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Earthquake Mitigation in the Lisbon and Lower Tagus Valley area, Portugal

1 J. Carvalho, R. Dias, C. Pinto, T. Cunha, J. Leote
2 S. Vilanova, J. Narciso
3 J. Borges
4 R. Ghose

1 Laboratório Nacional Energia e Geologia, Portugal
2 Instituto Superior Técnico, Portugal
3 Centro Geofísica de Évora, Portugal
4 Delft University of Technology, The Netherlands

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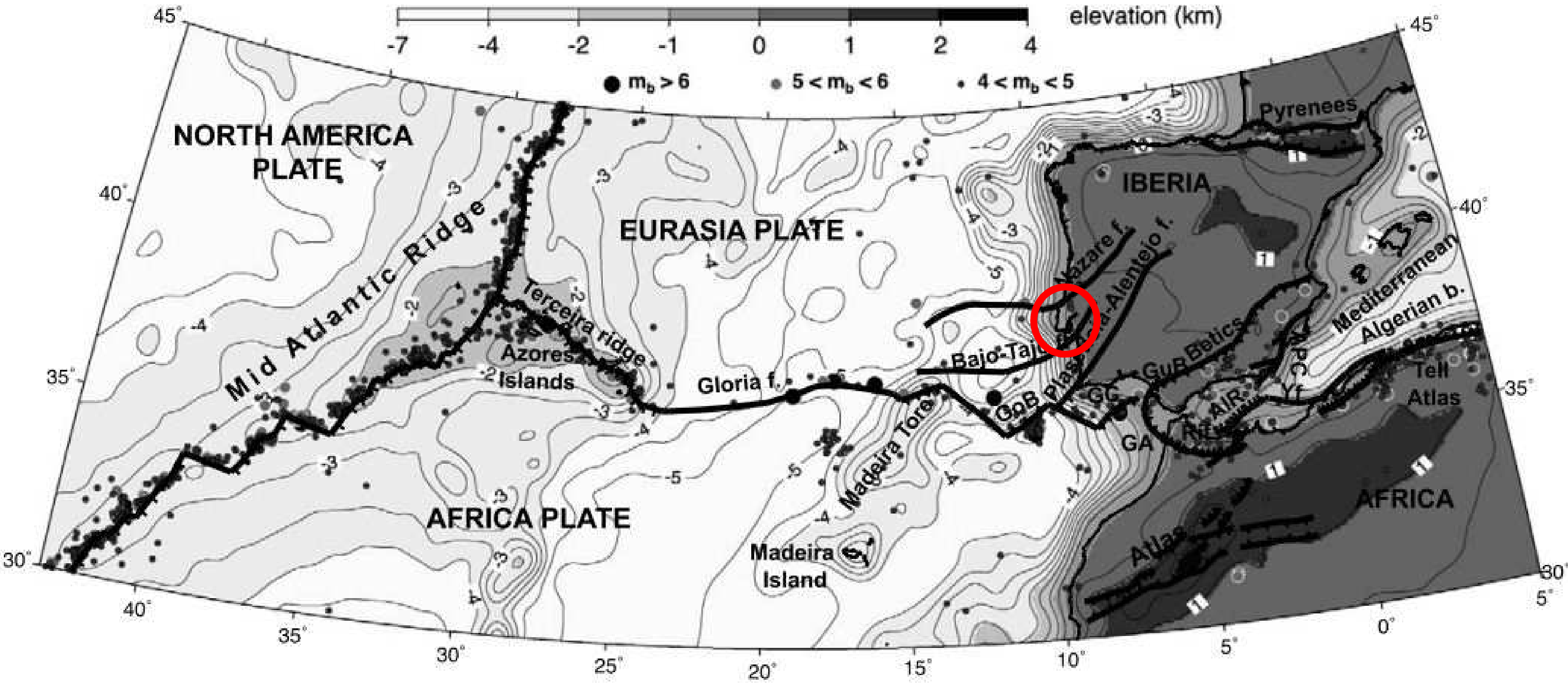
Presentation Outline

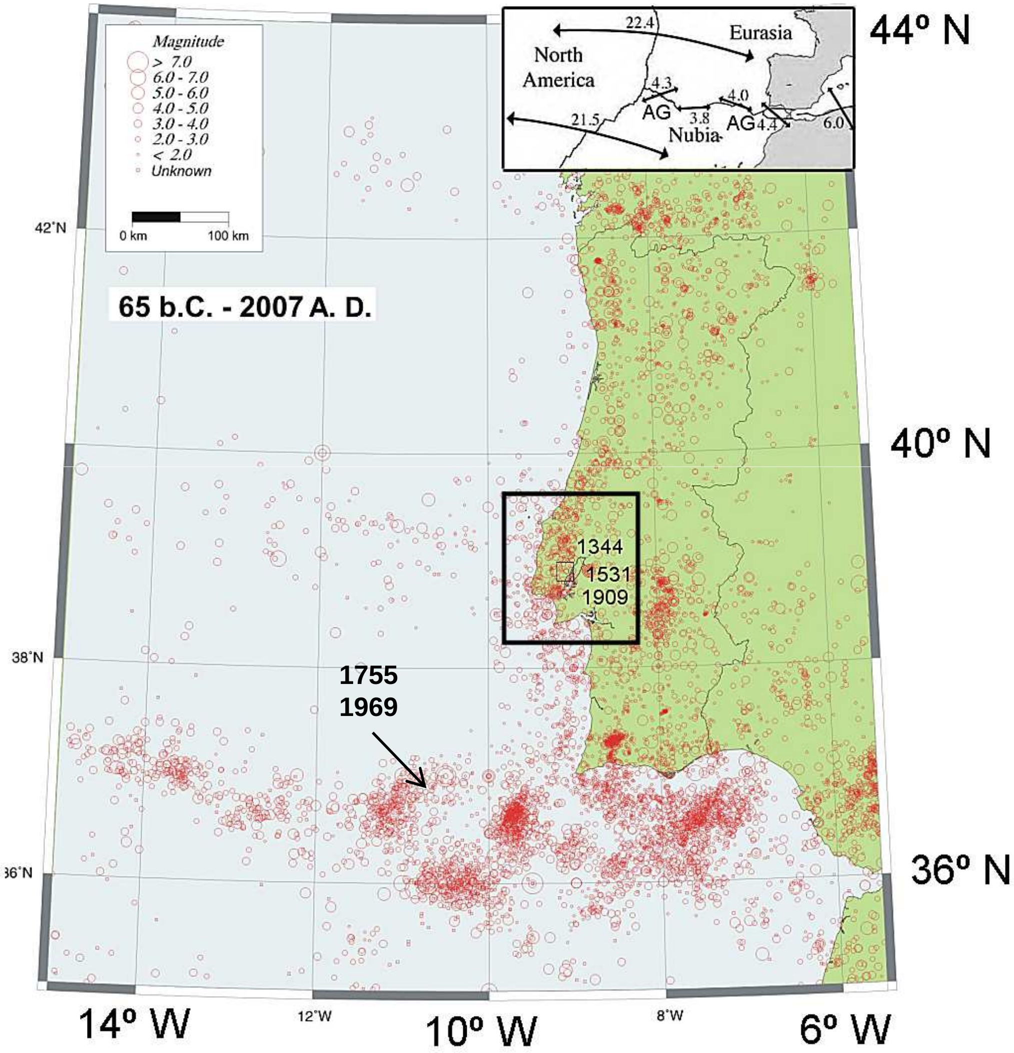
- **Introduction (seismicity, goals, problems)**
- **Methodology (Data acquisition and processing)**
- **VS30 and Soil Classification Maps**
- **Conclusions**

Study area tectonic setting



after Jiménez-Munt and Negredo, 2003 - EPSL

Seismicity for the period 65 BC – 2007 AD



after Instituto Português Mar e Atmosfera (IPMA)

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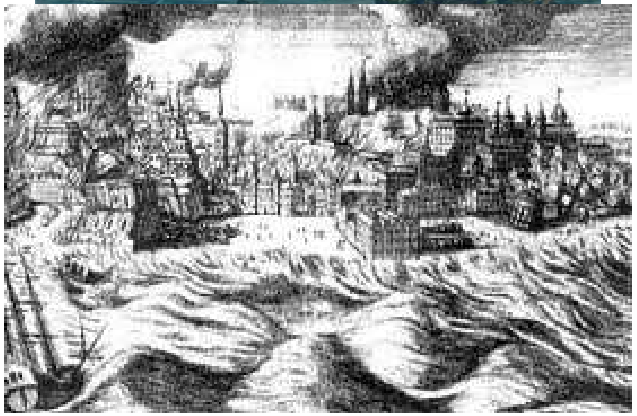
Examples of Destructive Earthquakes



1969 – 12 deaths
1909 – 46 “
1755 ~ 30 000 “
1531 ~ 1000 “
1344 100 < “

Goals

- Acquire shear wave data in the LTV region
- Produce Soil Classification and VS30 maps
- Improve seismic hazard analysis and earthquake mitigation

Problems

- Limited amount of time and financing to acquire data
- Complex geology
- Unavailable digital lithostratigraphic maps

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Metodology

1) Acquisition and interpretation of:
   - Seismic refraction data (P & S)
   - MASW data
   - Ambient vibration (single-station and array)
2) Compare results at specific sites with well data available
3) Use well data (geotechnical and water soundings) to interpret refraction data
4) Produce VS30 and Soil Classification (Eurocode 8 based) maps

Refraction Data Acquisition

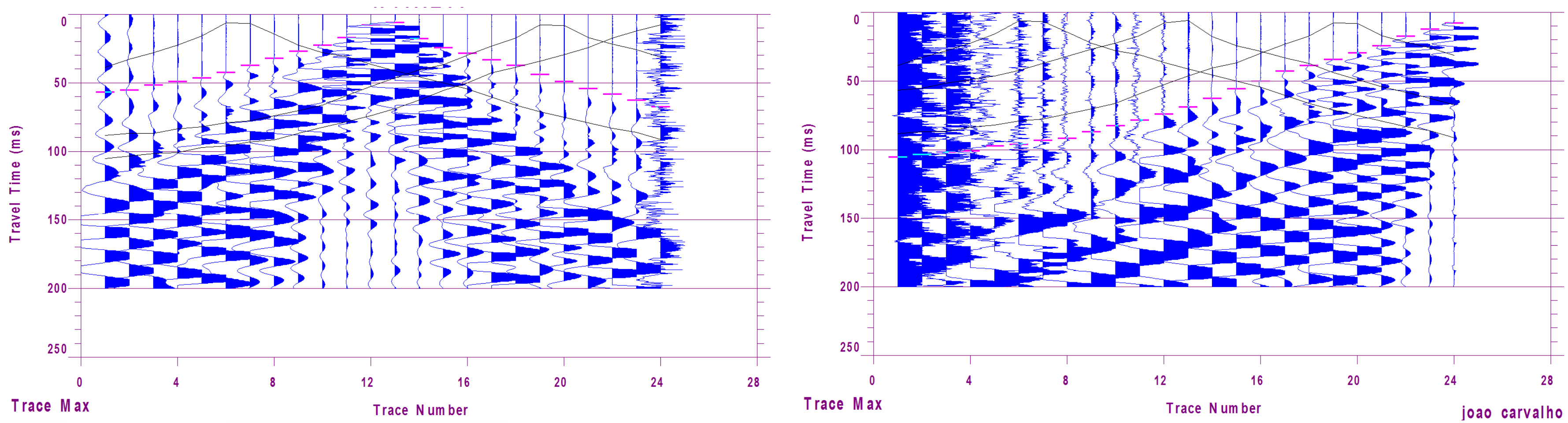
- 24 channel for P and 24 channel for S
- P-wave source: hammer and plate
- Shear wave source: wooden beam struck on both sides under the wheels of a Jeep
- Receiver spacing of 3.5m: total profile length 84 m
- 2 end-shots and 3 inside layout shots (first layer & reciprocal times)

P-wave source

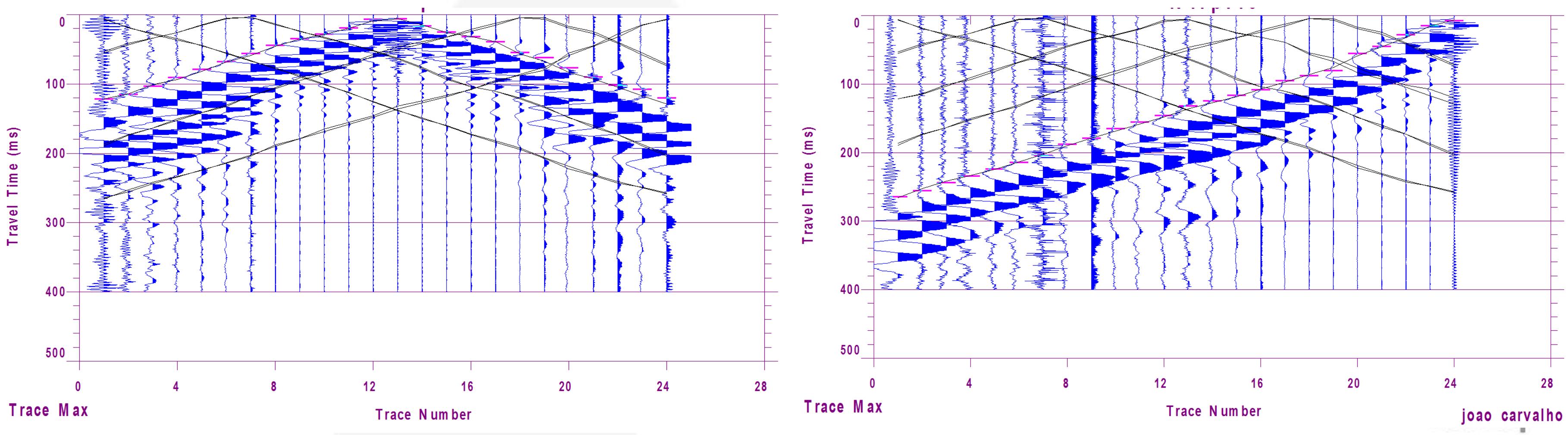
Shear-wave source

Example shot gathers

P-wave



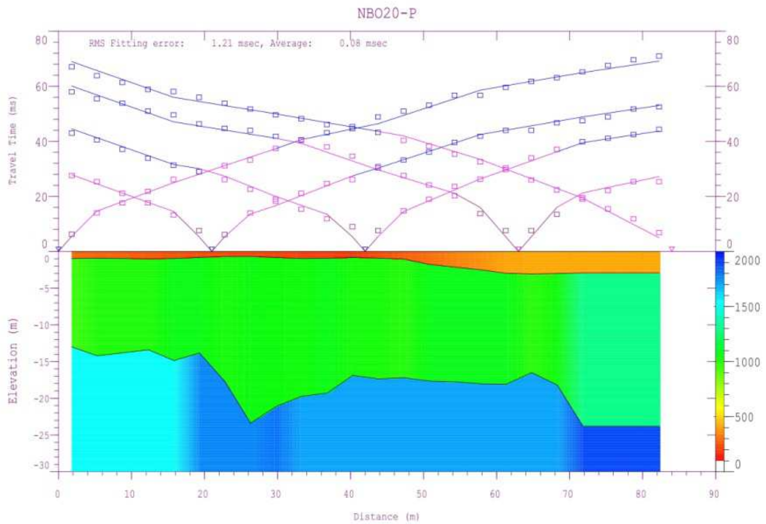
Shear-wave

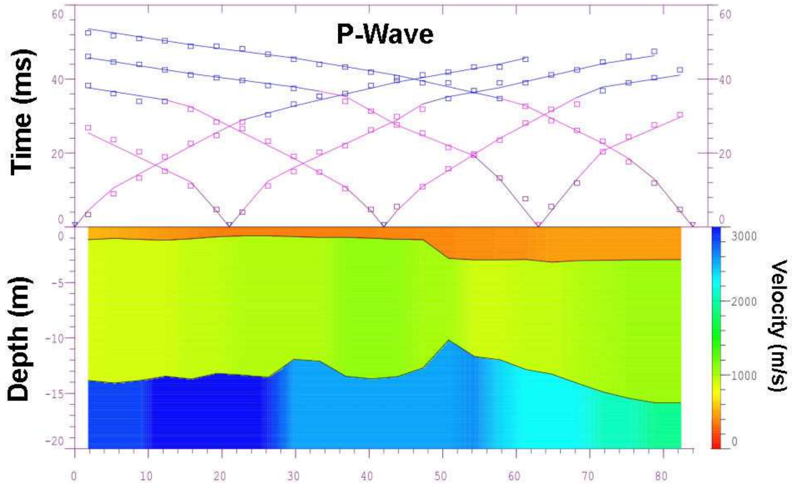


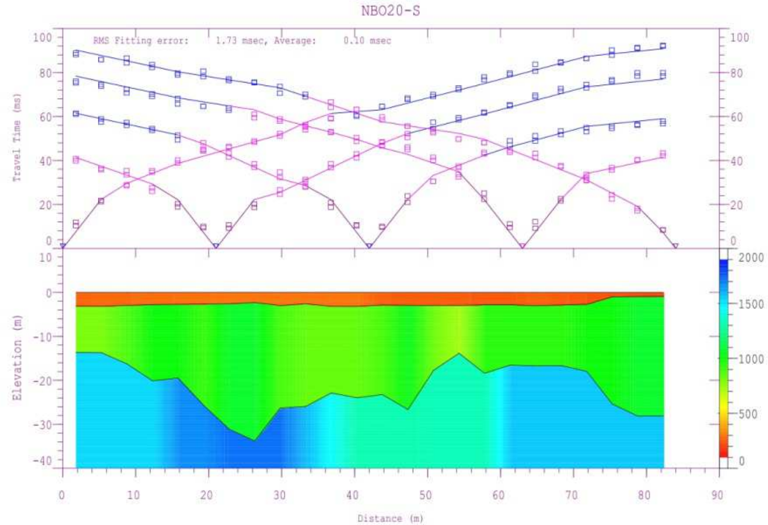
Refraction Data Interpretation

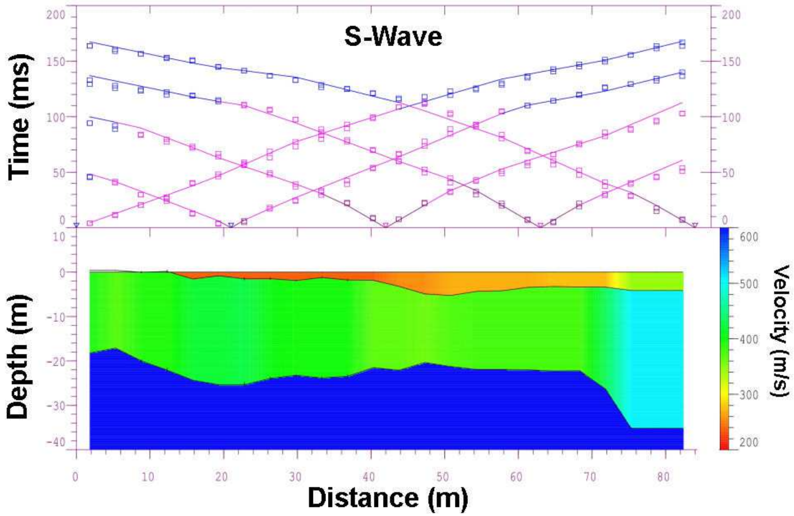
- Commercial software using generalized reciprocal method (Palmer, 1981) and slope intercept
- Use detailed geological and lithological data collected at each site
- Use nearby well data at same elevation

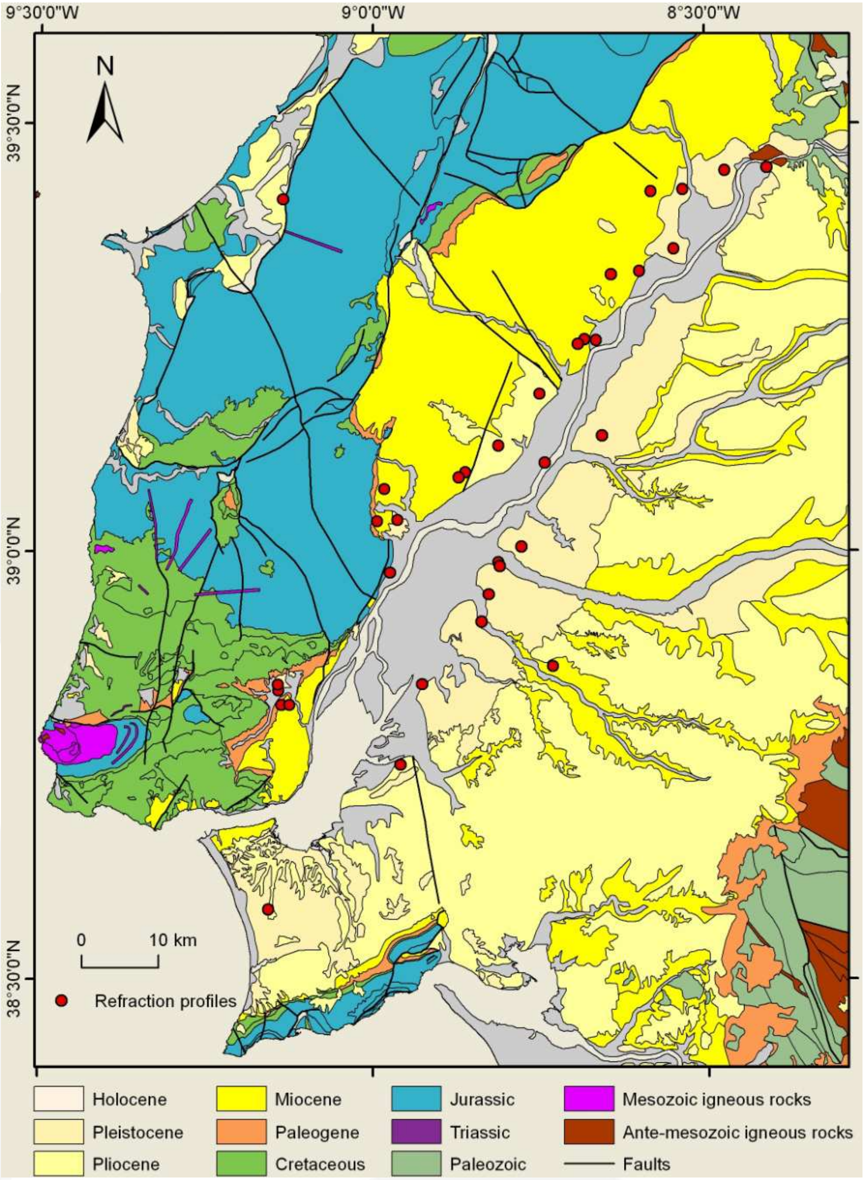
Examples of Refraction TD curves & models





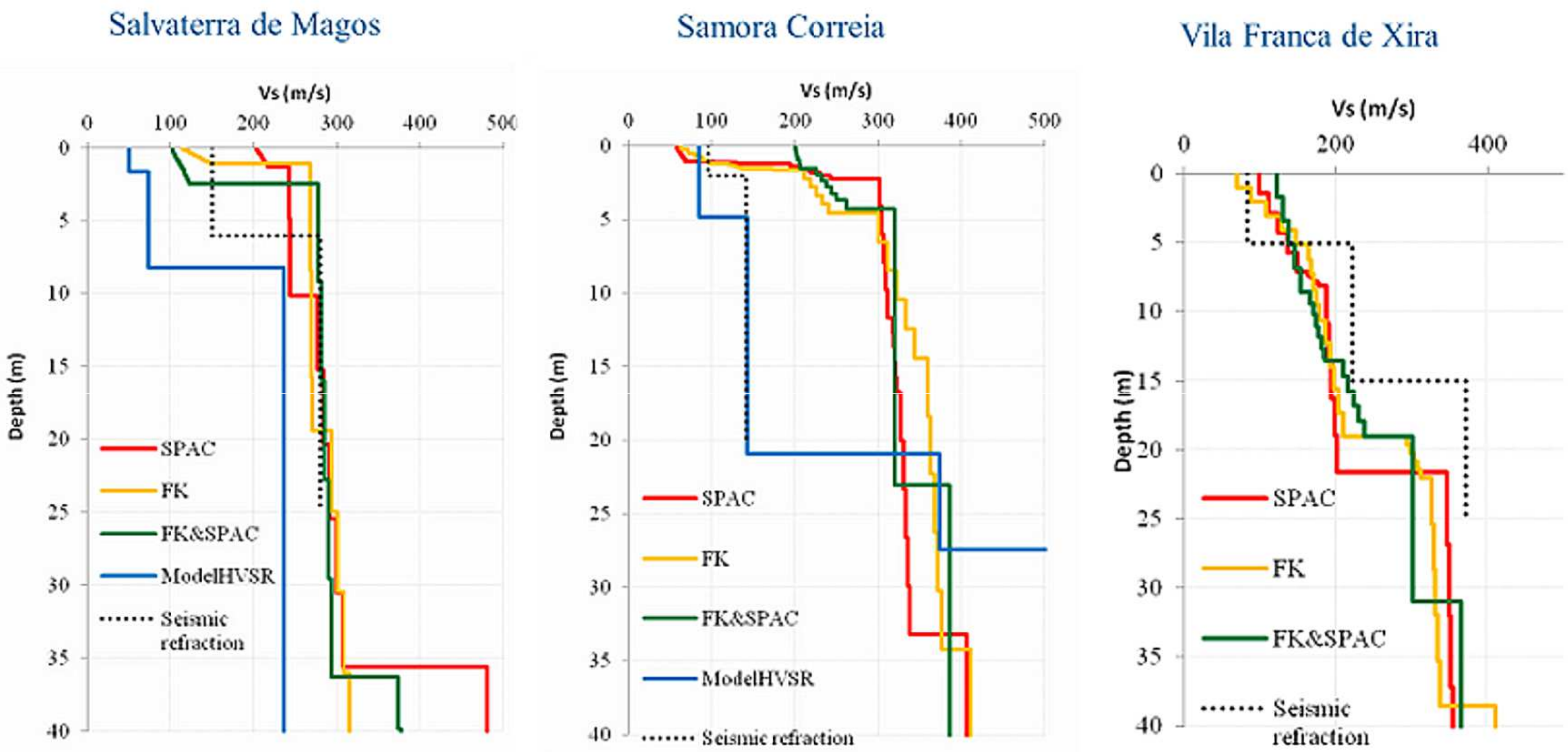






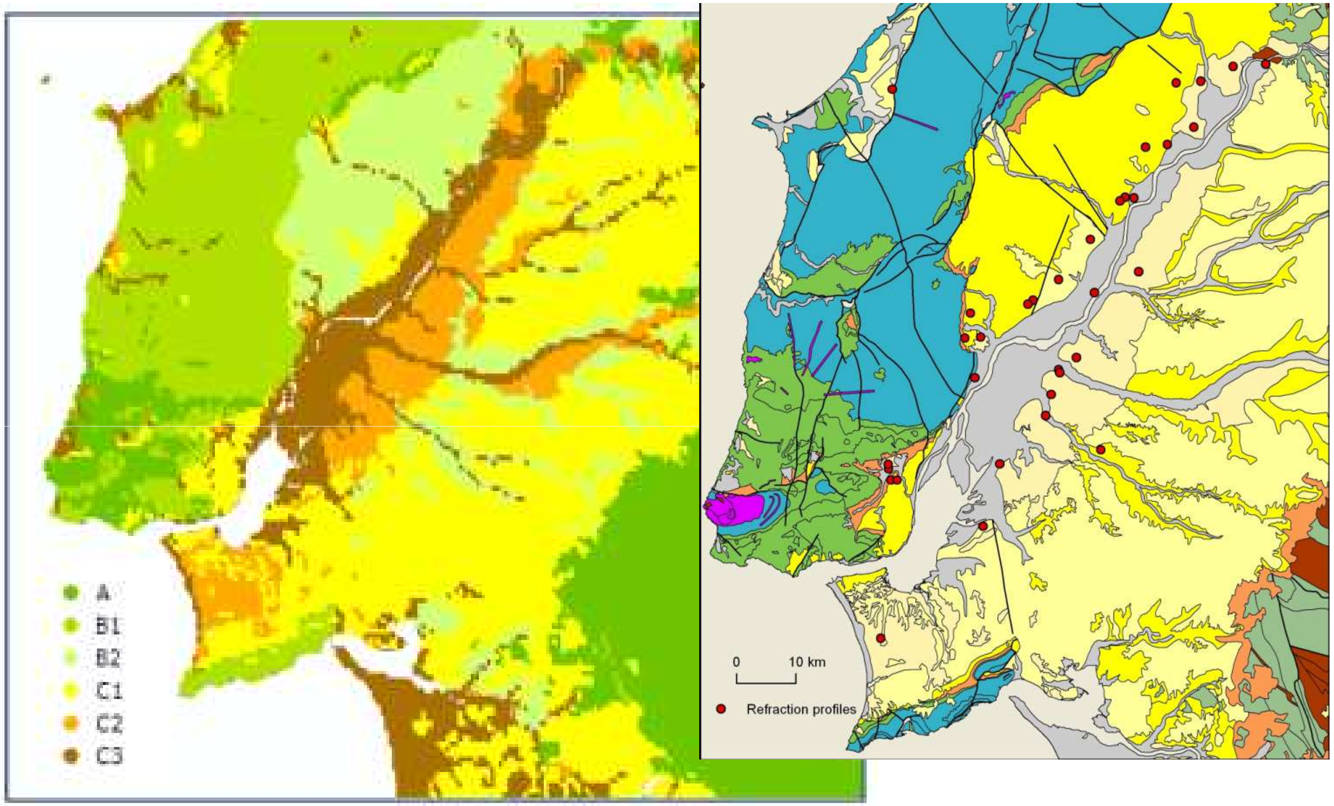
P and S-wave Data collected at 42 sites

Comparison of Refraction & Ambient Noise Data



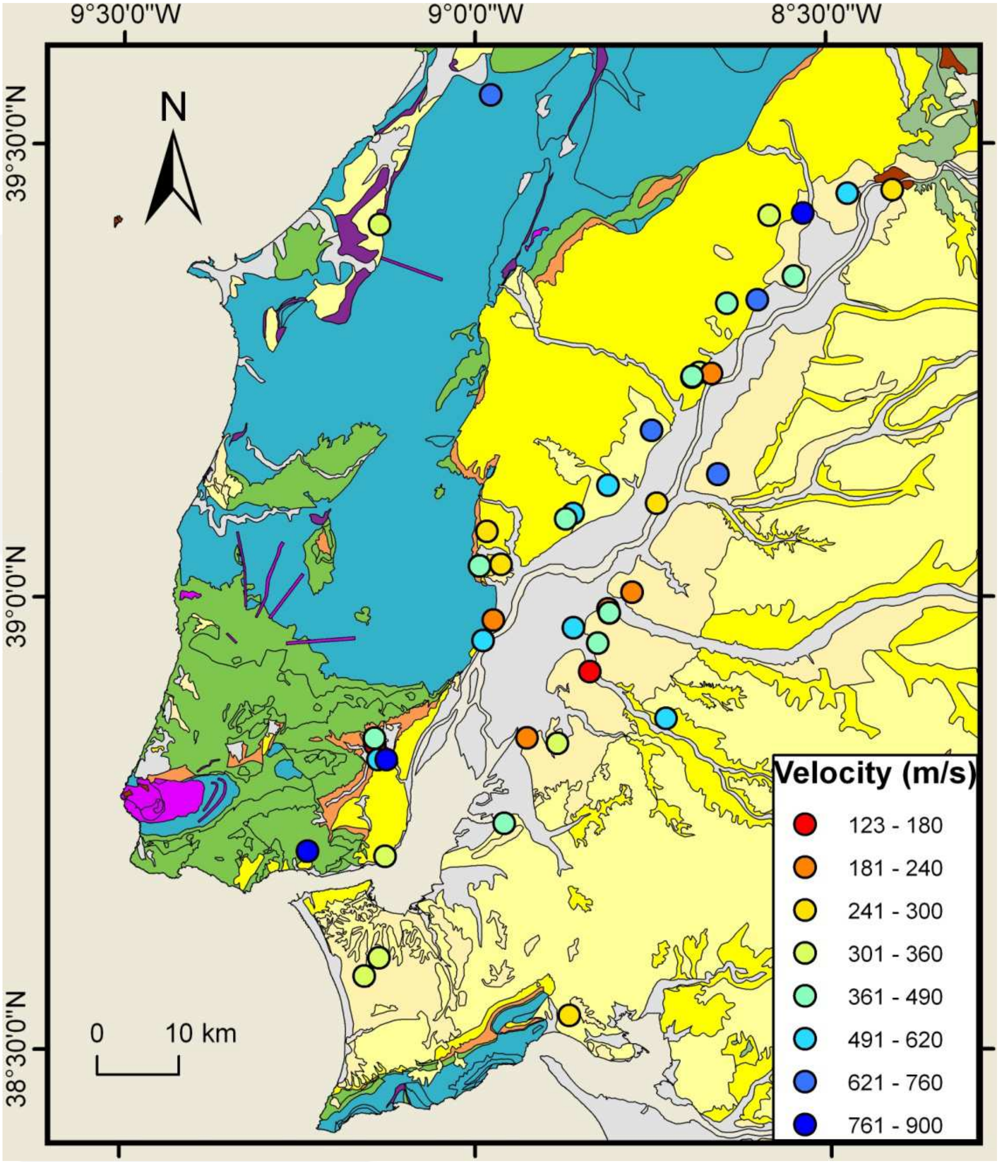
Teves-Costa et al., 2013

Preliminary 1: 10^6 scale VS30 Map using refraction and ambient noise

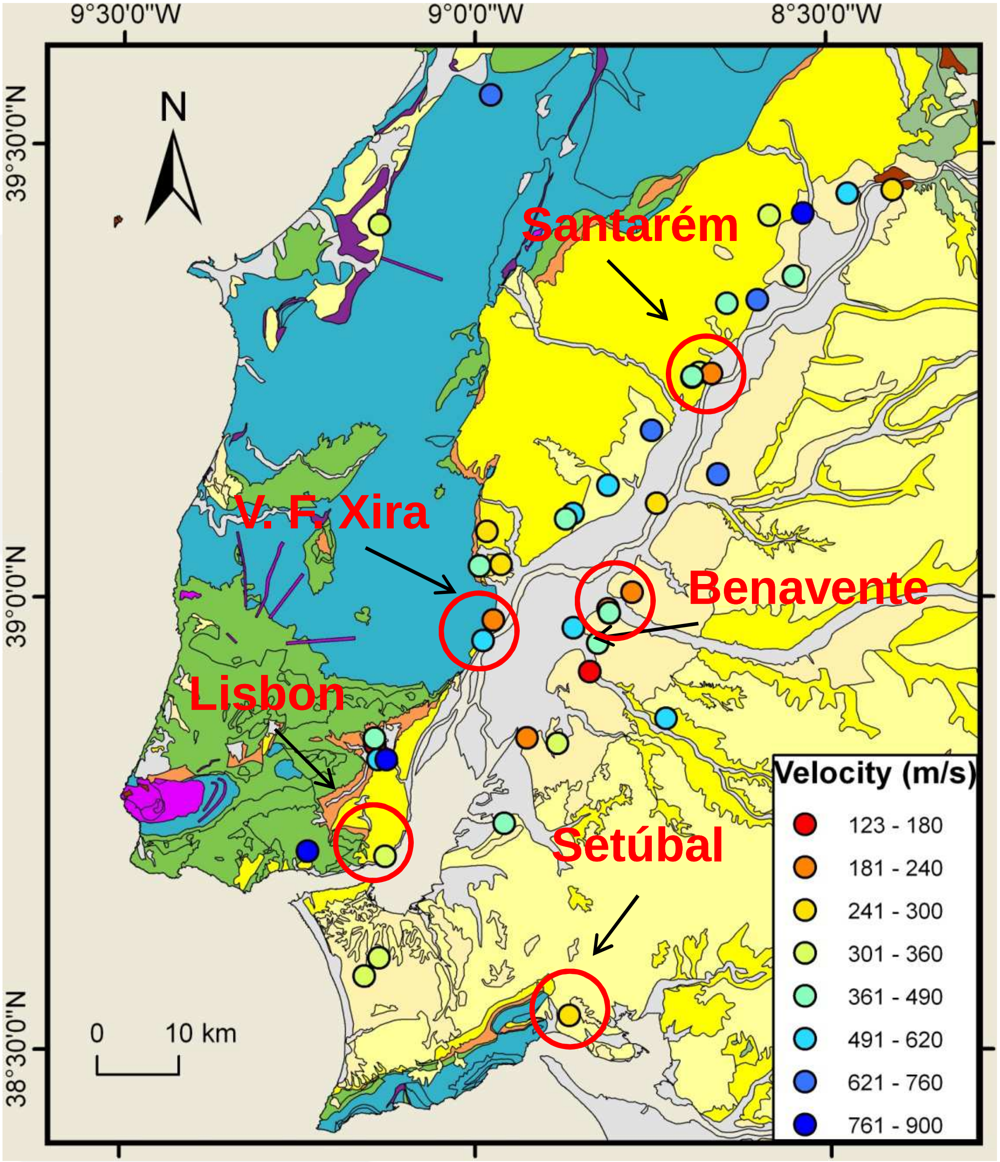


Teves-Costa et al., 2013

Preliminary 1: 10^6 scale VS30 Map using refraction data



Preliminary 1: 10^6 scale VS30 Map using refraction data



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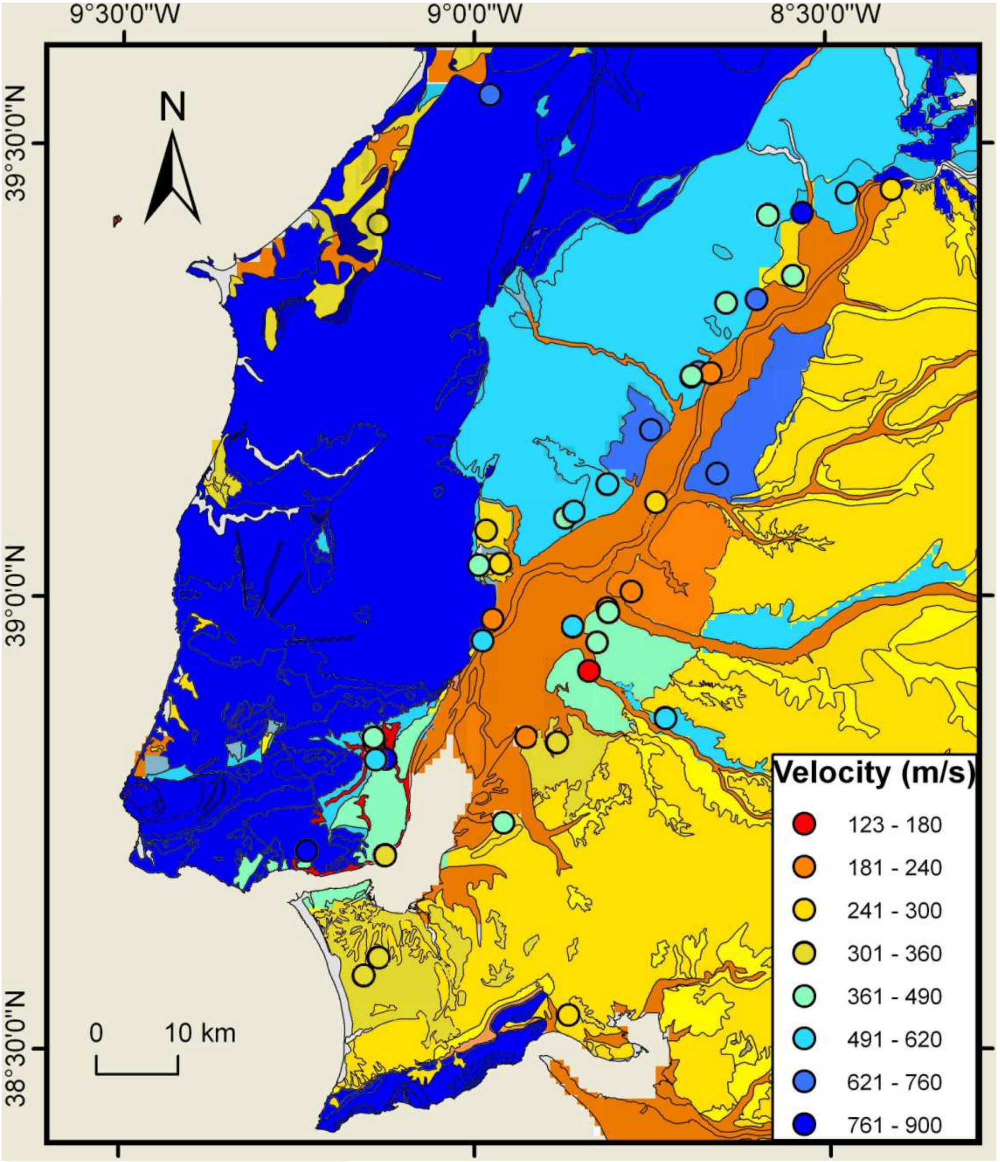
Preliminary Soil Classification Map



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Soil Classification - Criteria used

CLASS	CRITERIA 1	CRITERIA 2
Subsoil class **A**	Rock or geologic formation characterized by Vs >= 800 m/s	Compact deposits of sands, gravels or overconsolidated clays, several tens of meters thick (Vs >= 400 m/s at 10m depth)
Subsoil class **B**	Deep deposits of medium dense sands, gravel or stiff clays with thickness from several tens to hundreds of meters (Vs >= 200 m/s at depth to Vs >= 350 m/s at 50m depth (SPT N~60)	
Subsoil class **C**	Loose cohesionless deposits with or without soft cohesive layers (Vs < 200 m/s at depths <20m (SPT N<=10)	Deposits with soft-to-medium stiff cohesive soils (Vs < 200 m/s at depths <20m (SPT N<=10)

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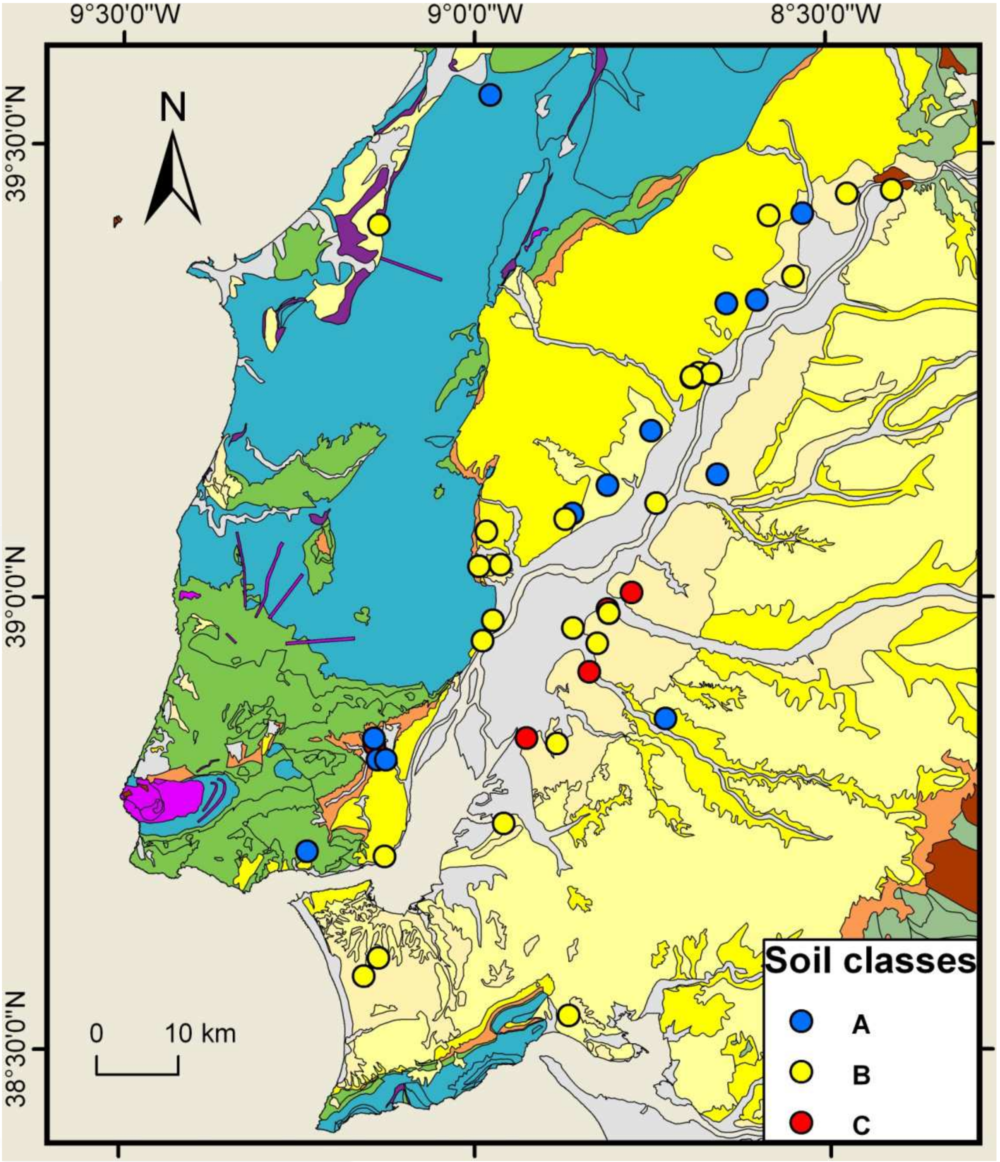
Preliminary Soil Classification Map



Preliminary Soil Classification Map

- Class C correspond to Holocene and Pleistocene sediments

- Holocene alluvium also have areas classified as B

- Pleistocene sediments show large variation and are also classified B or A

- Miocene formations can be either classified B or A

Conclusions

- **At this first phase of the study the highly complex geological nature of the study area where thickness and lateral lithological changes are constant, prevents a simple geographical generalization of the velocity and soil classification data points.**

Conclusions

- Preliminary VS30 and the soil classification maps presented here highlight a region of great susceptibility to earthquake shaking and where several cities are located. This region is covered by Holocene alluvium but other areas located over older geological formations also show a relatively moderate risk.

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•Landowners: Eng Rui Paixão, Companhia das Lezírias

References

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Thank You !

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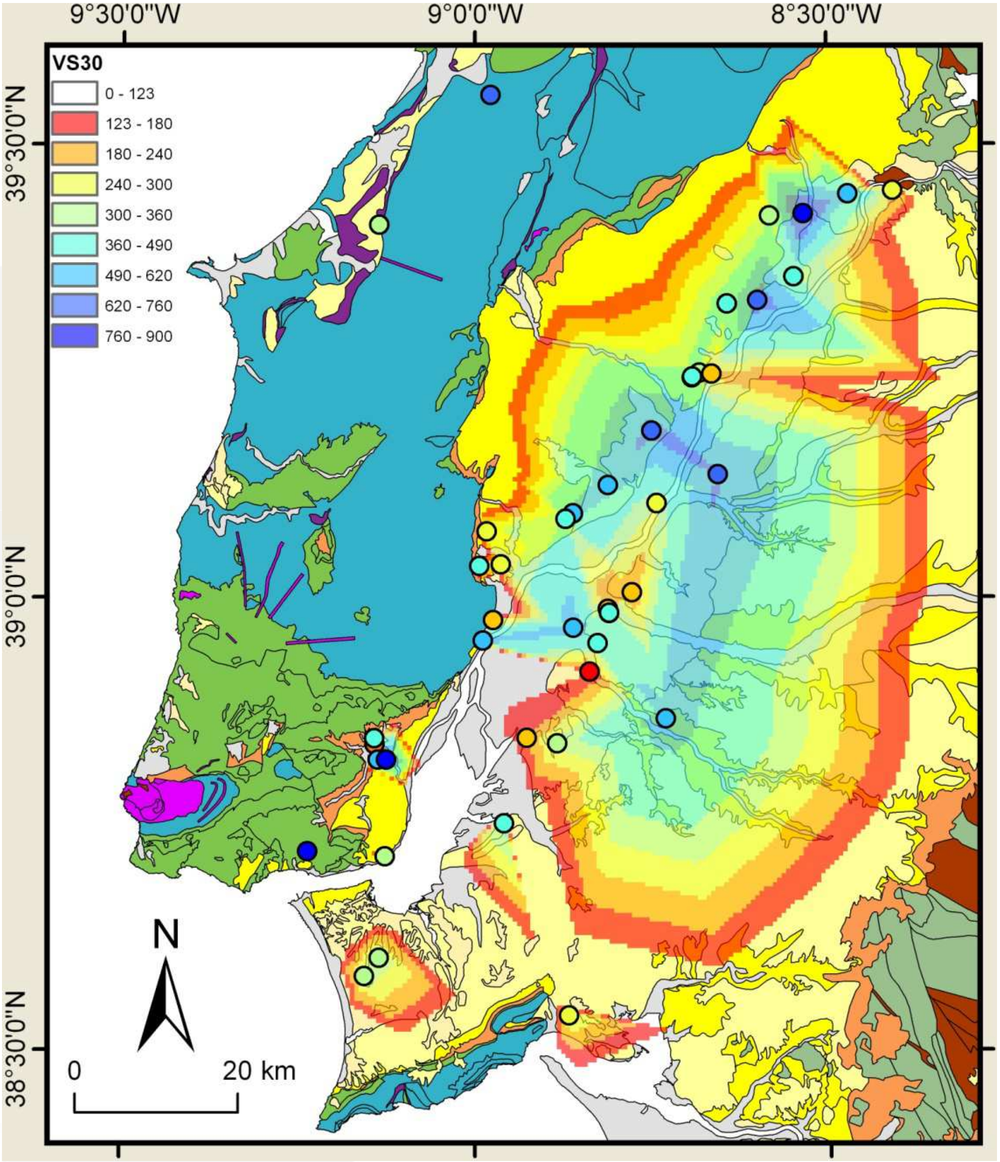
GOVERNO DE PORTUGAL

MINISTÉRIO DA ECONOMIA
E DO EMPREGO



9°30'0"W
9°0'0"W
8°30'0"W
39°30'0"N
39°0'0"N
38°30'0"N
VS30
0 - 123
123 - 180
180 - 240
240 - 300
300 - 360
360 - 490
490 - 620
620 - 760
760 - 900
N
0
20 km

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