



PROTEZIONE CIVILE  
Presidenza del Consiglio dei Ministri  
Dipartimento della Protezione Civile



Regione Emilia-Romagna



CONFERENZA DELLE REGIONI E  
DELLE PROVINCE AUTONOME

Attuazione dell'articolo 11 della legge 24 giugno 2009, n. 77

# MICROZONAZIONE SISMICA

## Elaborato 8

Prove MASW – HVSR

Regione Emilia-Romagna

Comune di San Secondo

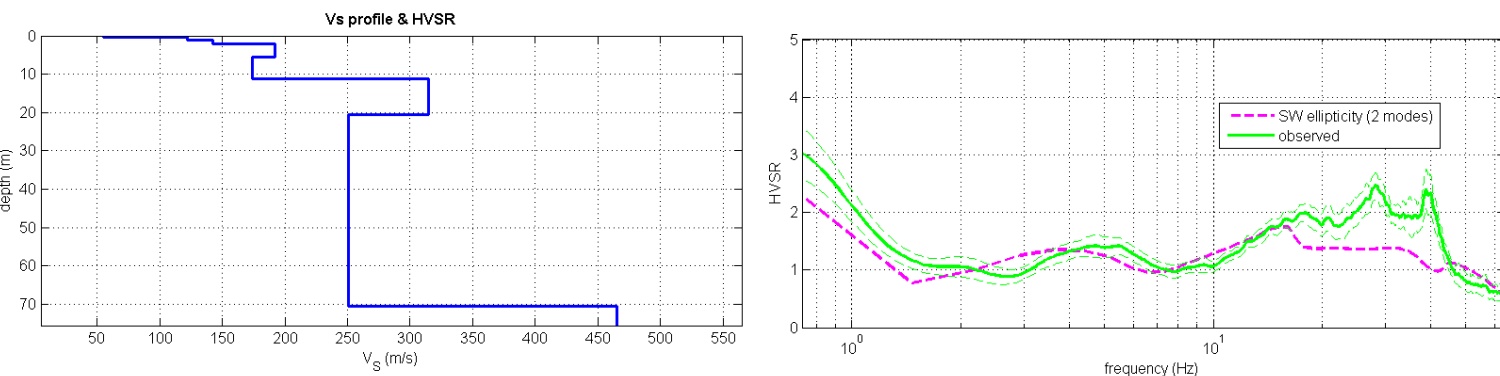
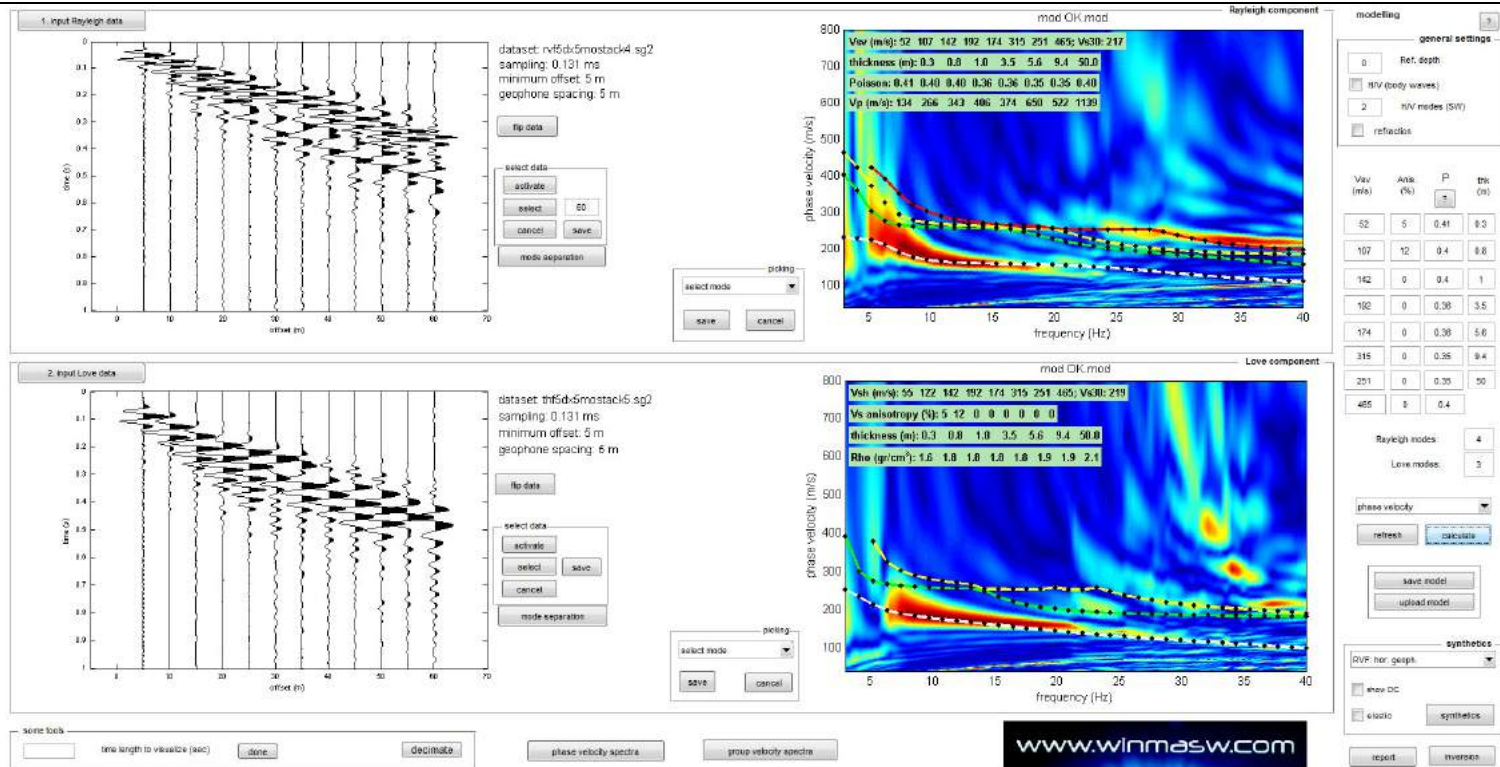


Regione Emilia-Romagna	Soggetto realizzatore Dott. Geol. Fabio Picinotti	Data Marzo 2020
		<b>MS3</b>

PROVE MASW + HVSR

034033L11 + 034033P197





Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,3	52	0,3
0,3	1,1	107	0,8
1,1	2,1	142	1,0
2,1	5,6	192	3,5
5,6	11,2	174	5,6
11,2	20,6	315	9,4
20,6	70,6	251	50,0
70,6	inf.	465	-

show data reset show location

step1 (optional) - electrode

125Hz new frequency resume

step2 - HV computation

remove events (each fac. & T) clean area

22 window length (s)

10 tapering (%)

2% spectral smoothing (triangular window)

show particle motion (raw data)

full input

compute

step3a (optional) - directivity analysis

compute

max freq: 22 Hz

step3b (optional) - directivity over time

directivity in time

save - optional1: save HVSR as 0.1s

save HVSR from 0.1 10 24 Hz

save HV curve (as 0.1s)

pick HV curve

save picked HV

compute SAME for picked curve

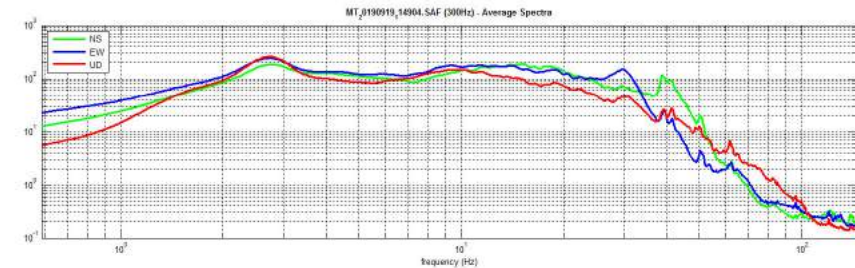
quick analysis (H/V ratio)

average Vs (m/s)

depth of the bedrock (m)

Vs of the bedrock

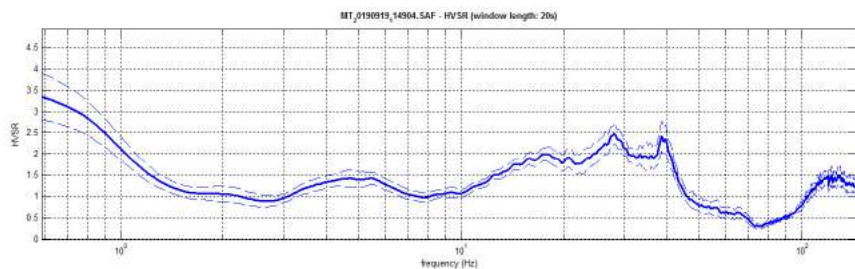
clean compute



Peak frequency (Hz): 4.8 (±1.8)  
Peak HVSR value: 1.4 (±0.2)

Criteria for a reliable H/V curve

- #1.  $[f_0 > 10/Lw]$ : 4.8 > 0.5 (OK)
- #2.  $[nc > 200]$ : 11238 > 200 (OK)
- #3.  $[f_0 > 0.5Hz; \sigma_A(f) < 2 \text{ for } 0.5f_0 < f < 2f_0]$  (OK)



Criteria for a clear H/V peak (at least 5 should be fulfilled)

- #1.  $[exists f^- \text{ in the range } [f_0/4, f_0] | AH/V(f^-) < A_0/2]$ : (NO)
- #2.  $[exists f^+ \text{ in the range } [f_0, 4f_0] | AH/V(f^+) < A_0/2]$ : (NO)
- #3.  $[A_0 > 2]$ : 1.4 < 2 (NO)
- #4.  $[f_{peak}[Ah/v(f) \pm \sigma_A(f)] = f_0 \pm 5\%]$ : (NO)
- #5.  $[\sigma_A(f) < \epsilon(f)]$ : 1.820 > 0.238 (NO)
- #6.  $[\sigma_A(f_0) < \theta(f_0)]$ : 0.199 < 1.58 (OK)

Peak frequency (Hz): 18.1 (±3.7)  
Peak HVSR value: 2.0 (±0.2)

Criteria for a reliable H/V curve

- #1.  $[f_0 > 10/Lw]$ : 18.1 > 0.5 (OK)
- #2.  $[nc > 200]$ : 42618 > 200 (OK)
- #3.  $[f_0 > 0.5Hz; \sigma_A(f) < 2 \text{ for } 0.5f_0 < f < 2f_0]$  (OK)

Criteria for a clear H/V peak (at least 5 should be fulfilled)

- #1.  $[exists f^- \text{ in the range } [f_0/4, f_0] | AH/V(f^-) < A_0/2]$ : yes, at frequency 8.1Hz (OK)
- #2.  $[exists f^+ \text{ in the range } [f_0, 4f_0] | AH/V(f^+) < A_0/2]$ : (NO)
- #3.  $[A_0 > 2]$ : 2.0 < 2 (NO)
- #4.  $[f_{peak}[Ah/v(f) \pm \sigma_A(f)] = f_0 \pm 5\%]$ : (OK)
- #5.  $[\sigma_A(f) < \epsilon(f)]$ : 3.653 > 0.903 (NO)
- #6.  $[\sigma_A(f_0) < \theta(f_0)]$ : 0.173 < 1.58 (OK)

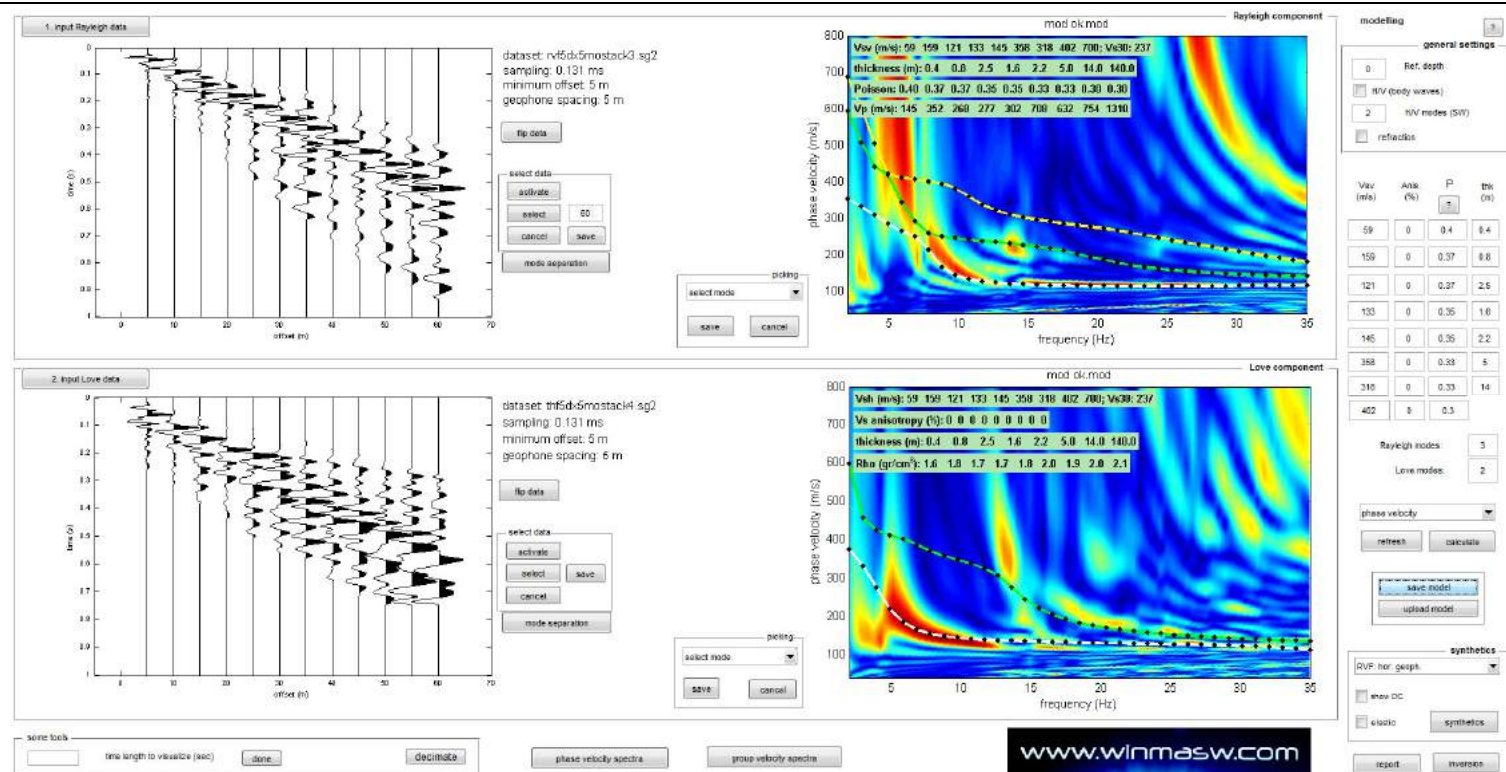
STRUMENTAZIONE	Località
Sismografo 24 canali (Echo 2002)	"Cimitero" di
Geofoni orizzontali 4.5 Hz	San
Sismografo SR04-GEOBOX	Secondo
Sensore 2.0 Hz	Parmense

COMMITTENTE:  
Geol. Fabio Picinotti

ESECUZIONE (12-  
19/09/2019):  
Geol. Filippo Segalini  
Geol. Davide Zucchi

034033L12 + 034033P198





Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,4	59	0,4
0,4	1,2	159	0,8
1,2	3,7	121	2,5
3,7	5,3	133	1,6
5,3	7,5	145	2,2
7,5	12,5	358	5,0
12,5	26,5	318	14,0
26,5	166,5	402	140,0
26,5	inf.	700	-

show data reset show location

step1 (optional) - decrease 150Hz new frequency recompute

step2 - HV computation

remove events both Rad & Tr clean axis

20 window length (s) 10 opening (%) 10% spectral smoothing (triangular window)

show particle motion (raw data) fast output

compute

step3a (optional) - directionality analysis

compute max freq 32 Hz

step3b (optional) - directionality over time

directionality in time time step 00 %

save - optional: save HVSR as it is

Save HV from 0.45 to 04 Hz

save HV curve (as it is)

save - optional: picking HV curve

pick HV curve save picked HV

compute SE SAMT for picked curve

quick analysis (H/V ratio)

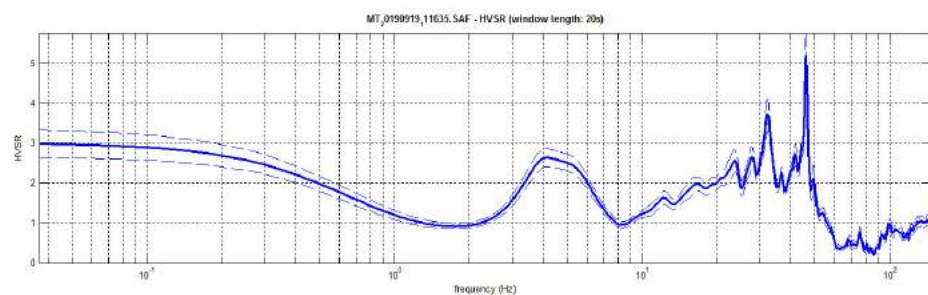
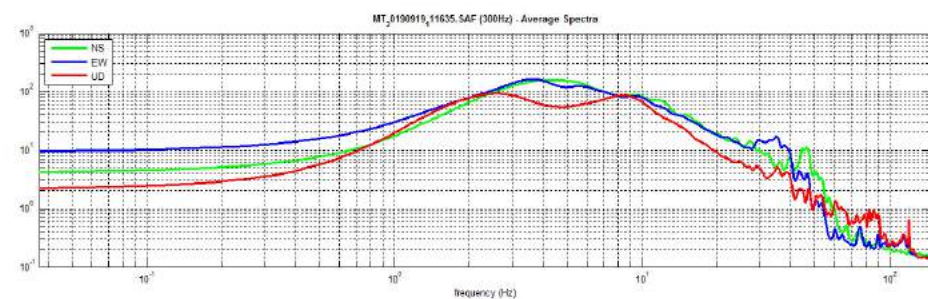
average V<sub>s</sub> (m/s) (from surface to bedrock)

20 depth of the bedrock (m)

1000 V<sub>s</sub> of the bedrock

compute

www.winmasw.com



Peak frequency (Hz): 4.2 (±3.9)

Peak HVSR value: 2.6 (±0.2)

== Criteria for a reliable H/V curve ==

#1. [f<sub>0</sub> > 10/Lw]: 4.2 > 0.5 (OK)

#2. [nc > 200]: 8519 > 200 (OK)

#3. [f<sub>0</sub> > 0.5Hz; sigmaA(f) < 2 for 0.5f<sub>0</sub> < f < 2f<sub>0</sub>] (OK)

== Criteria for a clear H/V peak (at least 5 should be fulfilled) ==

#1. [exists f- in the range [f<sub>0</sub>/4, f<sub>0</sub>] | AH/V(f-) < A0/2]: yes, at frequency 2.8Hz (OK)

#2. [exists f+ in the range [f<sub>0</sub>, 4f<sub>0</sub>] | AH/V(f+) < A0/2]: yes, at frequency 7.1Hz (OK)

#3. [A0 > 2]: 2.6 > 2 (OK)

#4. [fpeak[Ah/v(f) ± sigmaA(f)] = f<sub>0</sub> ± 5%]: (OK)

#5. [sigmaf < epsilon(f<sub>0</sub>)]: 3.913 > 0.209 (NO)

#6. [sigmaA(f<sub>0</sub>) < theta(f<sub>0</sub>)]: 0.229 < 1.58 (OK)

STRUMENTAZIONE

Sismografo 24 canali (Echo 2002)  
Geofoni orizzontali 4.5 Hz

Sismografo SR04-GEOBOX  
Sensore 2.0 Hz

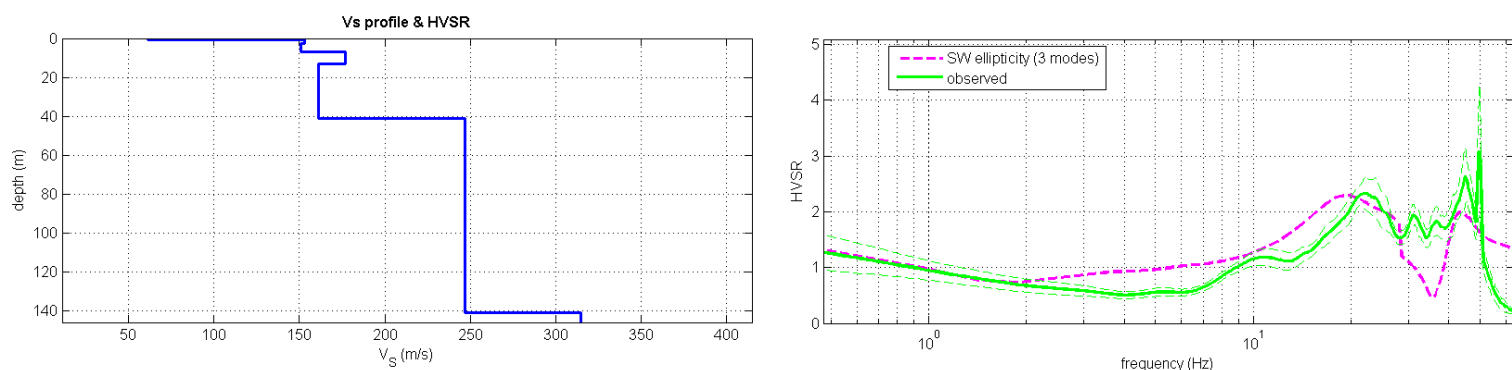
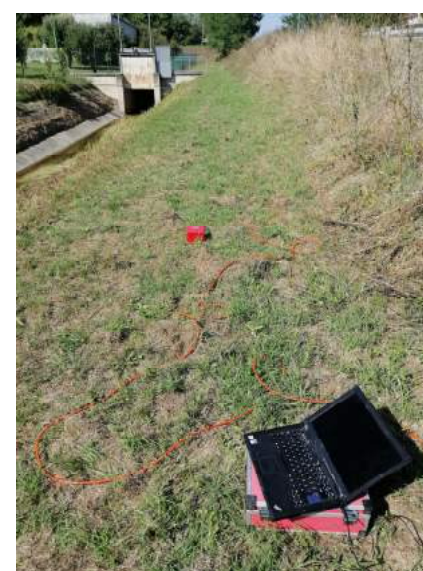
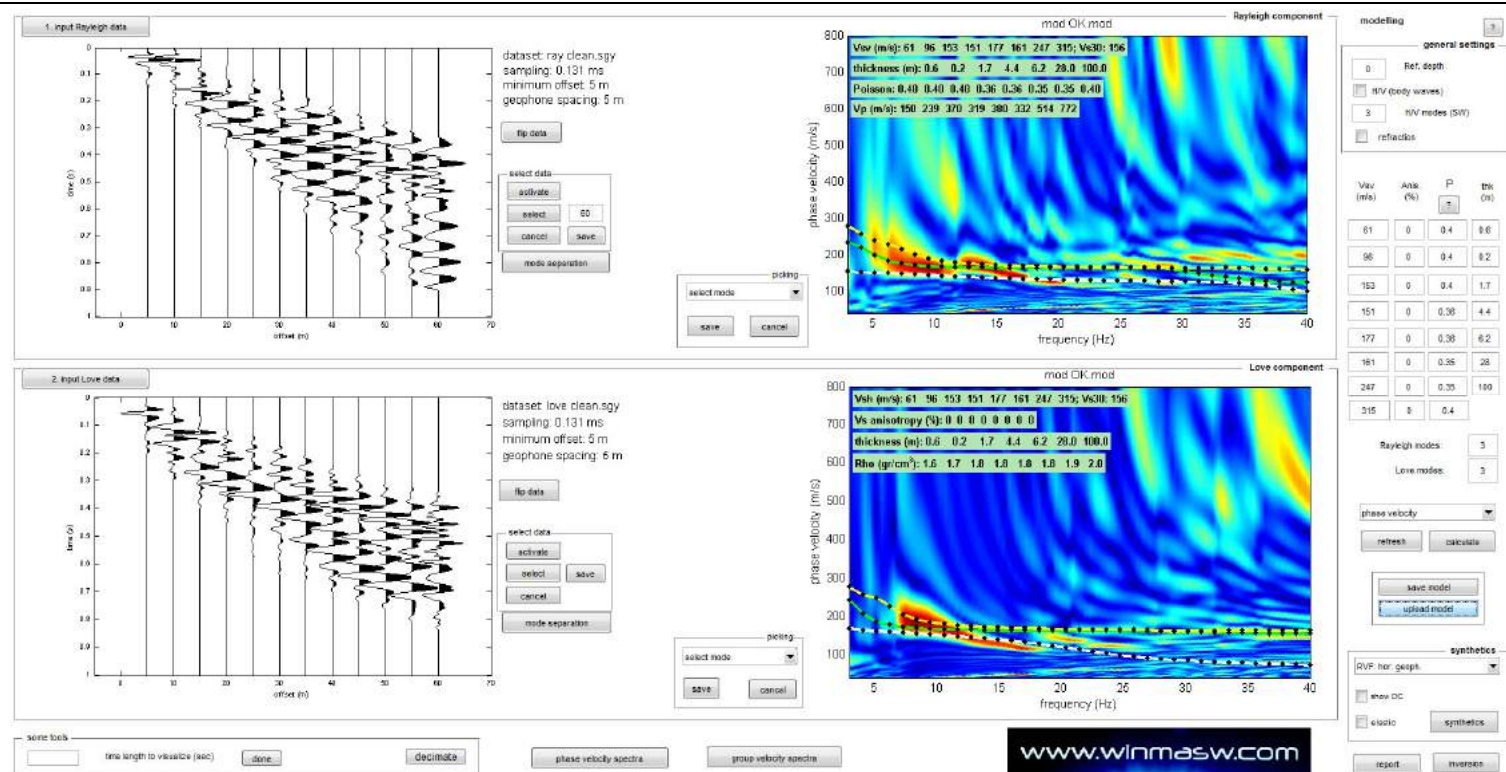
Località  
"Elisoccorso"  
di San  
Secondo  
Parmense

COMMITTENTE:  
Geol. Fabio Picinotti

ESECUZIONE (19/09/2019):  
Geol. Filippo Segalini  
Geol. Davide Zucchi

034033L13 + 034033P199





Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,6	61	0,6
0,6	0,8	96	0,2
0,8	2,5	153	1,7
2,5	6,9	151	4,4
6,9	13,1	177	6,2
13,1	41,1	161	28,0
41,1	141,1	247	100,0
141,1	inf.	315	-

show data reset show location

step1 (optional) - decrease 150Hz new frequency recompute

step2 - RV computation

remove events both Rad & Tr clean axis

20 window length (s) 10 tapering (%) 5% spectral smoothing (triangular window)

show particle motion (raw data) not output

compute

step3a (optional) - directionality analysis

compute max freq 32 Hz

step3b (optional) - directionality over time

directionality in time time step 00 %

save - optional1: save HVSR as it is

Save HV from 0.45 to 04 Hz

save HV curve (as it is)

save - optional2: picking RV curve

pick RV curve save picked RV

compute SE-SAME for picked curve

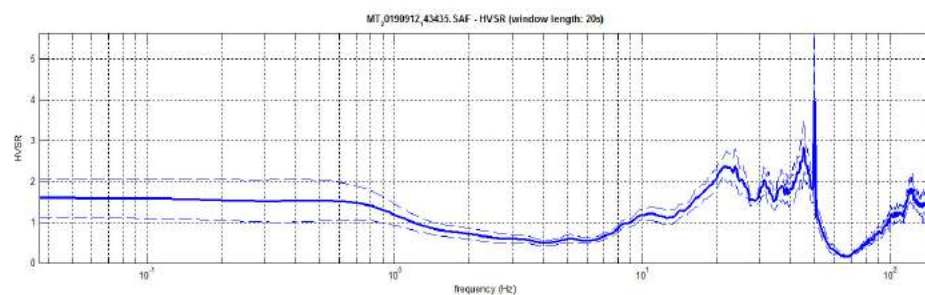
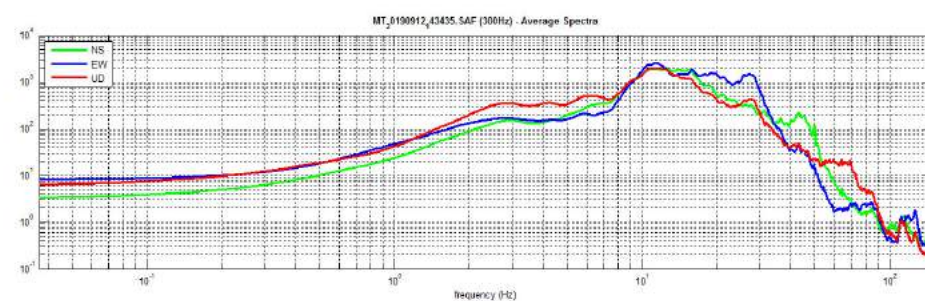
quick analysis (P-Vs-H)

average Vs (m/s) (from surface to bedrock)

100 depth of the bedrock (m)

1000 Vs of the bedrock

compute



STRUMENTAZIONE

Sismografo 24 canali (Echo 2002)

Geofoni orizzontali 4.5 Hz

Sismografo SR04-GEOBOX

Sensore 2.0 Hz

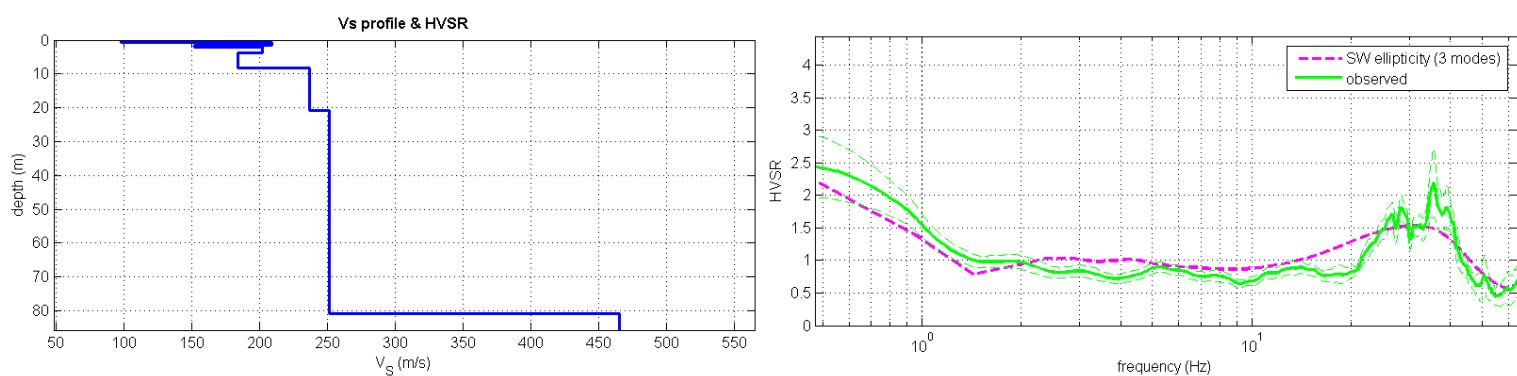
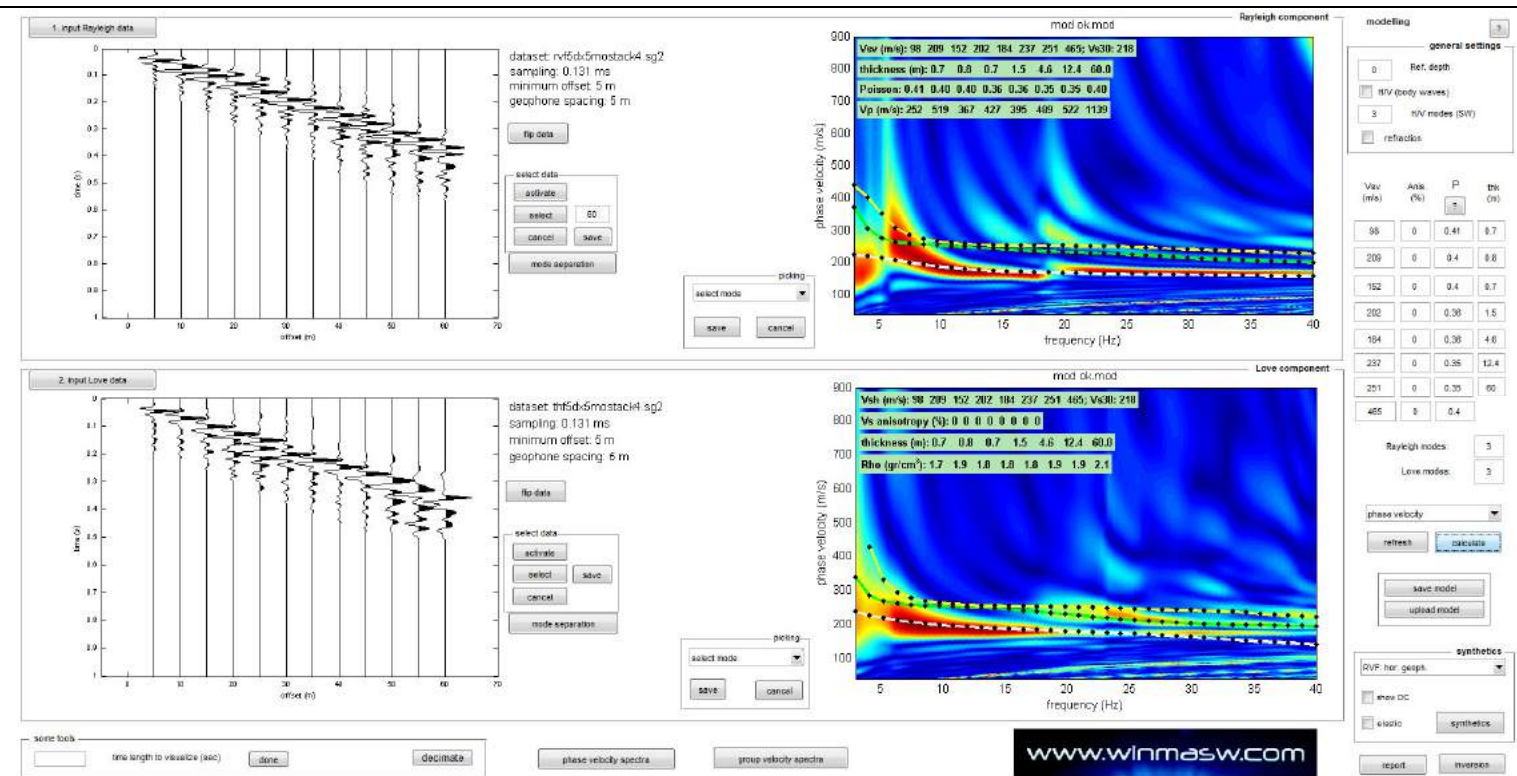
Località  
"Pizzo" di San  
Secondo  
Parmense

COMMITTENTE:  
Geol. Fabio Picinotti

ESECUZIONE (12/09/2019):  
Geol. Filippo Segalini  
Geol. Davide Zucchi



034033L14 + 034033P200



show data reset show location

step1 (optional) - decimate

100% new frequency resample

step2 - HV computation

remove events both flat & 70 clean axis

20 window length (s) tapering (%)

5% spectral smoothing (triangular window)

show particle motion (raw data) compute

step3a (optional) - directivity analysis

compute max freq 32 Hz

step3b (optional) - directivity over time

directivity to time time step 0.2 s

save - optional: save HVSR as it is

Save HV from 0.40 to 0.4 Hz

save HV curve (as it is)

save - optional: picking HV curve

pick HV curve save picked HV

compute SESAME for picked curve

quick analysis (H-V/LH)

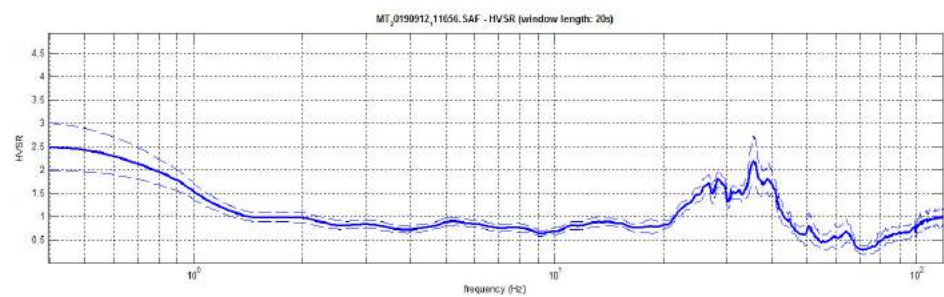
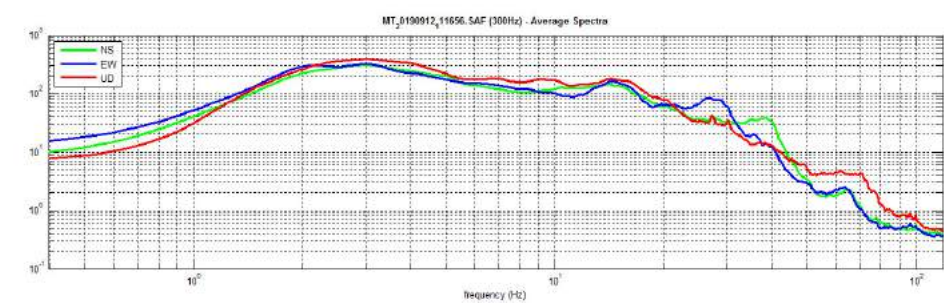
average Vs (m/s) (from surface to bedrock)

25 depth of the bedrock (m)

100 Vs of the bedrock

compute

www.winmasw.com



To model the HVSR (also pretty with MASW or RefVESAC data), save the HV curve, go to the "Velocity Spectra", "Modeling & Picking" panels and upload the saved HV curve.

Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,7	98	0,7
0,7	1,5	209	0,8
1,5	2,2	152	0,7
2,2	3,7	202	1,5
3,7	8,3	184	4,6
8,3	20,7	237	12,4
20,7	80,7	251	60,0
80,7	inf.	465	-

STRUMENTAZIONE

Sismografo 24 canali (Echo 2002)

Geofoni orizzontali 4.5 Hz

Sismografo SR04-GEOBOX

Sensore 2.0 Hz

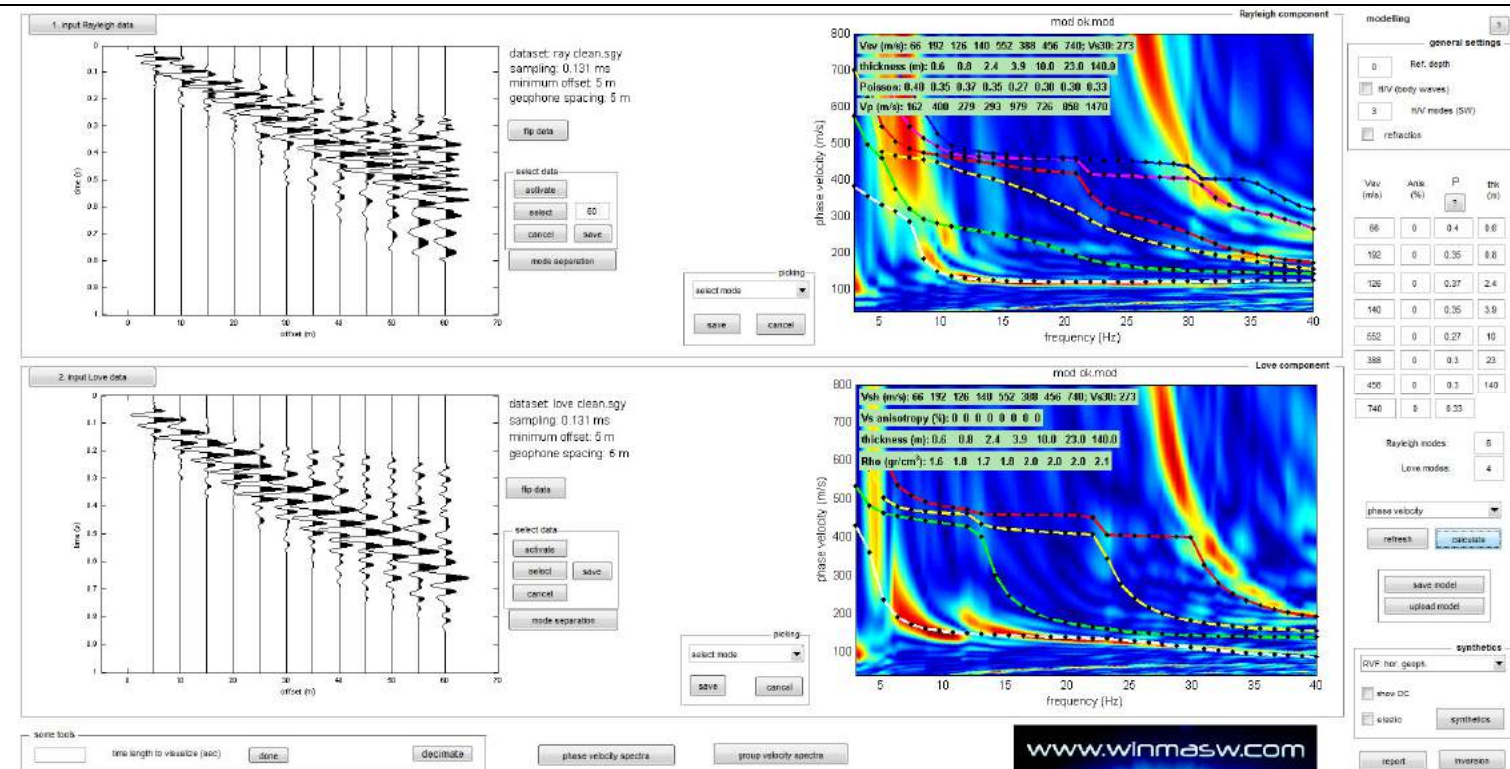
Località "Ponte  
su Taro" di San  
Secondo  
Parmense

COMMITTENTE:  
Geol. Fabio Picinotti

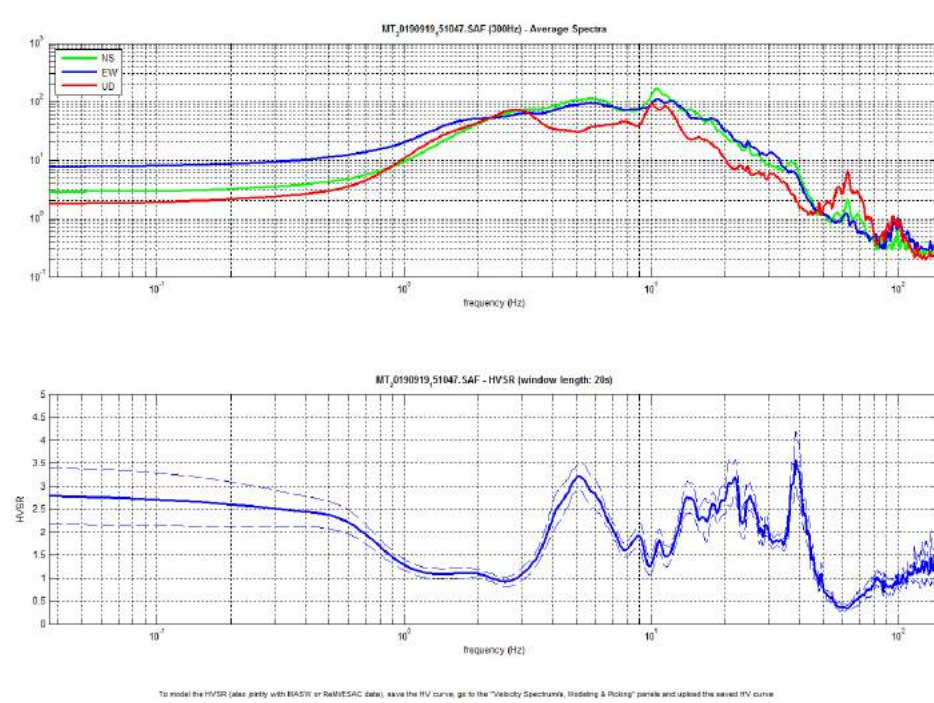
ESECUZIONE (12/09/2019):  
Geol. Filippo Segalini  
Geol. Davide Zucchi

034033L15 + 034033P201





Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,6	66	0,6
0,6	1,4	192	0,8
1,4	3,8	126	2,4
3,8	7,7	140	3,9
7,7	17,7	552	10,0
17,7	40,7	388	23,0
40,7	180,7	456	140,0
180,7	inf.	740	-



Peak frequency (Hz): 5.2 (±6.1)  
Peak HVSR value: 3.2 (±0.3)

- Criteria for a reliable H/V curve
- #1.  $[f_0 > 10/L.w]: 5.2 > 0.5$  (OK)
  - #2.  $[nc > 200]: 9297 > 200$  (OK)
  - #3.  $[f_0 > 0.5Hz; \sigma_{\sigma A}(f) < 2 \text{ for } 0.5f_0 < f < 2f_0]$  (OK)

- Criteria for a clear H/V peak (at least 5 should be fulfilled)
- #1. [exists  $f^-$  in the range  $[f_0/4, f_0]$  |  $AH/V(f^-) < A_0/2$ ]: yes, at frequency 3.6Hz (OK)
  - #2. [exists  $f^+$  in the range  $[f_0, 4f_0]$  |  $AH/V(f^+) < A_0/2$ ]: yes, at frequency 7.8Hz (OK)
  - #3.  $[A_0 > 2]: 3.2 > 2$  (OK)
  - #4.  $[f_{\text{peak}}[Ah/v(f) \pm \sigma_{\sigma A}(f)] = f_0 \pm 5\%]$ : (OK)
  - #5.  $[\sigma_{\text{mag}} < \epsilon_{\text{sigma}}(f_0)]: 6.065 > 0.258$  (NO)
  - #6.  $[\sigma_{\text{mag}}(f_0) < \theta(f_0)]: 0.265 < 1.58$  (OK)

STRUMENTAZIONE  
Sismografo 24 canali (Echo 2002)  
Geofoni orizzontali 4.5 Hz  
  
Sismografo SR04-GEOBOX  
Sensore 2.0 Hz

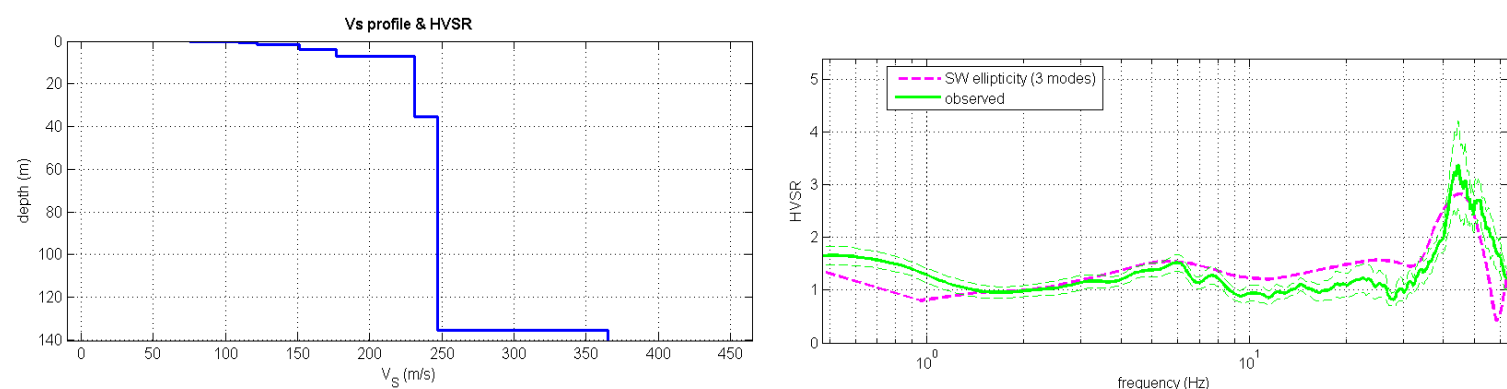
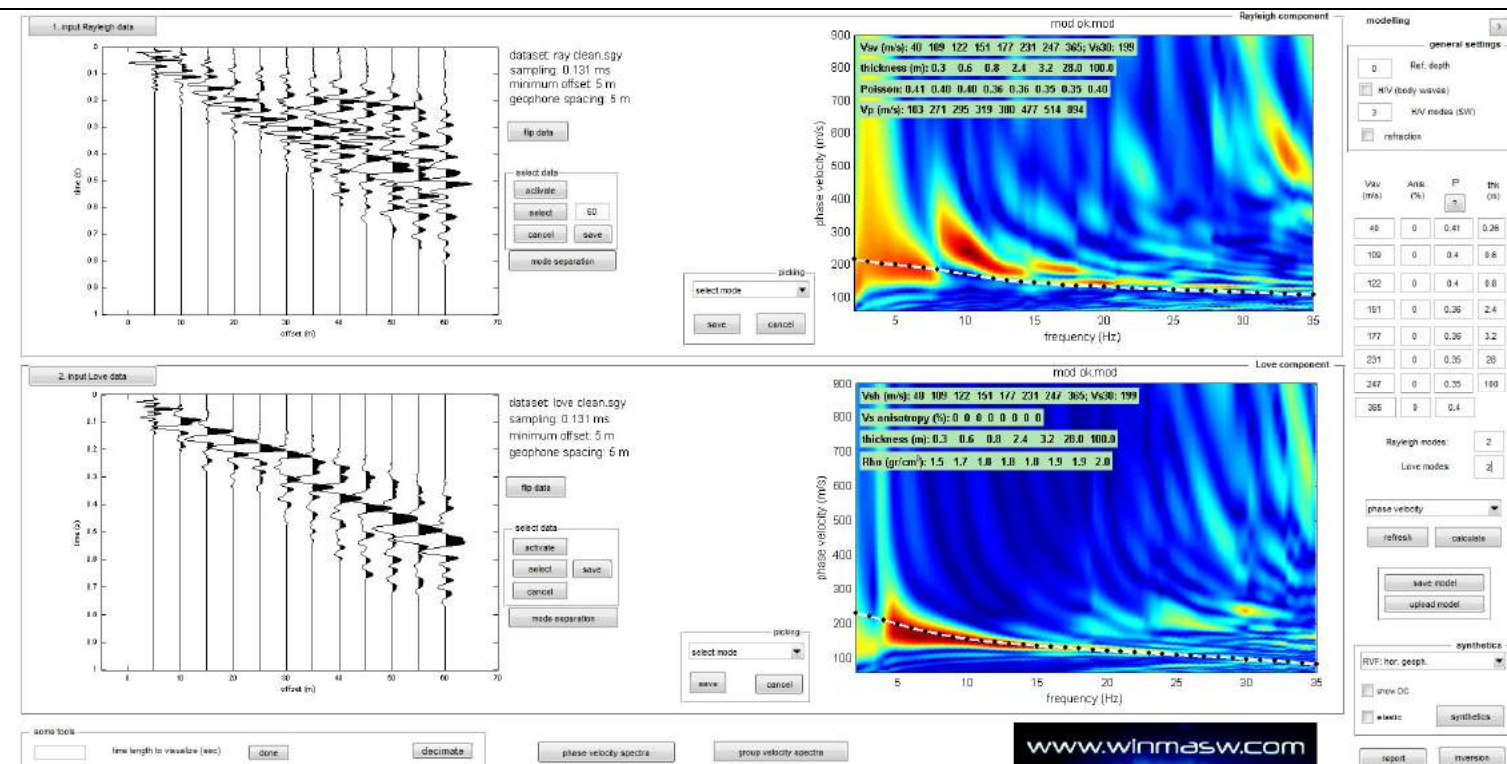
Località  
"Castellaicardi"  
di San Secondo  
Parmense

COMMITTENTE:  
Geol. Fabio Picinotti

ESECUZIONE (19/09/2019):  
Geol. Filippo Segalini  
Geol. Davide Zucchi

034033L16 + 034033P202





Profondità		Velocità	Spessore
(m da p.c.)		(m/s)	(m)
0,0	0,3	40	0,3
0,3	0,9	109	0,6
0,9	1,7	122	0,8
1,7	4,1	151	2,4
4,1	7,3	177	3,2
7,3	35,3	231	28,0
35,3	135,3	247	100,0
135,3	inf.	365	-

show data    reset    show location

step01 (optional) - decimate

120Hz    new frequency    resample

step02 - HV computation

remove events    both flat & 1%    clean axis

20    window length (s)    10    tapering (%)    5%    spectral smoothing (triangular window)

☐ show particle motion (raw data)    ☐ full output    compute

step03a (optional) - directivity analysis

complete    min freq: 32    Hz

step03b (optional) - directivity over time

directivity in time    data skip: 60    %

save - optional: save HV/SR as it is

Save HV from: 0.40    to: 64    Hz    save HV curve (as it is)

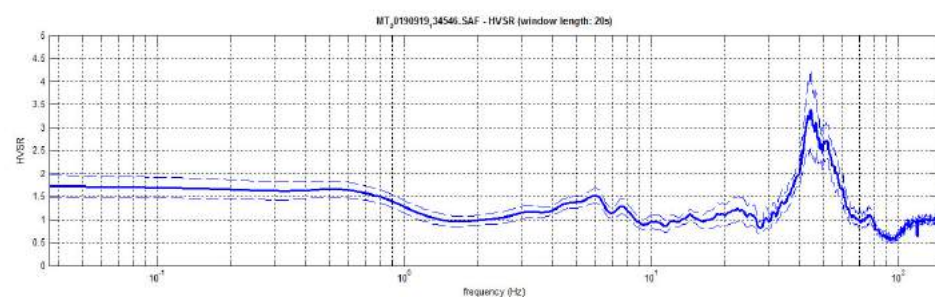
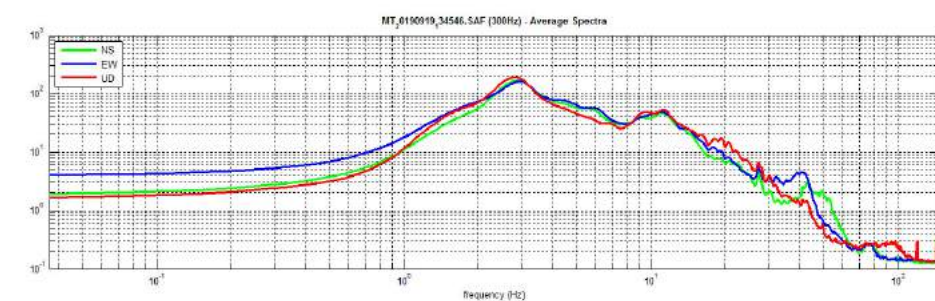
save - optional: picking HV curve

pick HV curve    save picked HV    complete SESAME for picked curve

quick analysis (f-v/s/f)

average Vs (m/s)    100    depth of the bedrock (m)    20    1/3 of the bedrock    1000

compute



Peak frequency (Hz): 5.9 (±6.1)

Peak HVSR value: 1.5 (±0.2)

== Criteria for a reliable H/V curve ==

- #1.  $[f_0 > 10/Lw]$ :  $5.9 > 0.5$  (OK)
- #2.  $[nc > 200]$ :  $14004 > 200$  (OK)
- #3.  $[f_0 > 0.5\text{Hz}; \sigma_A(f) < 2 \text{ for } 0.5f_0 < f < 2f_0]$  (OK)

== Criteria for a clear H/V peak (at least 5 should be fulfilled) ==

- #1.  $[\text{exists } f^- \text{ in the range } [f_0/4, f_0] \mid AH/V(f^-) < A_0/2]$ : (NO)
- #2.  $[\text{exists } f^+ \text{ in the range } [f_0, 4f_0] \mid AH/V(f^+) < A_0/2]$ : (NO)
- #3.  $[A_0 > 2]$ :  $1.5 < 2$  (NO)
- #4.  $[f_{\text{peak}}[Ah/v(f) \pm \sigma_A(f)] = f_0 \pm 5\%]$ : (OK)
- #5.  $[\sigma_A(f) < \epsilon(f_0)]$ :  $6.145 > 0.297$  (NO)
- #6.  $[\sigma_A(f_0) < \theta(f_0)]$ :  $0.158 < 1.58$  (OK)

STRUMENTAZIONE

Sismografo 24 canali (Echo 2002)

Geofoni orizzontali 4.5 Hz

Sismografo SR04-GEOBOX

Sensore 2.0 Hz

Località "La Valle" di San Secondo Parmense

COMMITTENTE:

Geol. Fabio Picinotti

ESECUZIONE (19/09/2019):

Geol. Filippo Segalini

Geol. Davide Zucchi