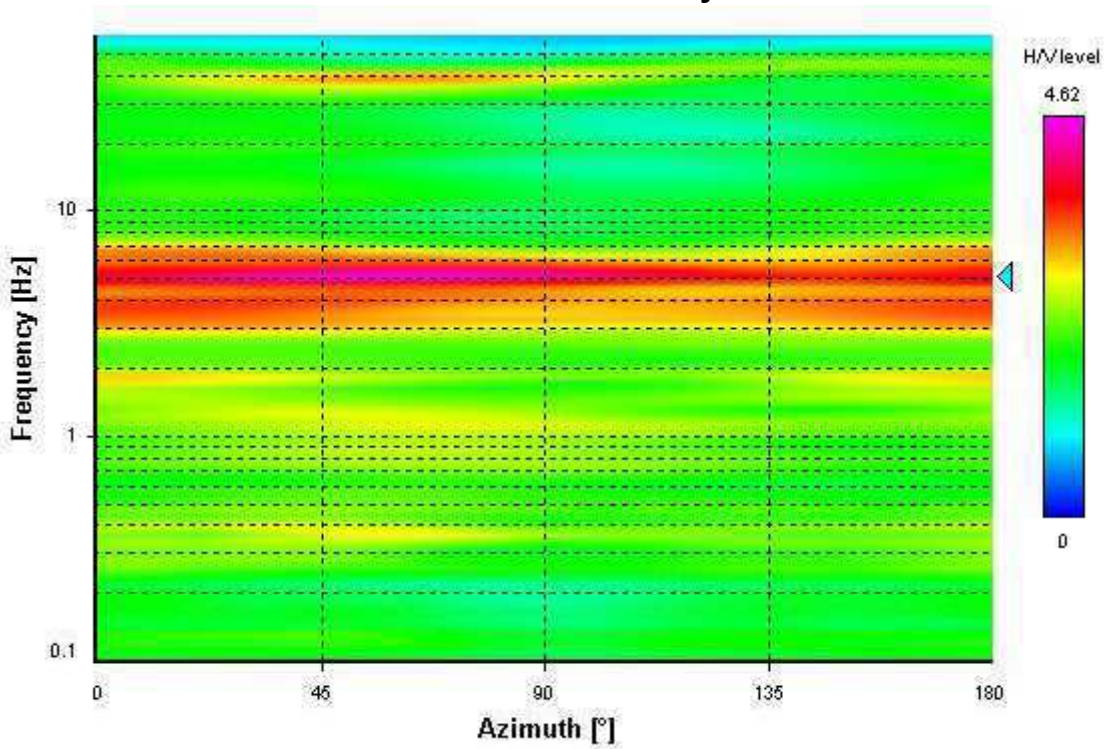
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



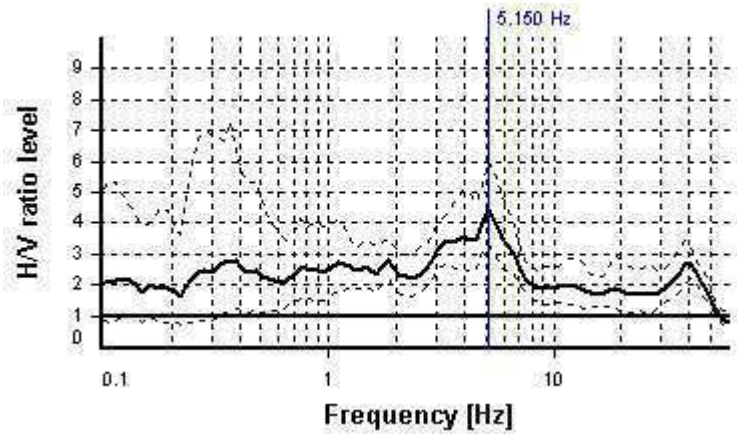
SESAME CRITERIA

Selected f_0 frequency

5.150 Hz

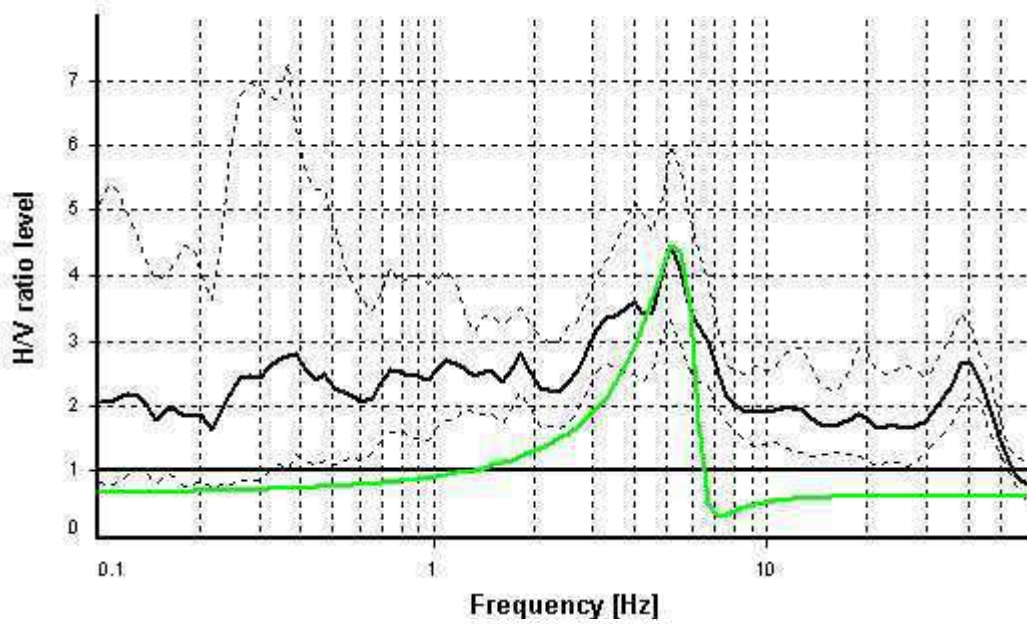
A_0 amplitude = 4.458

Average $f_0 = 4.905 \pm 0.769$



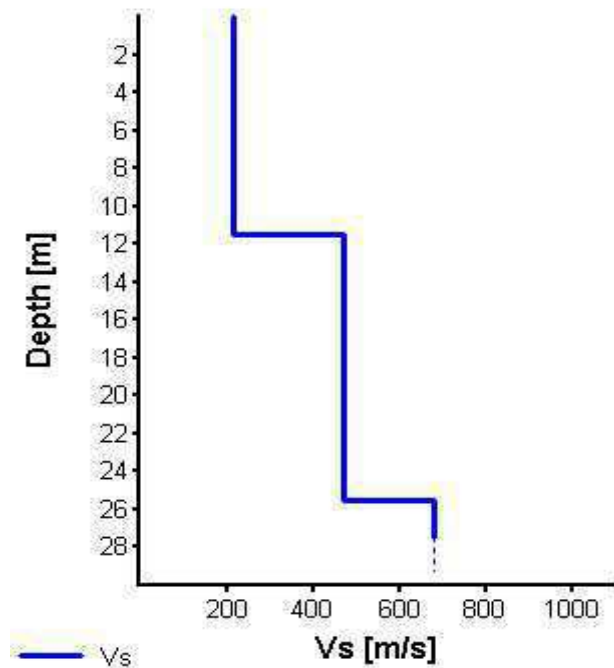
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	41 valid windows (length > 1.94 s) out of 41	OK
$n_c(f_0) > 200$	4222.83 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	2.37162 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	7.58862 Hz	OK
$A_0 > 2$	4.46 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.76924 >= 0.25749	NO
$\sigma_A(f_0) < \theta(f_0)$	1.34481 < 1.58	OK
Overall criteria fulfillment		OK

Synthetic HVSr modelling



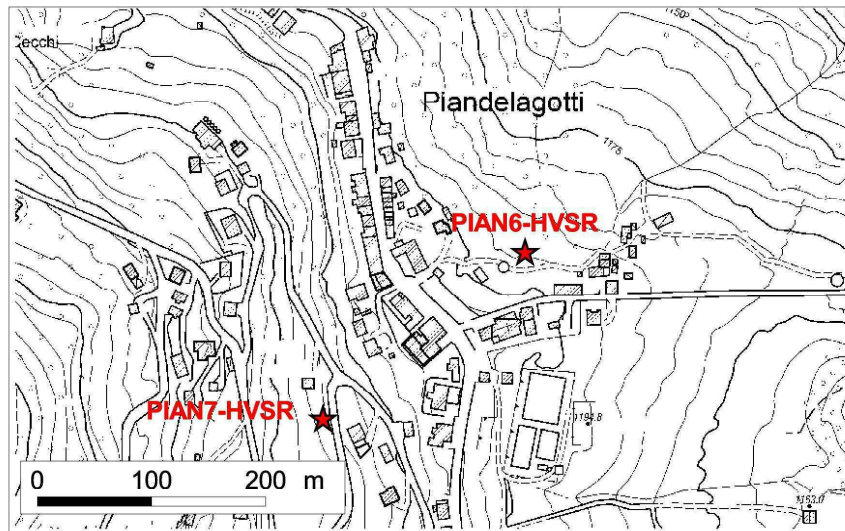
EXPERIMENTAL
HVSr
SYNTHETIC
HVSr

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
11.5	11.5	471	215	1800
14	25.5	942	470	1800
-	> 25.5	1310	680	2000



Vs 30 = 334 m/s (Offset = 0 m)

PIAN6-HVSR



PLACE INFORMATION

*Place ID:*PIAN6-HVSR

Address:

Latitude: 4906877

Longitude: 142061

Coordinate system: WGS84

Elevation: 1196 m s.l.m.

Weather: Sereno

Notes:

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

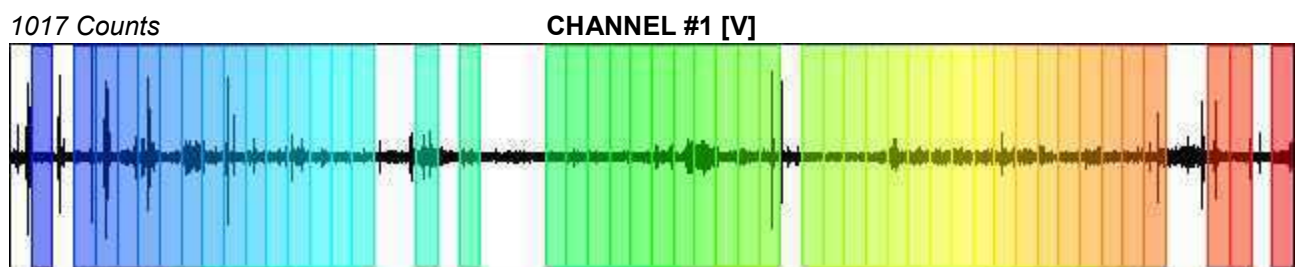
Recording start time: 2017/04/21 18:46:31

Recording length: 20 min

Windows count: 48

Average windows length: 20

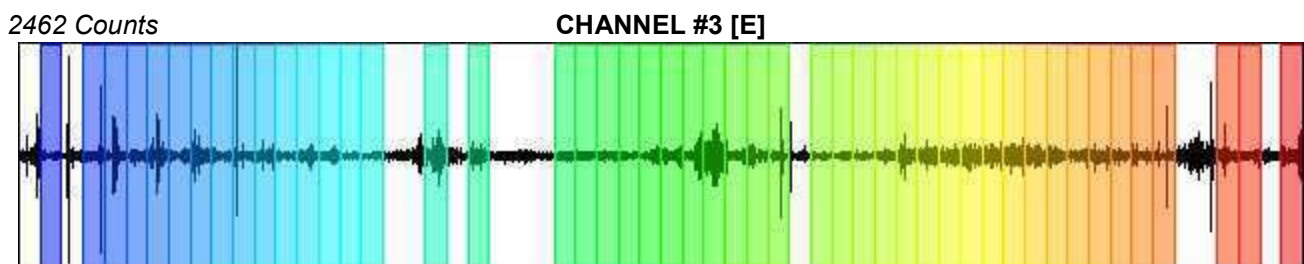
Signal coverage: 80%



-753 Counts



-1348 Counts



-2361 Counts

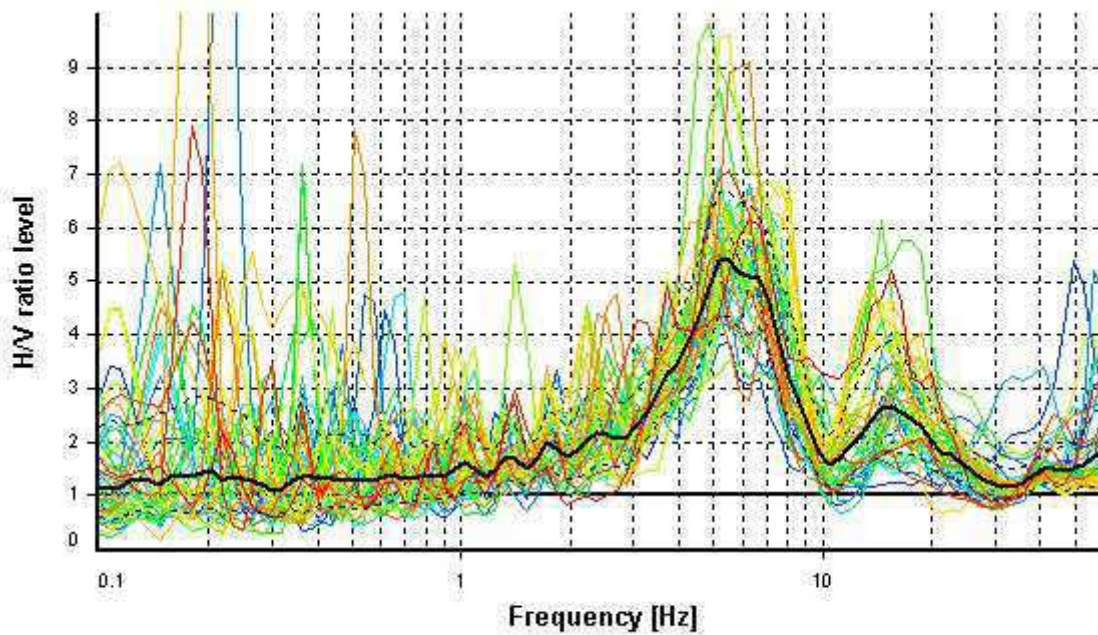
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

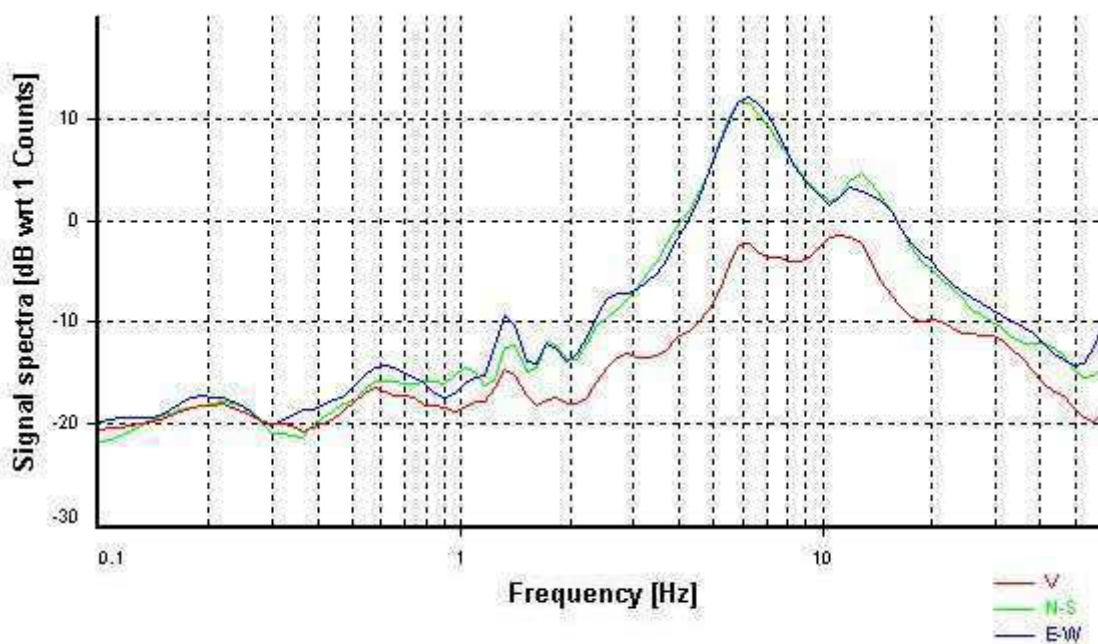
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

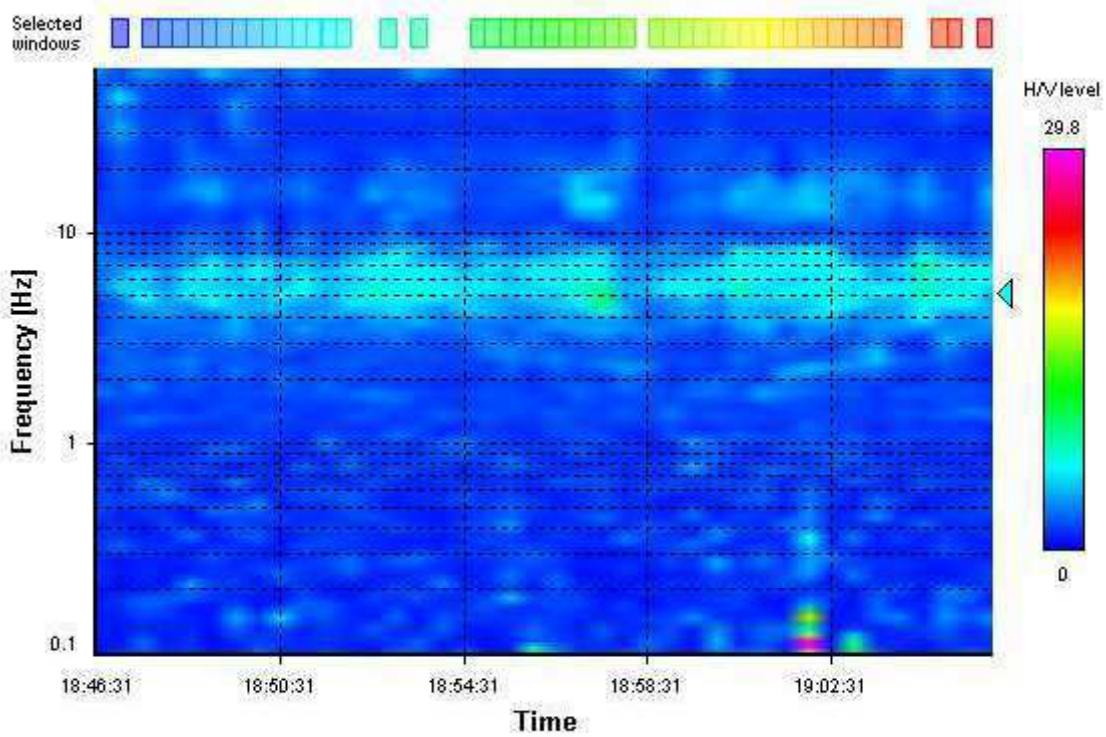
HVSR average



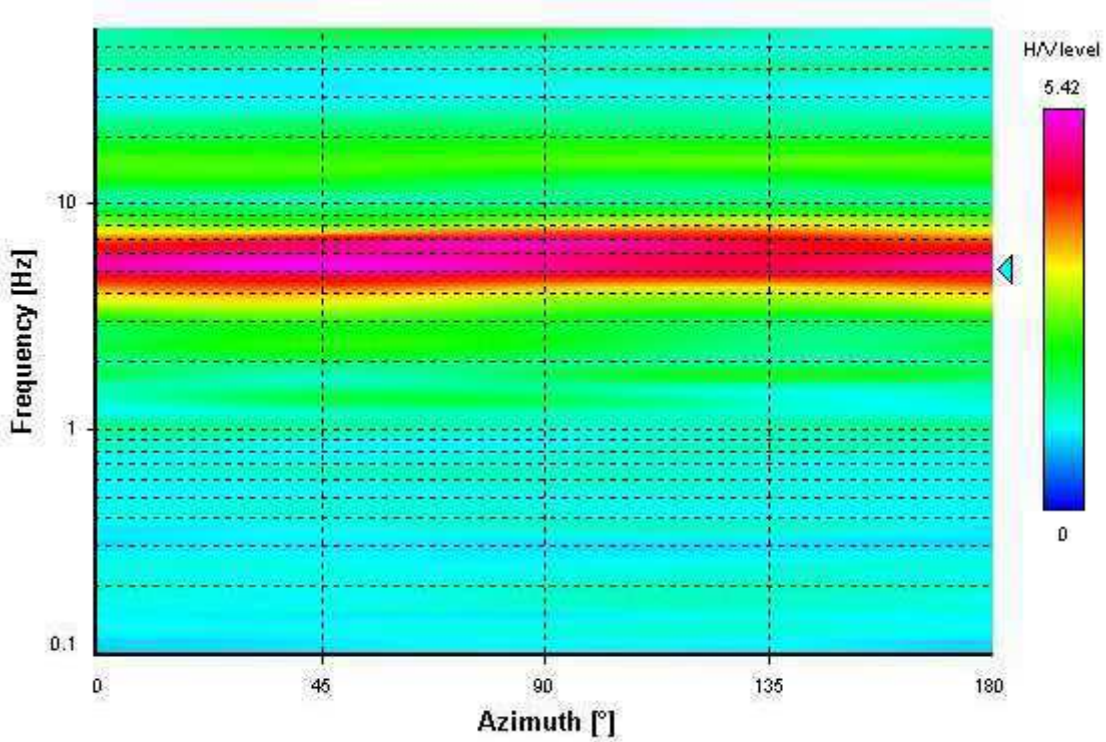
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



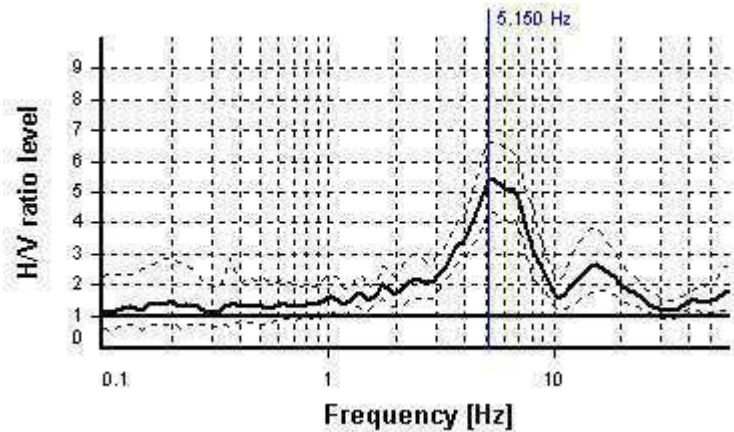
SESAME CRITERIA

Selected f_0 frequency

5.150 Hz

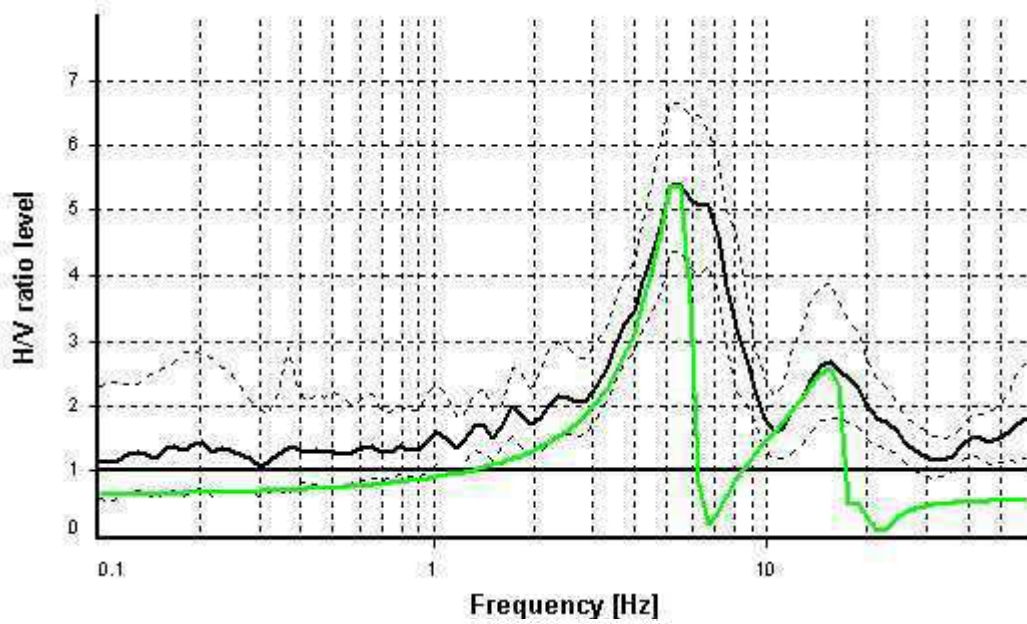
A_0 amplitude = 5.388

Average $f_0 = 5.764 \pm 0.786$



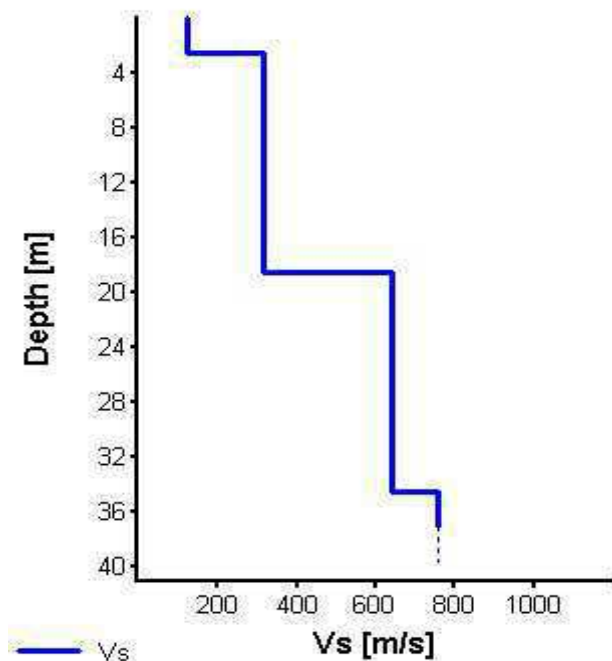
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	48 valid windows (length > 1.94 s) out of 48	OK
$n_c(f_0) > 200$	4943.81 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	3.27609 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	9.2119 Hz	OK
$A_0 > 2$	5.39 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% <= 5%	OK
$\sigma_f < \varepsilon(f_0)$	0.78647 >= 0.25749	NO
$\sigma_A(f_0) < \theta(f_0)$	1.23443 < 1.58	OK
Overall criteria fulfillment		OK

Synthetic HVSr modelling



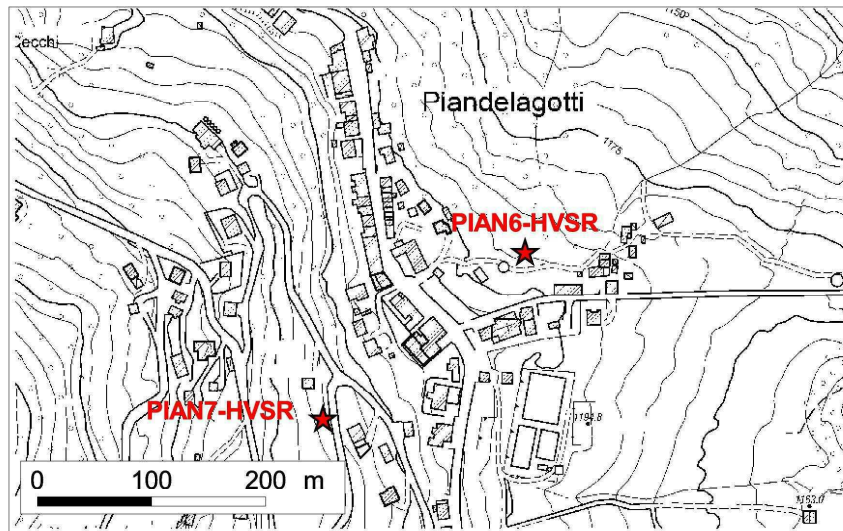
EXPERIMENTAL
HVSr
SYNTHETIC
HVSr

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
2.5	2.5	663	120	1800
16	18.5	943	315	1800
16	34.5	1409	640	1900
-	> 34.5	1682	760	2100



Vs 30 = 335 m/s (Offset = 0 m)

PIAN7-HVSR



PLACE INFORMATION

Place ID: PIAN7-HVSR

Address:

Latitude: 4906741

Longitude: 141890

Coordinate system: WGS84

Elevation: 1238 m s.l.m.

Weather: Sereno

Notes: Stima del VS30 molto conservativa in quanto unico picco, probabilmente stratigrafico, ad alta frequenza significativo di contrasto poco profondo.

SIGNAL AND WINDOWING

Sampling frequency: 300 Hz

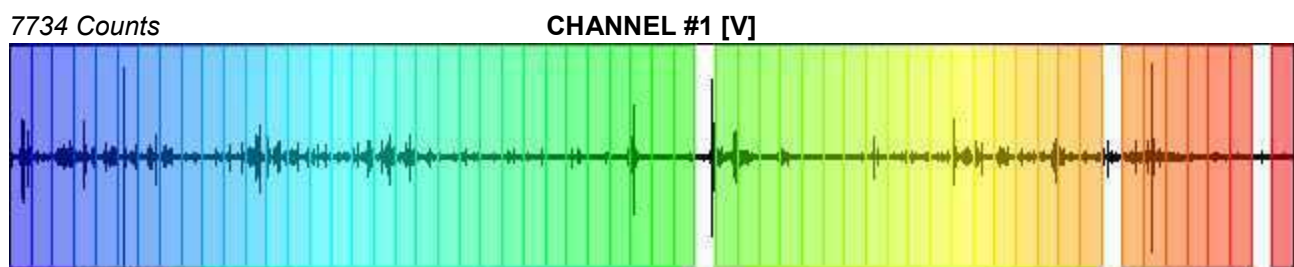
Recording start time: 2017/04/21 19:22:23

Recording length: 20 min

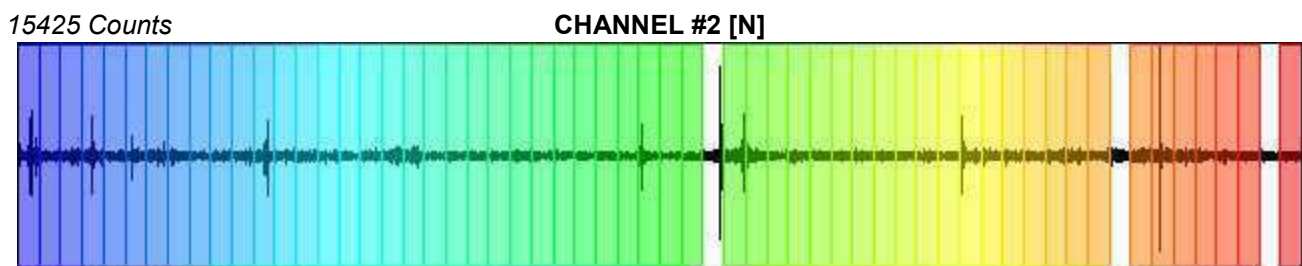
Windows count: 57

Average windows length: 20

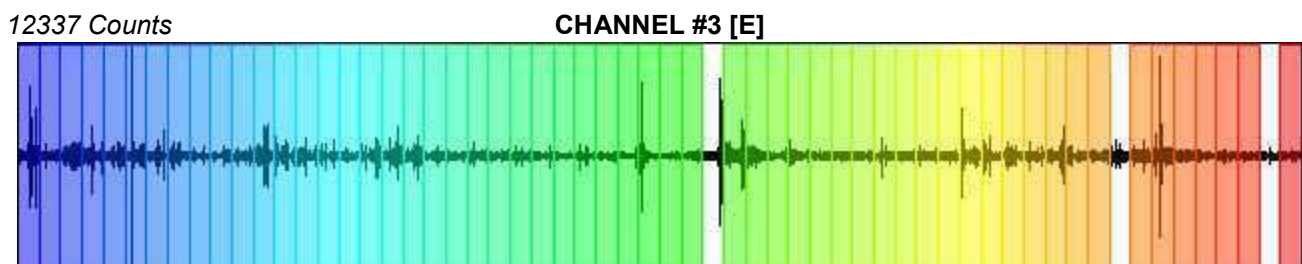
Signal coverage: 95%



-9234 Counts



-13213 Counts



-12430 Counts

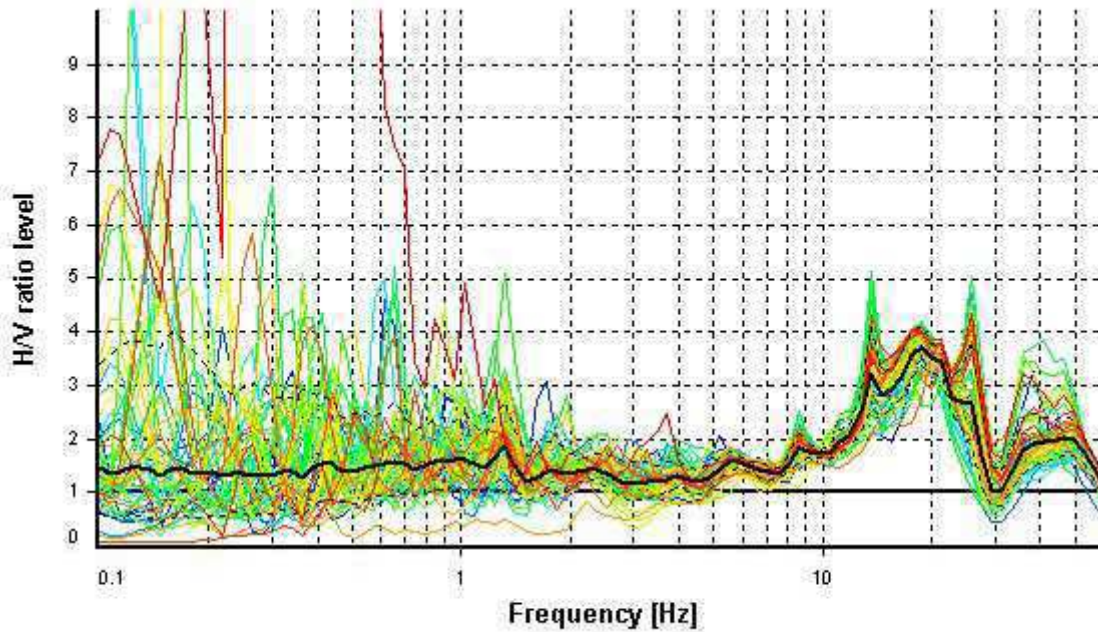
HVSR ANALYSIS

*Tapering:*Enabled (Bandwidth = 5%)

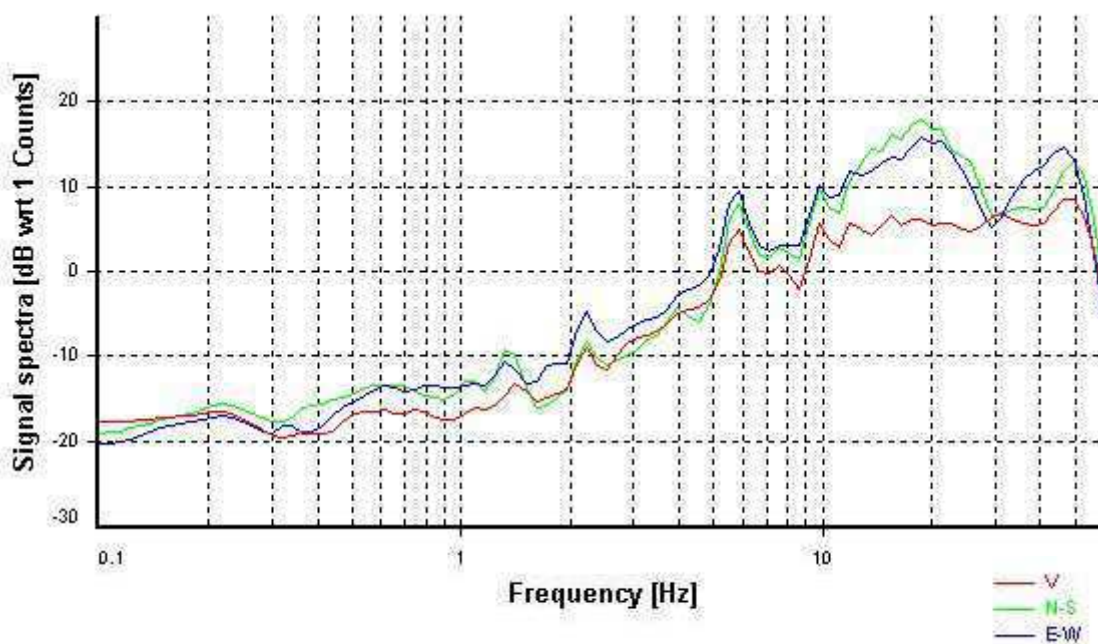
*Smoothing:*Konno-Ohmachi (Bandwidth coefficient = 40)

Instrumental correction: Disabled

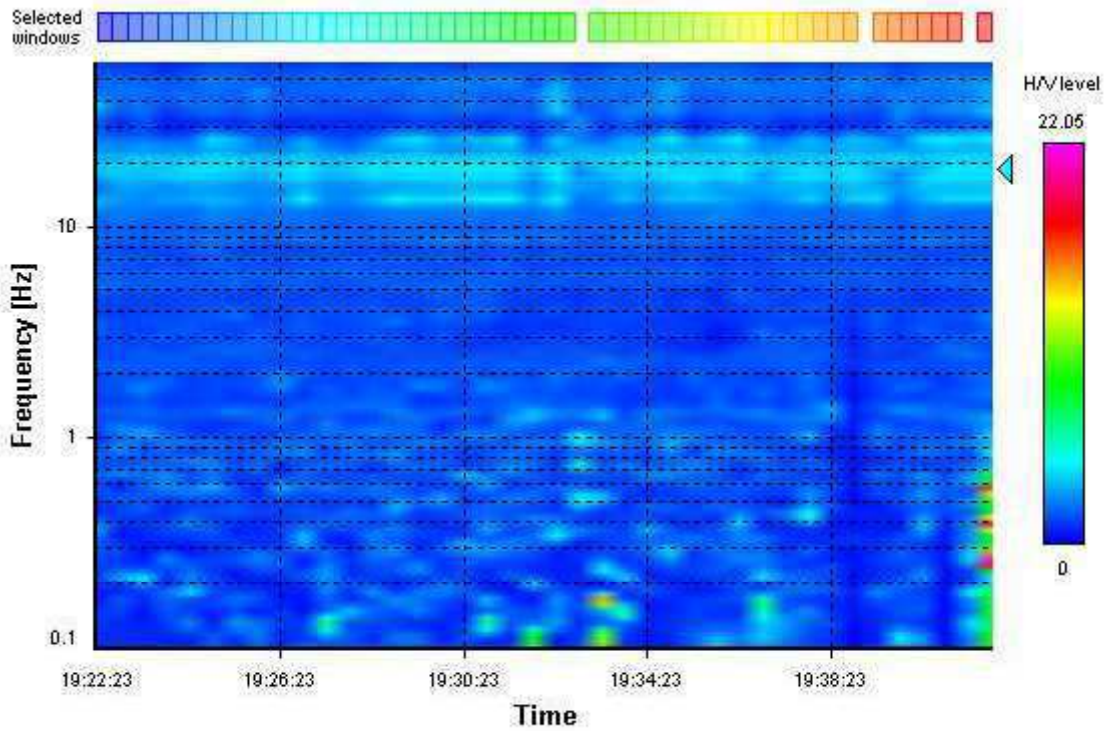
HVSR average



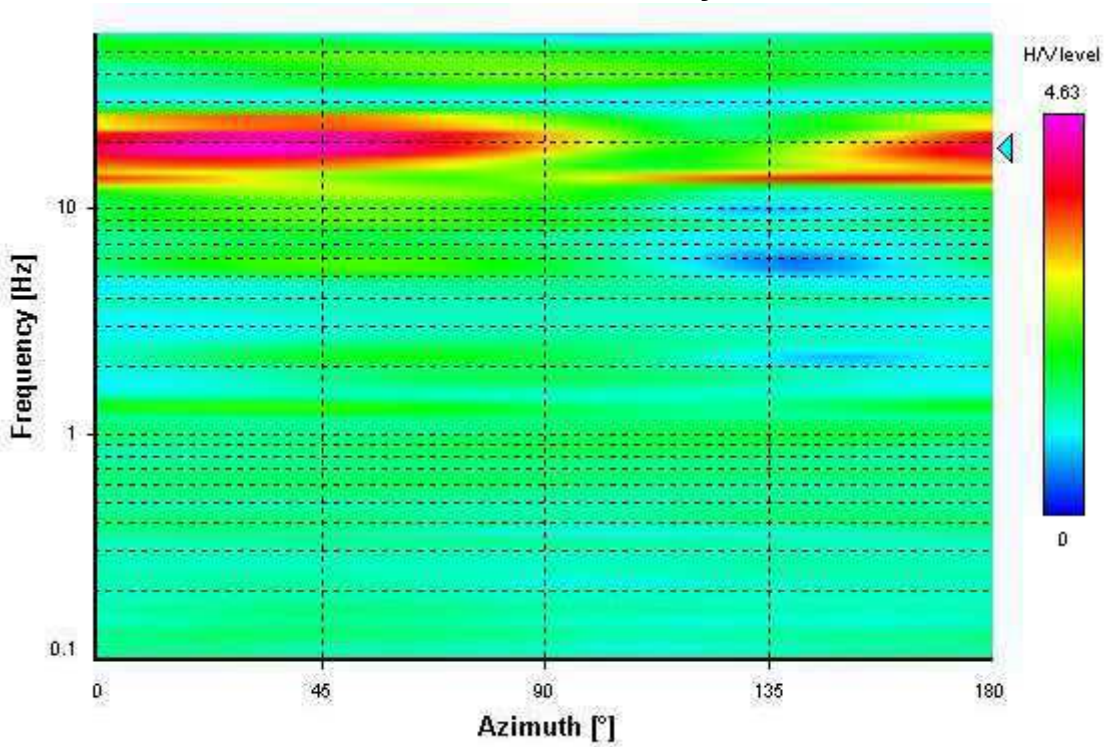
Signal spectra average



HVSR time-frequency analysis (30 seconds windows)



HVSR directional analysis



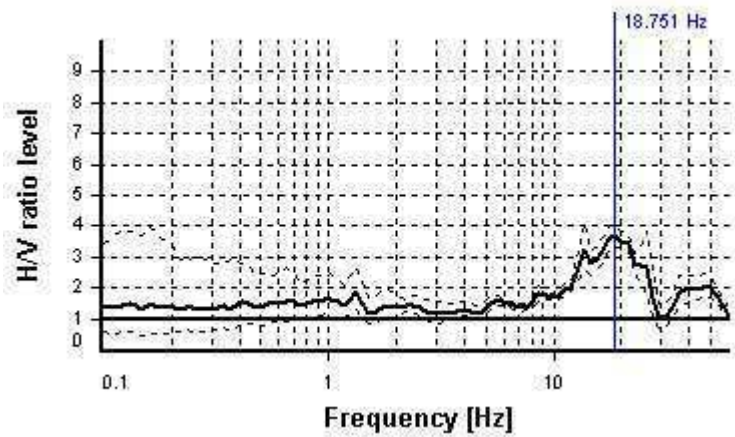
SESAME CRITERIA

Selected f_0 frequency

18.751 Hz

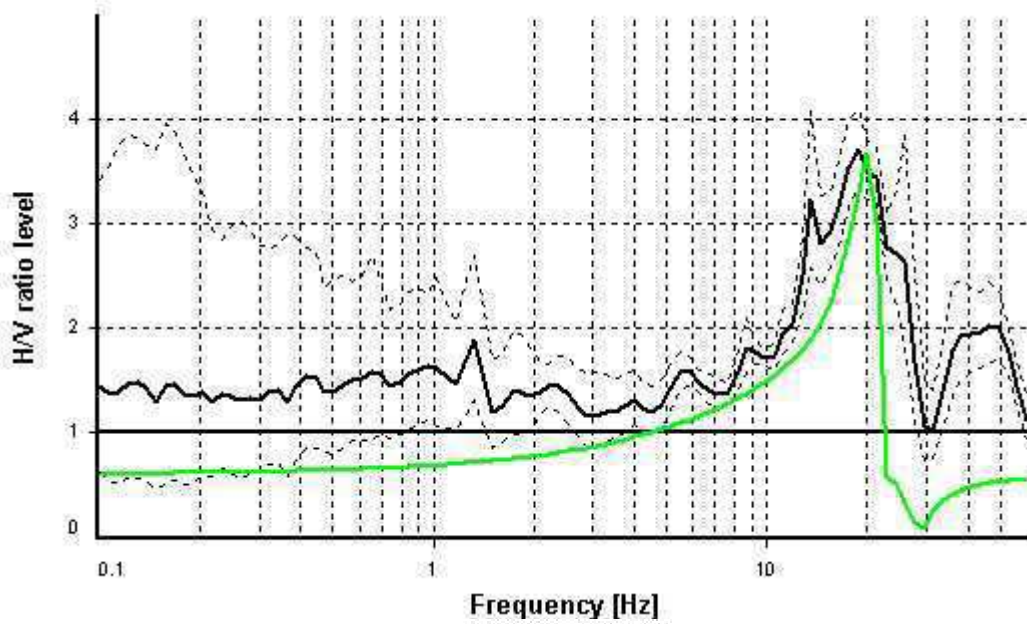
A_0 amplitude = 3.717

Average f_0 = 19.010 ± 3.322



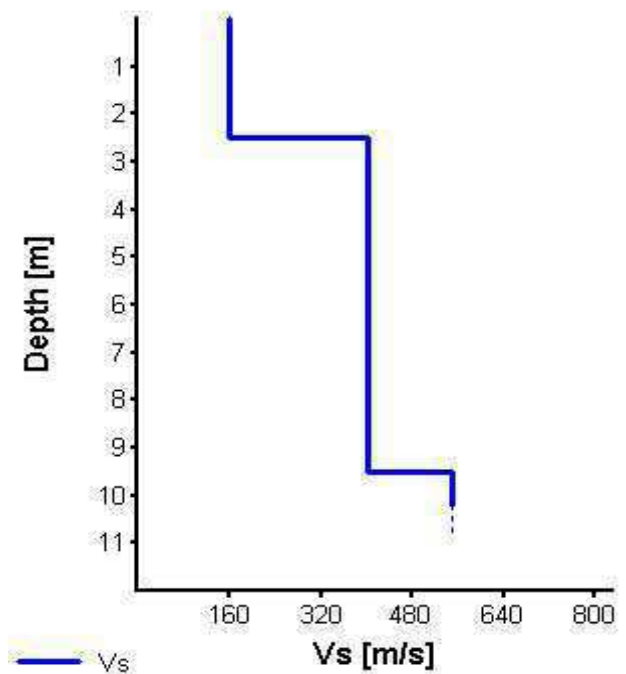
HVSR curve reliability criteria		
$f_0 > 10 / L_w$	57 valid windows (length > 0.53 s) out of 57	OK
$n_c(f_0) > 200$	21376.55 > 200	OK
$\sigma_A(f) < 2$ for $0.5f_0 < f < 2f_0$	Exceeded 0 times in 21	OK
HVSR peak clarity criteria		
$\exists f$ in $[f_0/4, f_0] \mid A_{H/V}(f) < A_0/2$	10.48271 Hz	OK
$\exists f^+$ in $[f_0, 4f_0] \mid A_{H/V}(f^+) < A_0/2$	27.63158 Hz	OK
$A_0 > 2$	3.72 > 2	OK
$f_{\text{peak}}[A_{H/V}(f) \pm \sigma_A(f)] = f_0 \pm 5\%$	0% ≤ 5%	OK
$\sigma_f < \varepsilon(f_0)$	3.32191 ≥ 0.93757	NO
$\sigma_A(f_0) < \theta(f_0)$	1.10378 < 1.58	OK
Overall criteria fulfillment		OK

Synthetic HVSr modelling



EXPERIMENTAL
HVSr
SYNTHETIC
HVSr

H [m]	D [m]	Vp [m/s]	Vs [m/s]	ρ [kg/m ³]
2.5	2.5	790	160	1800
7	9.5	2040	401	1900
-	> 9.5	1470	550	2000



Vs 30 = 426 m/s (Offset = 0 m)