



Advances in Engineering Geophysical Methods

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Fugro Middle East

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How do we reduce subsurface uncertainty with respect to abnormal subsurface conditions (voiding/weak zones)?

- geotechnical boreholes/sampling/wireline logging
- geophysical techniques

Geophysics can be used to optimise intrusive programmes and to interpolate between points of borehole control

The Geophysical Toolkit

- GPR
- EM
- Microgravity
- ERT
- Seismic refraction
- MASW



Site Conditions:

- dry limestone
- deep water table
- subdued topography
- low ground conductivity
- high K contrast target
- shallow target

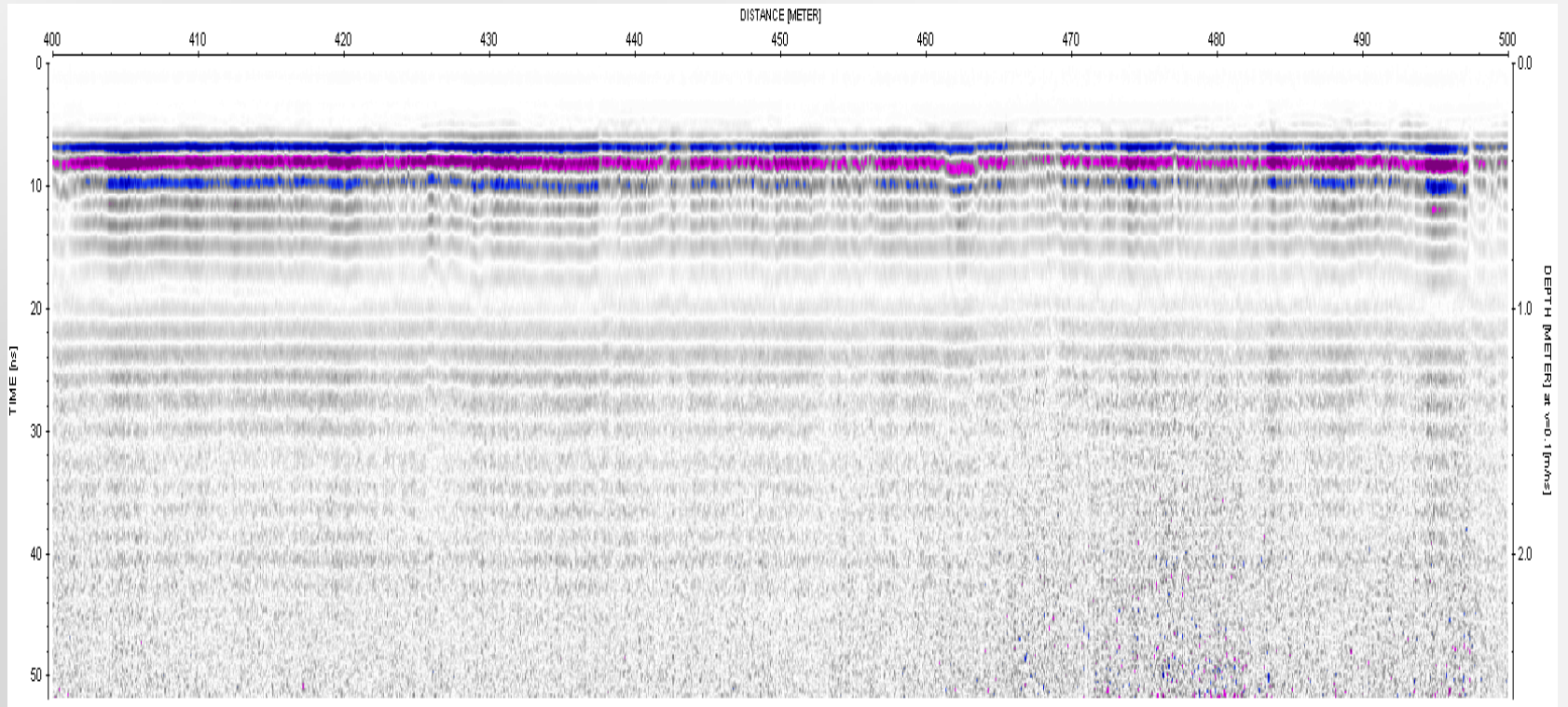
... **GPR**

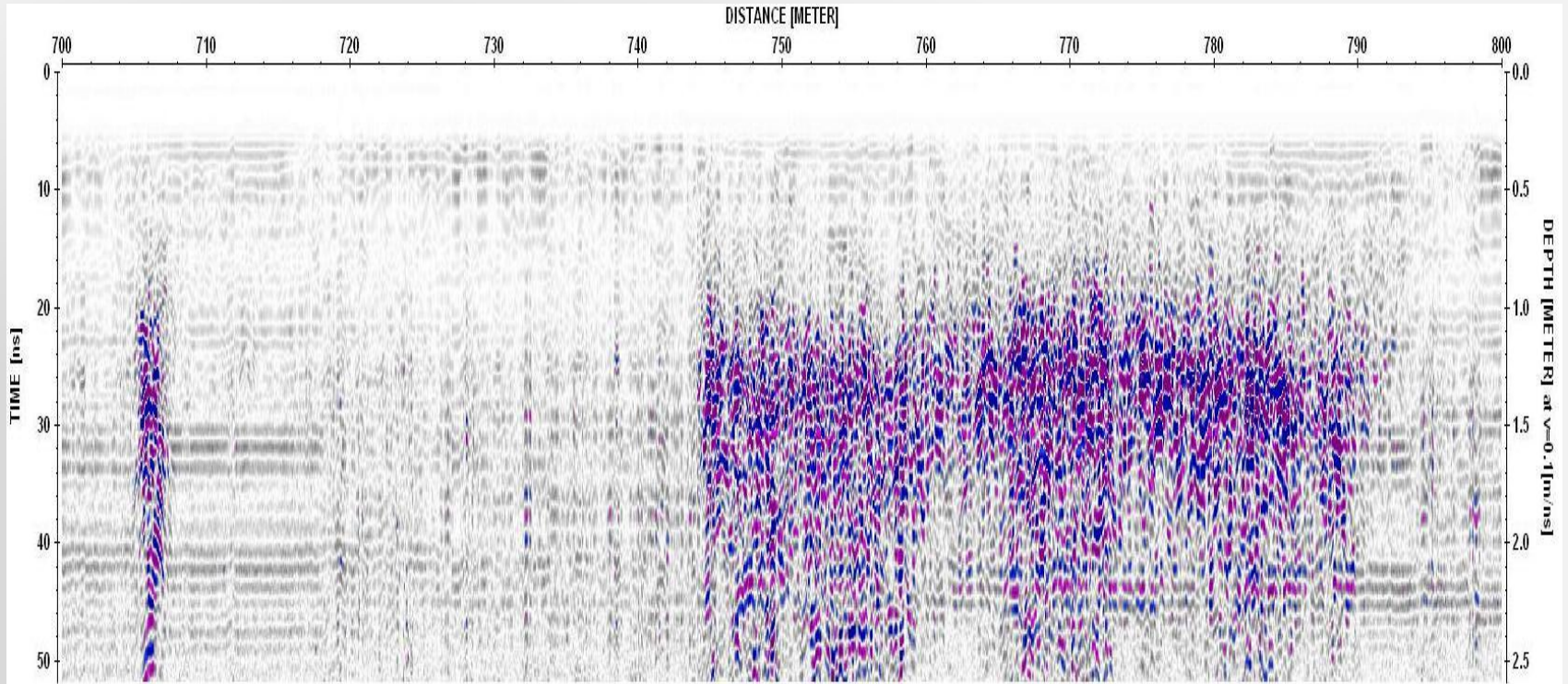


- 100 MHz system
- 0.25 m station interval
- 64 stacks per station

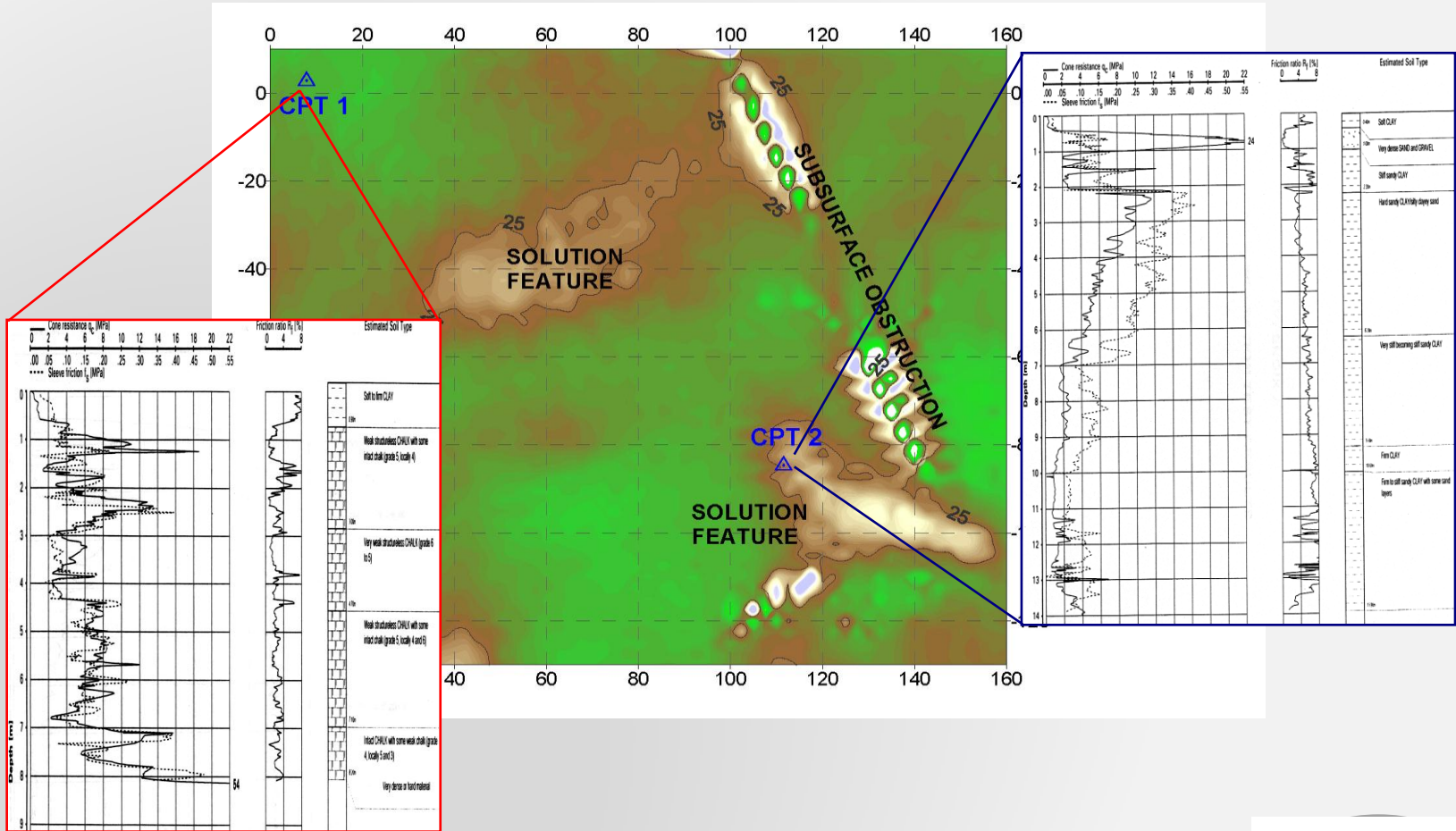


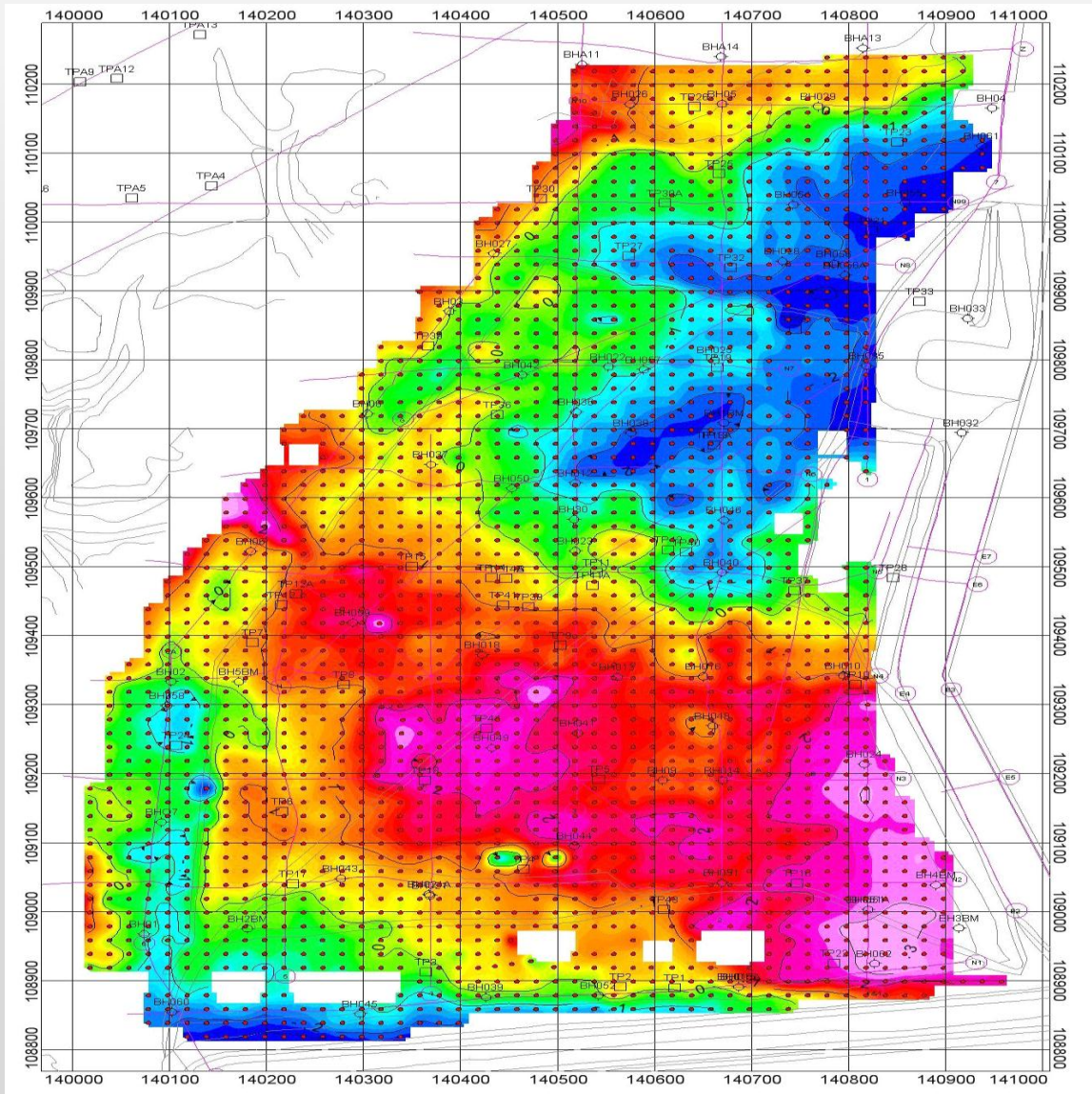
- no apparent relative movement
- structure 'dilates' at depth
- structure extends to surface





Electromagnetic Conductivity Profile







Development site

clays/marls over
Triassic limestone
and dolomite

many surface
features

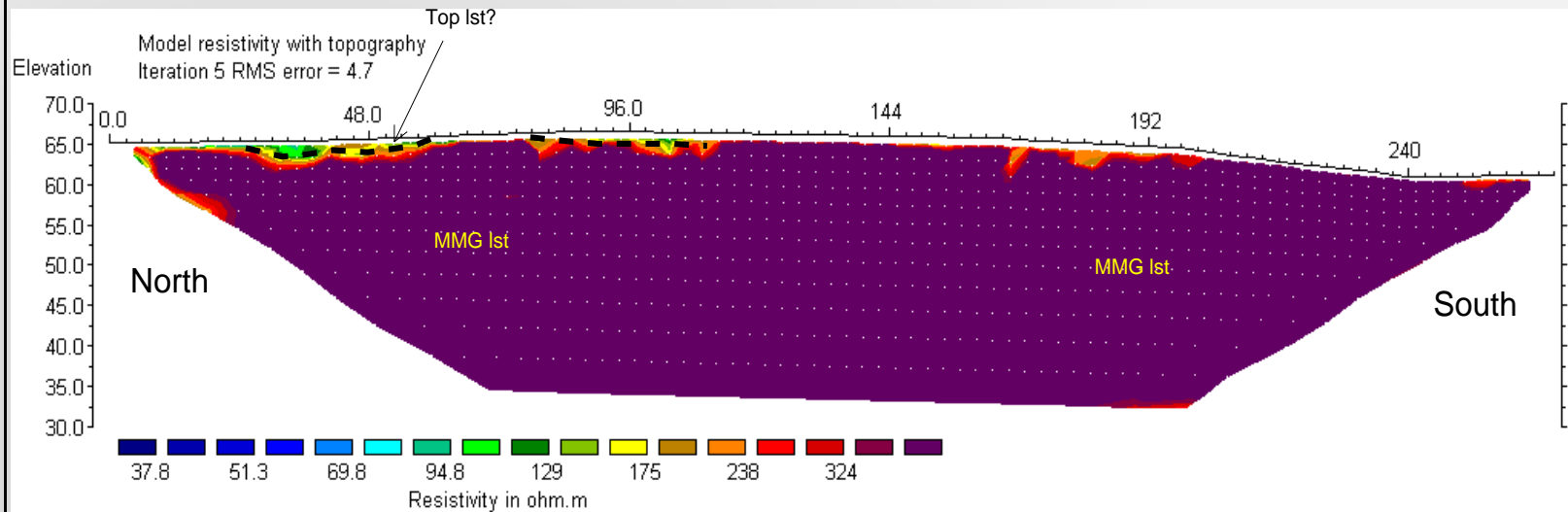
major faults

site bounded by Jurassic
and Carboniferous
strata

Parc Derwen Phase 3 Geophysical Investigation - Line 37 Preliminary Output

Line 37

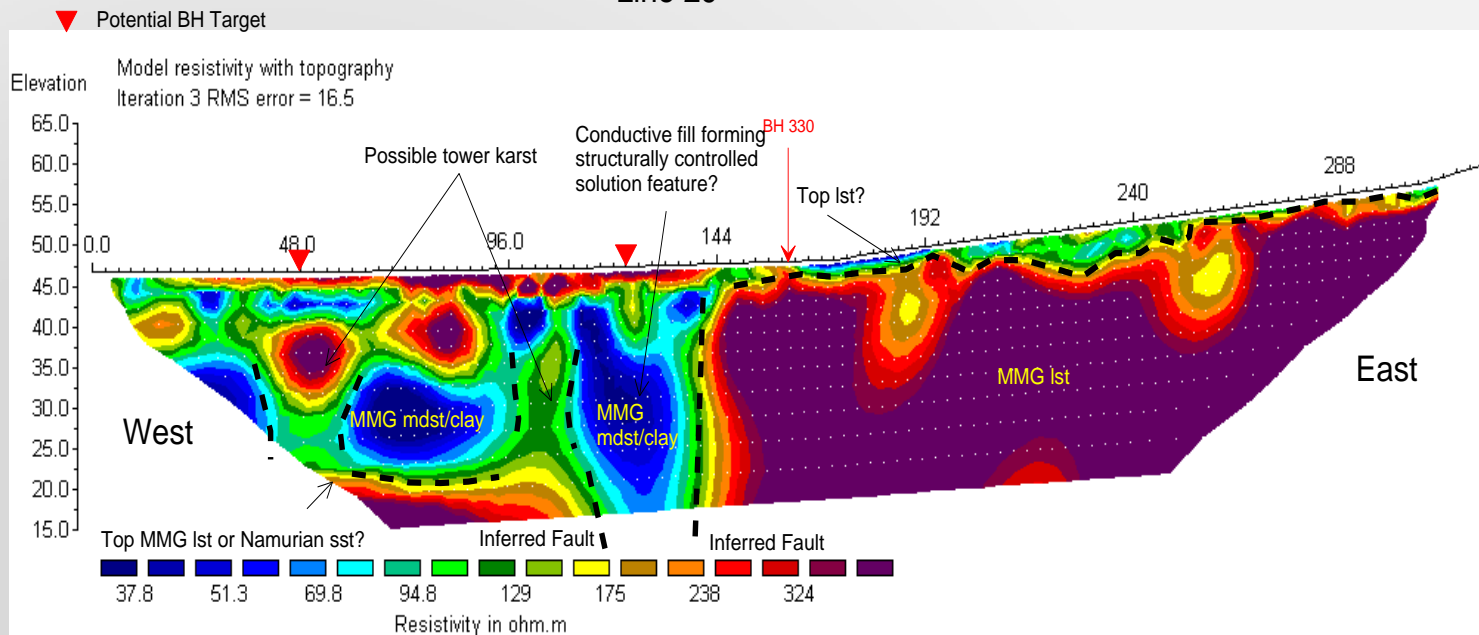
▼ Potential BH Target



Horizontal scale is 10.58 pixels per unit spacing
Vertical exaggeration in model section display = 1.41
First electrode is located at 0.0 m.
Last electrode is located at 267.0 m.

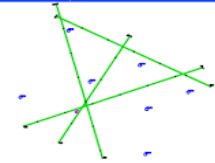
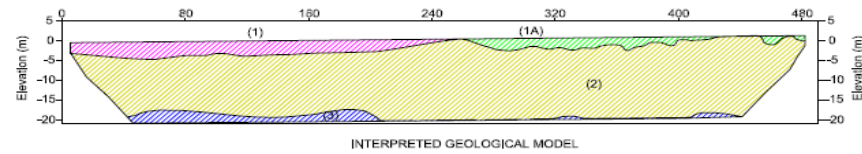
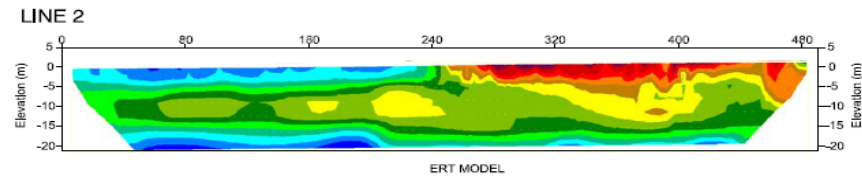
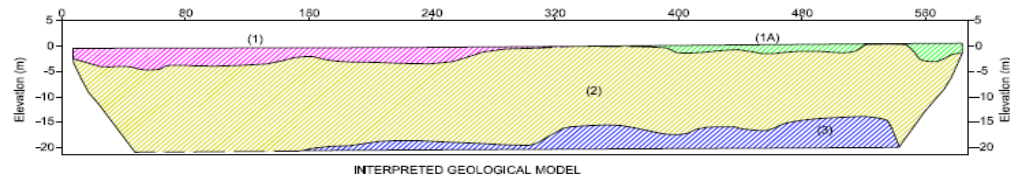
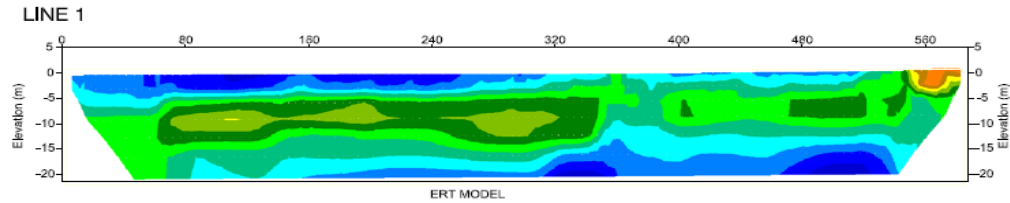
Parc Derwen Phase 3 Geophysical Investigation - Line 29 Preliminary Output

Line 29



Unit Electrode Spacing = 3.0 m.

Horizontal scale is 8.81 pixels per unit spacing
Vertical exaggeration in model section display = 1.64
First electrode is located at 0.0 m.
Last electrode is located at 321.0 m.



GENERAL LOCATION PLAN
Scale 1:13000

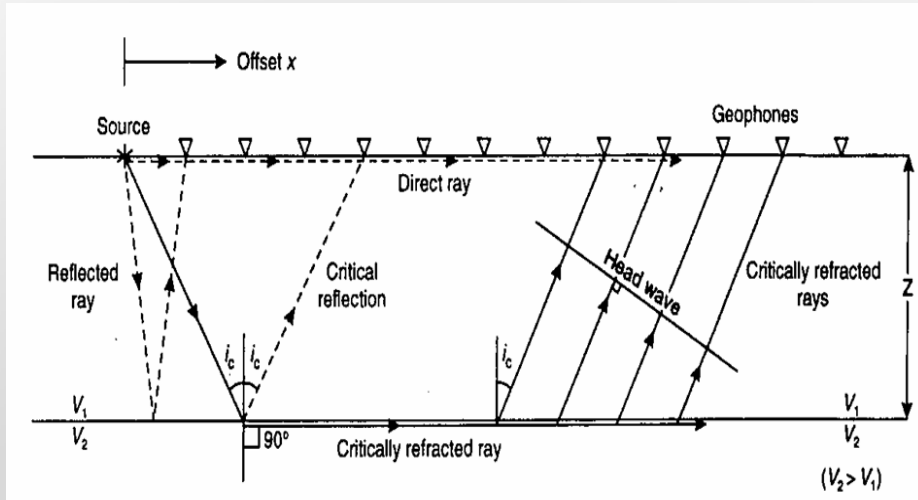
LEGEND:

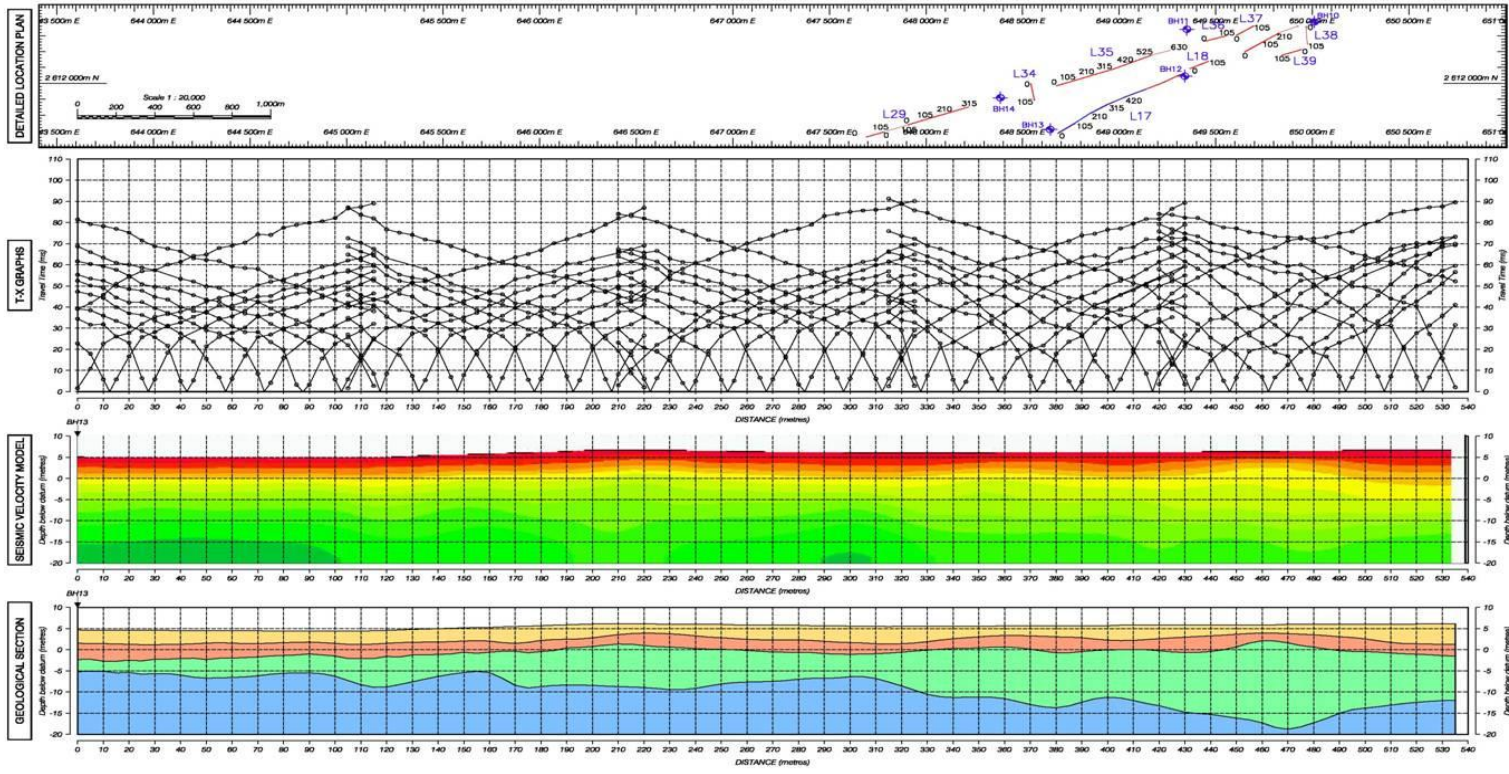


- UNIT 1
- UNIT 1A
- UNIT 2
- UNIT 3

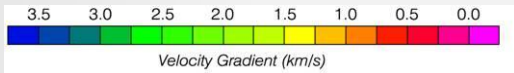
DATE:	
COMPANY:	FUGRO MIDDLE EAST geotechnical, marine engineers and surveyors
PROJECT:	
DWG. TITLE:	ERT AND GEOLOGICAL MODELS
DRAWN BY:	NER
DESIGNED BY:	NER
CHECKED BY:	NER
APPROVED BY:	NER
DATE:	
SCALE:	1:2500
PROJECT NO.:	
DWG. NO.:	
REV. NO.:	

GENERAL NOTES

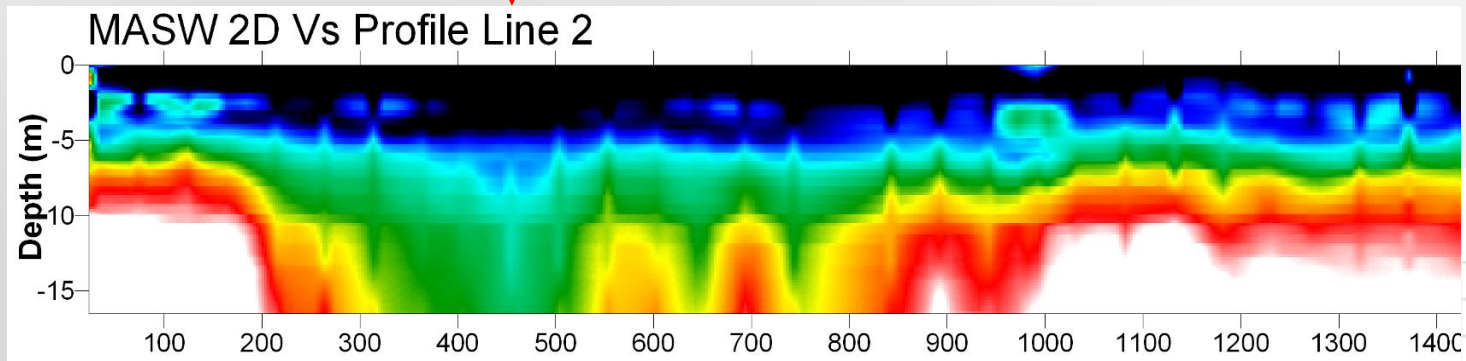




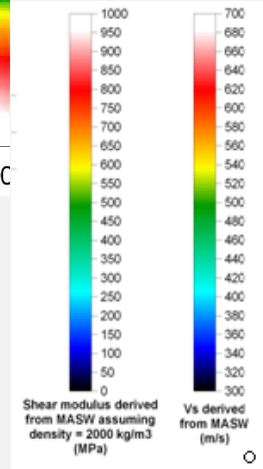
- Fine to Medium Sand
- Medium to Dense Sand
- Cemented Sands & Gravels
- Limestone



Position of cavity (offset 10m)



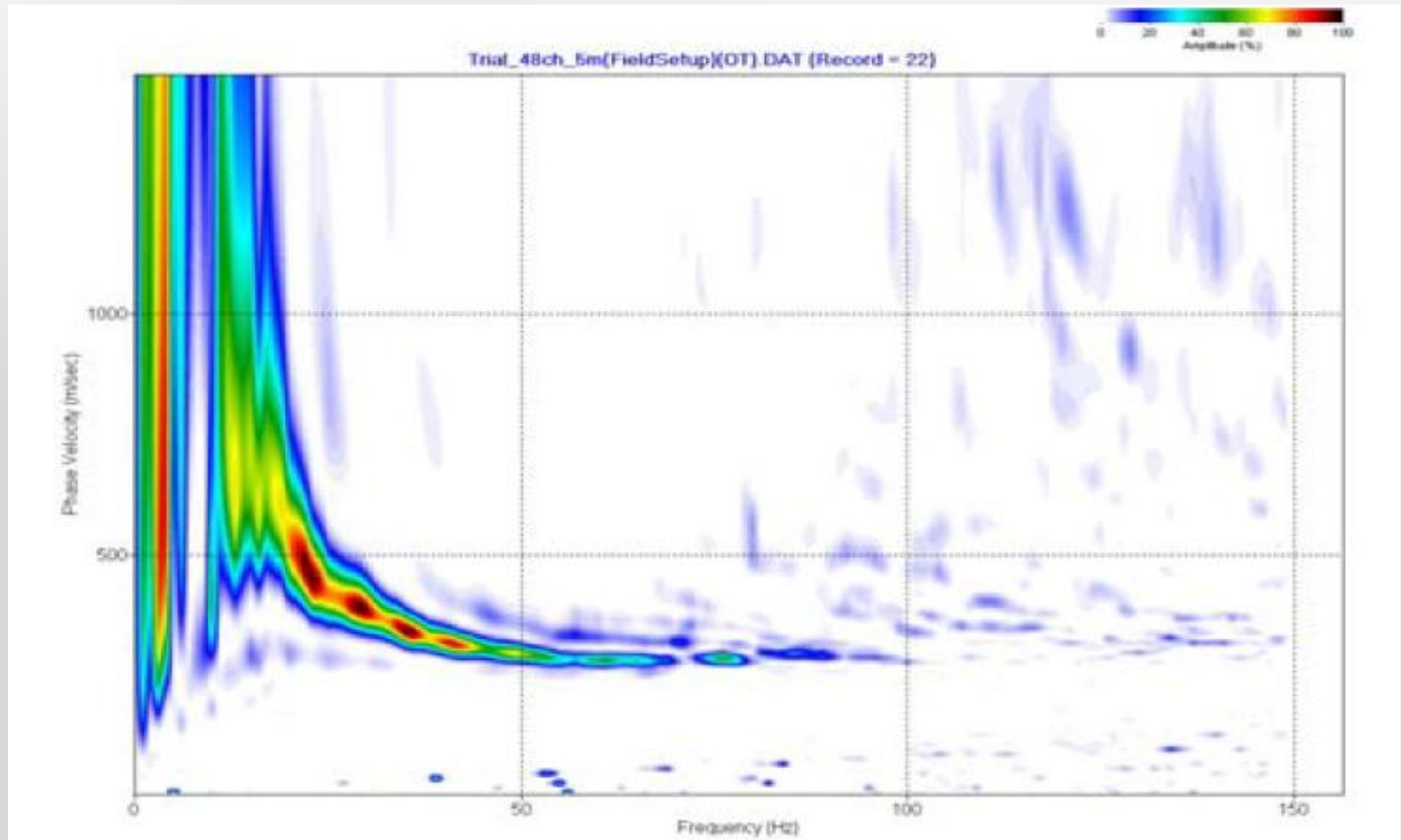
Low velocity zone indicates a major dissolution feature/area of weak ground



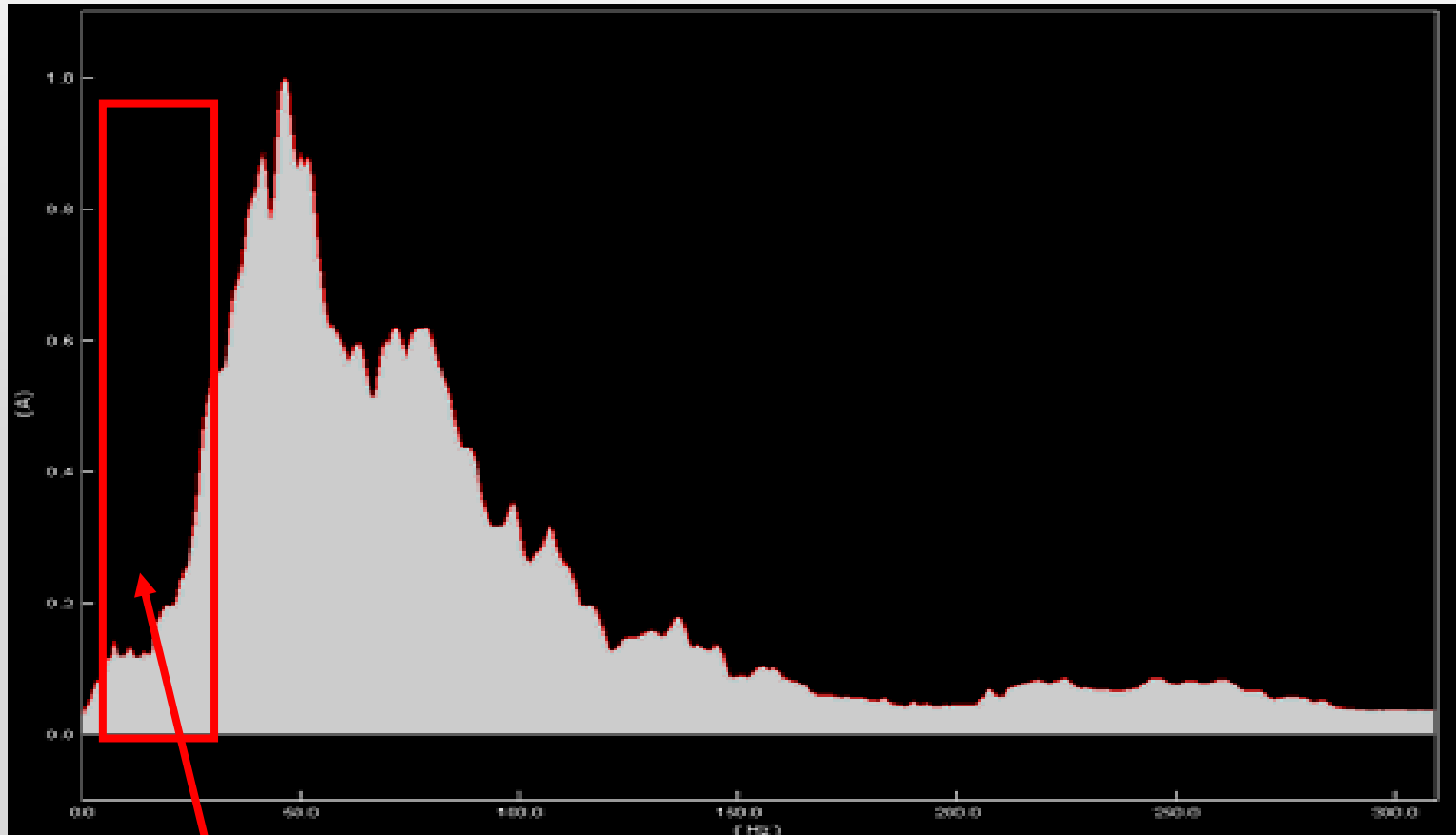
Limiting Factors For Investigation

- **MASW** – dependent on frequency content/site conditions
- **Refraction** – velocity inversion
- **Microgravity** – depth/resolution
- **ERT** – depth/resolution/masking
- **GPR** – conductivity
- **EM** – depth/resolution

MASW Dispersion Curve



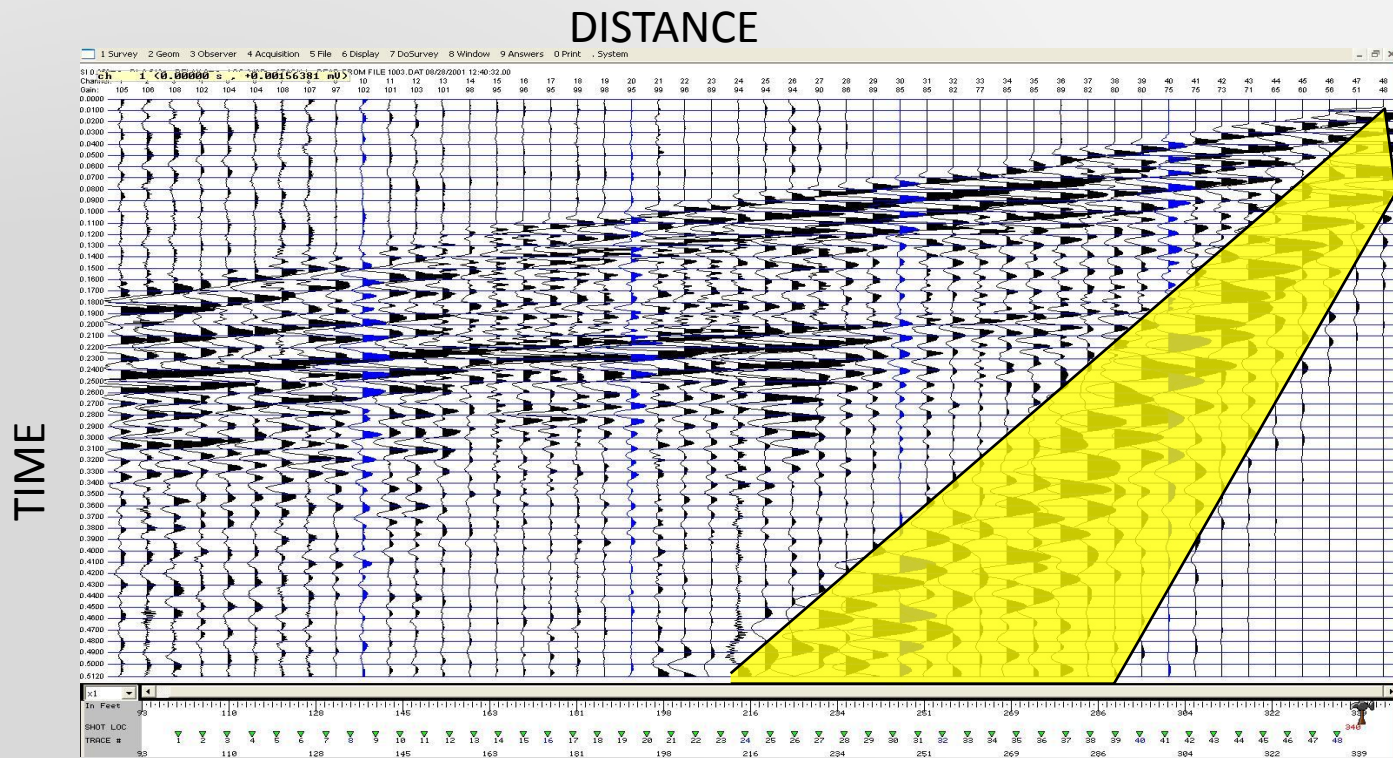
MASW – Low Frequency Requirements



Qatar applications > 20 m depth

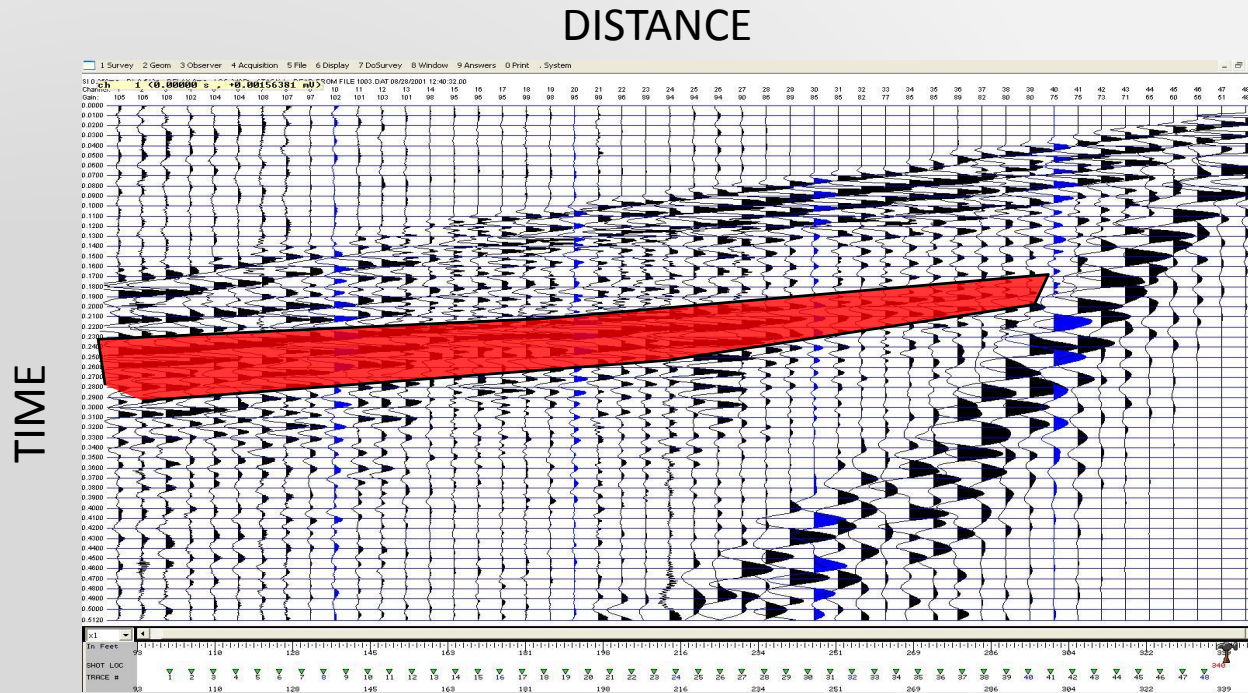
The Multicomponent Seismic Wavefield

Most shallow investigations use only the **slow velocity component** of the seismic wavefield



The Multicomponent Seismic Wavefield

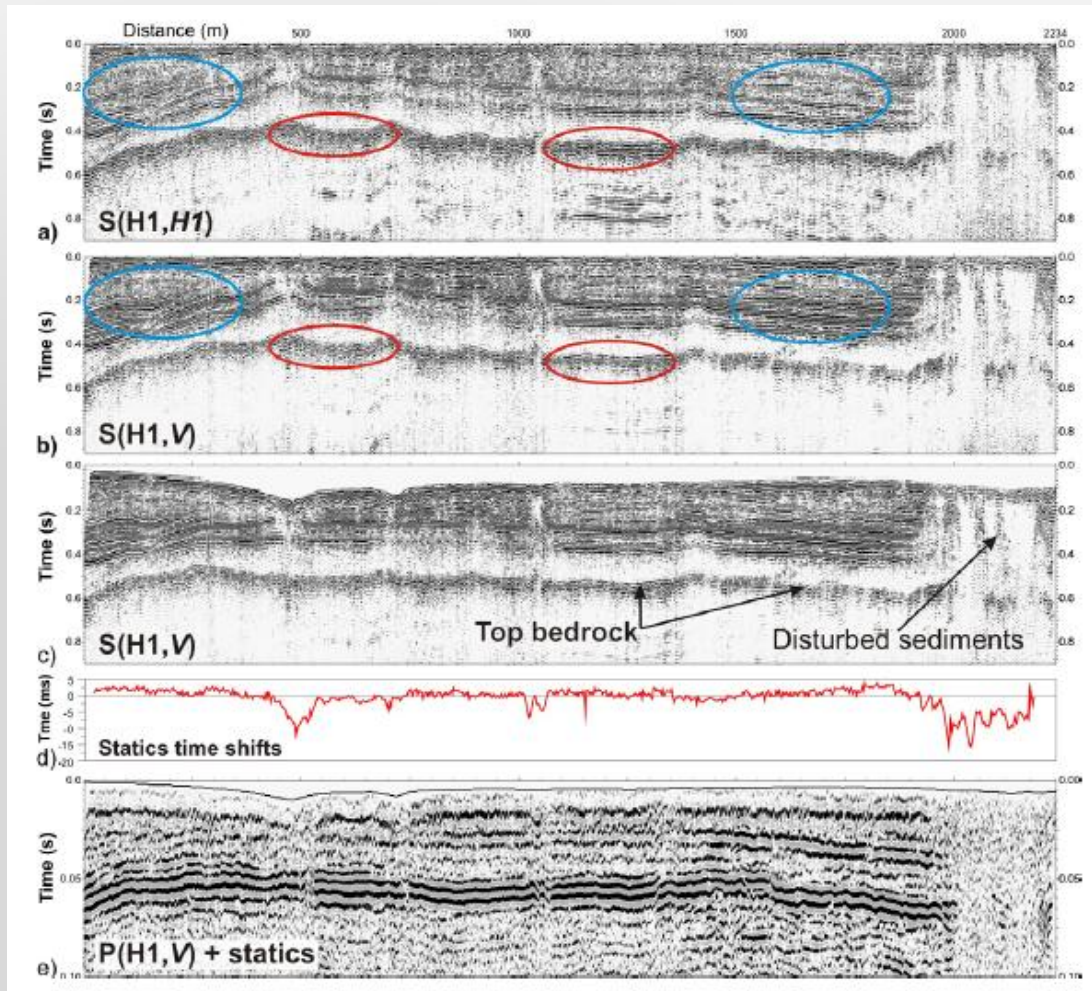
The higher velocity **reflected component** is not generally used for very shallow onshore geotechnical investigation < 40 m



P and S Wave Velocities by Material

Material	Vp (m/s)	Vs (m/s)
Air	330	N/A
Water	1450-1530	N/A
Soil	100-500	50-150
Made Ground	160-600	50-300
Sand (dry, loose)	200-1000	50-400
Sand (water saturated, loose)	1500-2000	50-400
Sand & Gravel	400-2300	100-750
Clay	1000-2500	200-700
Estuarine muds/clay	300-1800	150-600
Floodplain alluvium	1800-2200	100-500
Sandstone	1400-5000	700-2800
Mudstone	1600-5000	600-2500
Shales	2000-4100	600-2100

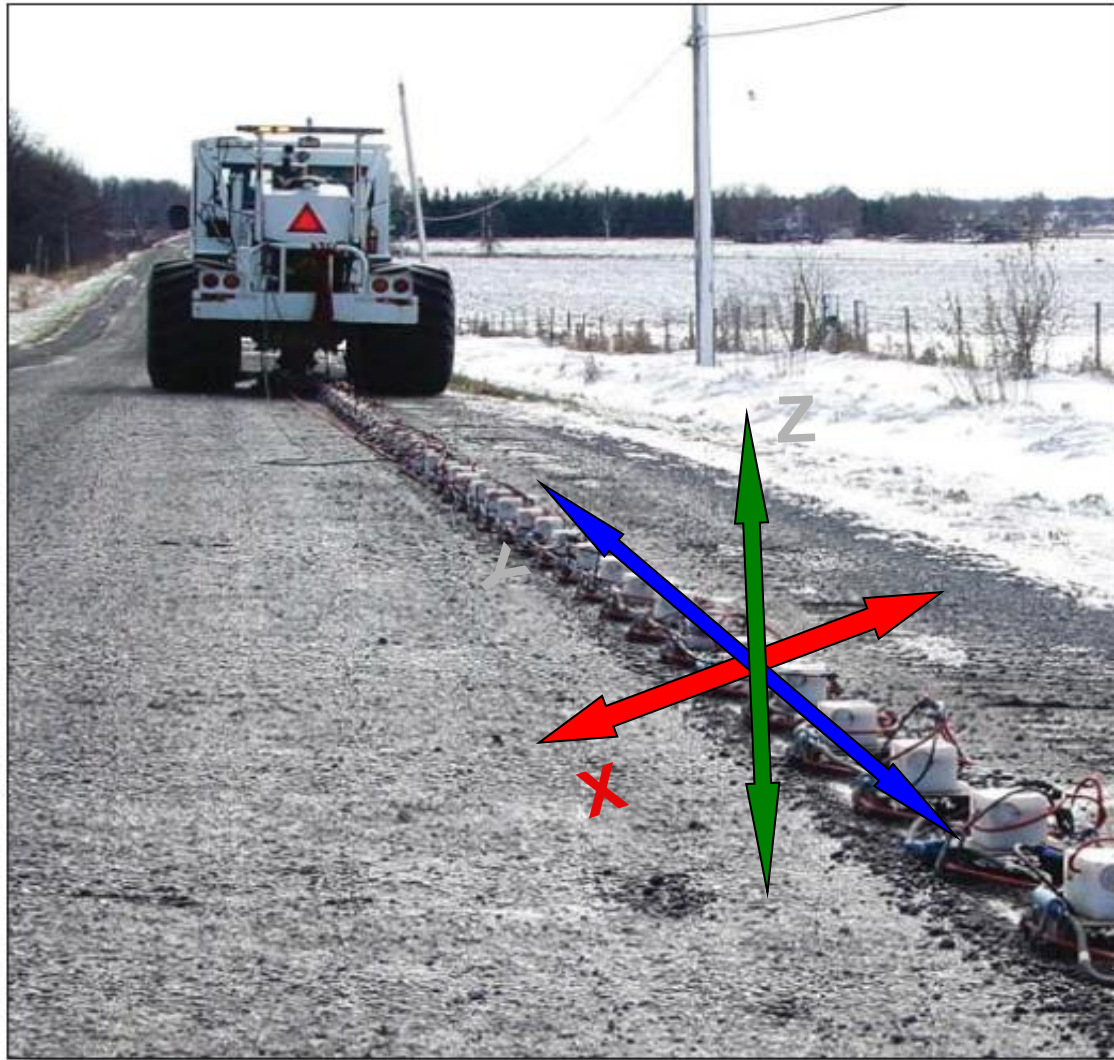
P- and S-Wave - Resolution



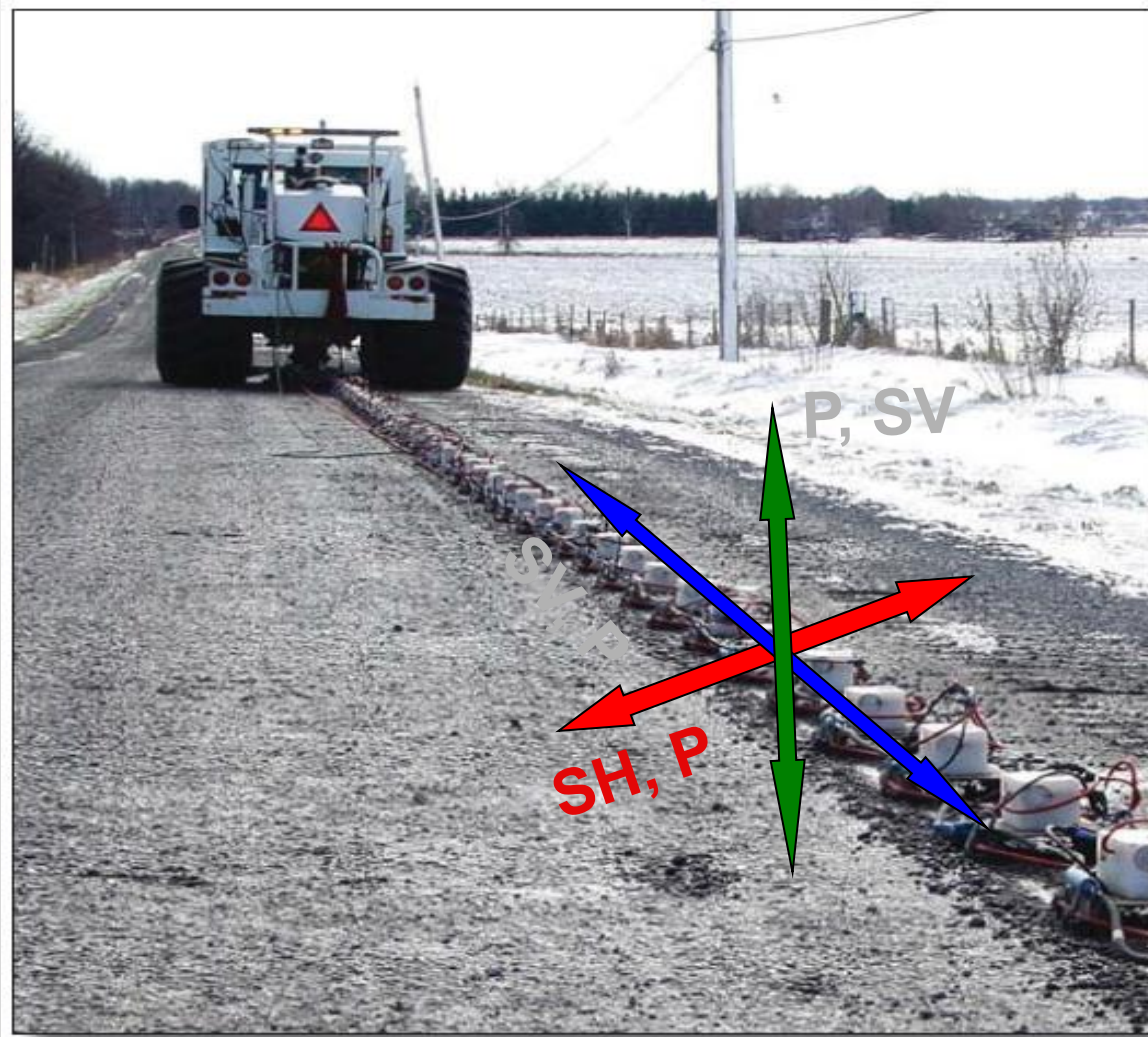
3C Land Streamer



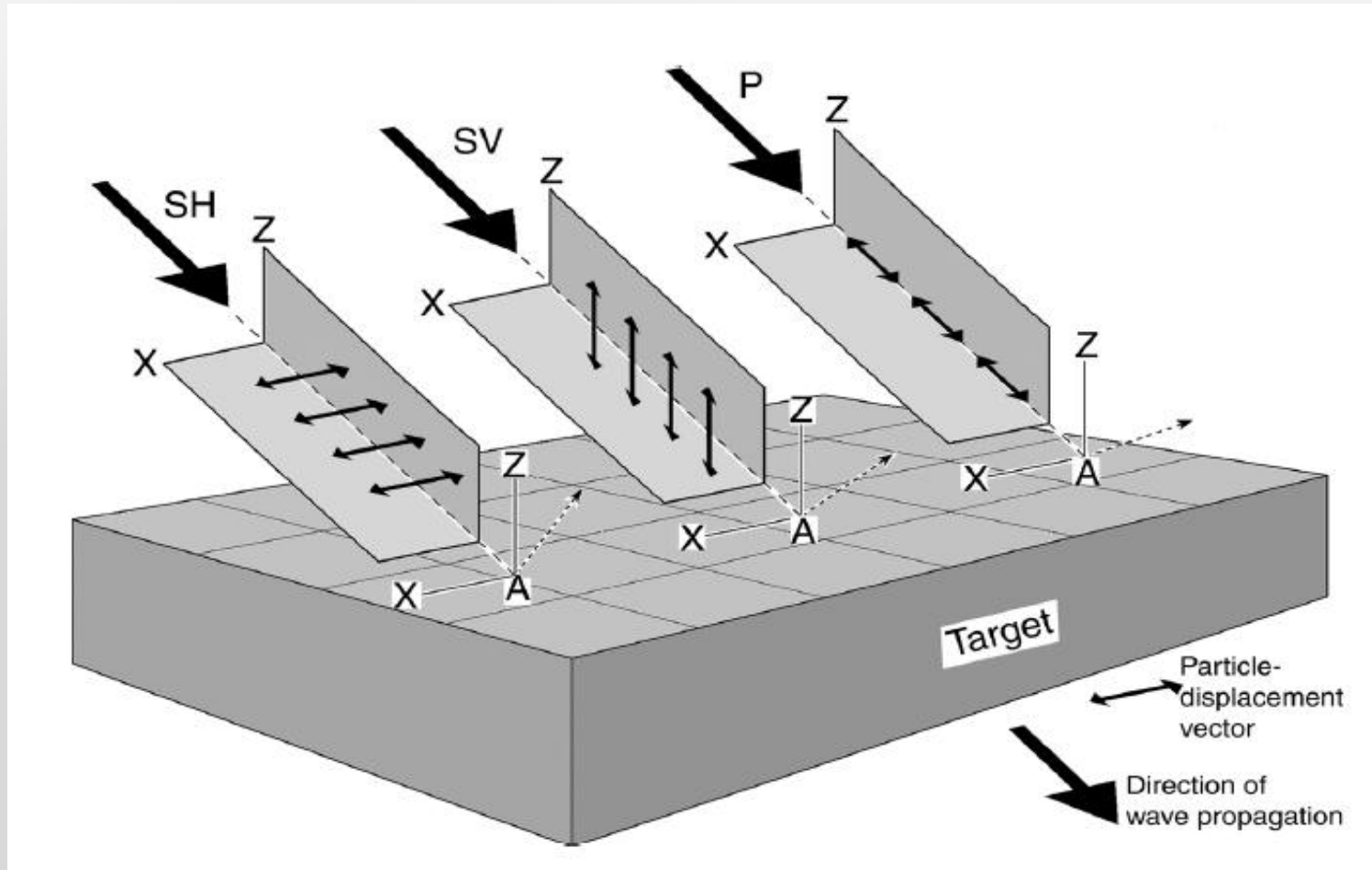
3C Land Streamer - Components



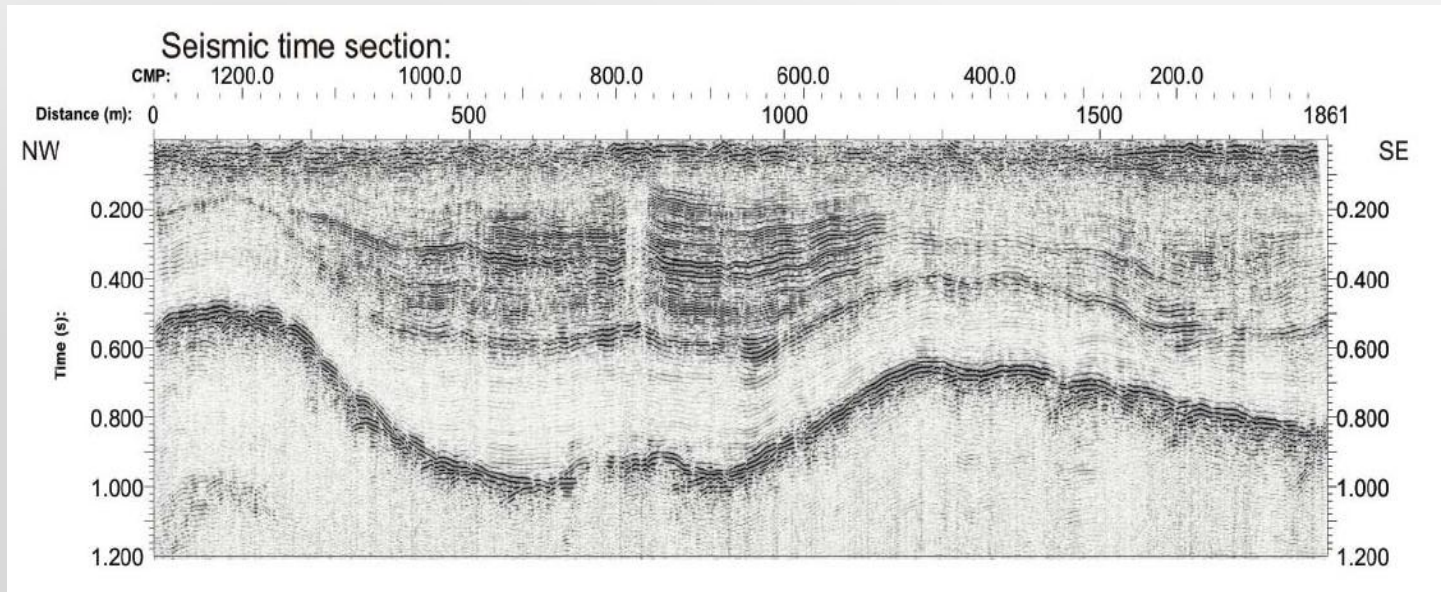
3C Land Streamer - Captured Wave Modes



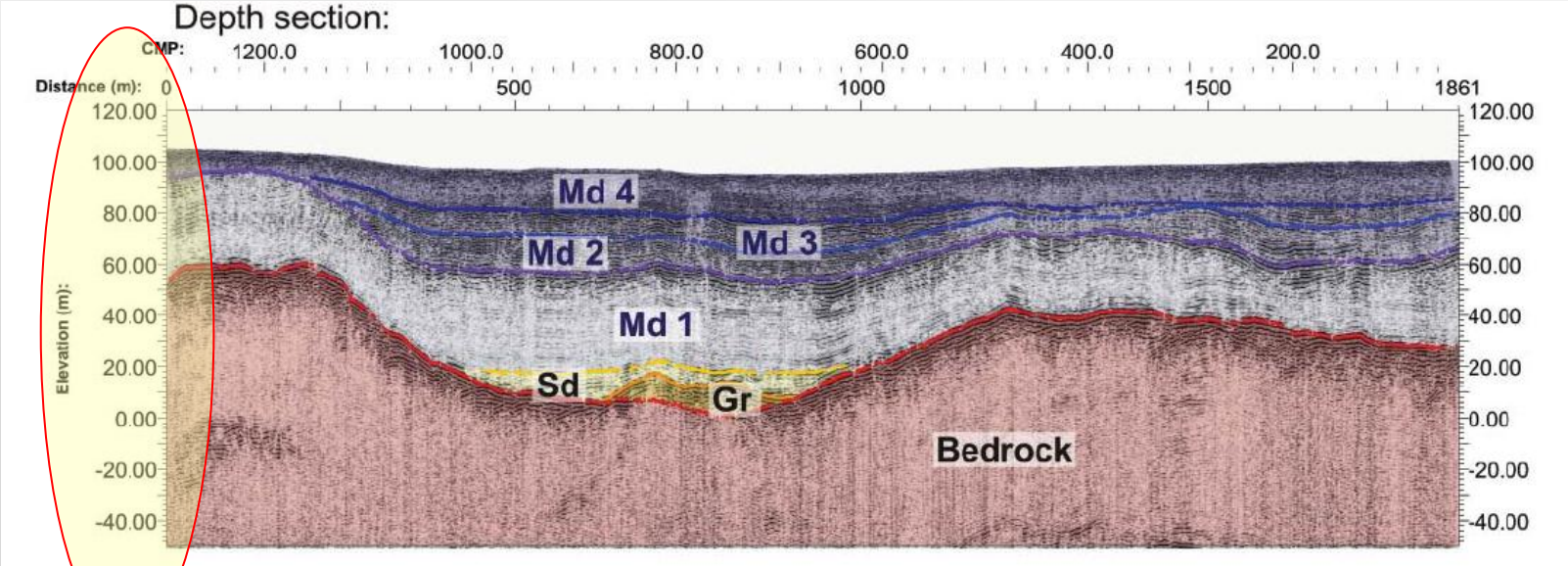
Wave modes and particle displacement vectors



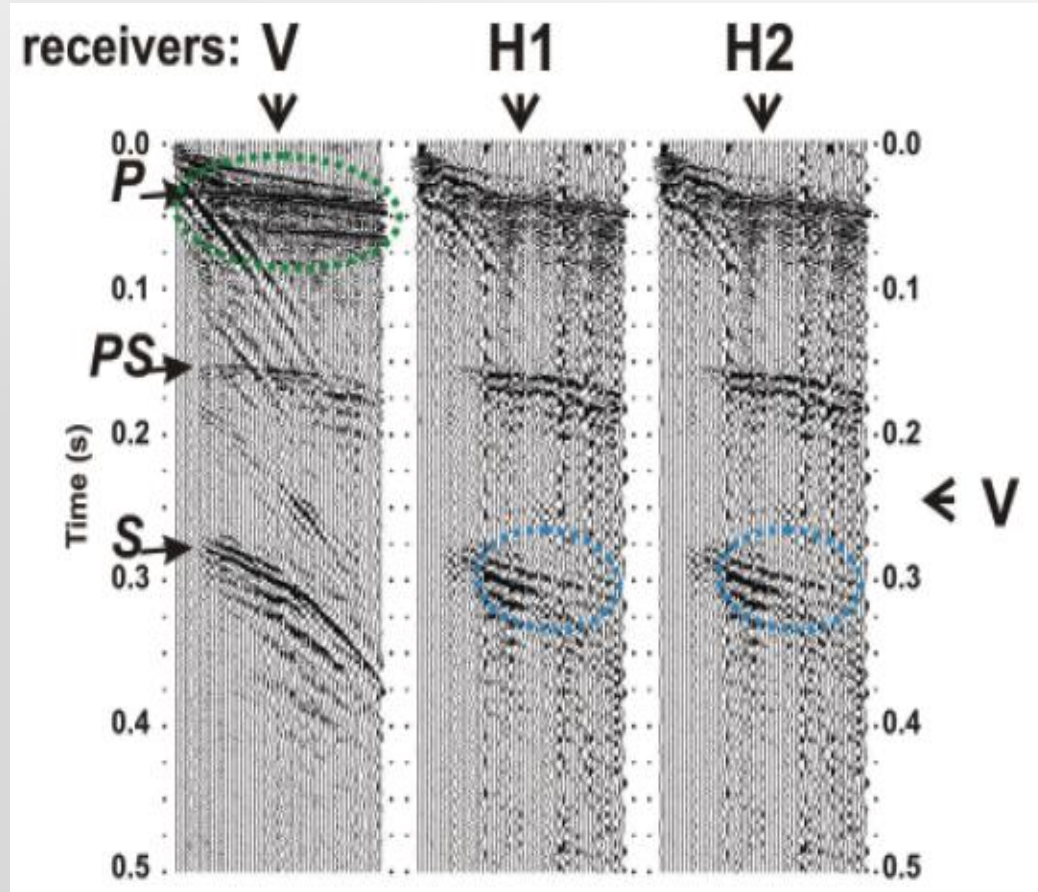
3C SV Section



Interpreted SV Profile



3C, Vertical Source



Uncertainty Reduction – Multicomponent Seismic

