OCEANEXT 2024
Meeting the challenges of maritime and coastal socio-ecosystems together

IUML
INSTITUT UNIVERSITAIRE MER & LITTORAL
FR CNRS 3473

Projet PROSE+ : Geomechanical characterization of heterogeneous seabed for wind turbine anchorages/foundations using non-destructive geophysical approaches: Small-scale laboratory experiments and full-scale sea measurements

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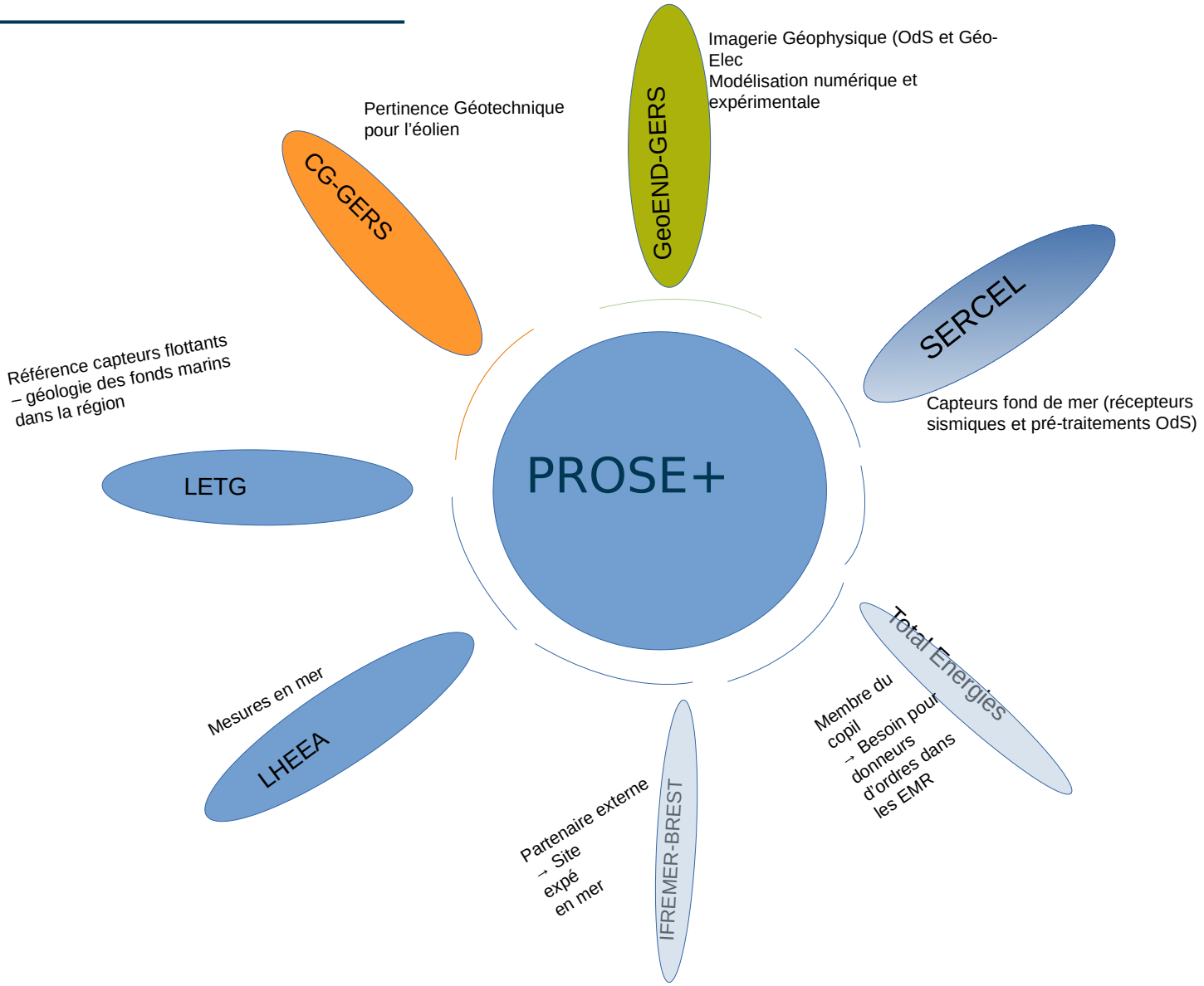
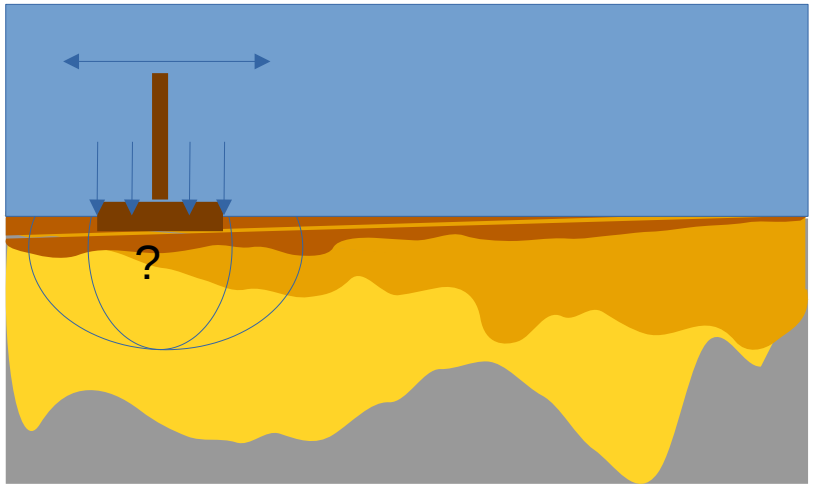
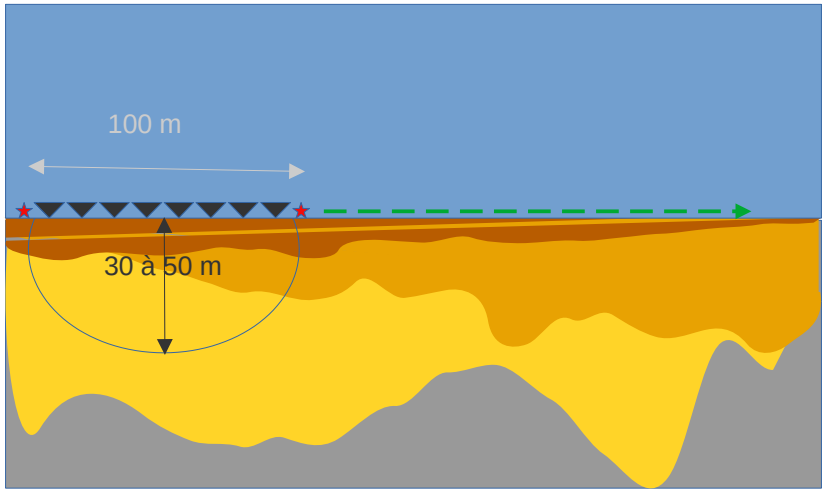
PROSE+ consortium



CE PROJET EST COFINANCÉ PAR LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL

INTRODUCTION, CONTEXT AND OBJECTIVES





Surface waves information from sea bottom recordings to recover the S waves velocity 2D profile of the offshore underground media

This parameter will make it possible to assess the spatial variation in the mechanical properties of the medium for geotechnical issues in the context of wind turbine construction projects.

OUTLINES

- → context and objectives for the geotechnical issue
- → few words about the imaging method developed
- → experimentation approaches
  - reduced scale measurements in laboratory
  - Field measurement at scale 1 off the Concarneau Coast
- → toward multi-disciplinary exploration

OUTLINES

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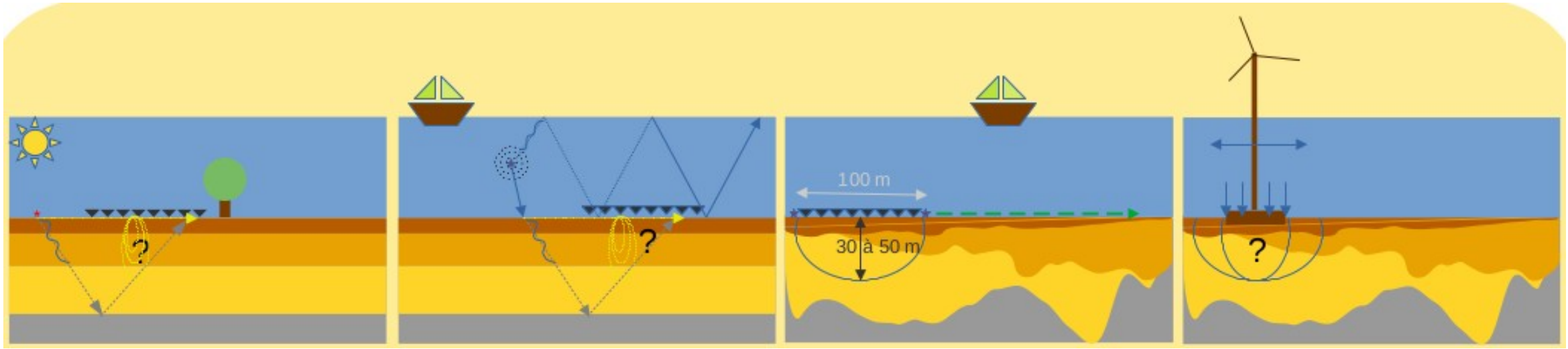
CONTEXT AND OBJECTIVES



- Surface waves information from sea bottom recordings to recover the S waves velocity 2D profile of the offshore underground media ?

- This parameter will make it possible to assess the spatial variation in the mechanical properties of the medium for geotechnical issues
- in the context of wind turbine construction projects.

- A first field campaign with Nodes sensors laying on the bottom sea and seismic shot with air-gun

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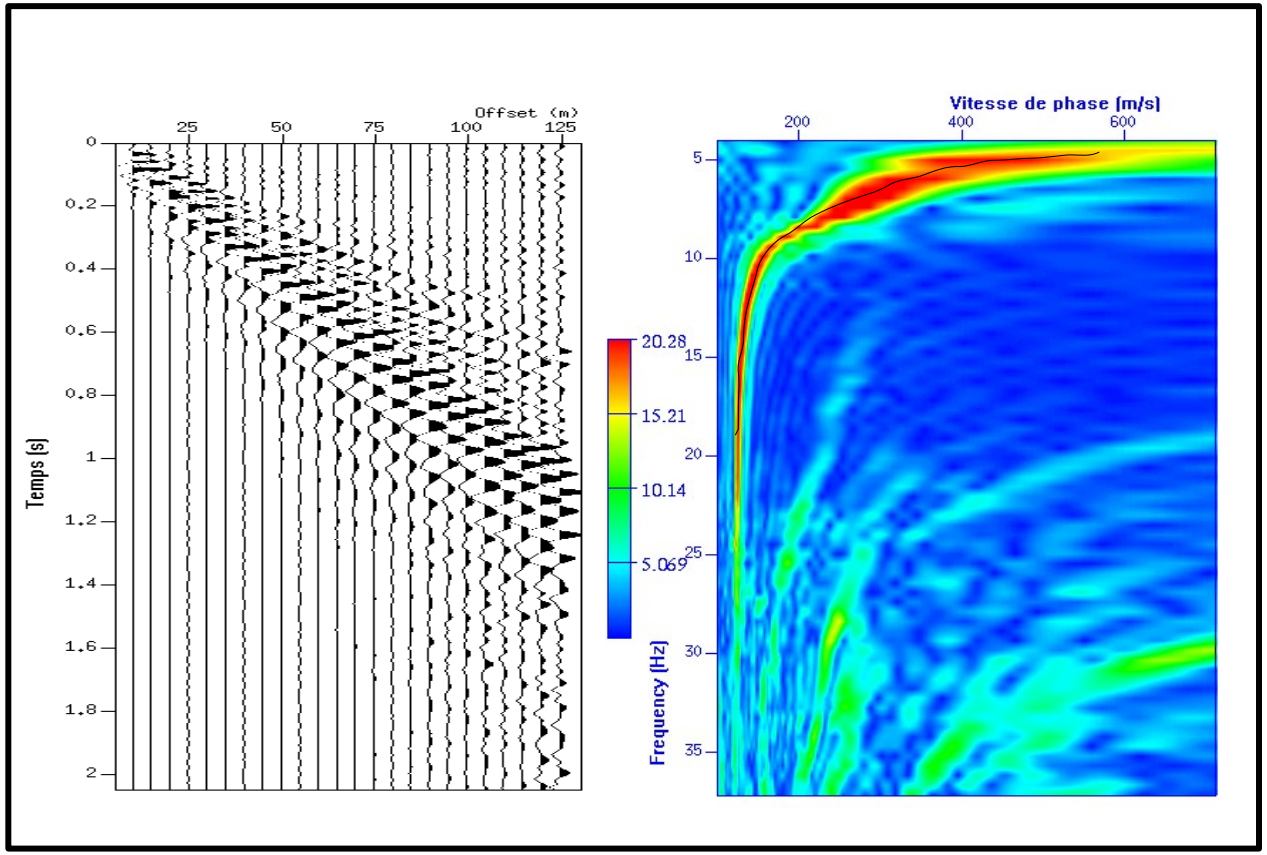
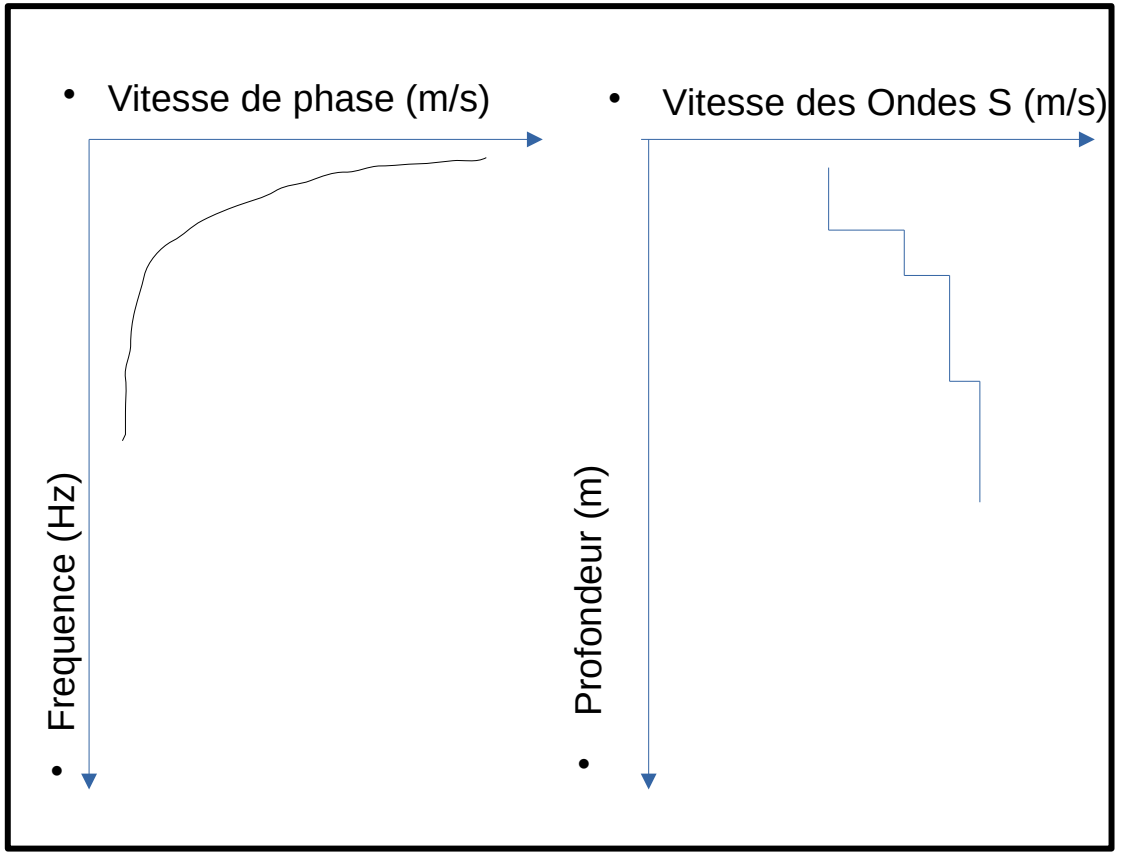
1D surface wave dispersion analysis : MASW method





Seismic shot → Dispersion Diagram → Dispersion curve → **1D INVERSION** → Velocity depth profile of S waves

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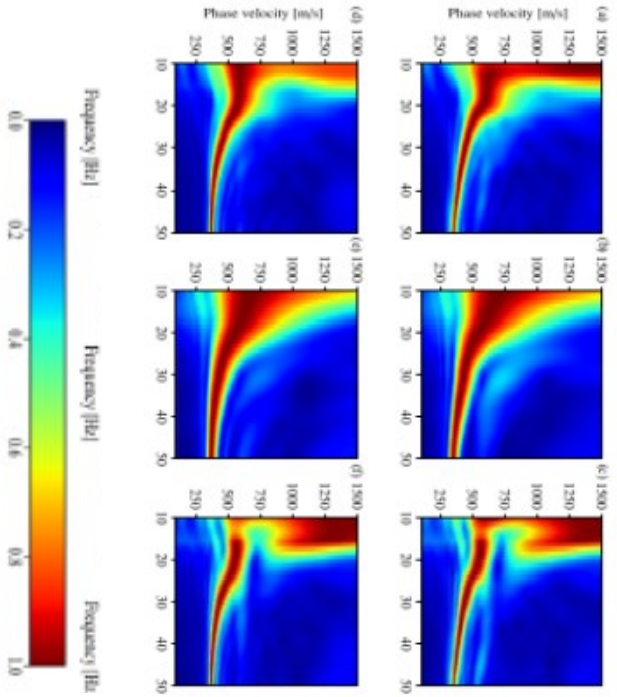
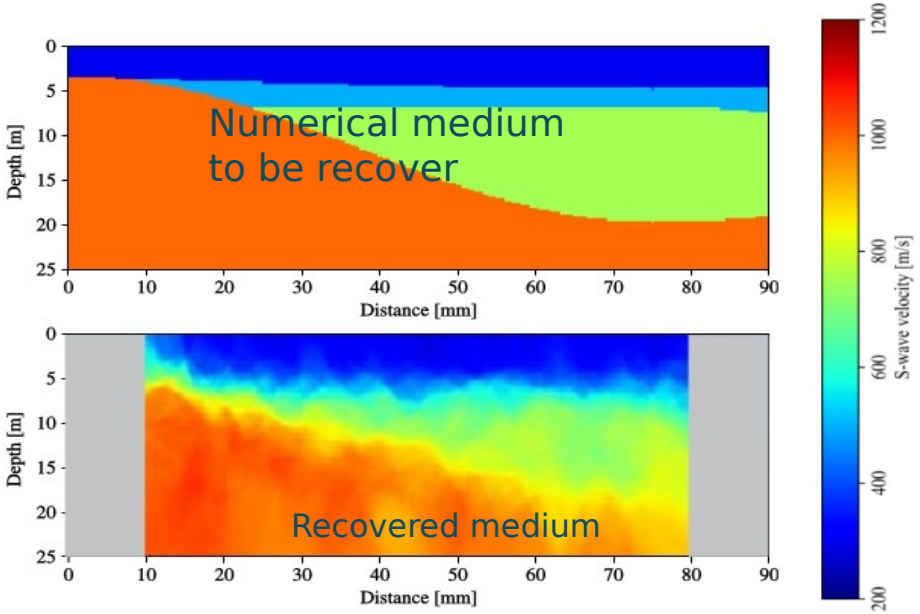
NUMERICAL DEVELOPMENTS FOR A 2D IMAGING PROCESS (PROSE project)

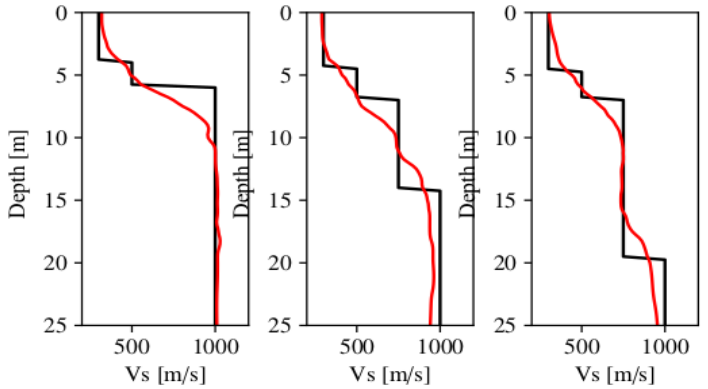
2D imaging method using interface waves developed for marine underground medium (Pageot et al., 2020)



Numerically simulated data (dispersion diagrams) for inversion using particle swarm optimization.



Medium and Imaging results
(The colors correspond to the velocities of S waves linked to the shear modulus)



3 depth profiles for 3 positions of the medium to be recovered (black lines) and the recovered medium (red lines).

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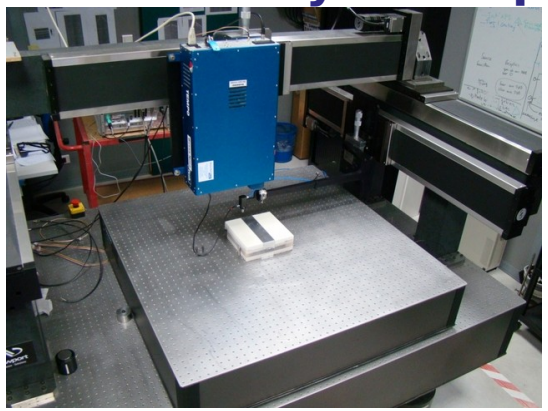
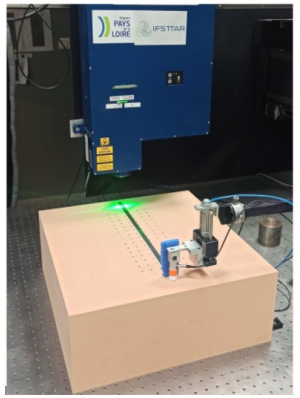
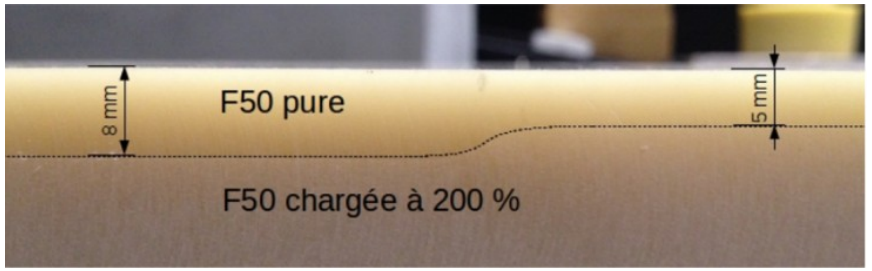
REDUCED SCALE MEASUREMENT

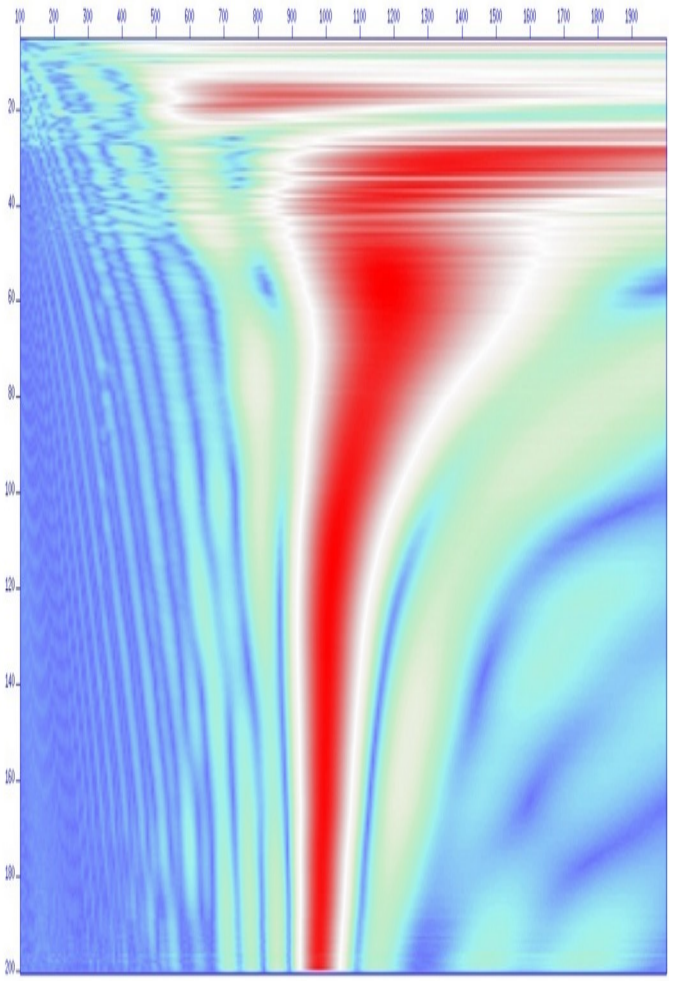
MUSC (Measurement at Ultrasonsic SCale) BENCH MEASUREMENT, Gustave Eiffel University – Campus Nantes

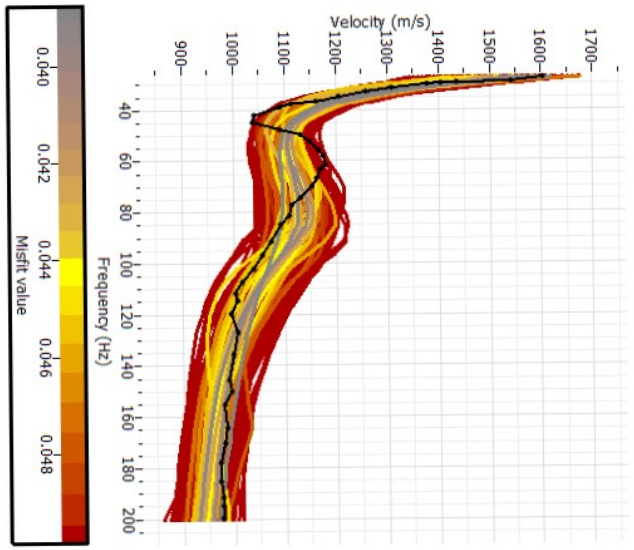


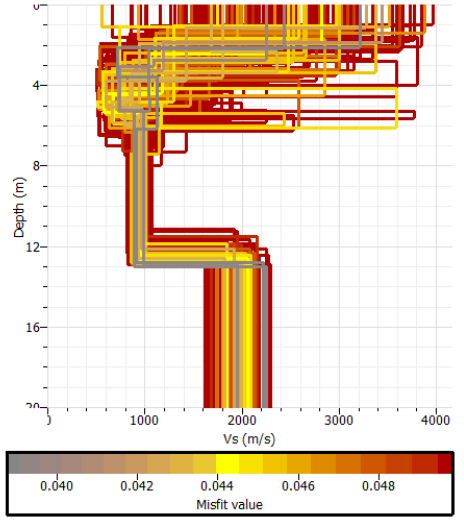




2 layer Resin Model







Dispersion Diagram obtained with reduced scale measurement

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OUTLINES

- Measurement location for this campaign off the coast of Concarneau in France
- Measurement configuration and sensors deployment
- Records and information on surface wave dispersion versus :
  - sensors type (hydrophones or accelerometers)
  - minimum offset of source position
  - source depth (air-gun)

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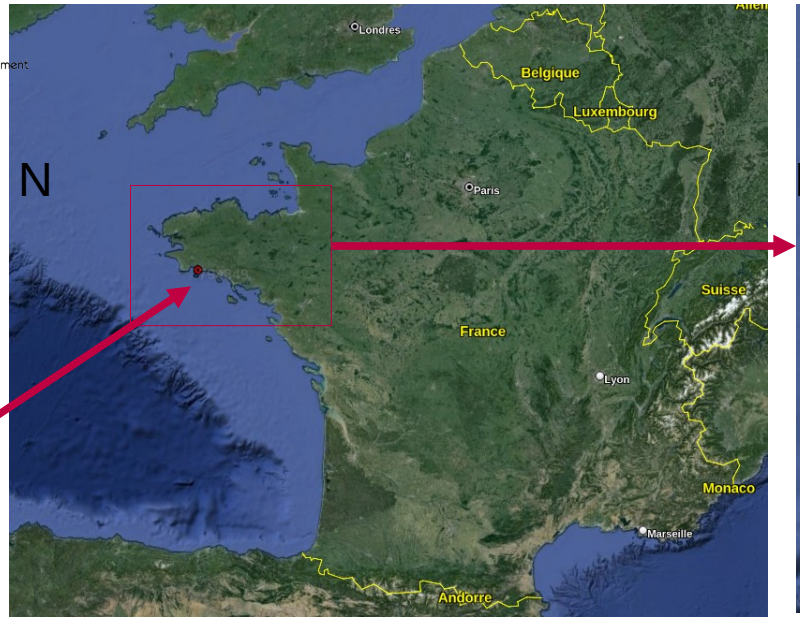
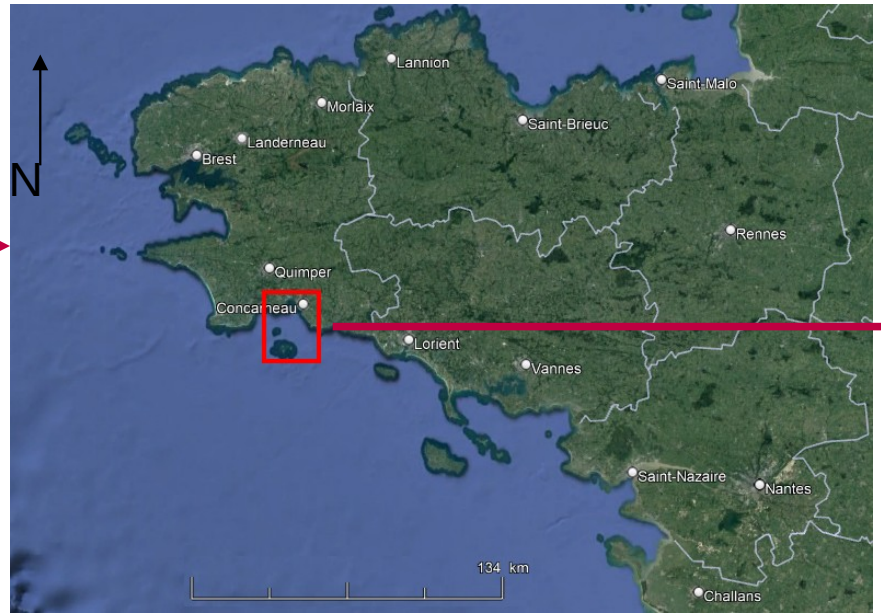
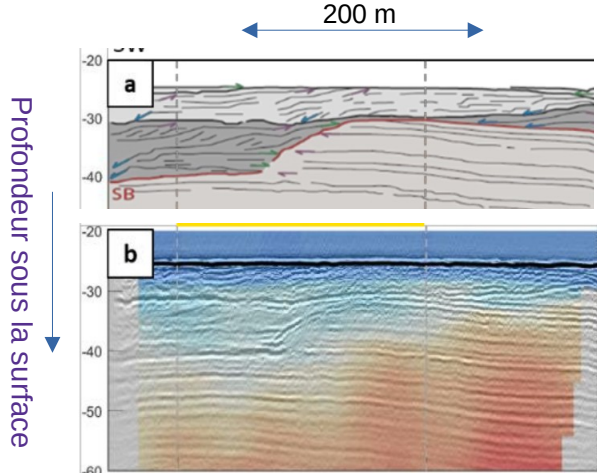
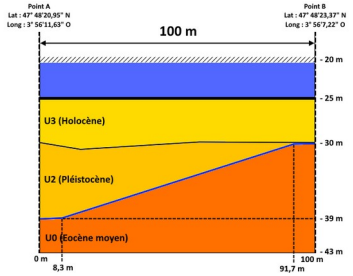
MEASUREMENT LOCATION





Coupe sismique interprétée à partir de mesures sismique réflexion au large de la pointe de Tregunc (baie de Concarneau, Fr)





Geological unit	Geological description/sediment type	P-wave velocity V_P [m/s]
Basement	Micaschist and gneiss	>2100
U0	Eocene substratum; nummulites limestone	1800 ~ 2800
U1	Coarse fluvial continental deposits	1500 ~ 1900
U2	Pleistocene estuarine tidal bars	1500 ~ 1900
U3a	Holocene mud	1500 ~ 1700
U3b	Holocene mud	1400 ~ 1700

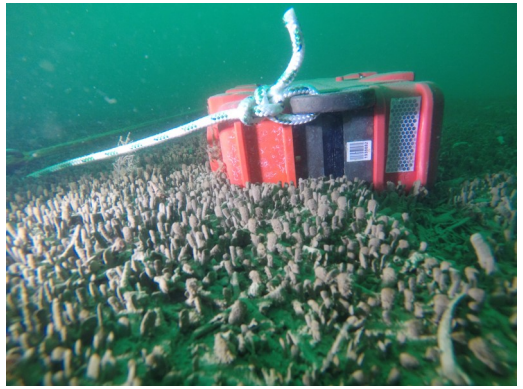
5 lines of receivers

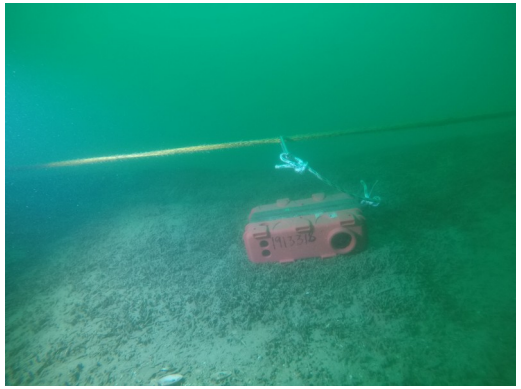
Référence : Flamme, J., P. Tarits, M. Fabre, G. Jouet, A. Ehrhold, A. Lepot, and B. Marsset. "Characterization of shallow gas in coastal environment using jointly marine ERT and UHR seismic Imaging." In NSG2020 4th Applied Shallow Marine Geophysics Conference, vol. 2020, no. 1, pp. 1-5. European Association of Geoscientists & Engineers, 2020.

SENSORS DEPLOYMENT

Deployment of receiver lines by workboat operated by Sercel

Control and adjustment
of receivers positions
by Ifremer divers

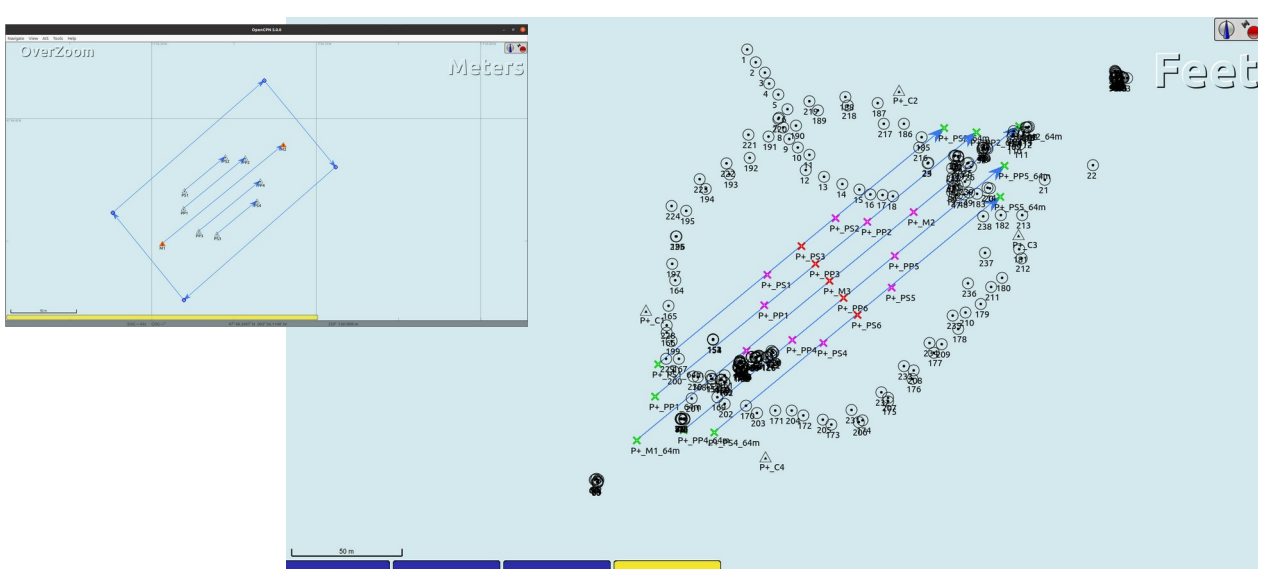


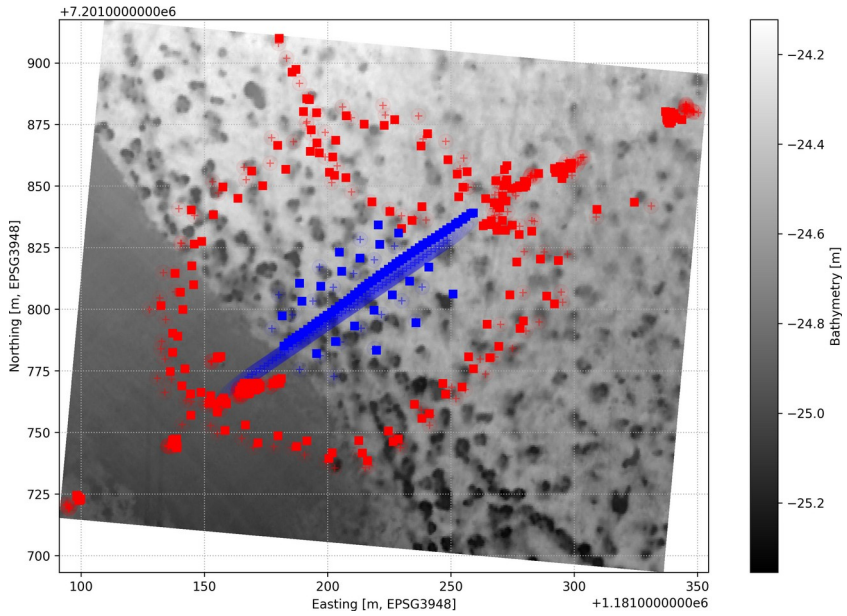


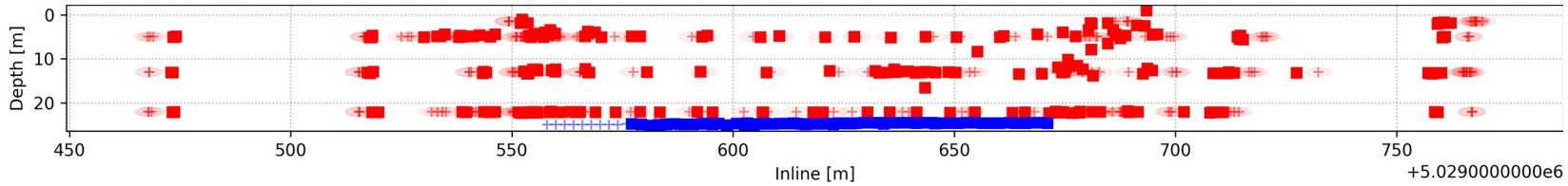
Seabed receivers : 4C GPR Nodes from Sercel

SOURCE AND RECEIVER POSITIONS

5 lines of receivers . The main line in the centre comprises 50 nodes spaced 2 m apart

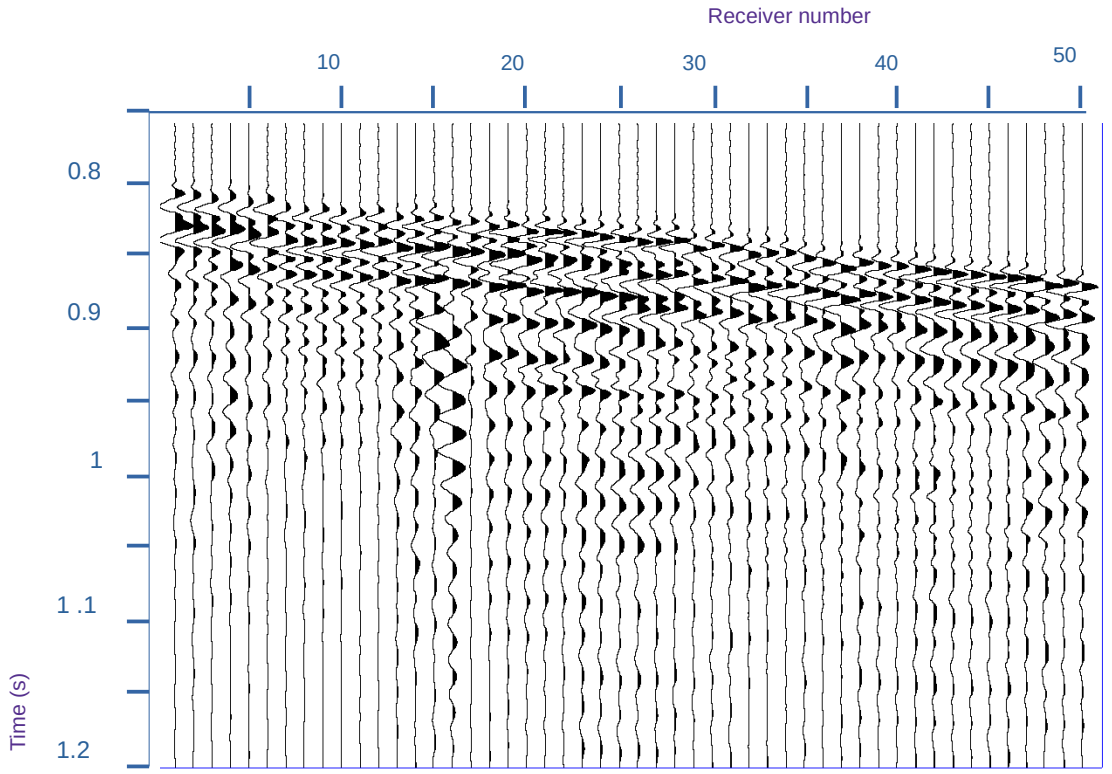




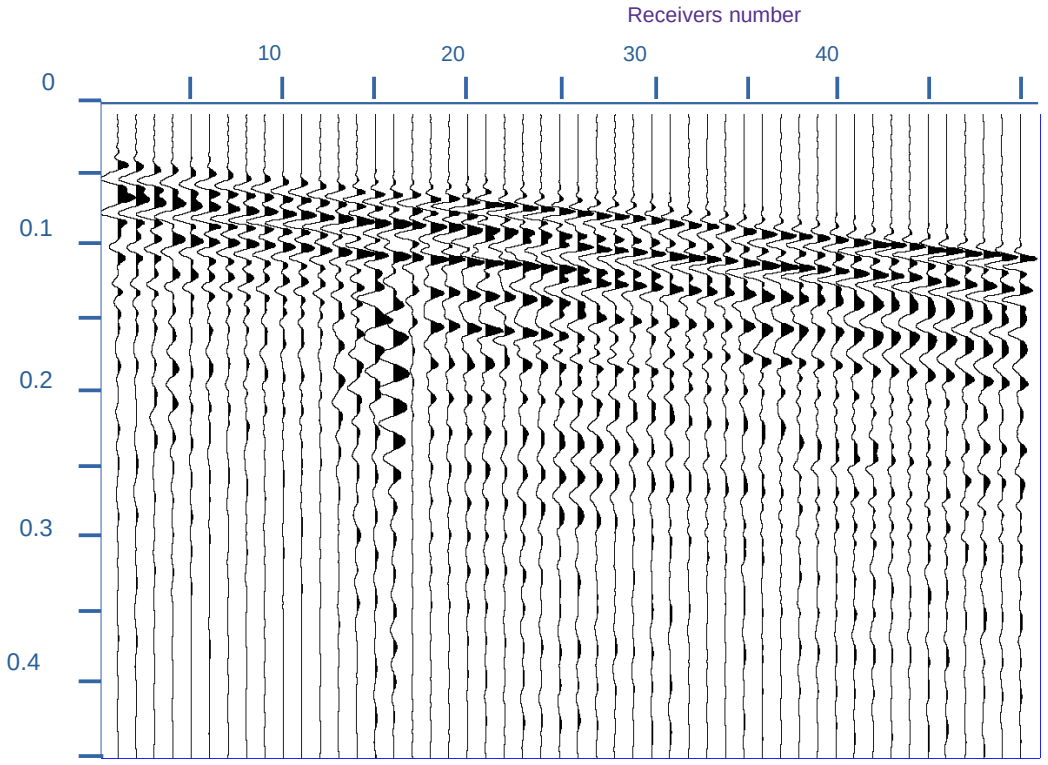


241 source positions (red points)
70 receivers positions (blue points)

EFFECT OF THE CLOCKDRIFT CORRECTION ON DATA



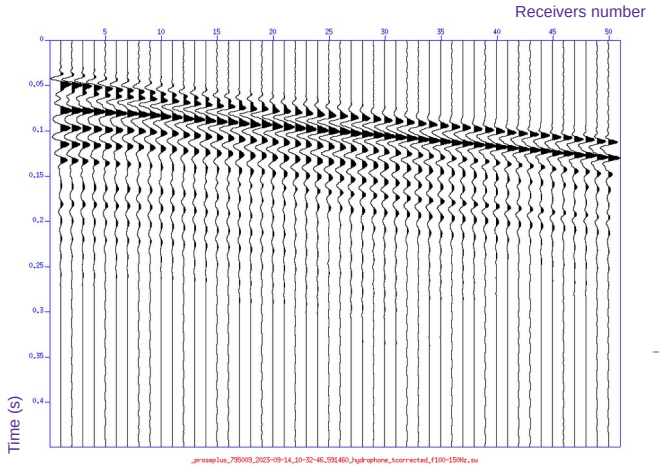
before clockdrift correction



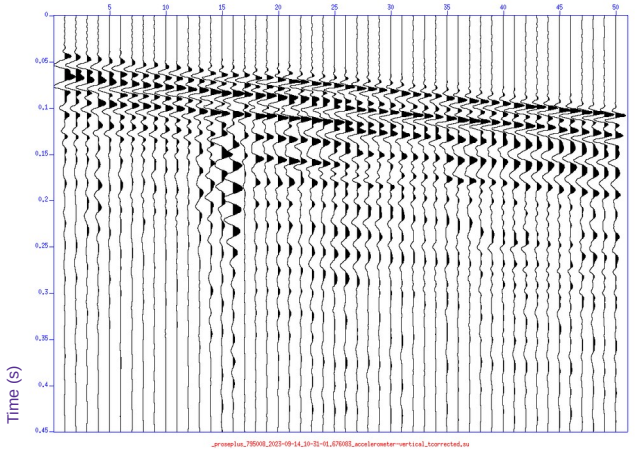
after clockdrift correction

Shot gathers recorded by vertical components of the accelerometer sensors

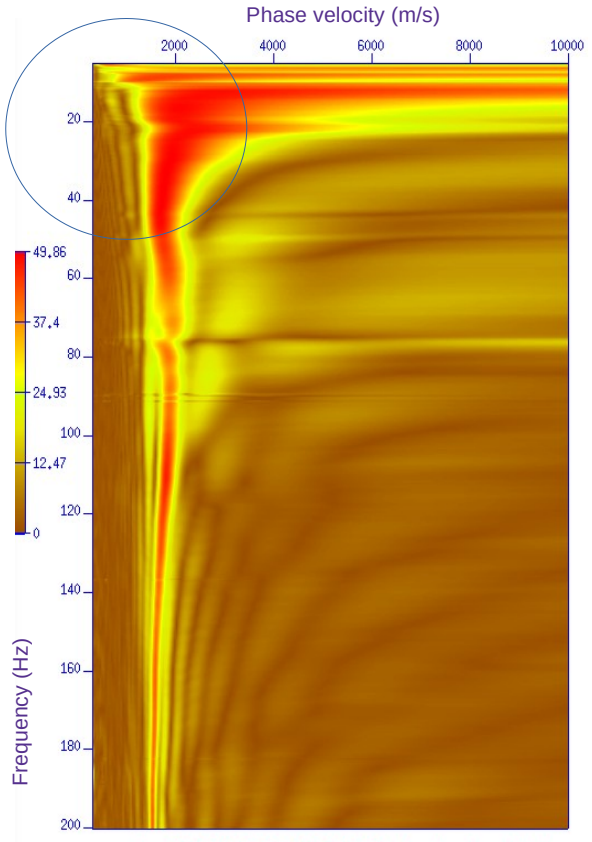
MEASUREMENT BY HYDROPHONES VS VERTICAL ACCELEROMETERS



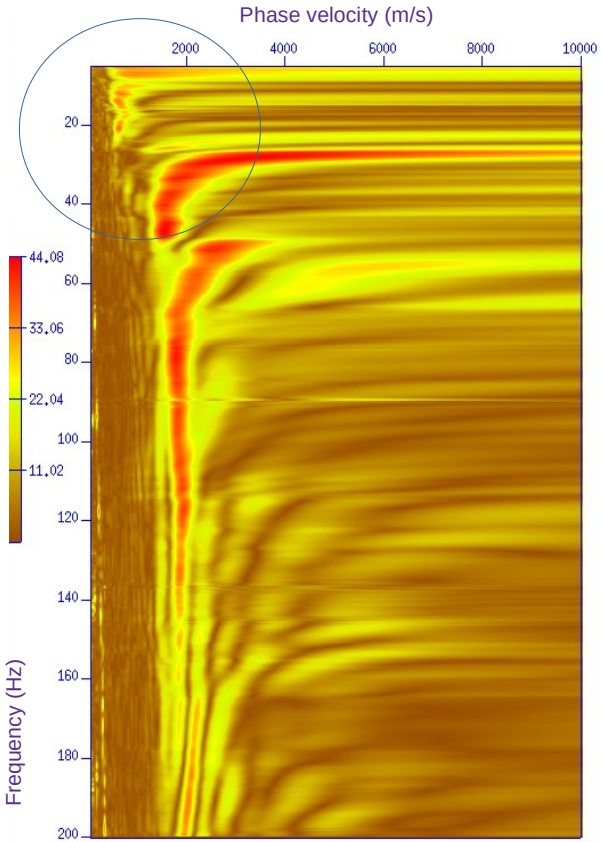
hydrophone



vertical components of the accelerometer

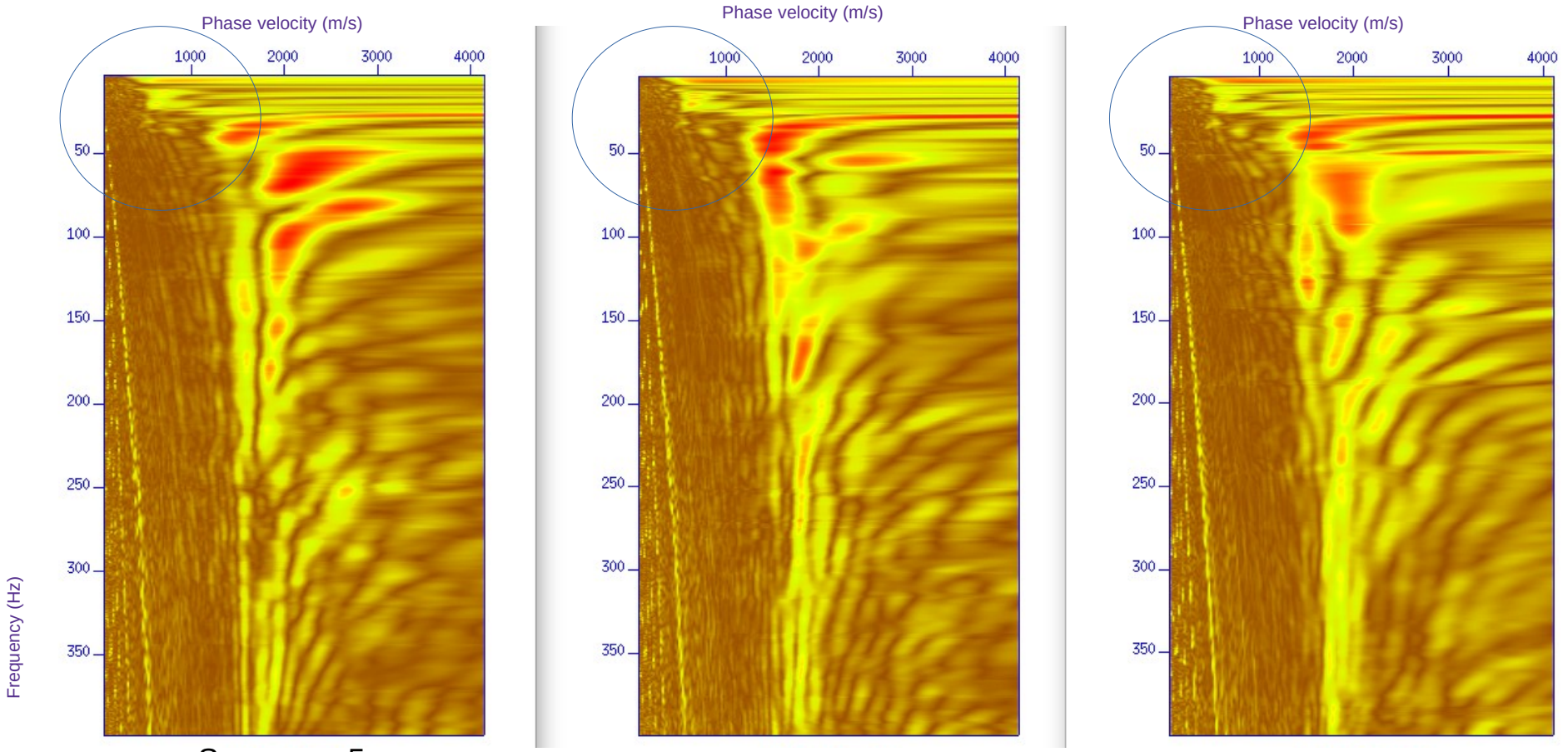


Dispersion diagram from hydrophone recordings



Dispersion diagram from vertical components of the accelerometer recordings

DISPERSION DIAGRAM VS SOURCE DEPTH
for vertical accelerometers



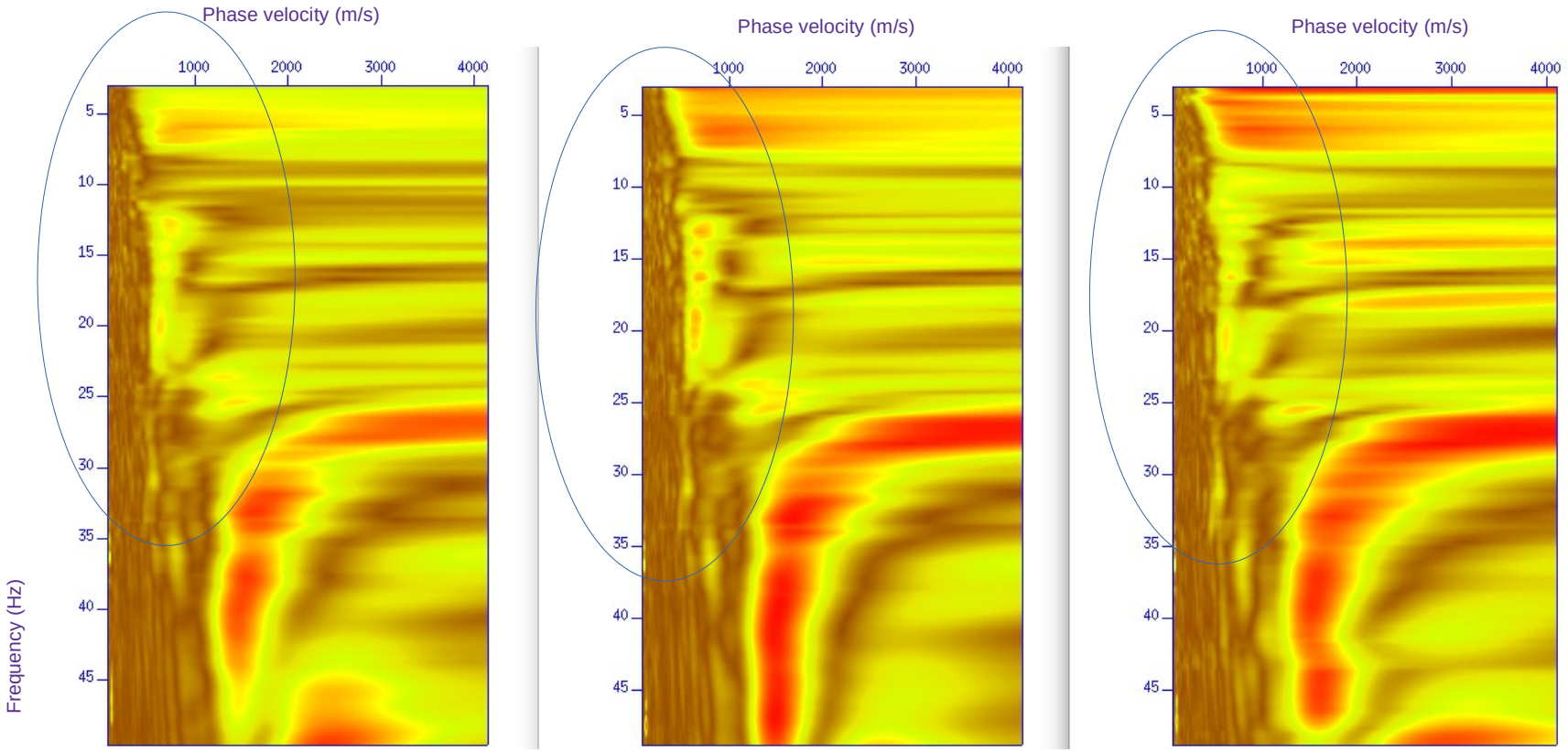
Source z= 5m

Source z= 13 m

Source z= 22 m

Min offset= 5m

DISPERSION DIAGRAM VS SOURCE DEPTH
Zoom of the previous slide



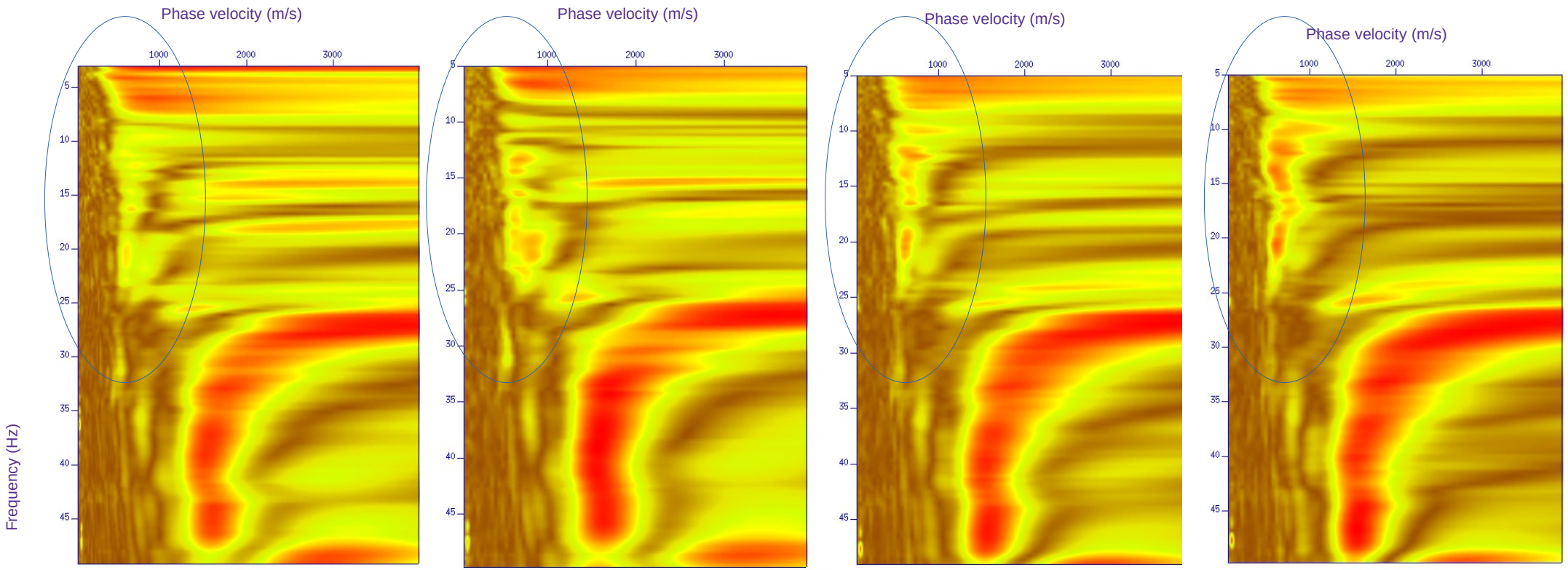
Source z= 5m

Source z= 13 m

Source z= 22 m

Min offset= 5m

DISPERSION DIAGRAM VS OFFSET FOR VERTICAL ACCELEROMETERS



Min offset = 5m

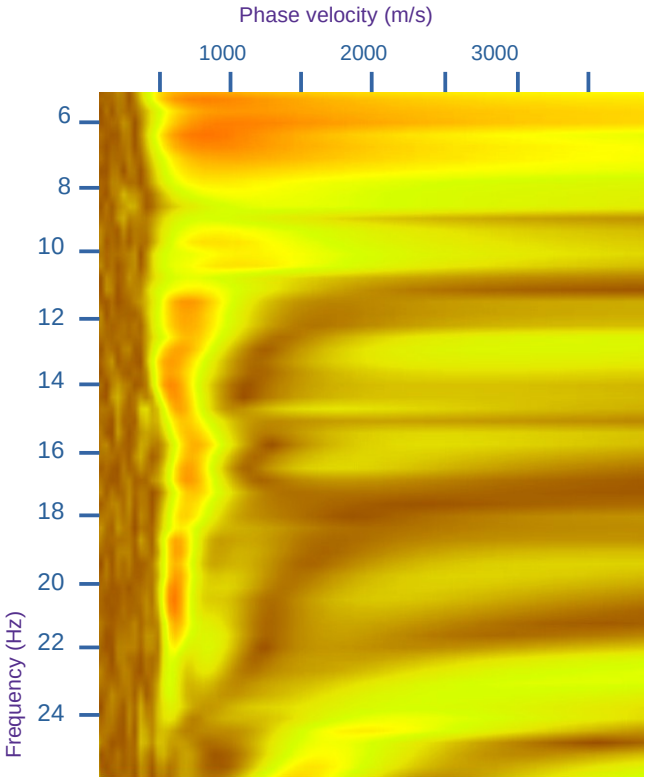
Min offset = 12 m

Min offset = 20 m

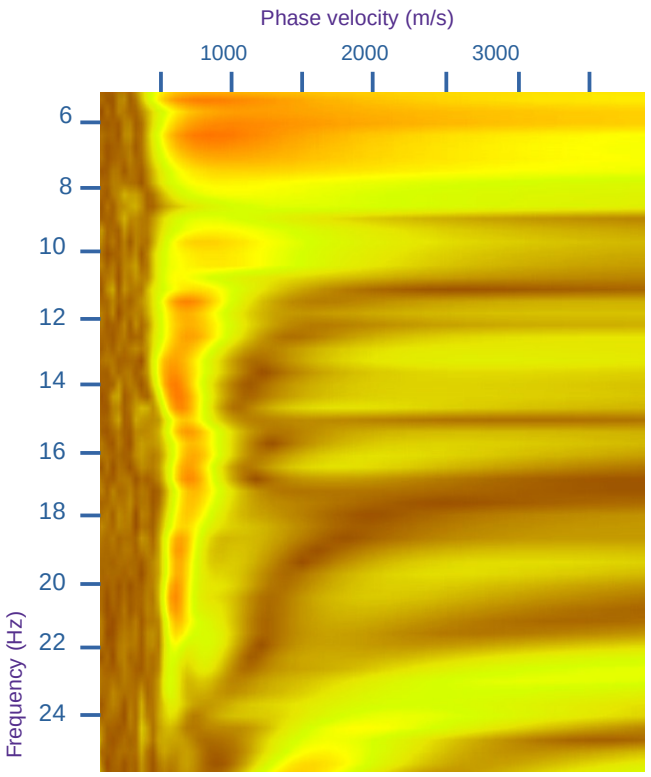
Min offset = 30 m

Source Z = 22 m

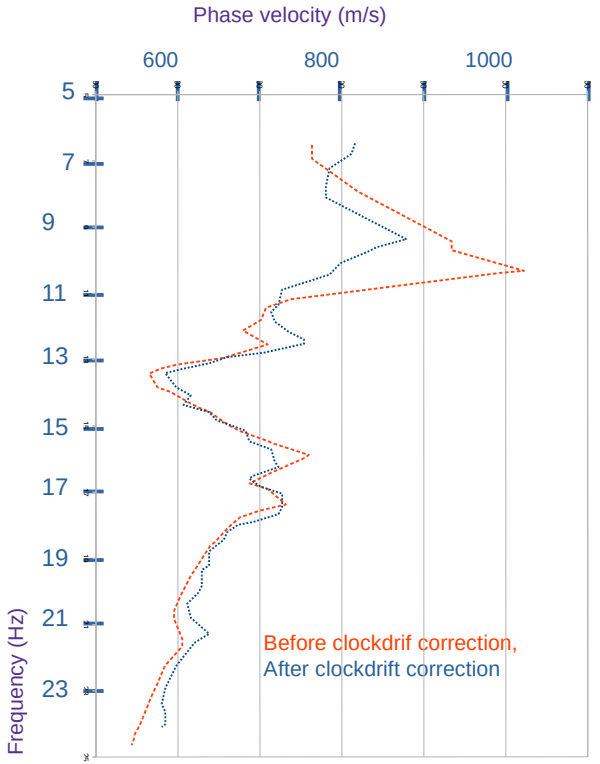
Phase velocity dispersion before and after clockdrift corrections



before clockdrift correction



after clockdrift correction



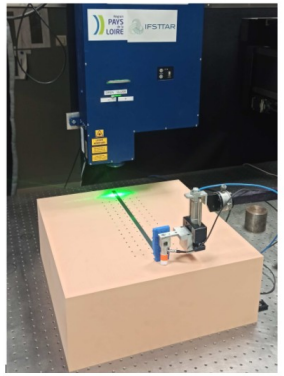
Picked frequencies corresponding to wavelengths in the range [15; 85] m

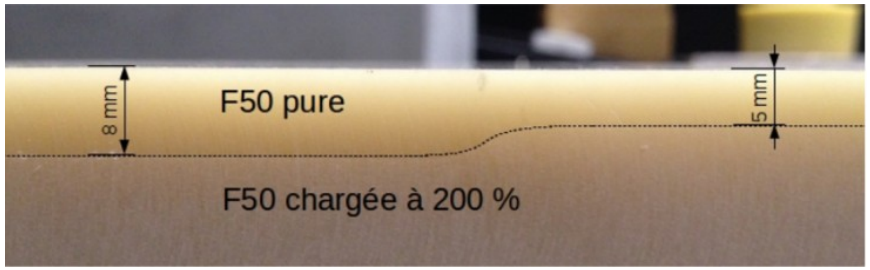
CONCLUSION AND PROSPECTS

- Data information for surface waves dispersion is higher for :
  - vertical accelerometers (in the frequency range of interest)
  - minimum offset of the source position equal to 30 m
  - source depth (air-gun) near the bottom sea (22 m)

- next steps :
  - Inversion of the Data with a 2D medium assumption to recover the Vs velocity profile
  - Reduced scale tests in a water tank
  - Towards environmental multi-disciplinary exploration

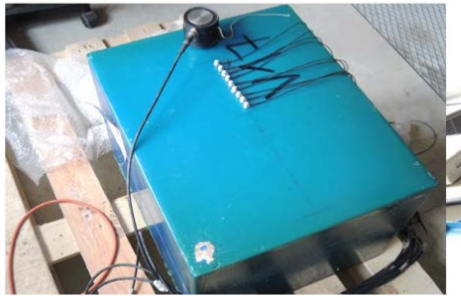
FURTHER PROGRAM : REDUCED SCALE TESTS





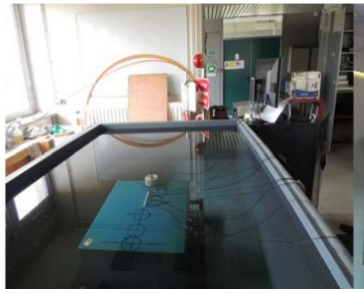
MUSC MEASUREMENT

Maquette de résine

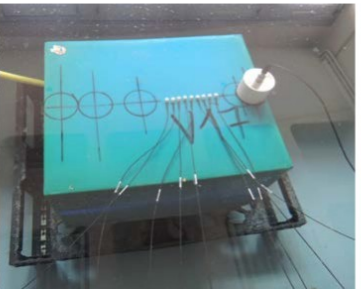


Acquisition en milieu non immergé

Cuve acoustique



Acquisition en milieu immergé



WATER TANK MEASUREMENT

OUTLINES

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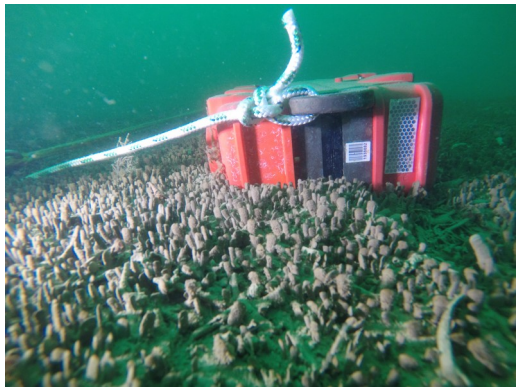
FURTHER APPROACH :

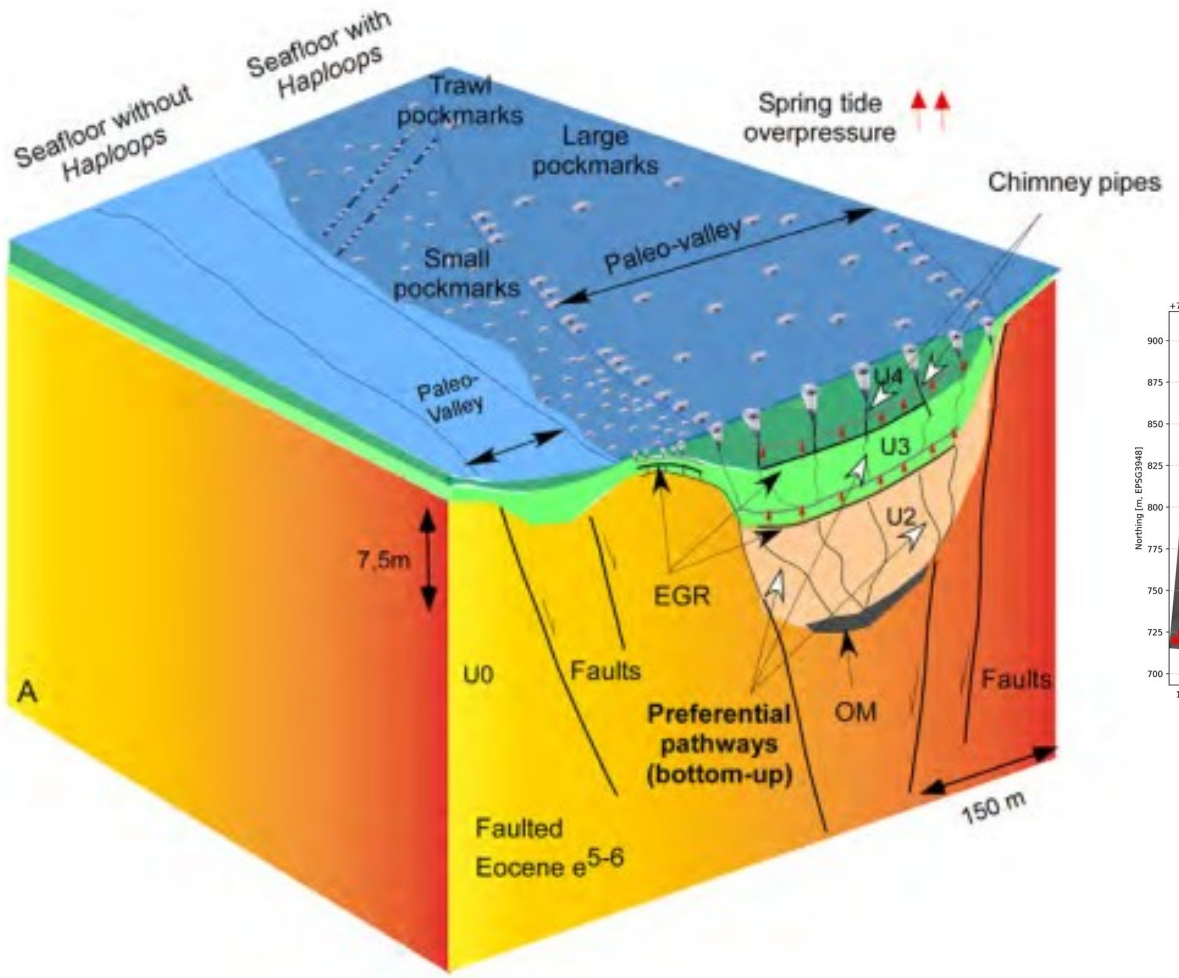
SEISMIC MEASUREMENT IN CONTEXT OF HAPLOOPS AND POCKMARKS :

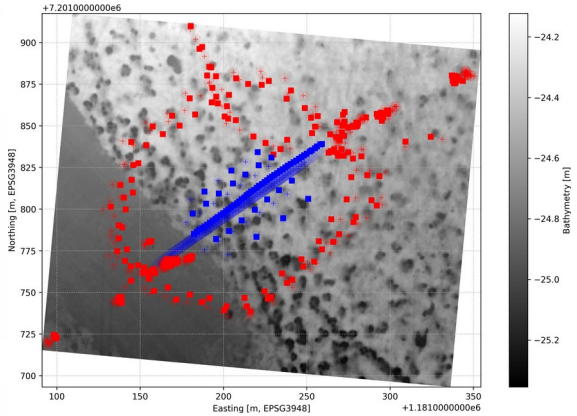
Methane outgassing markers (greenhouse gas)



Haploops

A. Baltzer *et al.*: BSGF 2017, Vol, 160050





Pockmarks

THANK YOU FOR YOUR ATTENTION