Task 3

Seismic site characterization by surface waves methods

Task responsibles:

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S. Parolai (GFZ)

1st semester evaluation by the International Evaluation Committee

Rome, INGV, Via Nizza, 128

November 20, 2008

Main activities

3.1 Introductory phase

      - review of existing Vs profiles in ITACA

      - selection of sites to be investigated

      - definition of investigation procedures by different RUs

      - benchmark on an existing dataset

3.2 In-field survey and determination of Vs profiles at selected stations

3.3 Synthesis of results and inclusion in ITACA

Task 3 – Deliverables

D6 *Responsibles* RU4 – Poli-TO RU8 - GFZ *Deadline* 12 m	Progress report on the application of surface-waves methods for seismic site characterization (Technical report) *Product of immediate interest to DPC*	This report will include the results of activities 3.1 and 3.2 (when already available), i.e., formulation of reference procedures to be used by project RUs, considering and when possible integrating the NERIES project results, and validation of these procedures by application to well documented sites
D7 *Responsibles* RU4 – Poli-TO RU8 - GFZ *Deadline* 24 m	Application of surface-waves methods for seismic site characterization of ITACA stations (Technical report) *Product of immediate interest to DPC*	This report will contain the summary of experimental activities carried out at the ITACA stations within this project and final considerations on their applicability for the determination of other descriptive parameters for site classification and for retaining relevant information for subsequent re-interpretations.

Task 3 − Criteria for station selection

- to maximize with the available budget the number of ITACA stations for which the Vs profile will be made available, including sites in moderate/high seismicity areas with limited knowledge about their seismic characterization;

- to include as many as possible stations with interesting acceleration records, even if obtained by analog stations;

- for rock stations, prefer complex geological configurations (lateral discontinuities, surface weathering, etc.).

Task 3 – Map of proposed sites

Task 3 – Planning tables

Preliminary in-field survey

	Sep 08	Okt 08	Nov 08	Dec 08	Jan 09	Feb 09	Mrz 09	Apr 09	Mai 09	Jun 09	Jul 09	Aug 09	Sep 09	Okt 09	Nov 09	Dez 09
UR8-UR1		■	■	■	■											
UR4	■															
UR2		■														
UR7-UR5		■				■	■									

Measurements

	Sep 08	Okt 08	Nov 08	Dez 08	Jan 09	Feb 09	Mrz 09	Apr 09	Mai 09	Jun 09	Jul 09	Aug 09	Sep 09	Okt 09	Nov 09	Dez 09
UR8-UR1								■	■							
UR4		■	■					■	■	■						
UR2								■	■							
UR7-UR5										■	■	■	■			

Task 3 − Summary of site conditions

Stiff soil	13
Rock	27
Stift/Rock	4
Soft soil	13
no classification	16

Task 3 − Investigation techniques

	Techniques	Sensors
UR8-UR1 (GFZ-INGV MI)	ESAC-FK	1 Hz sensors
UR4 (PoliTO)	FK-active and passive	4.5 Hz and 2 Hz
UR2 (INGV RM)	ESAC-FK	5 sec & 4.5 Hz
UR7-UR5 (Uni Siena-UniBAS)	ESAC/HVSR/Geomec	Tromino Brainspy

Task 3 − Investigation techniques (Surface Waves)
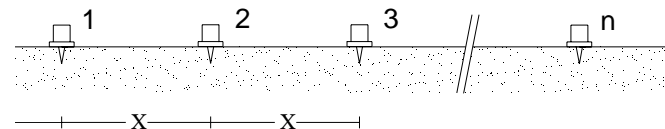
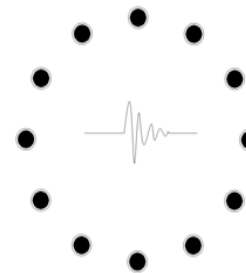**Active methods**

Multistation
(f-k, τ-p, ...)

Two-station (SASW)
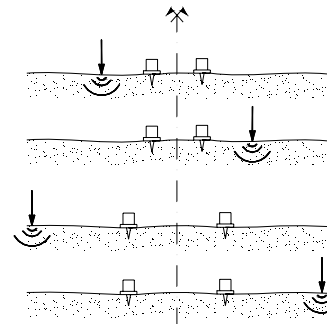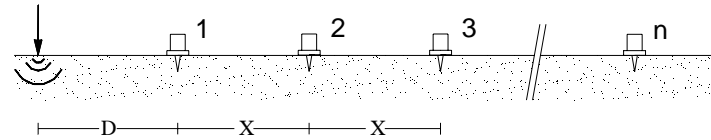
Passive methods
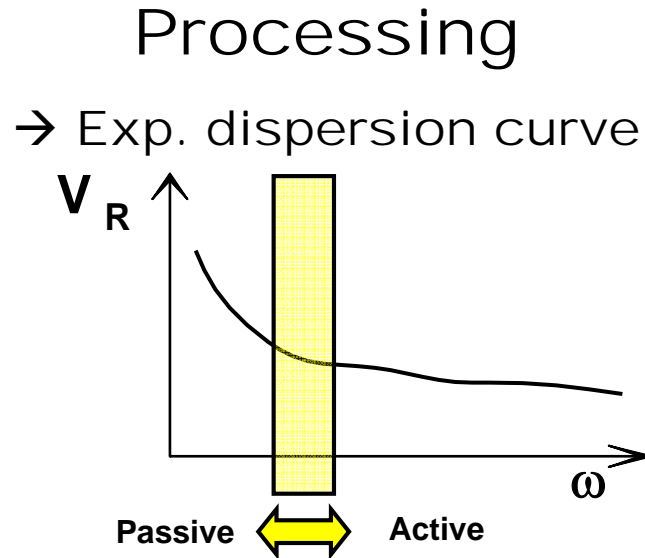
Spatial Array
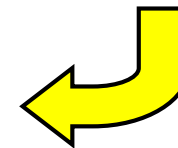SPAC, ESAC, *f-k* (FBDF, Capon, ...), ...

Linear array (ReMi)

?

Passive

Active

Processing

→ Exp. dispersion curve

V_R

ω

Passive ⟷ Active

Inversion

V_S

Active

Passive

Z
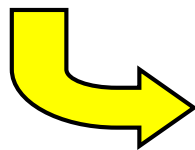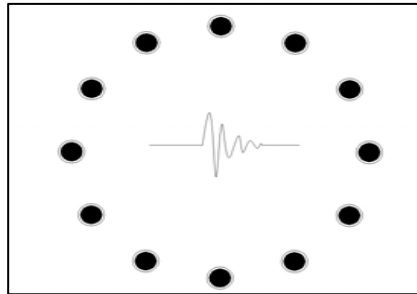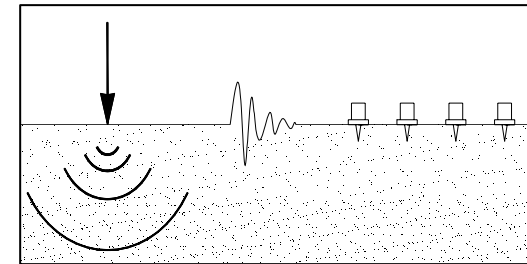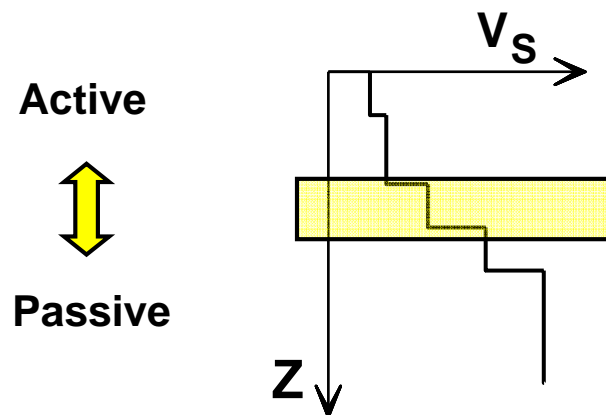
Detailed table for U4: 18 SELECTED SITES
Regions: Liguria, Piemone, Sicilia

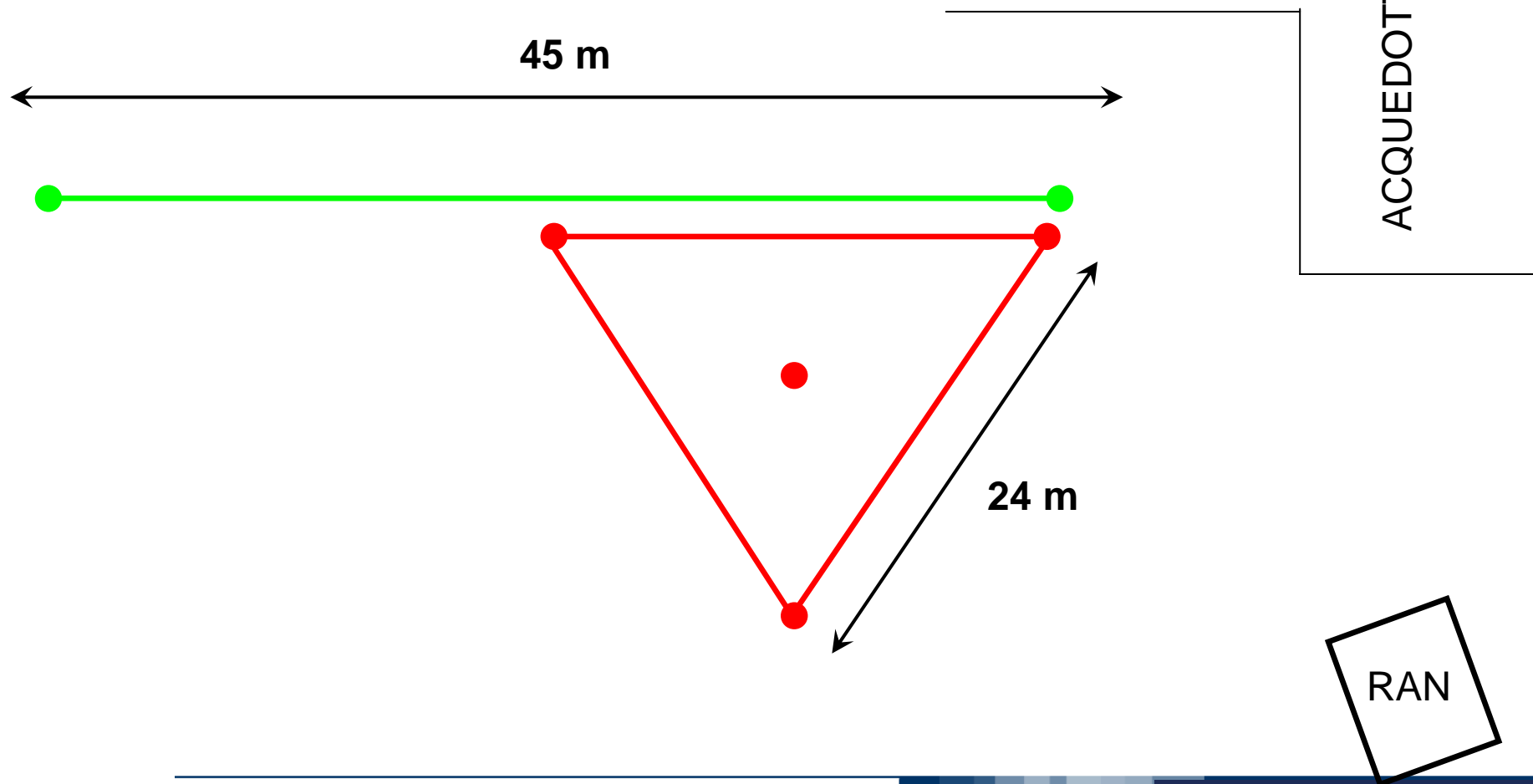| Itype	Code	Locality	Region	C_site	Technique	Instruments	# rec
D	RNS*	RONCO SCRIVIA	LIGURIA	rock	fk-attiva	geode 48 ch, geofoni V 4.5Hz	0
D	SEL*	SESTRI LEVANTE	LIGURIA	rock	fk-attiva	geode 48 ch, geofoni V 4.5Hz	0
D	GNV*	GENOVA	LIGURIA	rock	fk-attiva	geode 48 ch, geofoni V 4.5Hz	0
D	LSP*	LA SPEZIA	LIGURIA	rock	fk-attiva	geode 48 ch, geofoni V 4.5Hz	0
D	VRL*	VARESE LIGURE	LIGURIA	rock	fk-attiva	geode 48 ch, geofoni V 4.5Hz	0
A	TRT*	TORTONA	Piemonte		fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	1
A	NZZ*	NIZZA MON.	Piemonte		fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	1
D	PNR*	PINEROLO	Piemonte		fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	1
D	GEA	GELA	SICILIA	soft soil	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	0
D	CLG	CALTAGIRONE	SICILIA	rock	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	7+1
D	PTT0*	PATTI	SICILIA		fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	13+5
D	SPR*	SPERONE (MESSINA)	SICILIA	stiff soil	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	1
D	TOR*	TORTORICI	SICILIA	rock	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	6+2
D	ISI	ISPICA	SICILIA	rock	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	4+2
D	NTE	NOTO	SICILIA	stiff soil	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	6
D	PLZ	PALAZZOLO ACREIDE	SICILIA	stiff soil	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	8+1
D	SRC	SIRACUSA	SICILIA	rock	fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	4
A	GRR	GIARRE	SICILIA		fk-active&passive	geode 48 ch, geofoni V 4.5Hz&2Hz	6

Varese Ligure

VARESE LIGURE

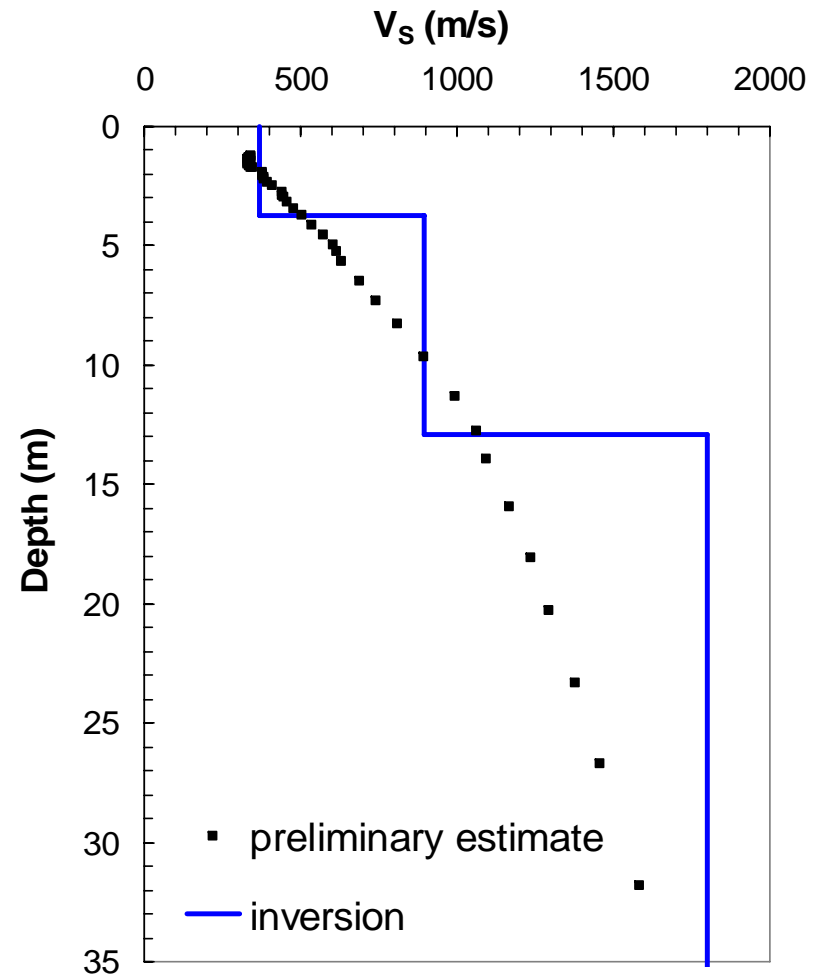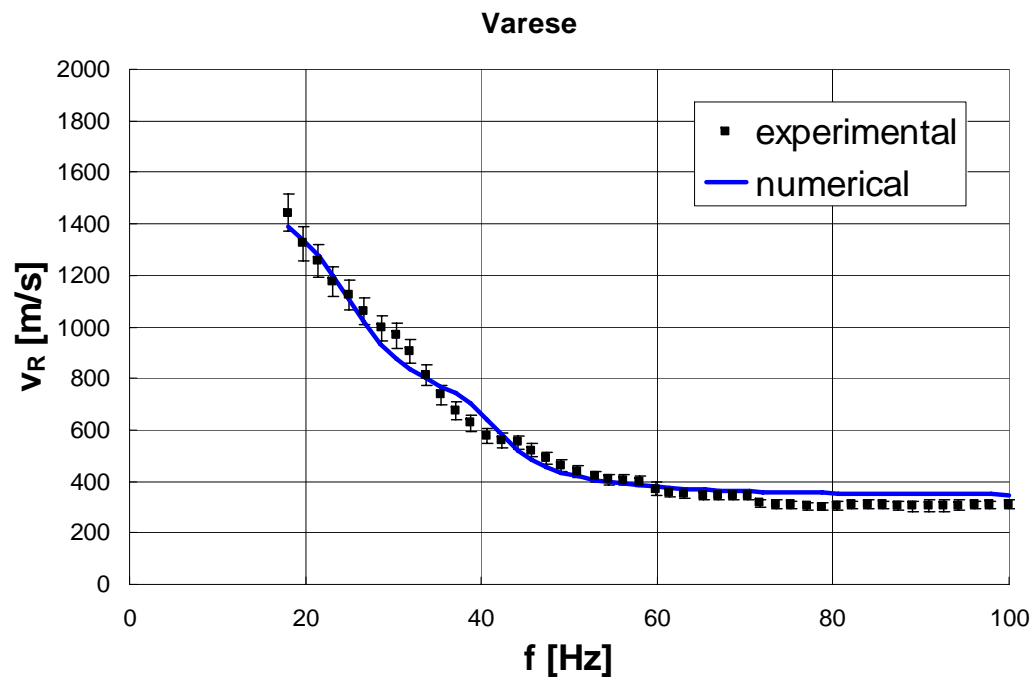SWM Attive L = 42.3 m; Dx = 0.9 m;
G = 48 - 4.5 Hz

SWM Passive G = 4 TX - 2 Hz

45 m

ACQUEDOTTO

24 m

RAN

UR4 Polito

VARESE LIGURE
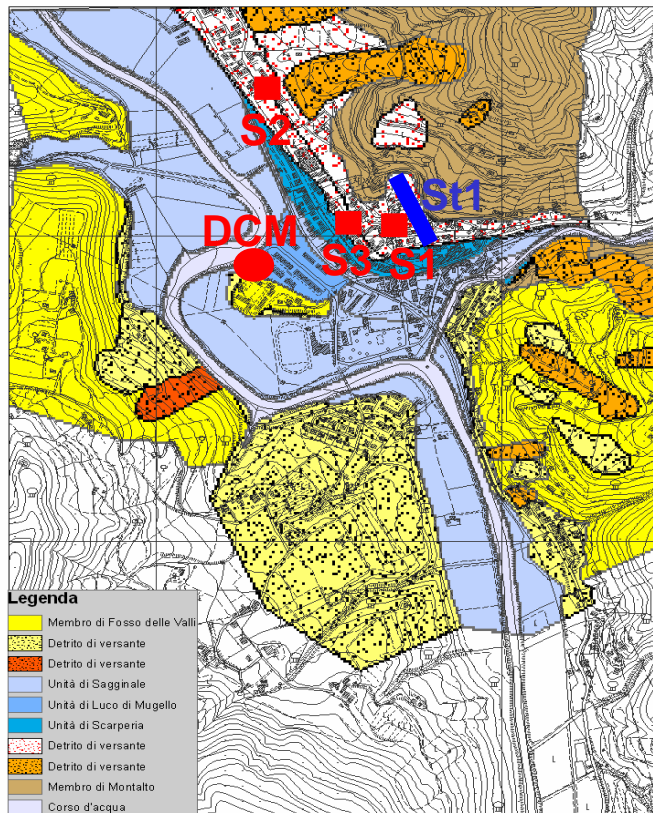
Detailed table for U2: 7 SELECTED SITES
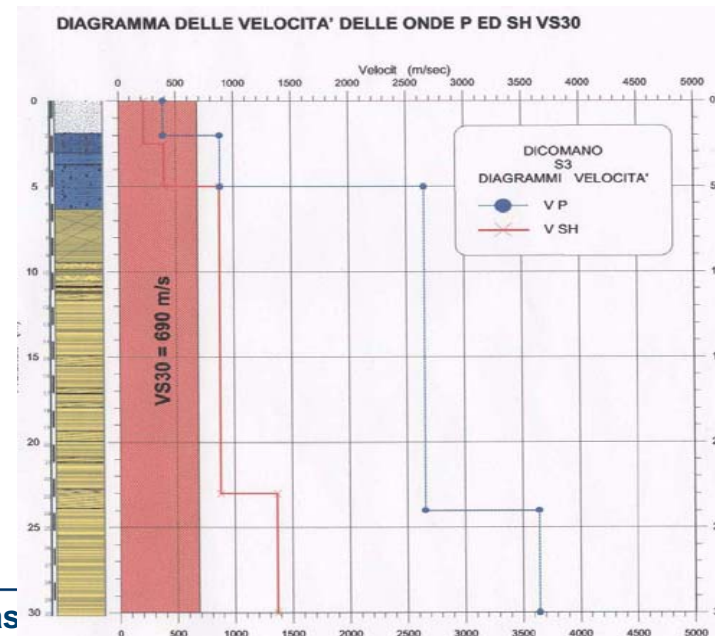## Regions: Abruzzo, Lazio, Toscana

Selected sites

Itype	Code	Locality	Region	C_site	Technique	Instruments	# rec
D	GSA	Assergi	Abruzzo	stiff soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	6+5
D	AVZ*	Avezzano	Abruzzo	soft-stiff soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	6+9
D	BTT2*	Borgo Ottomila	Abruzzo	soft soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	3
D	CSS	Cassino	Lazio	?	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	2+9
A	RTI	Rieti	Lazio	soft soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	6
D	BBN	Bibbiena	Toscana	?	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	1
D	DGA	Dicomano	Toscana	soft soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	0
D	FRE	Firenzuola	Toscana	?	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
A	MRT	Mercato San Severino	Campania	soft soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
D	TLS	Telese Terme	Campania	?	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
D	VRP	Vairano Patenora	Campania	?	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
D	SNN	Sannicandro Garganico	Puglia	stiff soil/rock	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
D	SSV	San Severo	Puglia	stiff soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	
D	SNS	San Sepolcro	Toscana	soft soil	ESAC-Fk active-passive	RefTek-Marslite, Lennartz Le3D 5s, Geode, Geospace 4.5 Hz	

Dicomano

Numero di registrazioni (triggers): 0

STESA LITOSTRATIGRAFICA St1 - ONDE P ed SH
Dicomano (FI) - Loc. Capoluogo

Legenda
355 m/s Velocità sismica onde P in metri al secondo
185 m/s Velocità sismica onde SH in metri al secondo
DHS1 Ubicazione prova down-hole in onde P ed SH
Limite stratigrafico
Terreni di riporto di spessore superiore a 2m (hr)
Detrito di versante (a)
Depositi alluvionali - Unità di Scarperia (SIV1=bl)
Siltiti e marne - Membro di Fosso delle Valli (FAL5)

Legenda
Membro di Fosso delle Valli
Detrito di versante
Detrito di versante
Unità di Sagginale
Unità di Luco di Mugello
Unità di Scarperia
Detrito di versante
Detrito di versante
Membro di Montalto
Corso d'acqua

Stazione installata nel centro dell abitato di Dicomano

DIAGRAMMA DELLE VELOCITA' DELLE ONDE P ED SH VS30

DICOMANO S3 DIAGRAMMI VELOCITA'
V P
V SH

VS30 = 690 m/s

Task 3 – Detailed table for U8-UR1

10 SELECTED SITES
Regions: Emilia Romagna, Basilicata (UR8)

Itype	Code	Locality	Region	C_site	Technique	Instruments	# rec
D	MAR	Matera	Basilicata	Stiff soil	ESAC-Fk	EDL- Mark-L4C-3D	4
D	LGN	Lagonegro	Basilicata	Stiff soil	ESAC-Fk	EDL- Mark-L4C-3D	4
A	GRM	Grumento Nova	Basilicata		ESAC-Fk	EDL- Mark-L4C-3D	3
D	SNA	Sant'Arcangelo	Basilicata		ESAC-Fk	EDL- Mark-L4C-3D	1
D	CES*	Cesenatico	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	0
D	SSU*	Sassuolo	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	0
D	ARG*	Argenta	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	0
D	FAZ*	Faenza	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	5
D	CTL*	Cattolica	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	0
D	RIM*	Rimini	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	0
A	NVL*	Novellara	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	4
D	FER	Ferrara	Emilia R.	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	
D	NOR	Norcia	Umbria	soft soil	ESAC-Fk	EDL- Mark-L4C-3D	>100

*performed survey   excluded sites

Argenta

Accelerometer

75 m

100 m

FAENZA

Scuola Elementare
MARTIRI DI CEFALONIA

School garden

Communication gate between the two school

RAN station

TASK3: Characterization of ROCK SITES

The activity aims at developing an experimental protocol to carry out rapid and low-cost seismic characterization of stiff soil/rock mass sites by the joint analysis of geomechanical/geotechnical and geophysical data.

The protocol is based on:

1. Geological survey around the accelerometric station;

2. Identification of morphological properties of the site and quantification of fracture-level through synthetic parameters;

3. Passive seismic surveys (single station and array configurations) in order to evaluate the presence and the role of possible sub-soil alteration phenomena.

10 SELECTED SITES
Regions: Lazio, Abruzzo, Molise, Calabria, Basilicata (UR5)

Itype	Code	Locality	Region	C_site	Technique	Instruments	# rec
D	CMM	CASTIGLIONE MESSER MARINO	Abruzzo	Rock	ESAC/HVSR/Interf/Geomecc	Tromino, Brainspy	11
D	CPS	CAPESTRANO	Abruzzo	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	16
D	SCN	SCANNO	Abruzzo	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	1
D	RSN	ROSSANO	Calabria	stiff soil	ESAC/HVSR/Geomecc	Tromino, Brainspy	13
D	VBM	VIBO MARINA	Calabria	soft soil	ESAC/HVSR/Geomecc	Tromino, Brainspy	1
D	VBV	VIBO VALENTIA	Calabria	stiff soil	ESAC/HVSR/Geomecc	Tromino, Brainspy	10
D	BVM	BOVA MARINA	Calabria	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	2
A	ATN*	ATINA	Lazio	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	2
A	MTC*	MONTECASSINO (CASSINO)	Lazio	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	1
D	SCM	S. CROCE DI MAGLIANO	Molise	Rock	ESAC/HVSR/Geomecc	Tromino, Brainspy	5

*performed survey

Alternative sites

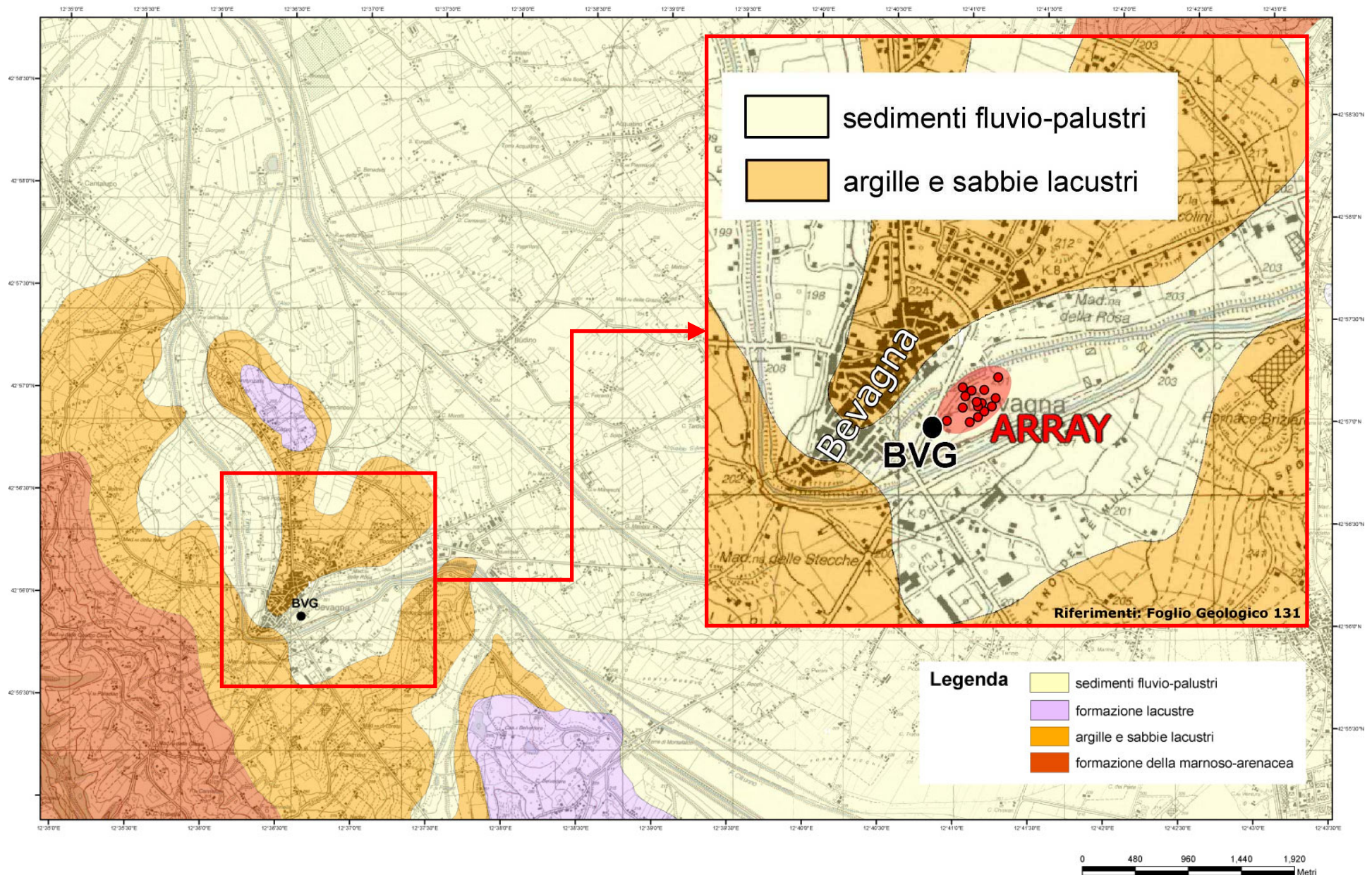| A/D	Code	Locality	Region	# Rec. (al 12/07)
D	CDS	CASTEL DI SANGRO	Abruzzo	4
D	LDP	LAMA DEI PELIGNI	Abruzzo	22
D	PSC	PESCASSEROLI	Abruzzo	12
D	ACR	ACRI	Calabria	6
D	CVL	CASTROVILLARI	Calabria	3
D	MRM	MORMANNO	Calabria	3
D	NCO	NICOTERA (SCUOLA)	Calabria	2
D	SCI*	SCILLA	Calabria	3
D	SGV	S. GIOVANNI IN FIORE	Calabria	15
D	SPS	SPEZZANO DELLA SILA	Calabria	8
D	SSA	S. STEFANO IN ASPROMONTE	Calabria	13

*performed survey

MONTECASSINO

Geology

Geo-mechanical observation

Passive seismic survey
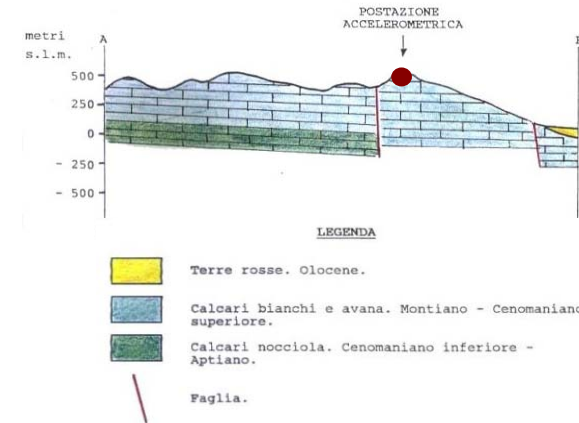
Linear arrays: 100x50 m

Task 3 − Benchmark case: the blind prediction of Bevagna Vs profile

sedimenti fluvio-palustri

argille e sabbie lacustri

Bevagna

BVG

ARRAY

Riferimenti: Foglio Geologico 131

Legenda
sedimenti fluvio-palustri
formazione lacustre
argille e sabbie lacustri
formazione della marnoso-arenacea

BVG

0   480   960   1,440   1,920
Metri
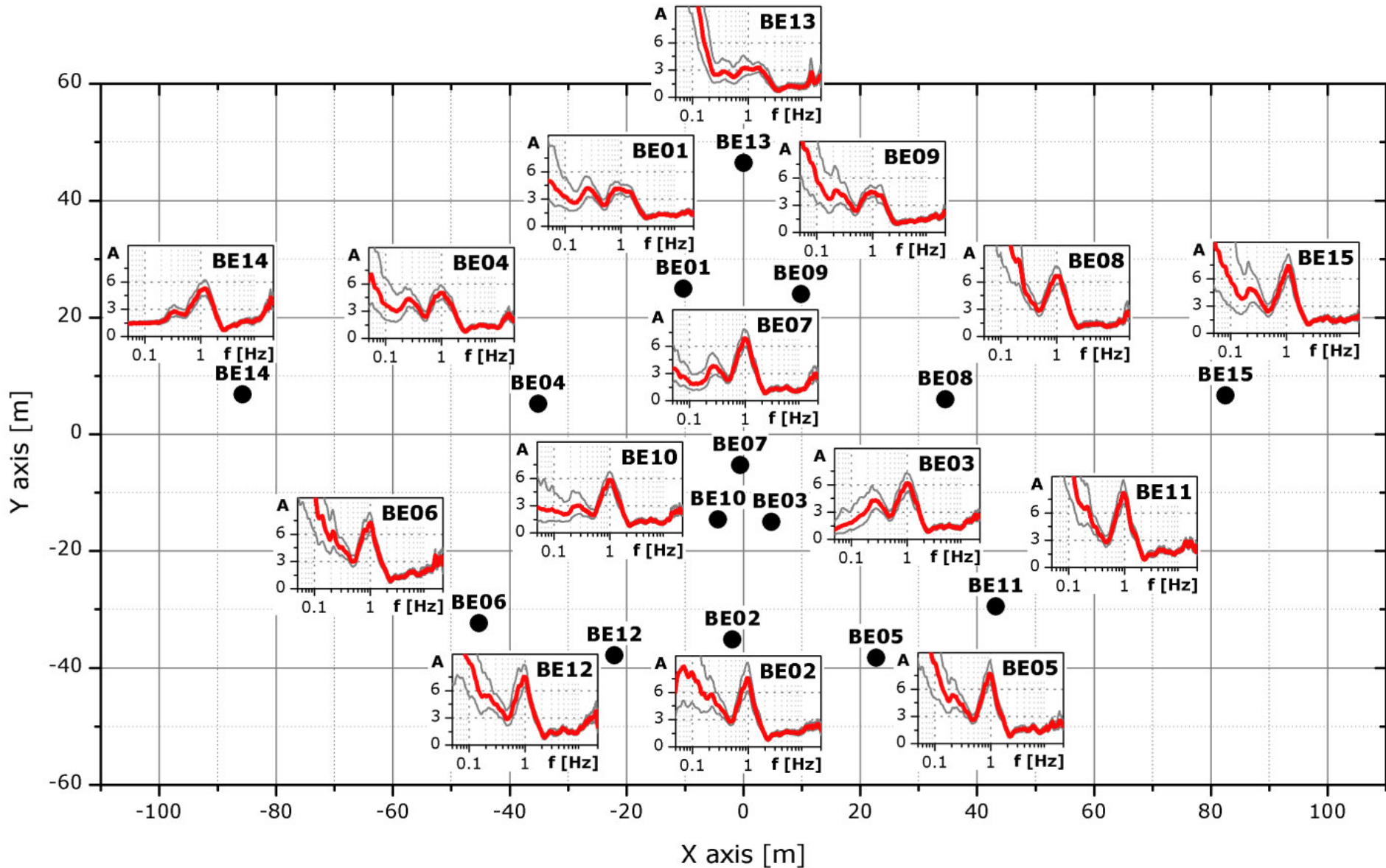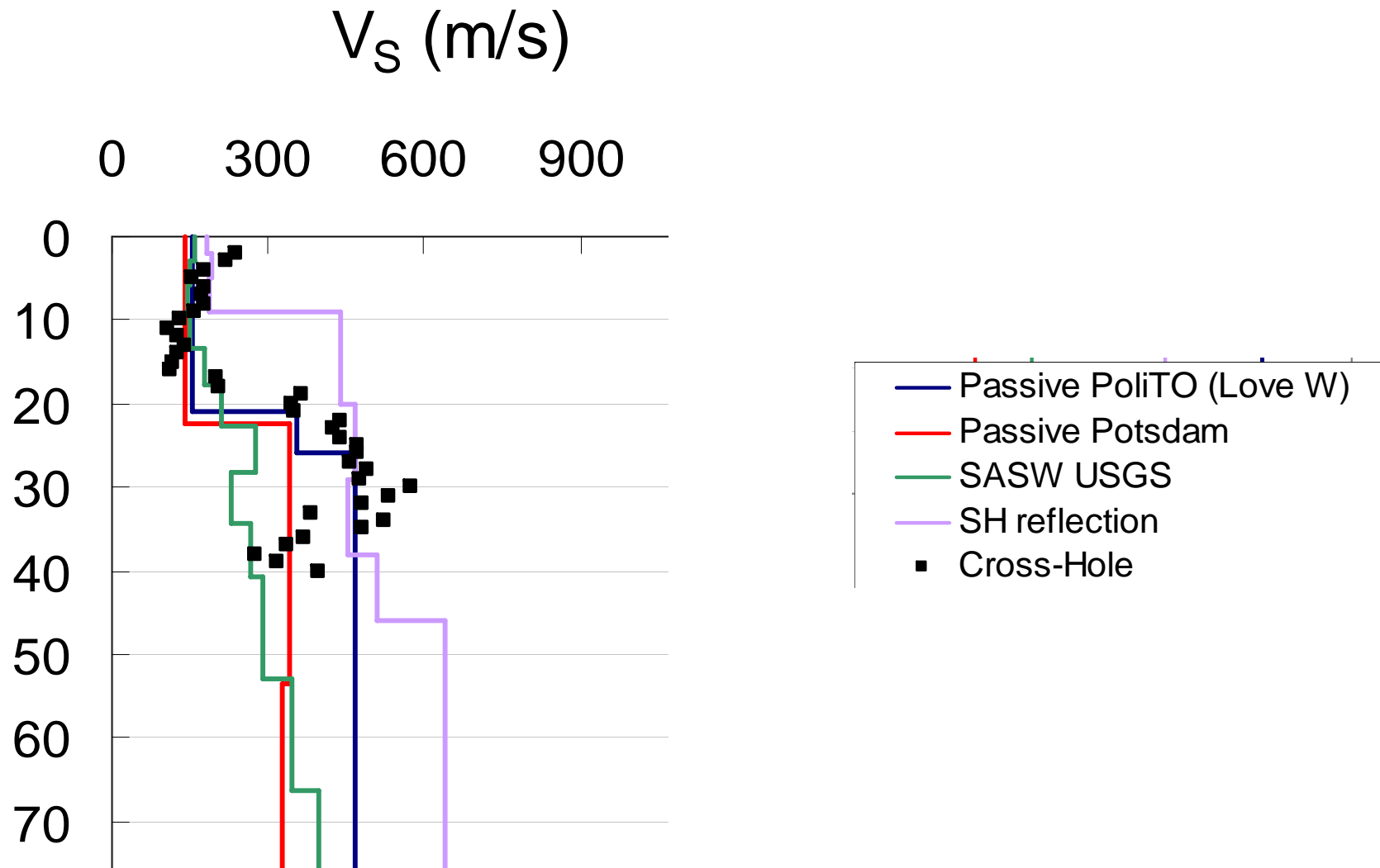
Task 3 – Survey of existing Vs profiles

USGS - SASW tests Umbria-Marche

| SITE	SITE NAME	TOWN	REGION	LAT	LON	NEHRP	Vs_30 (m/s)	NEHRP(SUB)	VS_100 (m/s)
254BEV	BEVAGNA CHURCH ST	BEVAGNA	UMBRIA	42.932	12.611	D	182	D-	278
255 SMI	MARIA	FOLIGNO	UMBRIA	42.954	12.699	C	395	C-	527
256CSA	CASTEL NUOVO ASSISI	ASSISI	UMBRIA	43.008	12.591	D	293	D+	440
257CLF	COLFIORITO	COLFIORITO	UMBRIA	43.037	12.921	D	317	D+	719
258CLC	COLFIORITO-CASERMETTE	COLFIORITO	UMBRIA	43.029	12.890	C	405	C-	720
259NCR	NOCERA STATION-B	NOCERA	UMBRIA	43.111	12.785	C	428	C-	938
260NCB	BISCONTIN STATION-C	UMBRA - B NOCERA	UMBRIA	43.104	12.805	C	442	C-	823
261NCS	GRAVEL ROAD	UMBRA - C	UMBRIA	43.148	12.791	C	694	C+	1170
262GBP	GUBBIO SOIL SITE PIANA	GUBBIO	UMBRIA	43.314	12.590	C	492	C+	864
263GBB	GUBBIO - PARK COLLO	GUBBIO	UMBRIA	43.358	12.595	B	922	B-	1759
264NCI	NORCIA INDUSTRIAL PARK	NORCIA	UMBRIA	42.780	13.097	C	551	C+	546
265NRC	NORCIA SITE C	NORCIA SITE C	UMBRIA	42.792	13.097	C	677	C+	1148
266NRA	NORCIA TEMP. STA. A	NORCIA	UMBRIA	42.796	13.081	D	218	D-	264
267CSC	CASCIA	CASCIA	UMBRIA	42.719	13.012	C	540	C+	993
268CSP	CASCIA PETRUCCI APTMTS	CASCIA	UMBRIA	42.718	13.018	D	339	D+	488
269SLW	SELLANO WEST	SELLANO	UMBRIA	42.886	12.922	C	509	C-	713
270MTL	MATELICA	MATELICA	MARCHE	43.248	13.008	C	437	C-	767

USGS - SASW tests Umbria-Marche

Problems with phase unwrapping in experimental data

Comparison of CH profiles at Sturno (Irpinia)
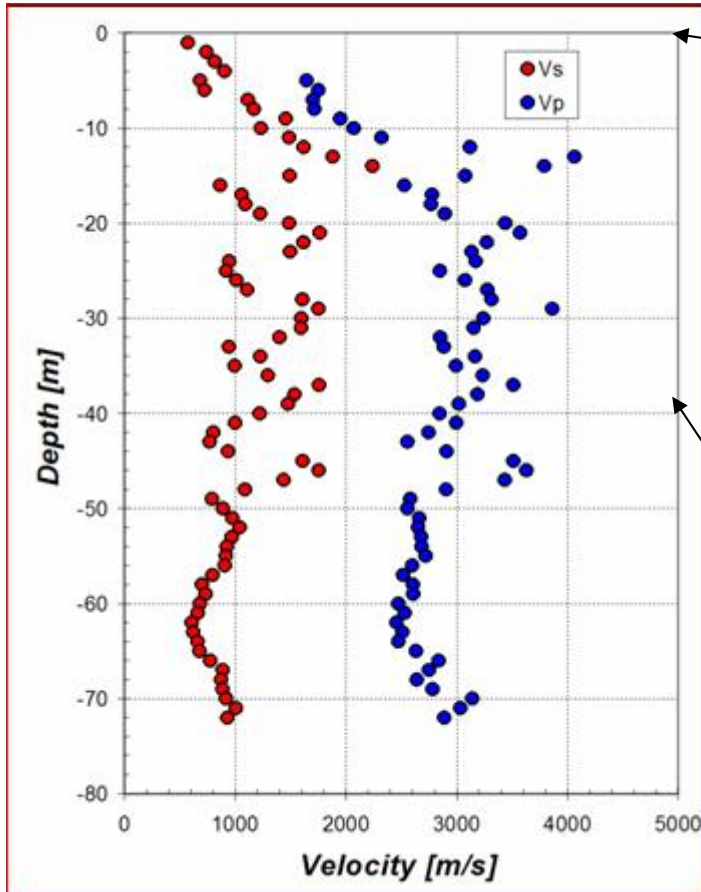
ISMES 1991; EC8=A
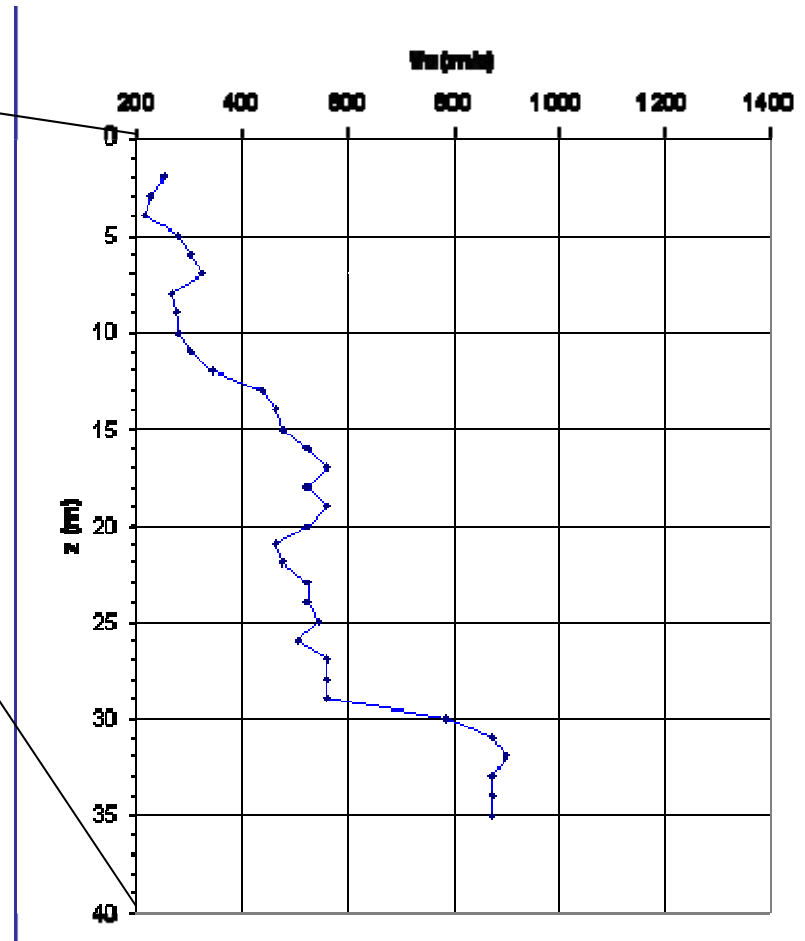
Prof. E. Cardarelli University of
Rome "La Sapienza" 2007; EC8=B

3. Site characterization by surface waves methods				
Definition of procedures for site characterization	X			
Application of active and passive techniques to several existing datasets and comparison of results obtained by different research groups	X	X		
Determination of shear wave velocity profiles at a selected number of accelerometer stations		X	X	
Synthesis of results and inclusion in ITACA through Task 2				X

Planned

Completed, although reduced in scope

Started on schedule

Problems

This task is going on schedule.

Problems to assess the reliability of some of the existing V_s profiles.

Number of stations with seismic site characterization still insufficient → funding for new DHs at selected sites?