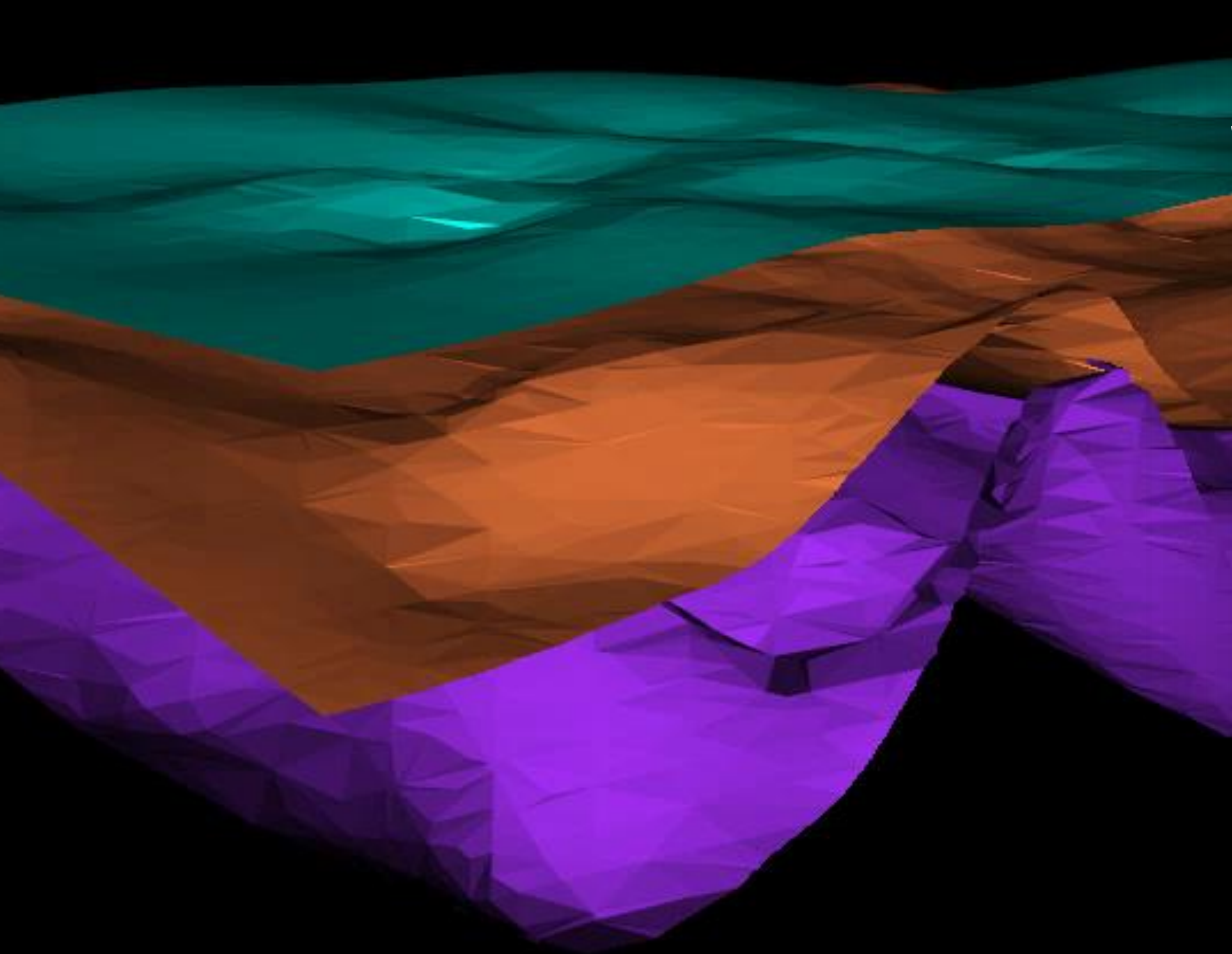

3D GEOLOGICAL MODELLING OF THE WESTERN SECTOR OF THE PO PLAIN (ITALY) FOR SEISMIC SITE RESPONSE EVALUATION

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Vienna, 28 April, 2023

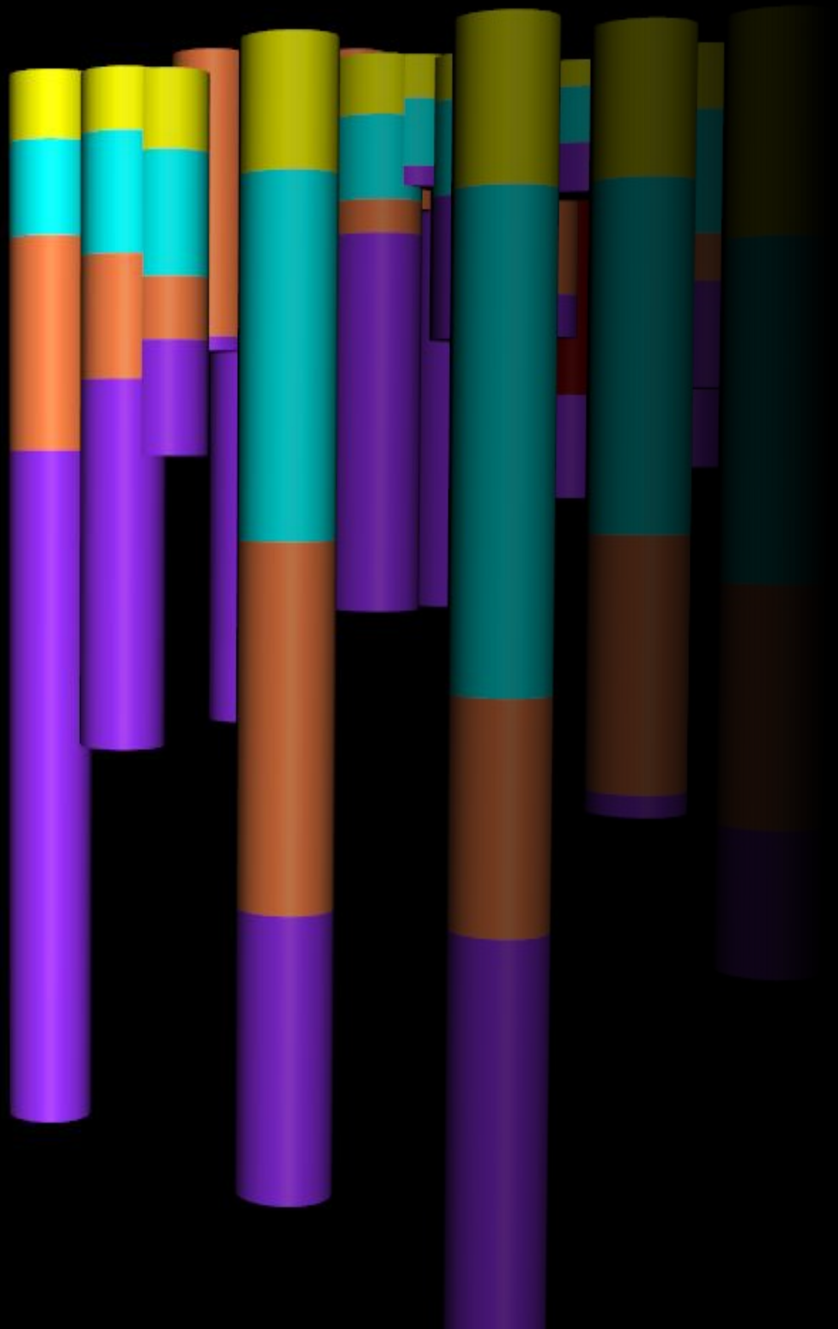
Aim of this study

I. Create a 3D seismostratigraphic model of the west-central sector of the Po Plain (Northern Italy).

II. Build the Pliocene base, the marine Quaternary and the continental Quaternary base.

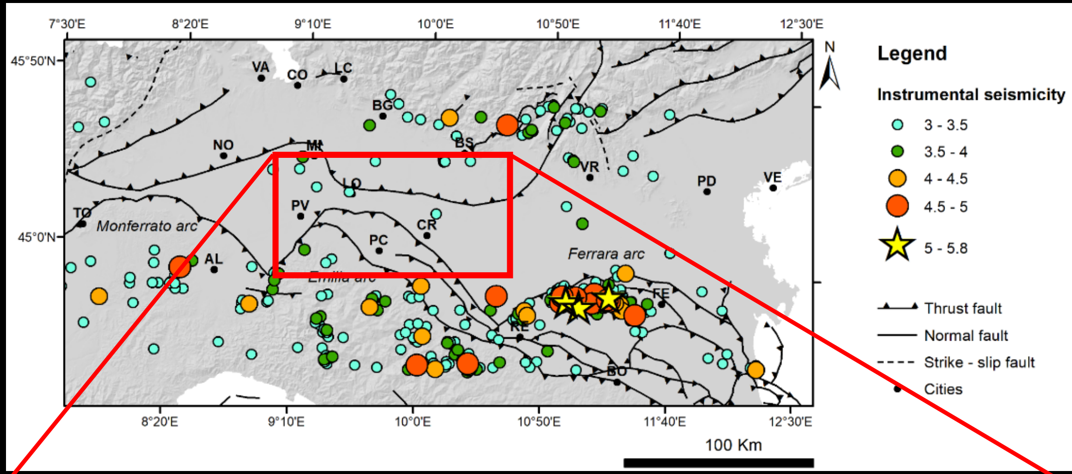
III. Assign them geophysical properties such as Vs gradients and Vs_{30}.

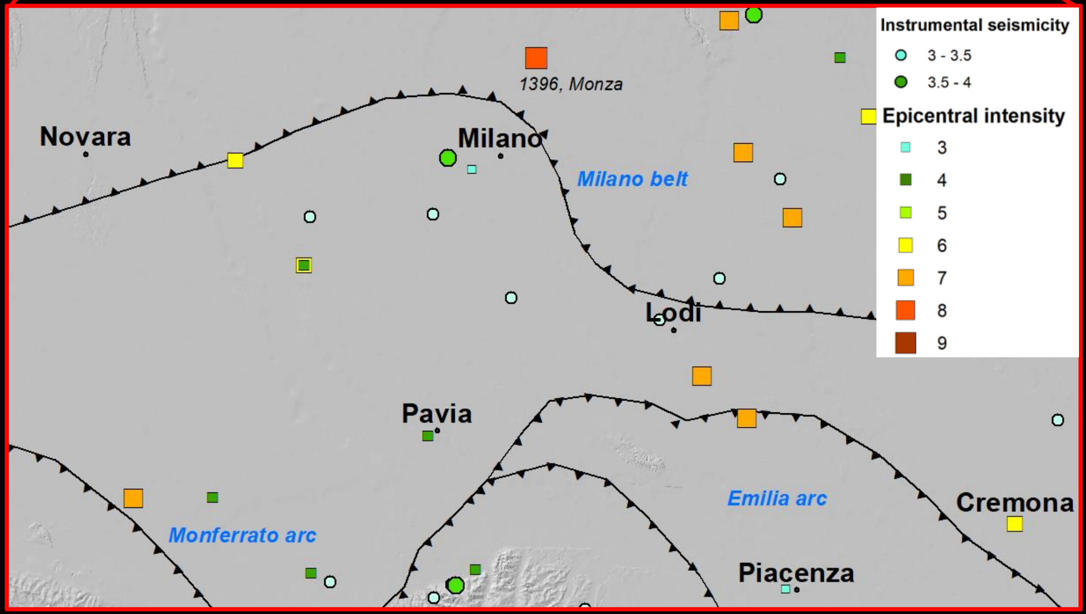
IV. Validate the model with empirical observations from site characterization studies.



The western Po Plain sedimentary basin

- Foreland of two mountain chains of opposite vergence (Alps and Apennines)
- **Sedimentation**: dismantling + fluvial sedimentation + Pleistocene glaciations → **8 km** in the depocenters
- **Tectonic structures**: Milano belt and Apennine arcs
- Seismic hazard is not evenly distributed but **historical earthquakes occurred in the study area** (1396 Monza, VIII MCS)





Workflow

1 DATA COLLECTION

Literature data

Geological cross-sections

Stratigraphic and velocity data

VIDEPI project
Vs profiles

Microtremor data

Single station measurements

2 ELABORATION

Geological cross-sections digitizing

VIDEPI and sonic logs elaboration, Vs_{30} Map

HVSR analysis and f_0 identification with Geopsy

3 3D MODELLING

3D SEISMOSTRATIGRAPHIC MODEL in GeoModeller

i) **Pliocene base**
ii) **Pleistocene base**
iii) **Continental – Marine Quaternary transition**

↓

iv) Vs_{30} map at the top
v) Vs gradients to the modelled units

4 VALIDATION

1D ground response analysis with STRATA

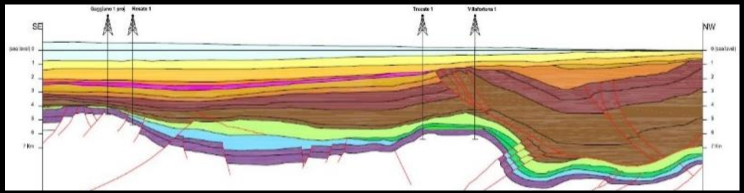
Cross – check of 1D ground response with HVSR and the seismostratigraphic model

1 Data collection

Literature data

11
Geological cross-sections

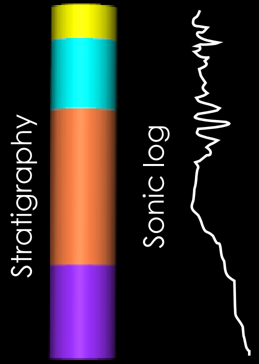
- 9 from Pieri and Groppi, 1981
- 1 from Casero, 2004
- 1 from Fantoni and Franciosi, 2010
- 1 from Maesano et. al., 2015



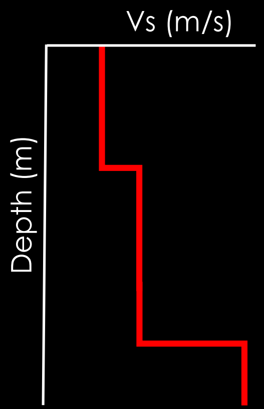
Casero, 2004

Stratigraphic and velocity data

336
VIDEPI boreholes and 46 sonic logs

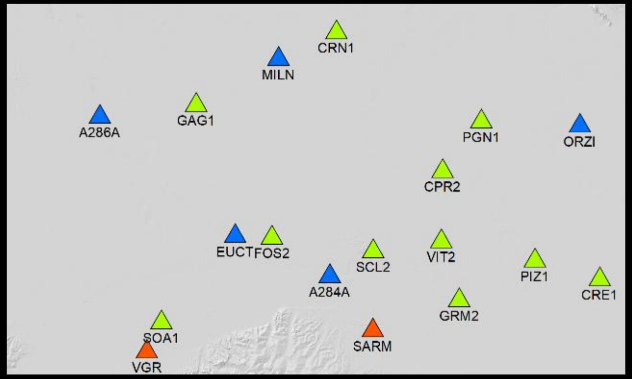


1850
Shallow Vs profiles



Microtremor data

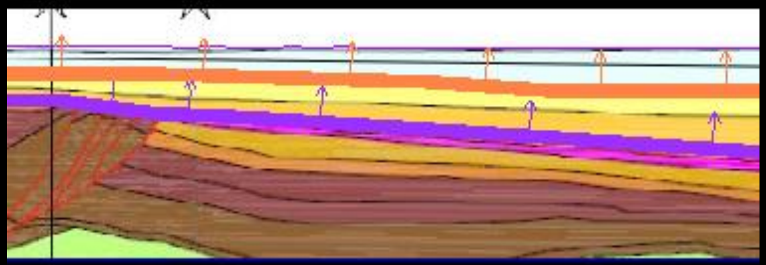
18
Seismic stations



- Permanent stations (IV, Z3)
- Permanent stations (IT)
- Temporary stations

2 Data elaboration

Cross – sections digitizing



Casero, 2004

Pliocene top

Miocene top

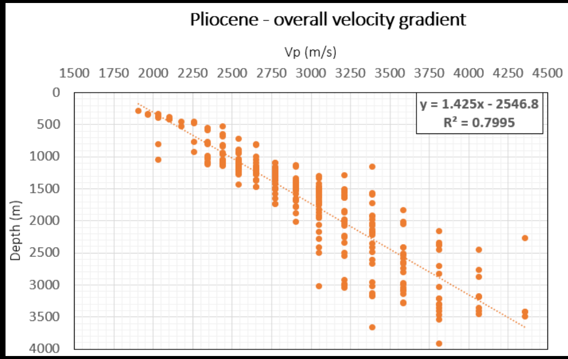
VIDEPI boreholes management and Vs profiles

VIDEPI Borehole stratigraphies in a .csv file

ID Borehole	From	To	Litho
BELGIOIOSO_001	0	250	QC
BELGIOIOSO_001	250	308	QM
BELGIOIOSO_001	308	470	P
BELGIOIOSO_001	470	1500	M

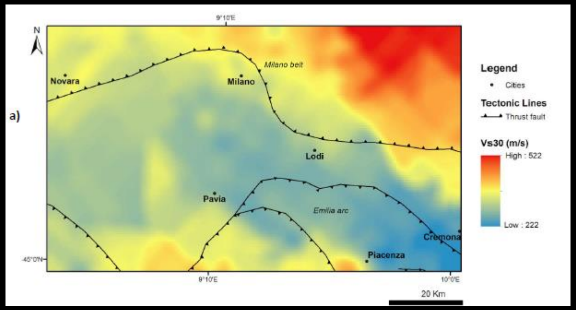
From **VIDEPI sonic logs** to velocity gradients

$$Vs = \frac{Vp}{\sqrt{3}}$$

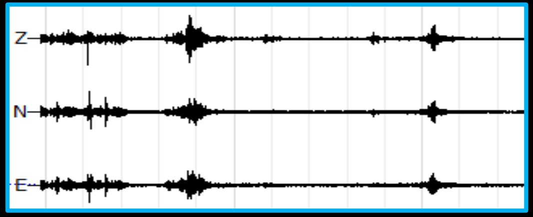


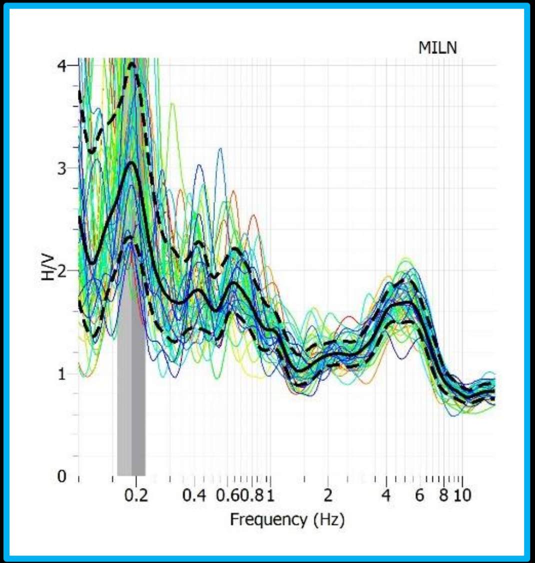
Vs_{30} map

from shallow Vs profiles (MASW, DH, REMI, ESAC)



H/V analysis

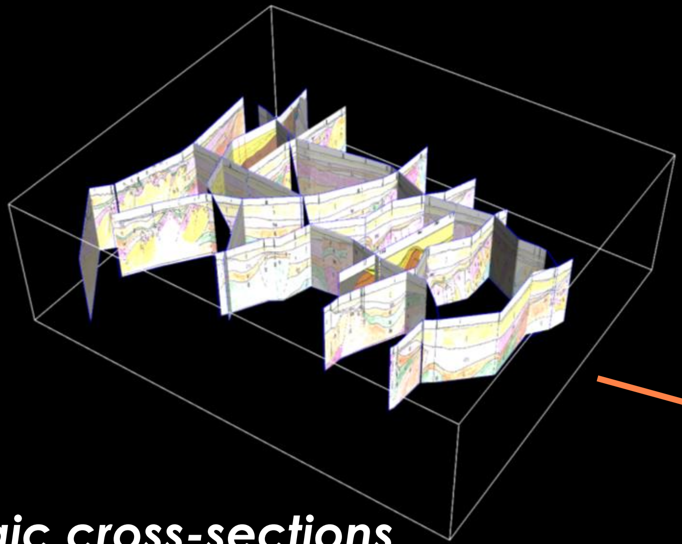




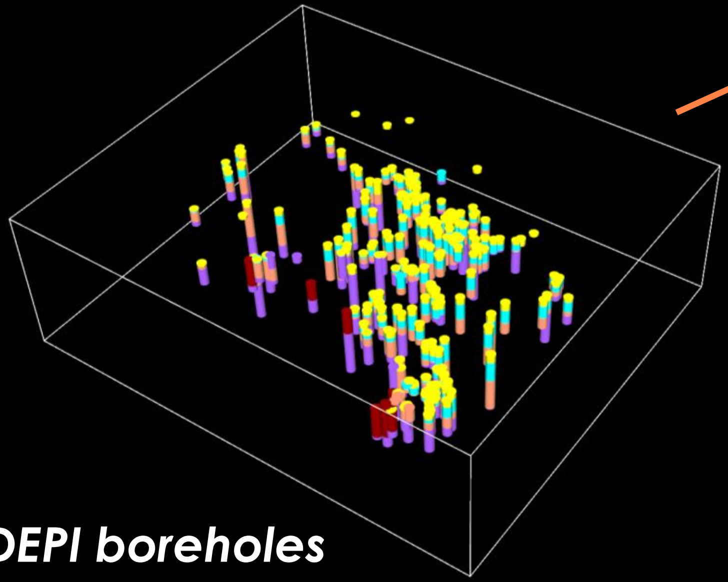
Fundamental frequency f_0

3

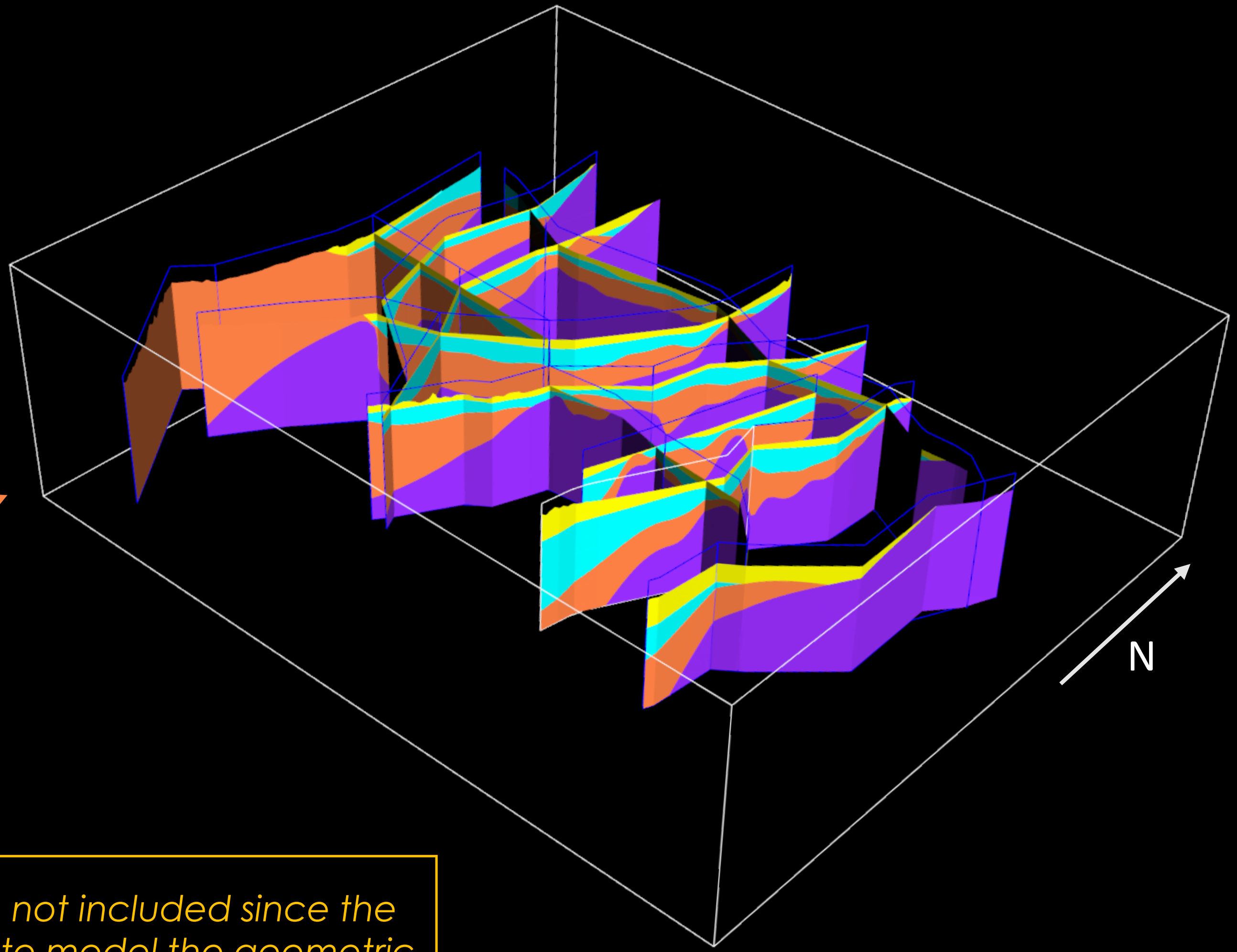
3D modelling



Geologic cross-sections



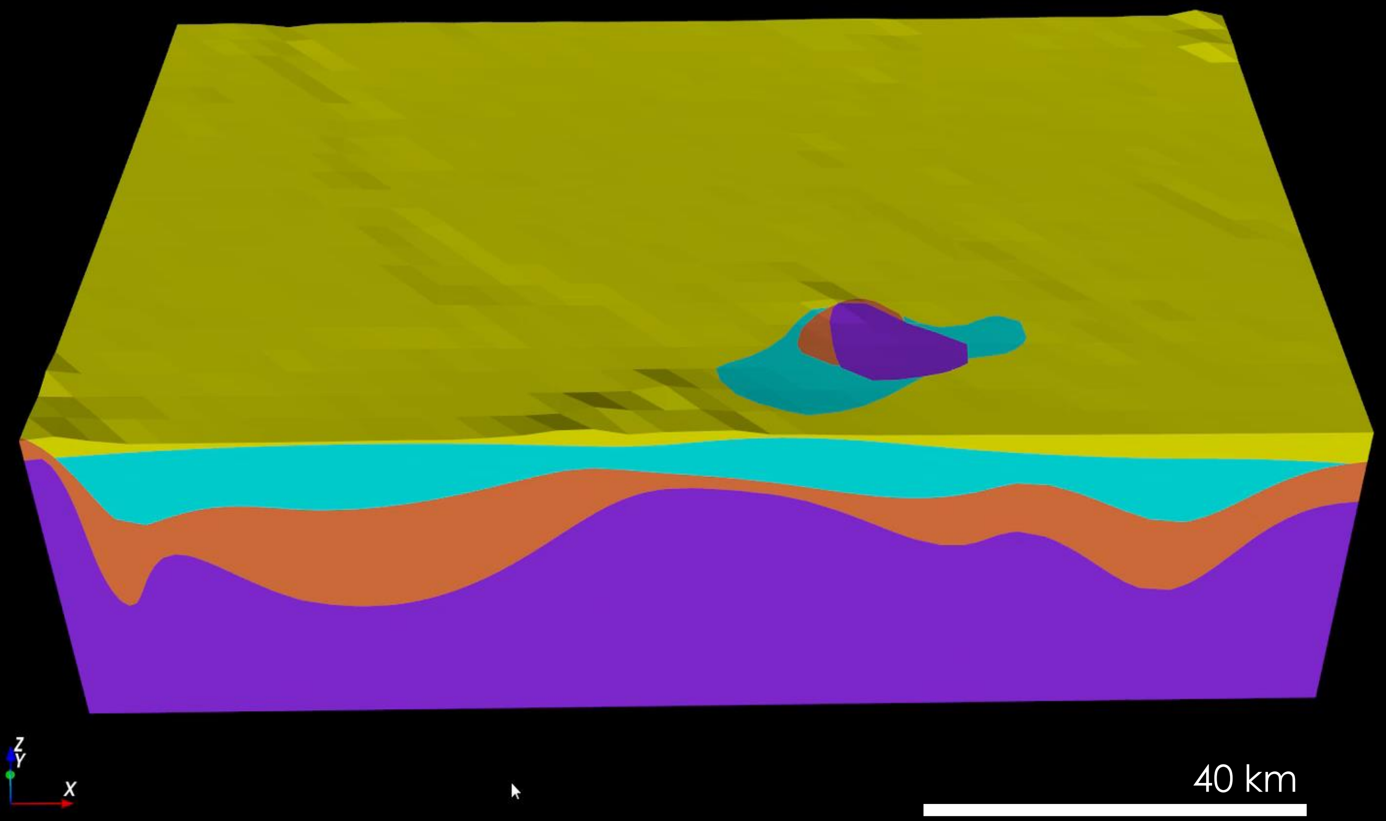
VIDEPI boreholes



Faults are not included since the purpose is to model the geometric relations among sedimentary units

3D geological modelling

Y axis indicates the North



Stratigraphic pile

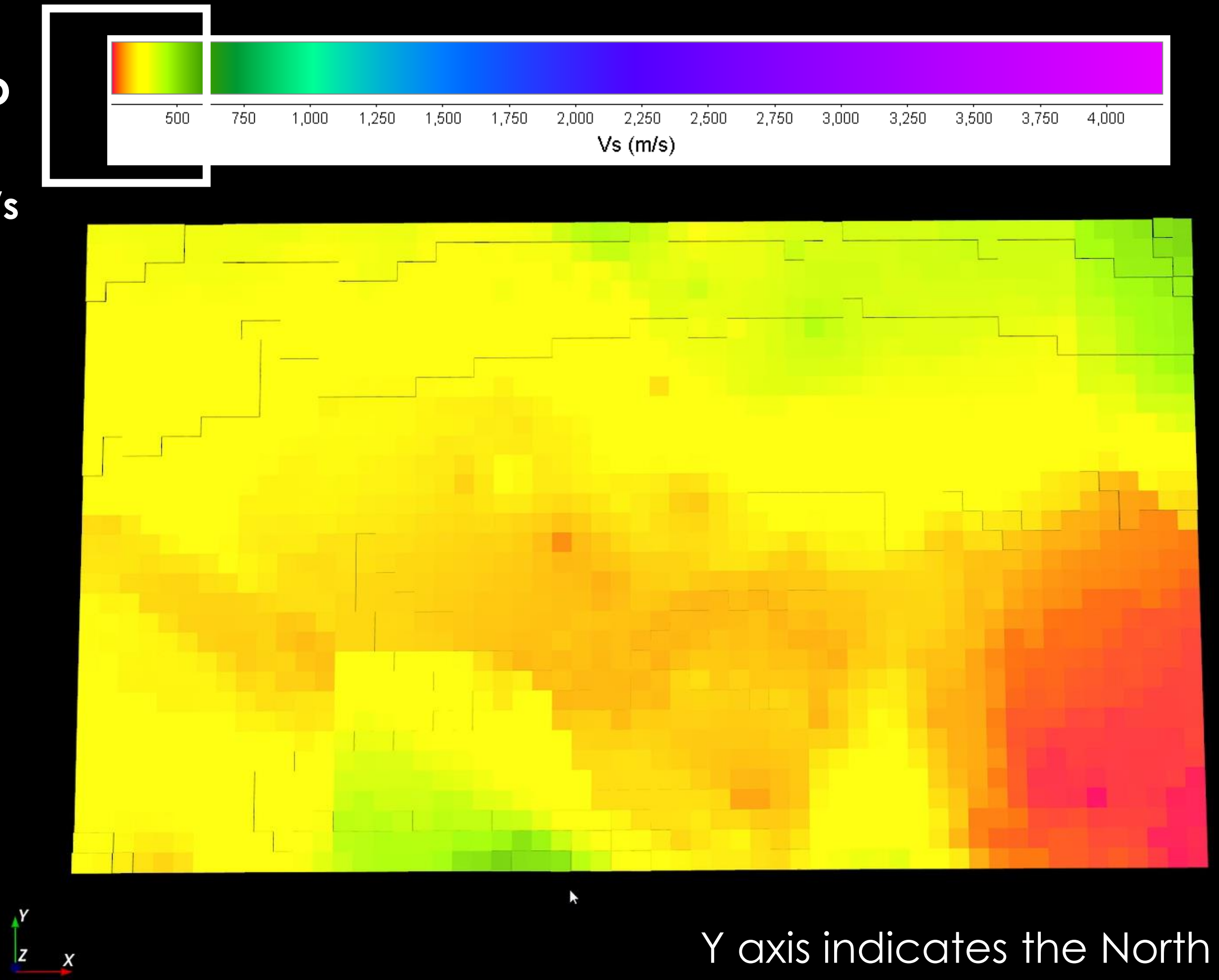
- Continental Quaternary
- Marine Quaternary
- Pliocene
- Miocene

The interpolation is less reliable close to San Colombano hill

Assignment of geophysical properties

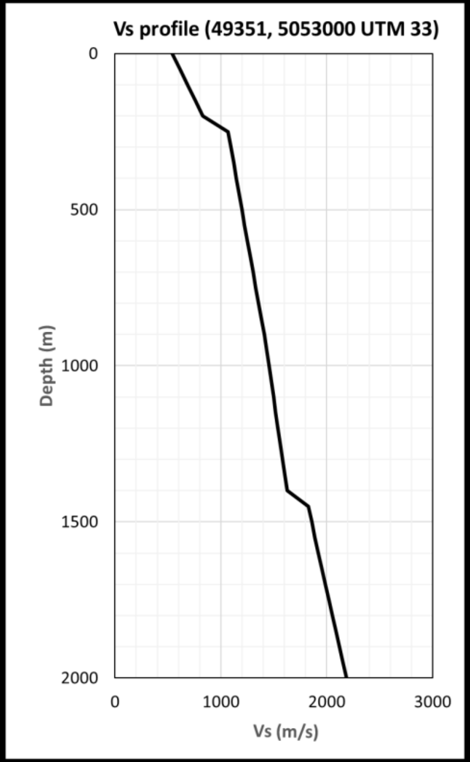
Vs_{30} map

222-522 m/s



Y axis indicates the North

A shear wave velocity profile can be obtained for any set of coordinates (lat – lon) with a 2 x 2 km detail

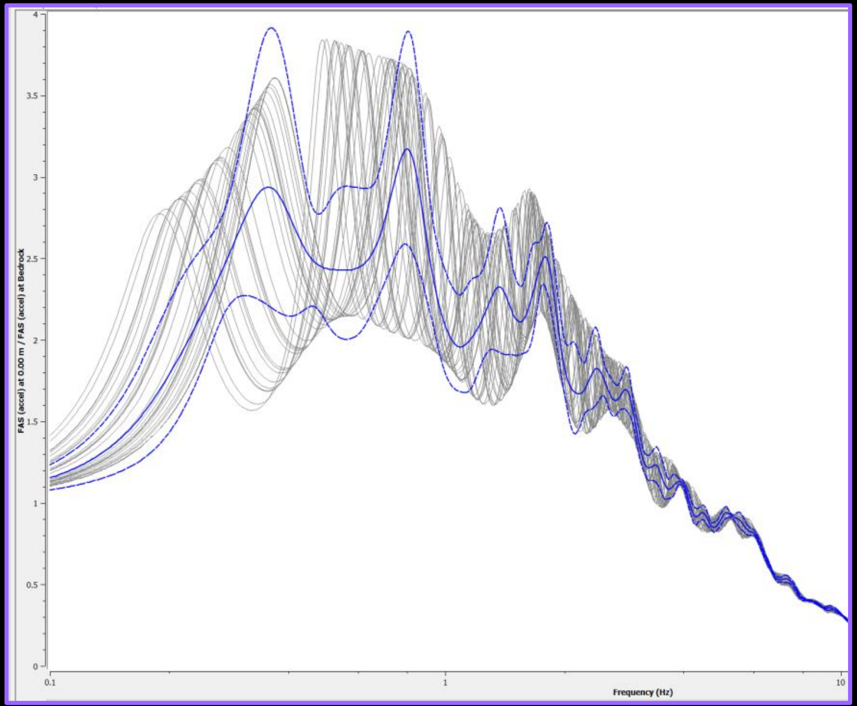


4

Validation – 1D ground response analysis

INPUT in STRATA

- **18 Vs profiles** extracted from the seismostratigraphic model
- Assignment of unit weight and damping to the sediments
- One accelerogram as input motion in the time domain (**linear elastic approach**)
- **50 randomizations** for each velocity profile varying the bedrock depth (Pliocene base)

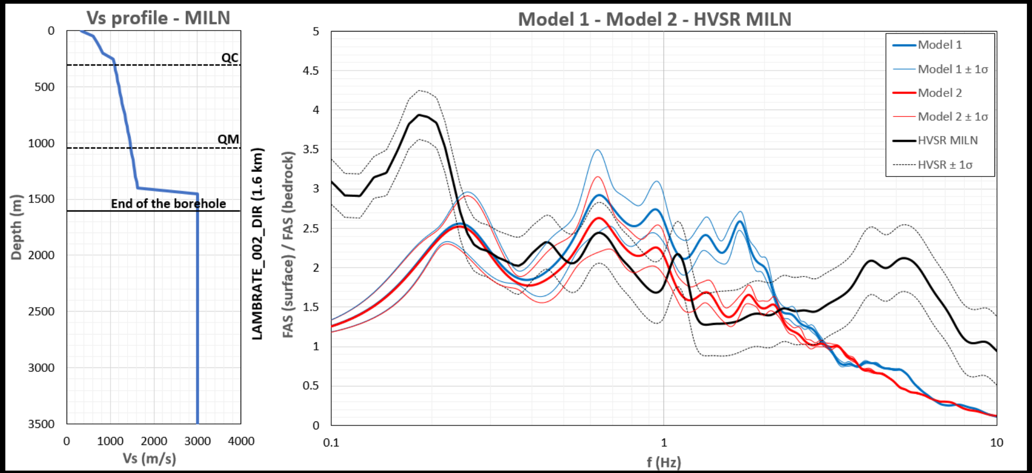


OUTPUT in STRATA

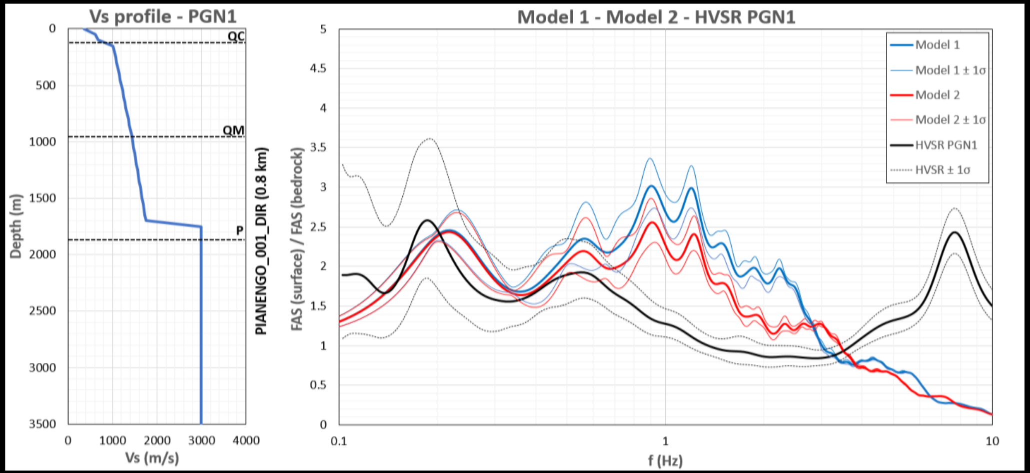
The ratio of **Fourier Amplitude Spectra (FAS)** between the sediments and the outcropping bedrock in a frequency range between 0.1 Hz and 10 Hz.

Validation - results

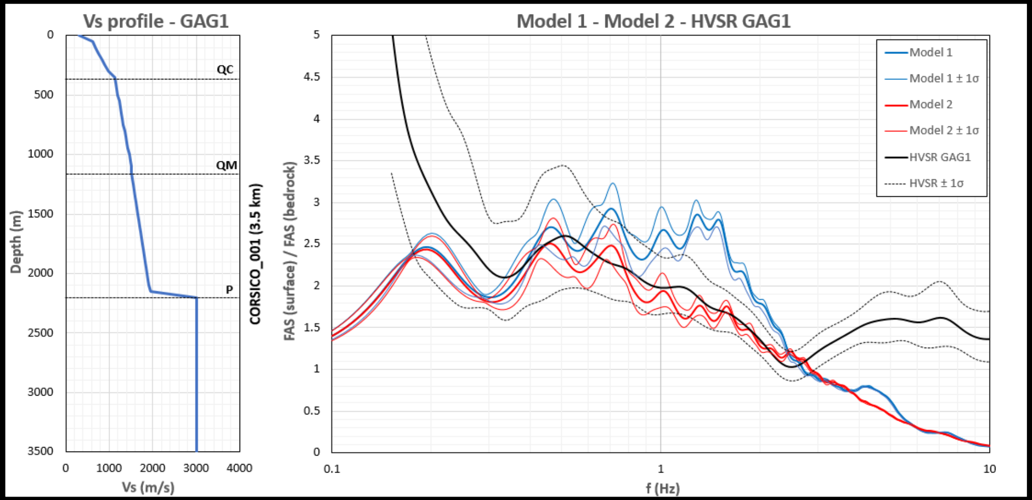
Milano station



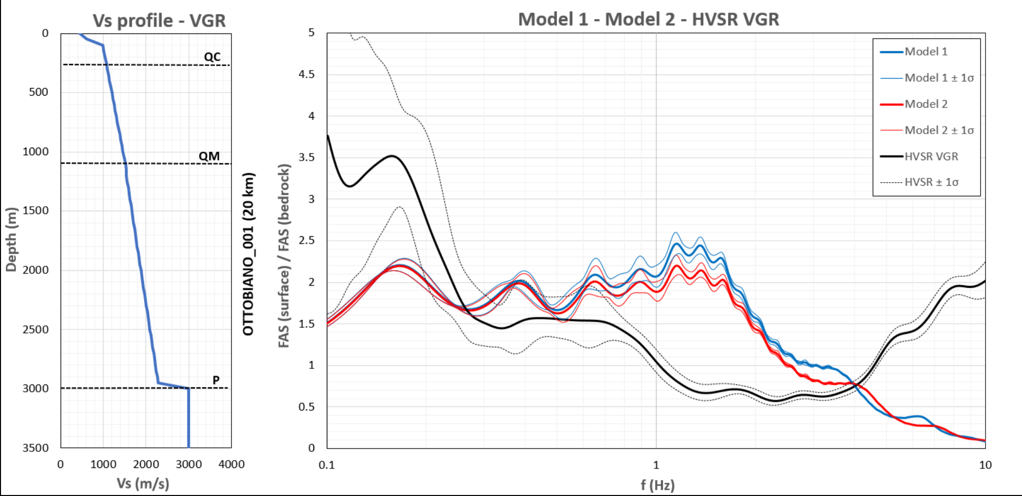
Pianengo station



Gaggiano station



Voghera station



Conclusions

- We built a 3D seismostratigraphic model of the western-central Po Plain area, including the geophysical properties of the following units: **i) Miocene, ii) Pliocene, iii) marine Quaternary, and iv) continental Quaternary**
- Validation comparing 1D ground response modelling and H/V curves
- **f_0 0.1 – 0.3 Hz** > Pliocene base in the depocenters
- **f_0 0.5 – 0.8 Hz** > Pliocene base close to the San Colombano hill

Improvements:

1. Thrust fault modelling close to the Emilia arc
2. Additional microtremor measurements
3. Additional detailed geological cross – sections

Future applications:

1. Computation of earthquake shaking scenarios considering site effects
2. Computation of site amplification with 2D/3D numerical modelling

} **Relevant for seismic hazard analysis**

Thank you for your attention!

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