Underwater Multichannel Analysis Surface Wave (U-MASW)

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Near Surface Geophysical Techniques

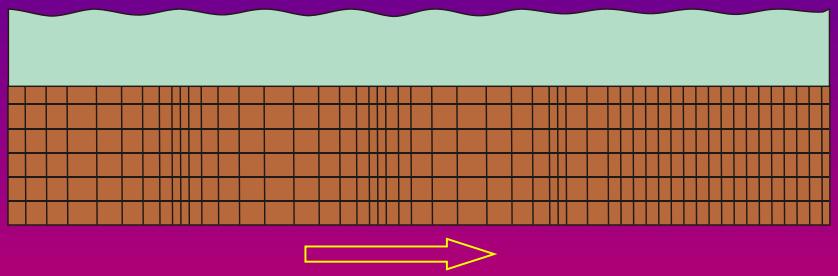
Introduction

Marine surface wave: Scholte wave
1) Properties
2) Numerical Inversion
3) Results

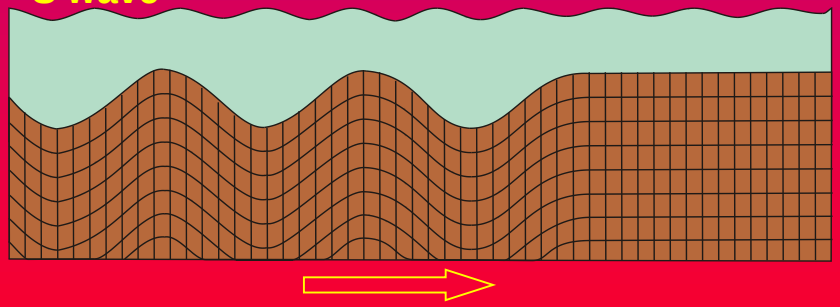
Conclusion

Introduction

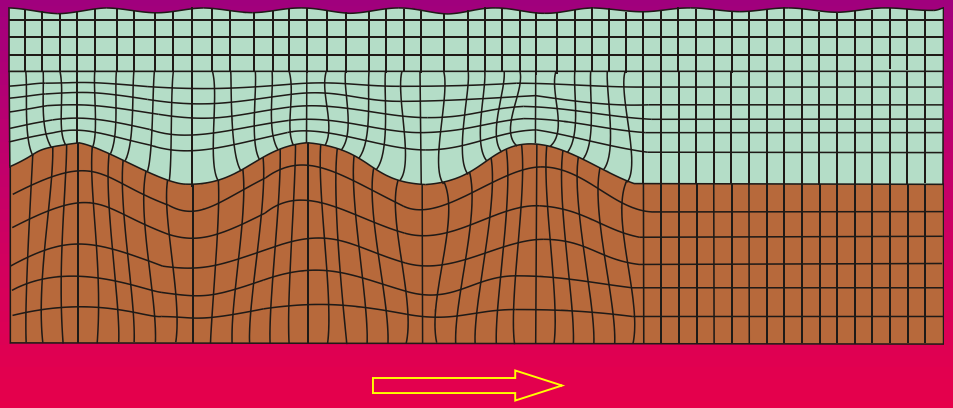
P wave



S wave



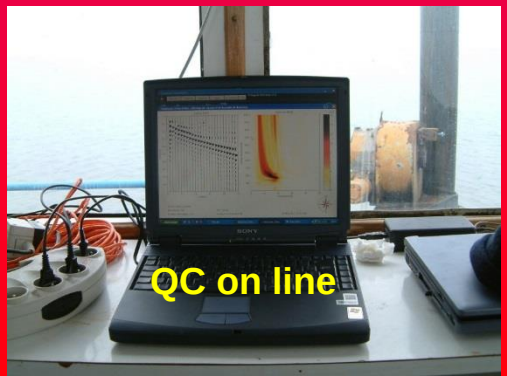
Surface wave: Scholte



Equipments

Umbilical and sledge

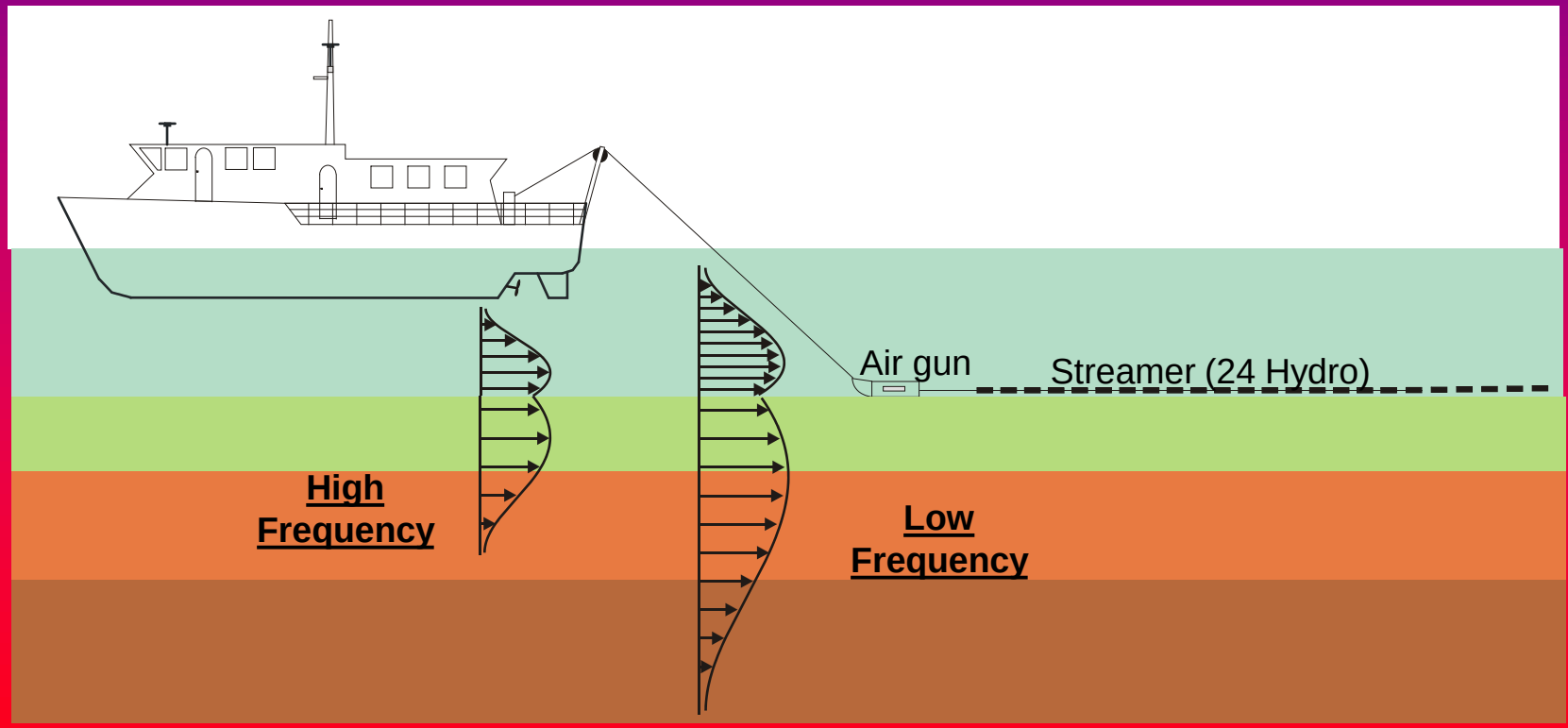
- **seismic recorder GEODES (24 channels)**
- **SGOS acquisition software**
- **Low frequency streamers (24 hydrophones equally spaced: 2 and 5 m)**
- **Umbilical from 100 to 400 m**
- **Sledge with an air gun Sodera**
- **Laptop for the QC on line**



Underwater Multichanel Acquisition Surface Wave (U-MASW)

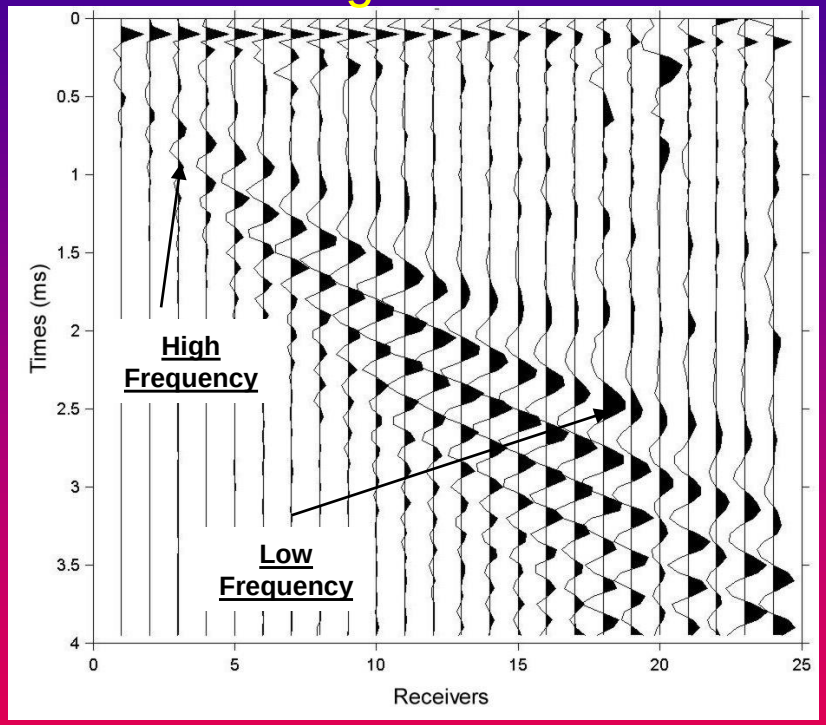
- The propagation is function of the geometry (layer thickness) and shear wave properties of the soil.

- The penetration is function of the wavelength



Marine surface wave: Scholte wave

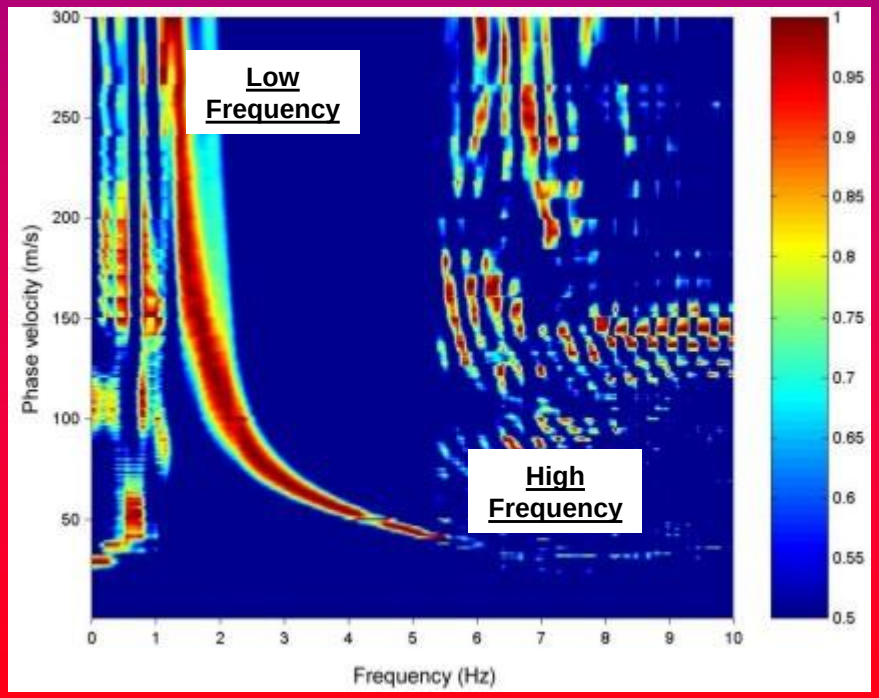
Signal



P-tau transform or "slant stack"

(velocity spectral analysis)

Dispersivity



Numerical model

Water : ρ_o = 1, Vp1 =1500 m/s, H_o

Layer 1 : ρ1 ; z1 ; Vp1 ; Vs1

Layer 2 : ρ2 ; z2 ; Vp2 ; Vs2

Layer i : ρi ; zi ; Vpi ; Vsi

Layer n : ρn ; zn ; Vpn ; Vsn

Substrate : ρ ; Vp ; Vs

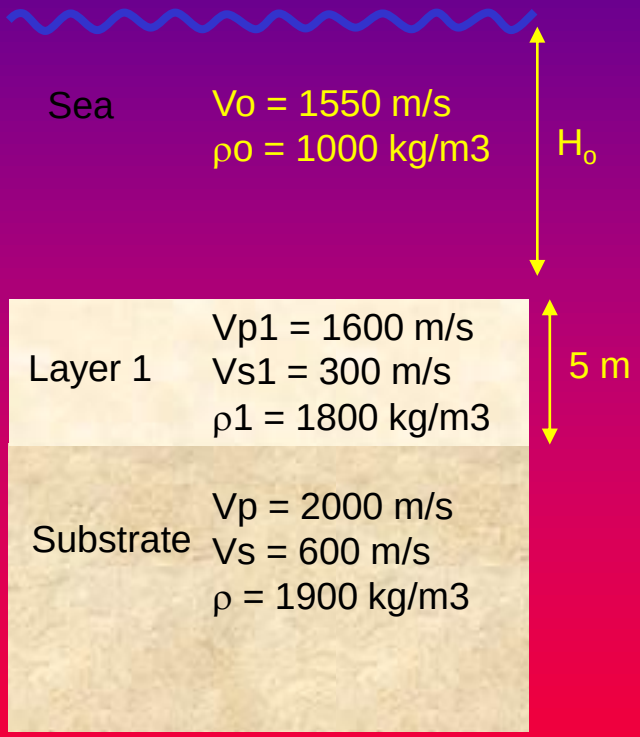
Water :
H_o : water depth measured during the survey
ρo and Vp1 are fixed

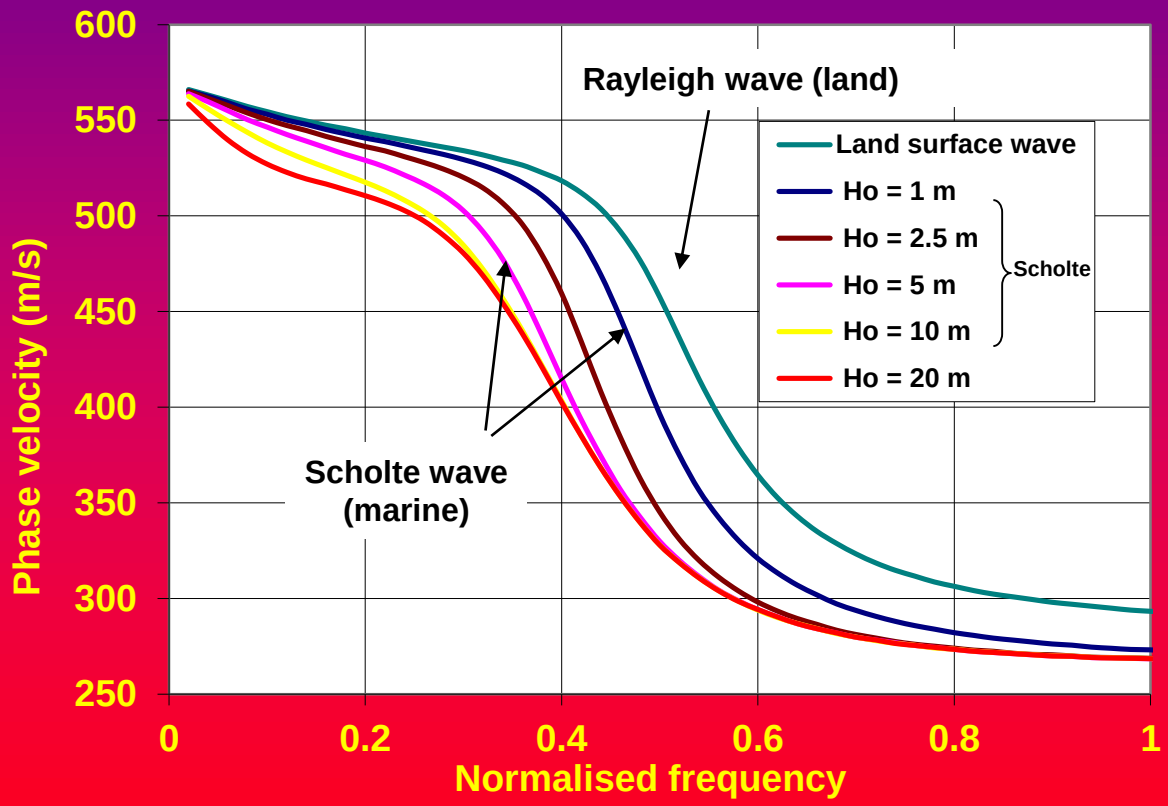
Layer i :
ρi : density
zi : layer base position
Vpi : P wave velocity
Vsi : S wave velocity

Equations of continuity of displacement and stress lead to a system of equations. The resolution of this system give access to the model dispersive curve.

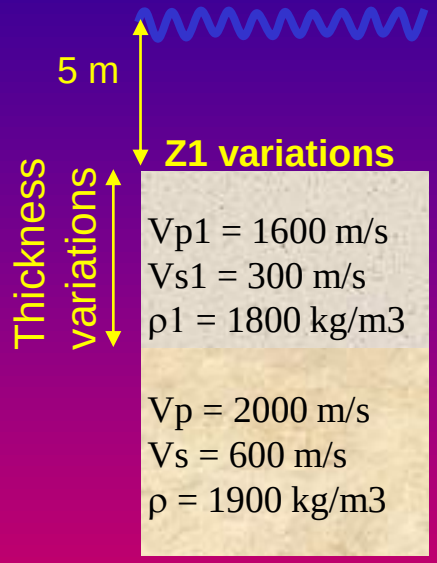
Automated inversion by iterative procedure minimize the difference between the theoretical and experimental dispersion curve

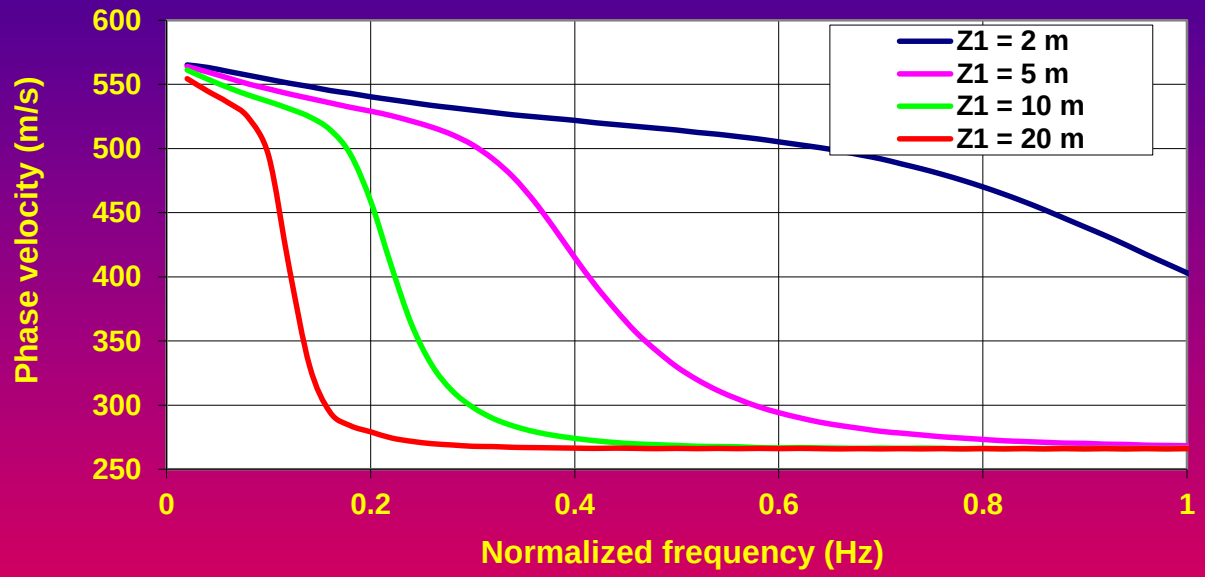
Majors parameters: water depth

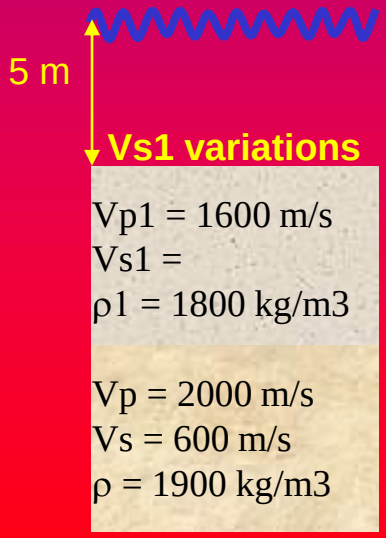


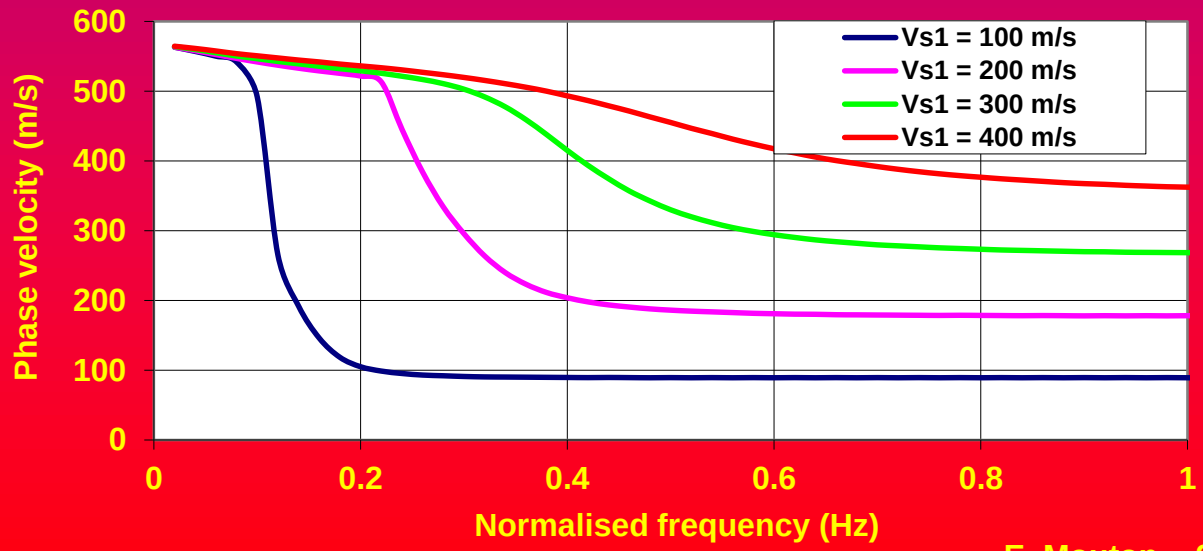


Majors parameters: thickness, shear wave velocity









U-MASW : summary

1) Major parameters :

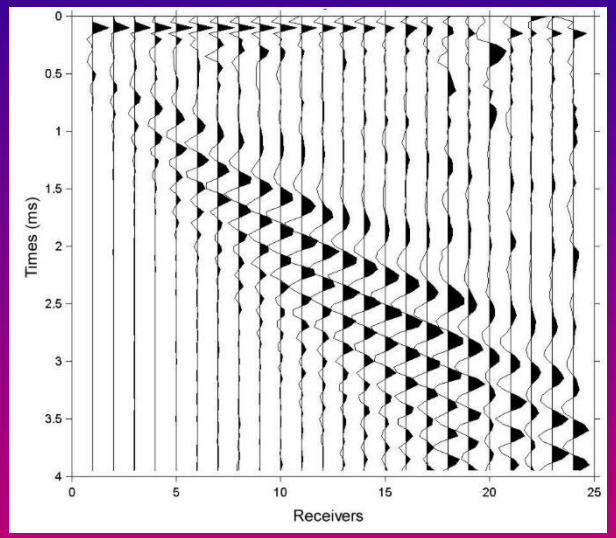
- water depth measured during the survey
- layers thickness
- shear wave velocity

2) Depth investigation depends on the frequency range

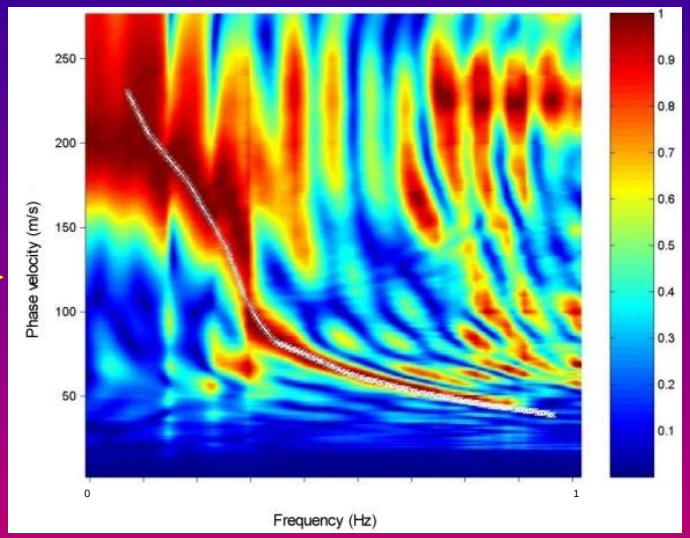
depth max # wavelength (λ) = interface wave velocity / frequency

Processing

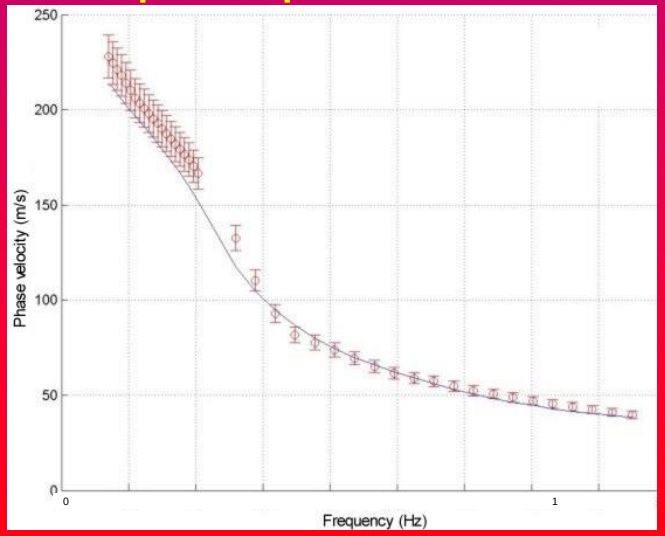
Acquisition



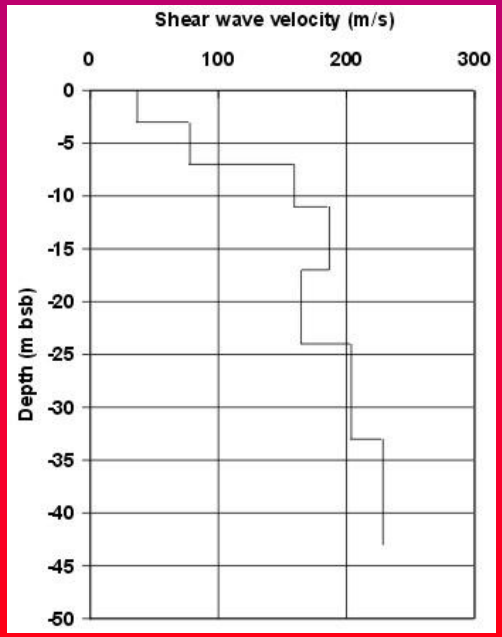
Dispersion



Dispersion picked and modelled



Vs function of the depth



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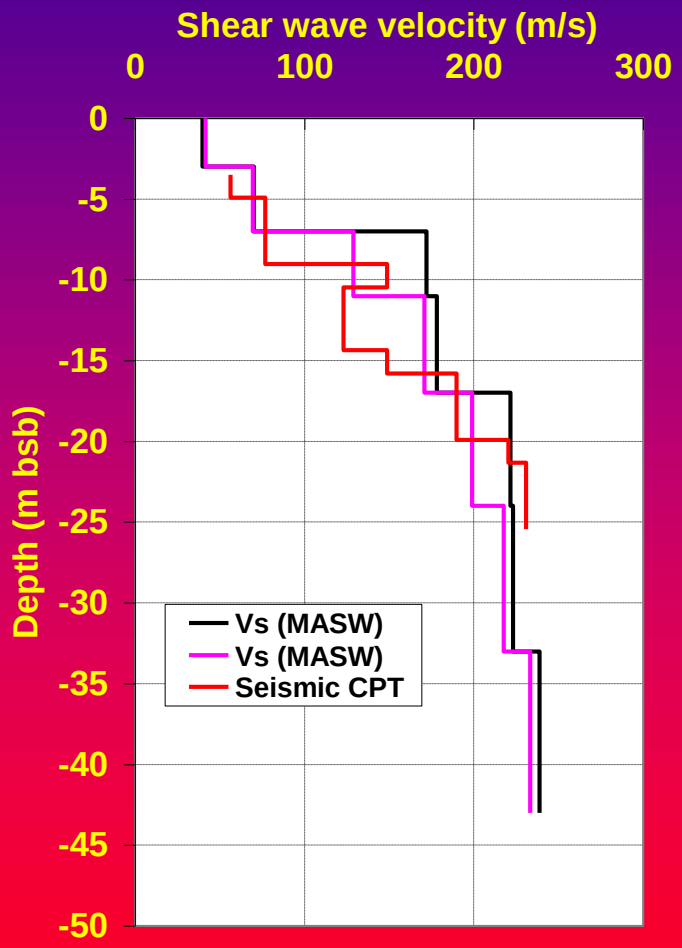
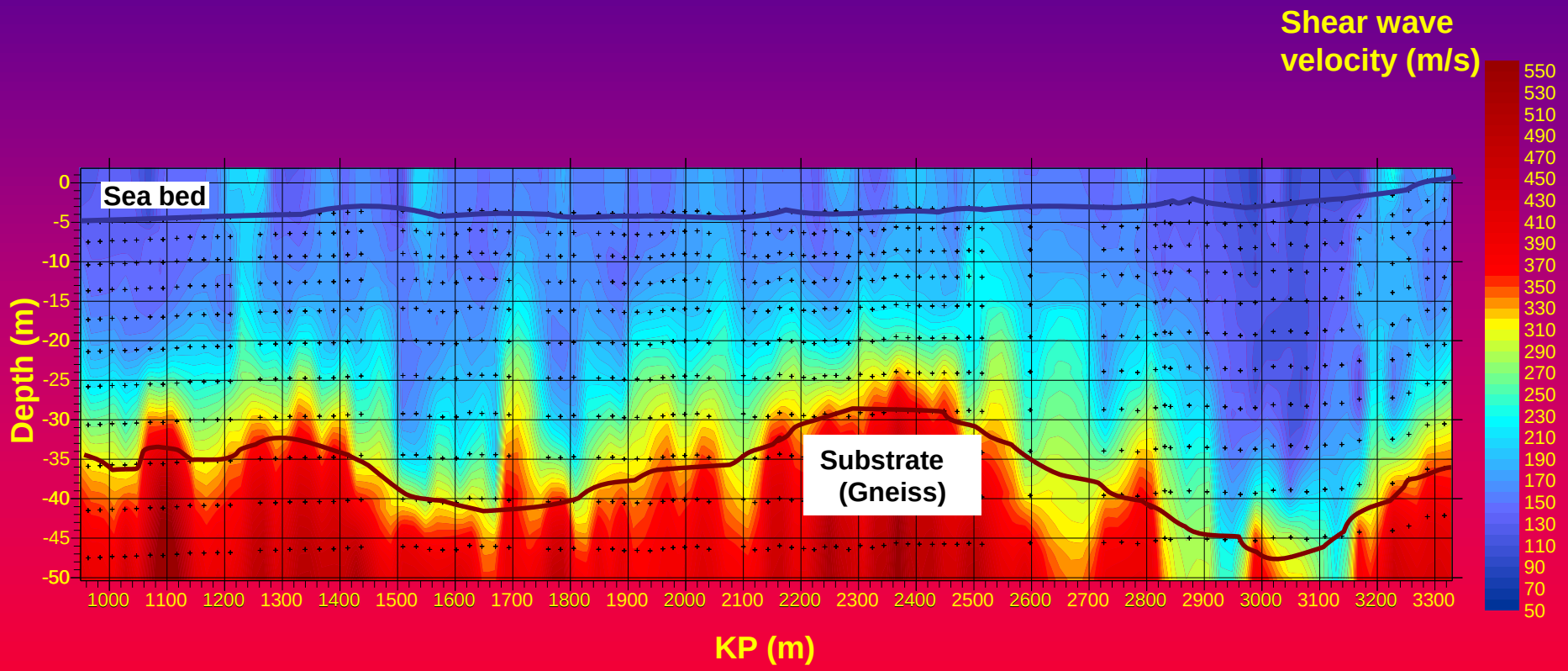
Shear wave velocity : U-MASW and Seismic CPT



	Marine survey	
	Refraction Vp (m/s)	Surface wave Vs(m/s)
Water	1550	
Silt	1550	50-200
Clay	1550	400-600
Saturated sand	1550-2200	320-880

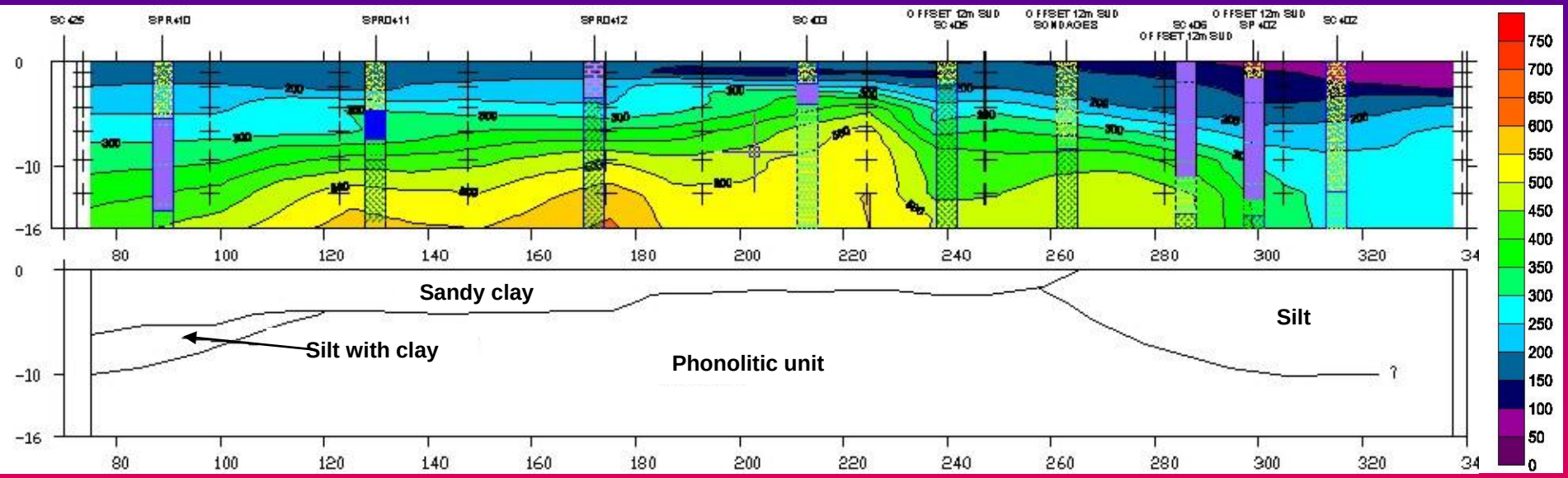
Continuous shear wave velocity profile



Field operation conditions :

- **water depth : 1 to 10 m**
- **presence of gas charged sediment**

Characterization of nature and stiffness



Evaluation of the proportion of the different materials

Conclusions: U-MASW

Field operations parameters:

- Water depth from 1 to 50 m
- Maximum depth investigation for the shear wave velocity: about 40m.

Advantages:

- We can provide shear wave velocity profiles along several kilometres of route in few days of operations
- Anomalous site conditions can be identified during the survey
- Penetration not limited by the water depth
- Direct correlation with measurements using seismic CPT,
- Marine surface wave penetrate in soil also of gas charged sediments
- In situ measurement of the small strain shear modulus G_o of marine sediment (soil structure interaction problems).

Conclusion

- Marine surface wave is well adapted to qualify quickly a site:
  - Pipeline or cable route (soil-pipeline interactions)
  - Harbour development
  - LNG and oil terminal
  - Coastal equipment
  - …