

An overview of Seismic Surveying

Newbury Geology Society
28 February, 2023



seis·mic

[ˈsaɪzmɪk] 🗣️

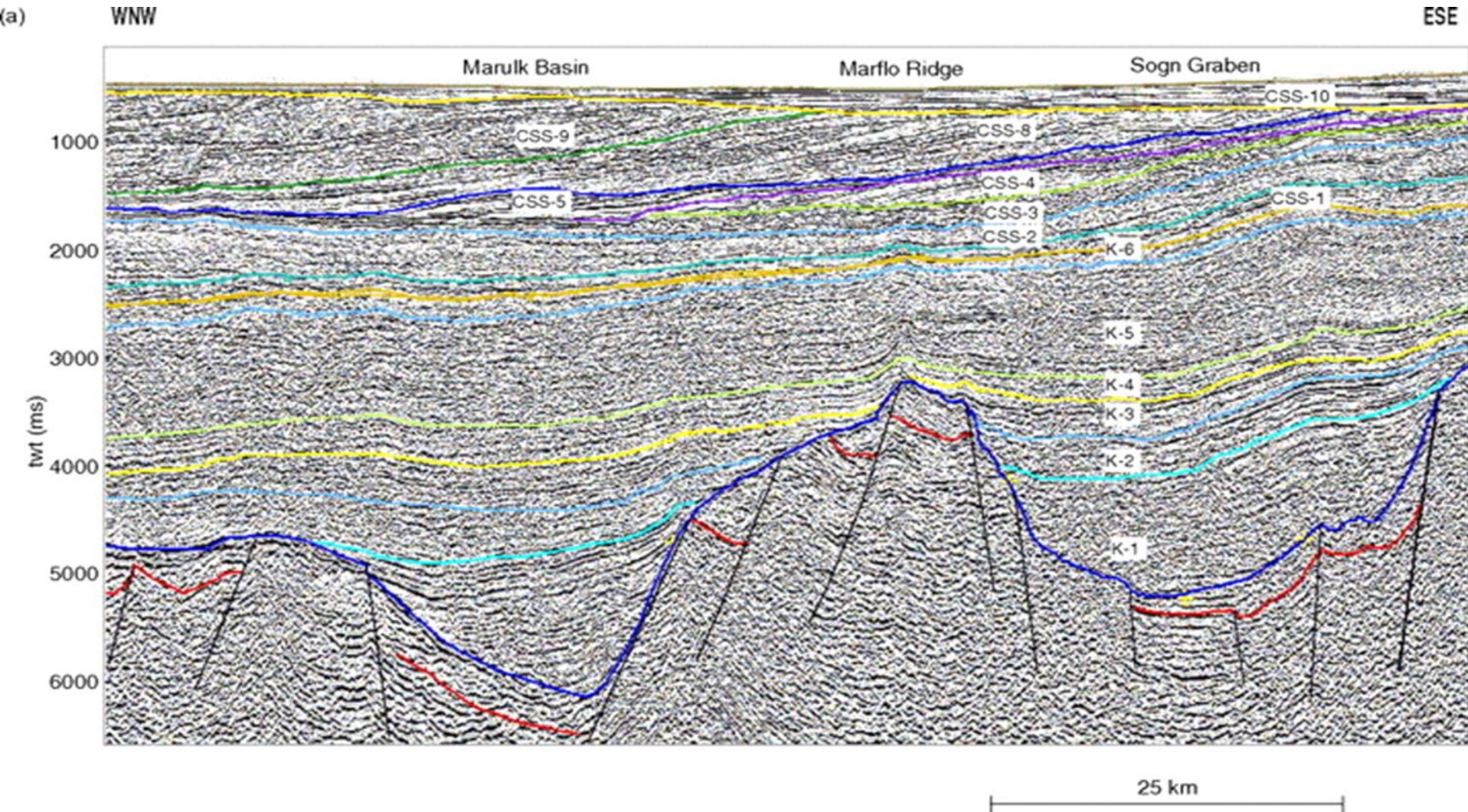
ADJECTIVE

relating to earthquakes or other vibrations of the earth and its crust:

"after a few days of seismic activity the volcanic eruption started"

- relating to or denoting geological surveying methods involving vibrations produced artificially by explosions:

"seismic data show the deep structure of rift systems"



seis·mic

[ˈsaɪzmɪk] 🔊

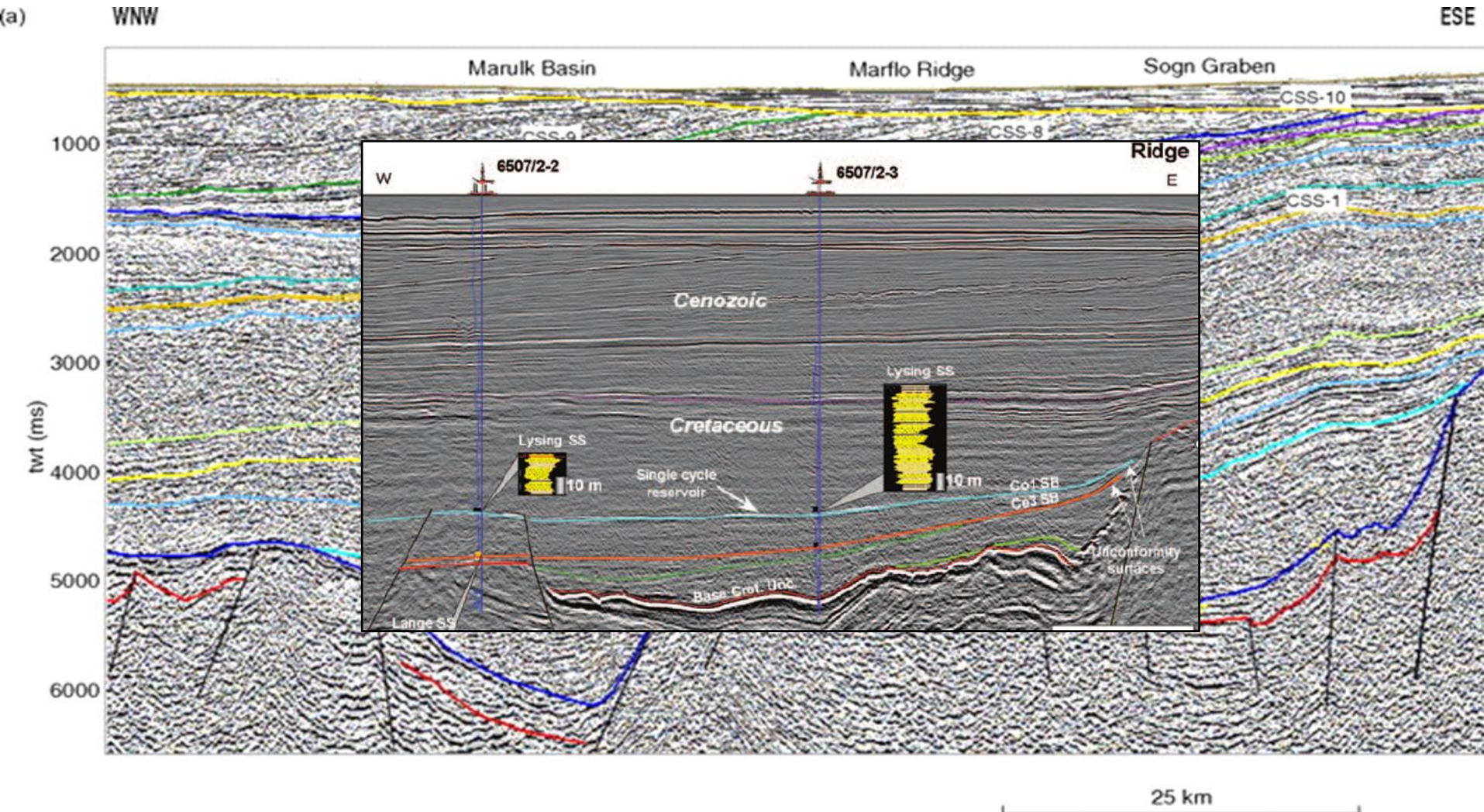
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Finding hydrocarbons.

1. Find a basin.

Hydrocarbons form and accumulate in sedimentary basins.

Geological study, including surface features.

Geophysical studies, primarily gravity and magnetics.

Form a hypothetical model, featuring:

- a source rock,
- a reservoir,
- a trap,
- the right maturity.

Cost
\$1-2m

Time
1 yr

Risk
low

2. Exploration seismic

Image the subsurface structure.

2D seismic (cheap) or 3D seismic (less cheap!)

Process the results.

Interpret the results.

Pick drill sites.

\$100-200m

3 yr

medium

3. Exploration & appraisal drilling

Drill selected locations to locate hydrocarbons, test production rates.

\$500+m

2 yr

high

4. Go for production

Production drilling.

Production facilities.

Export infrastructure.

\$5bn

5 yr

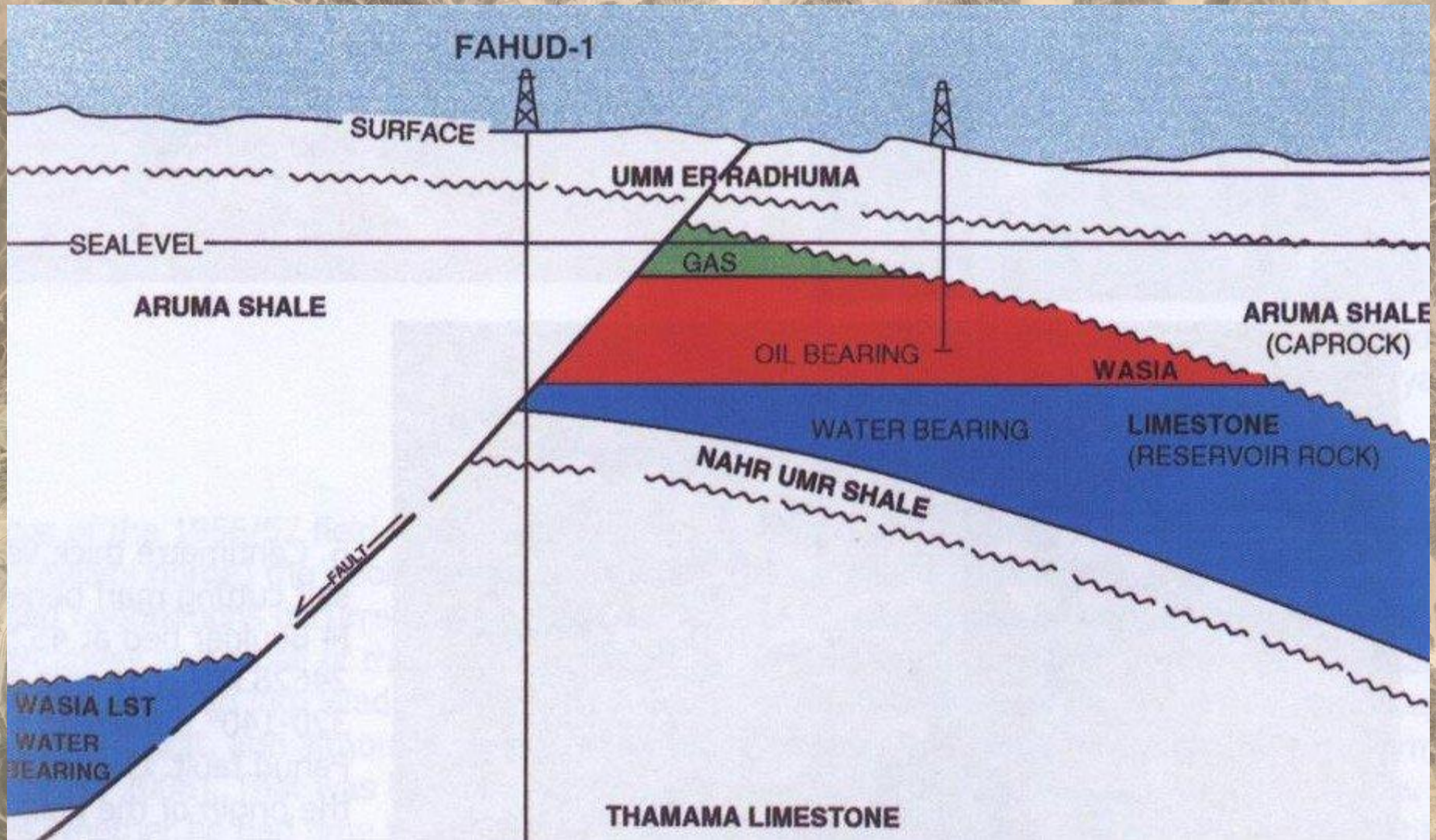
low



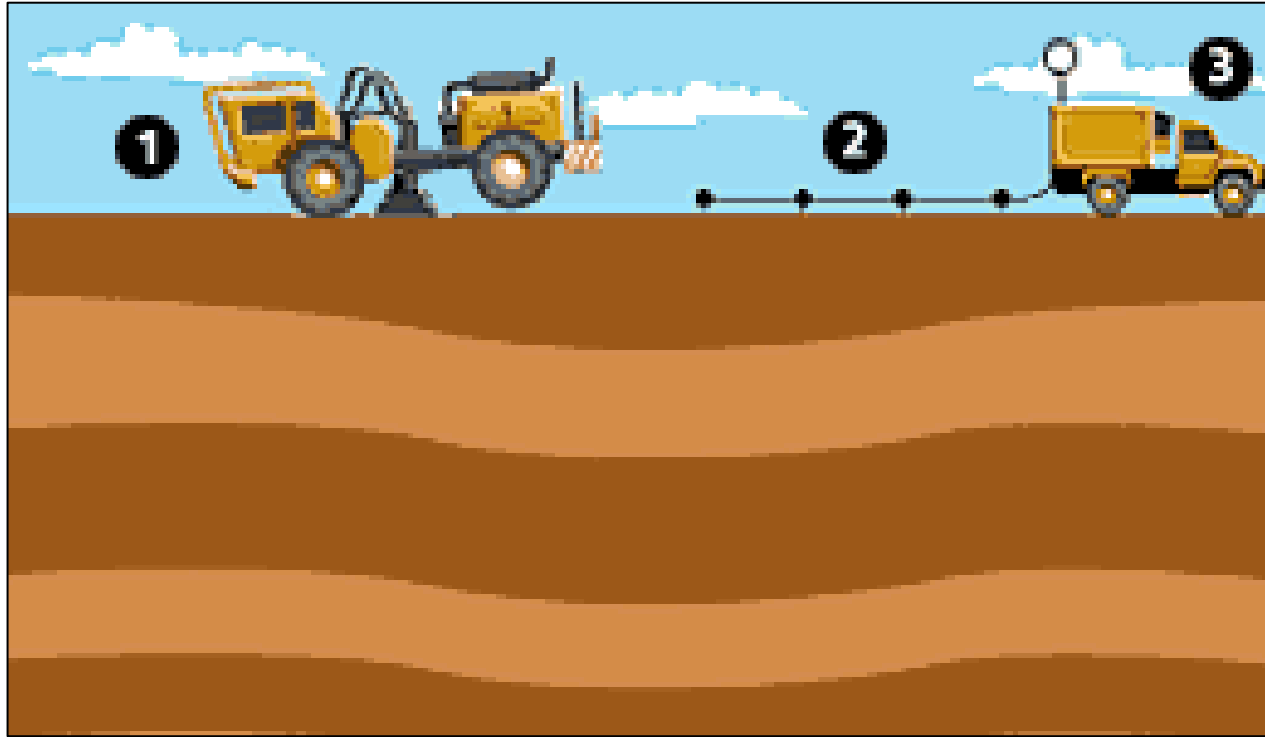
Before seismic...



Before seismic...



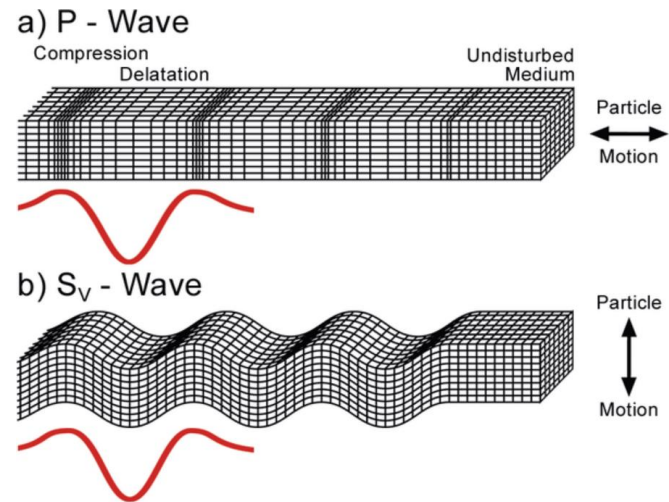
Seismic survey basics

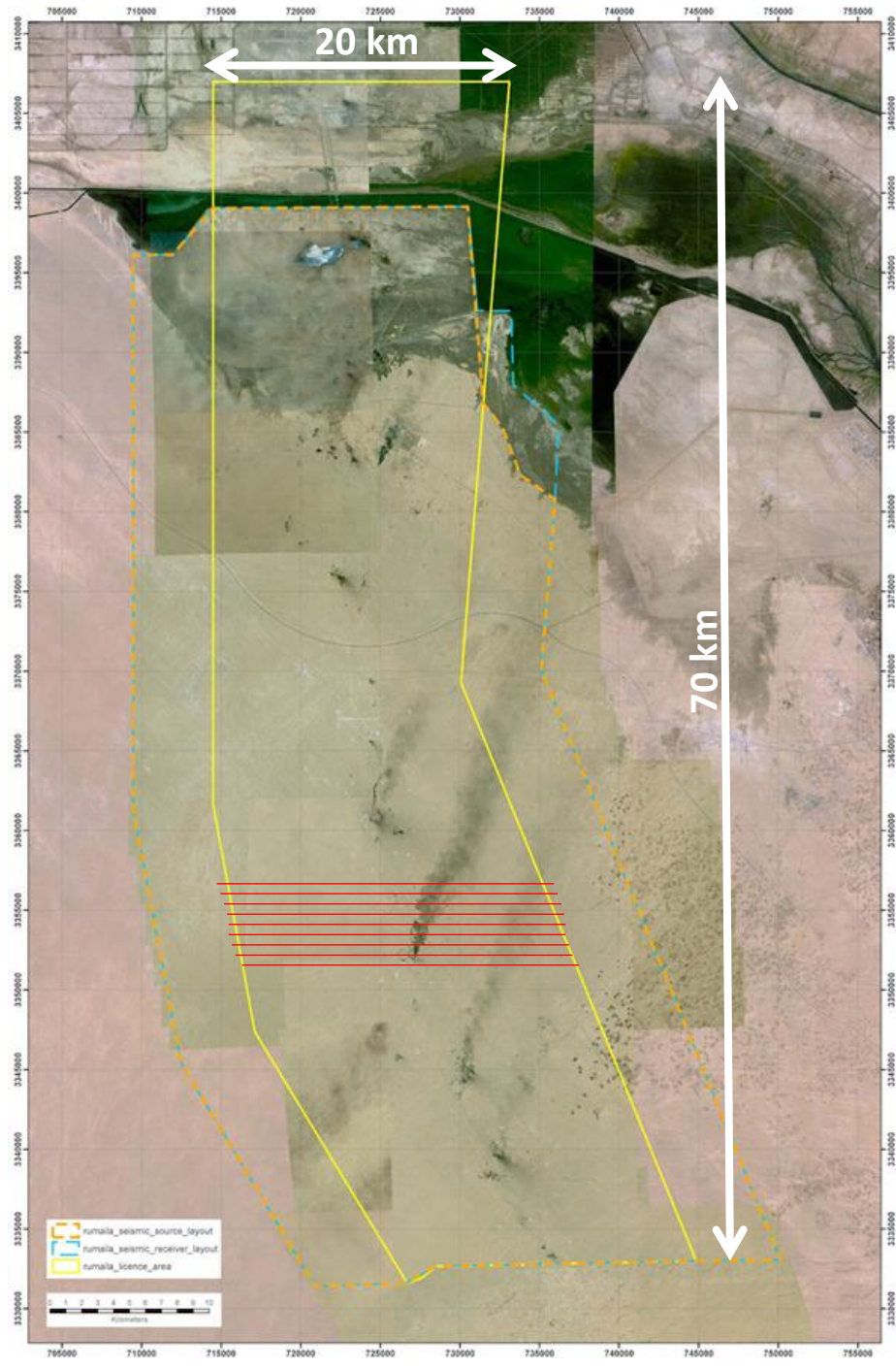


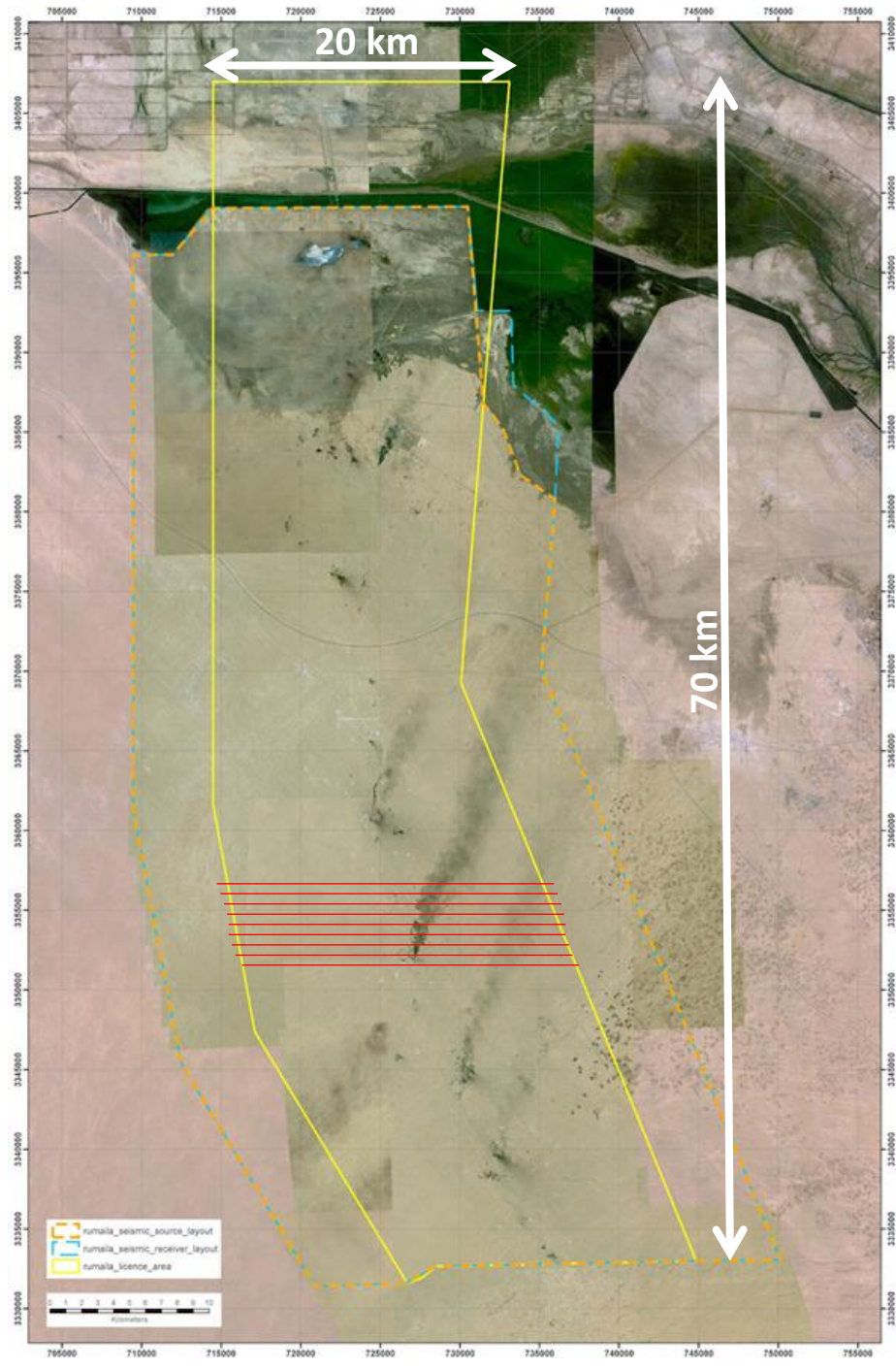
1. Seismic source
2. Seismic receivers (geophones)
3. Recording system

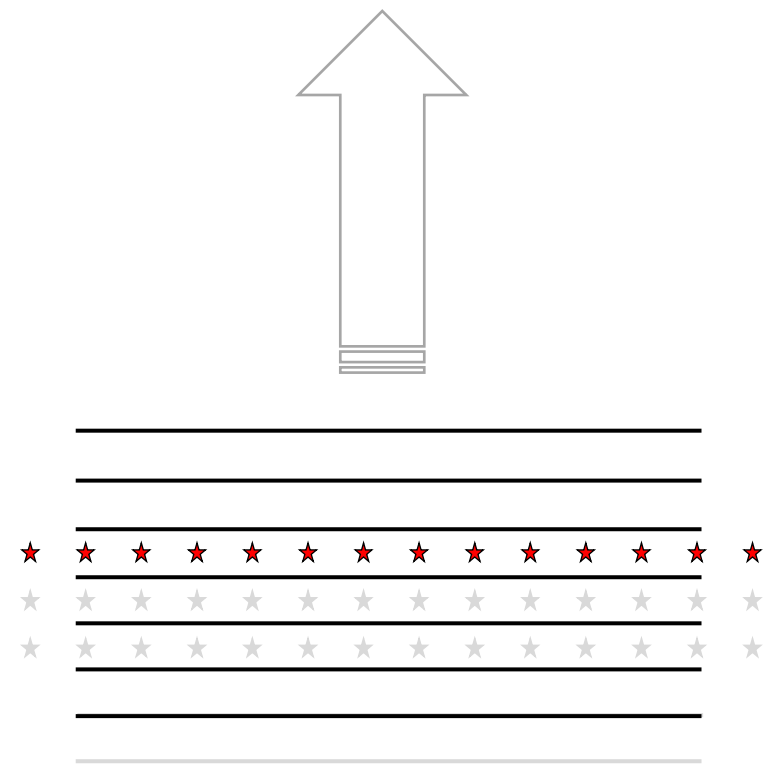
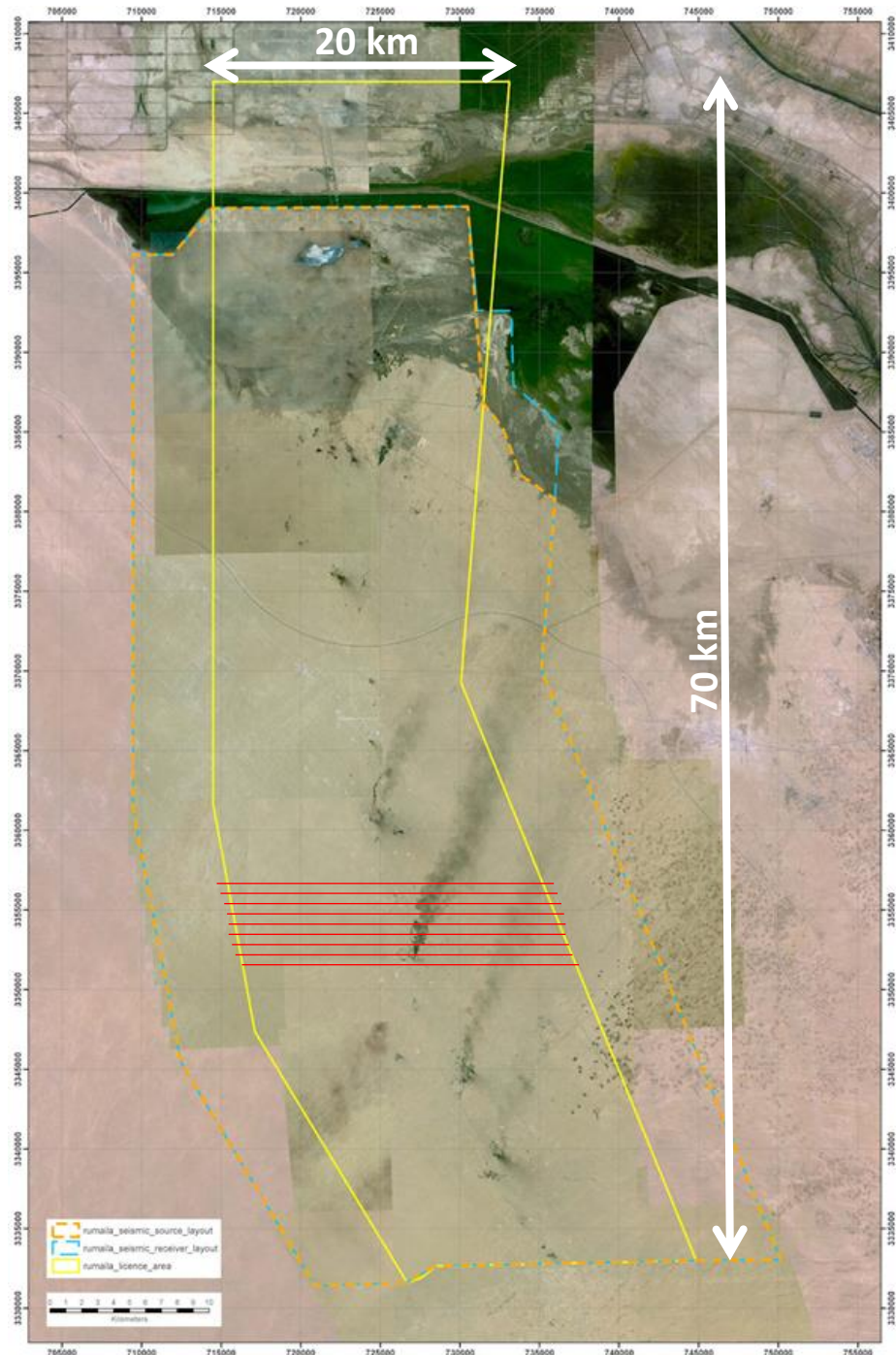
P wave: pressure wave; alternating compressions & rarefactions; particle displacement is parallel to propagation, e.g. sound

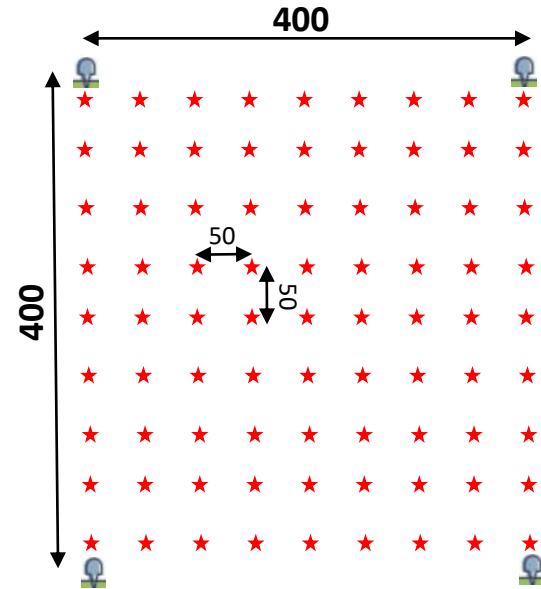
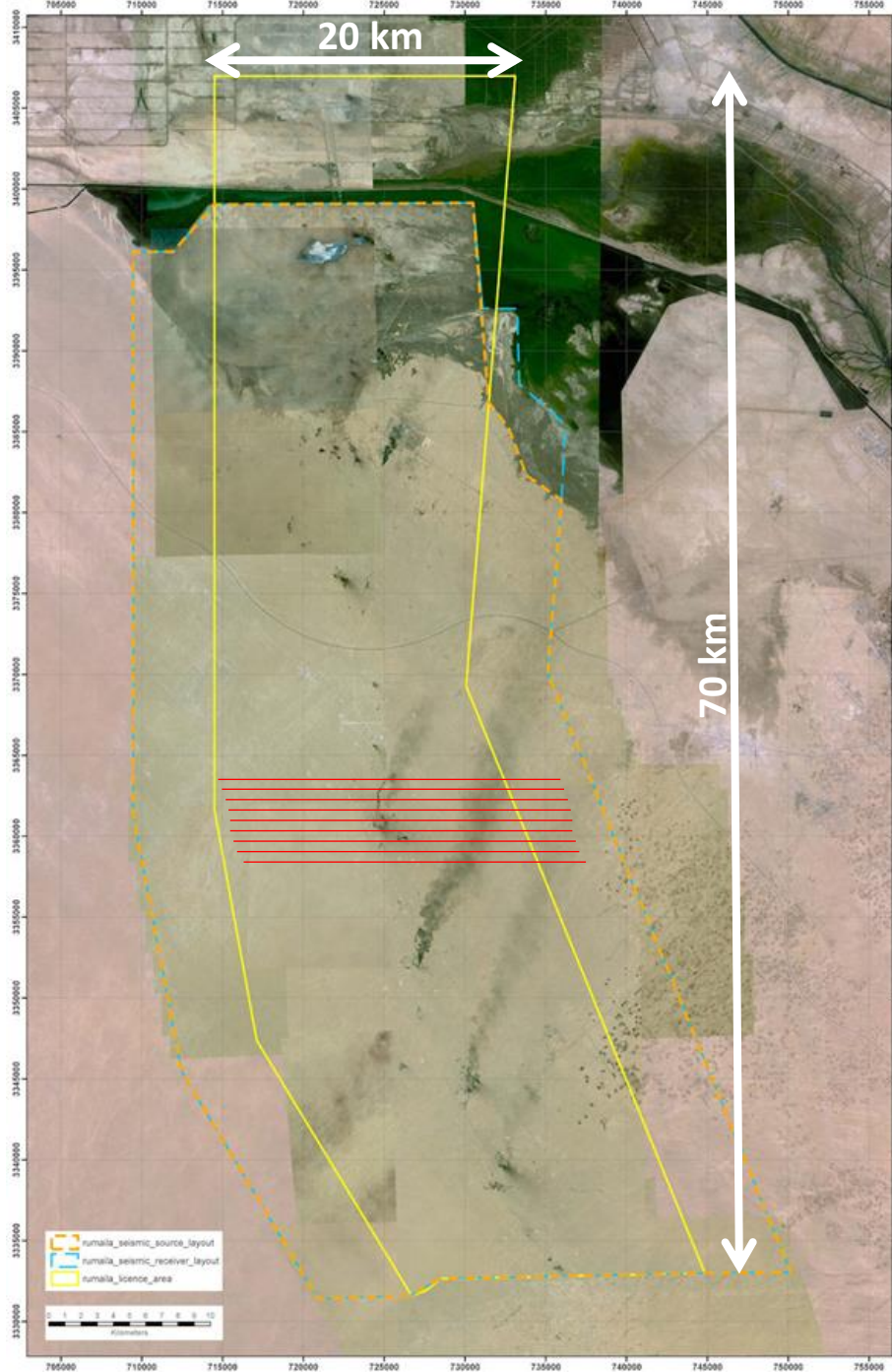
S wave: shear wave; particle displacement is perpendicular to propagation; can't travel through water







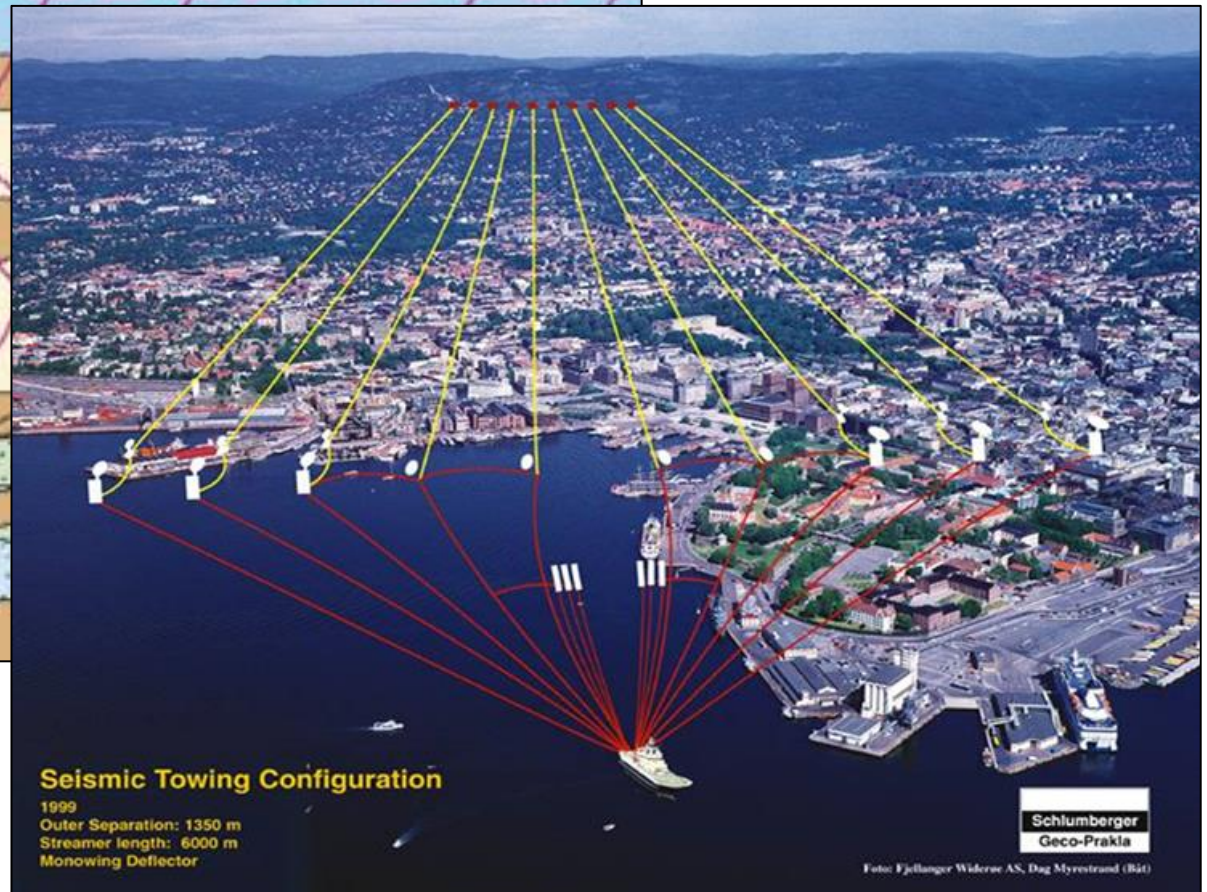
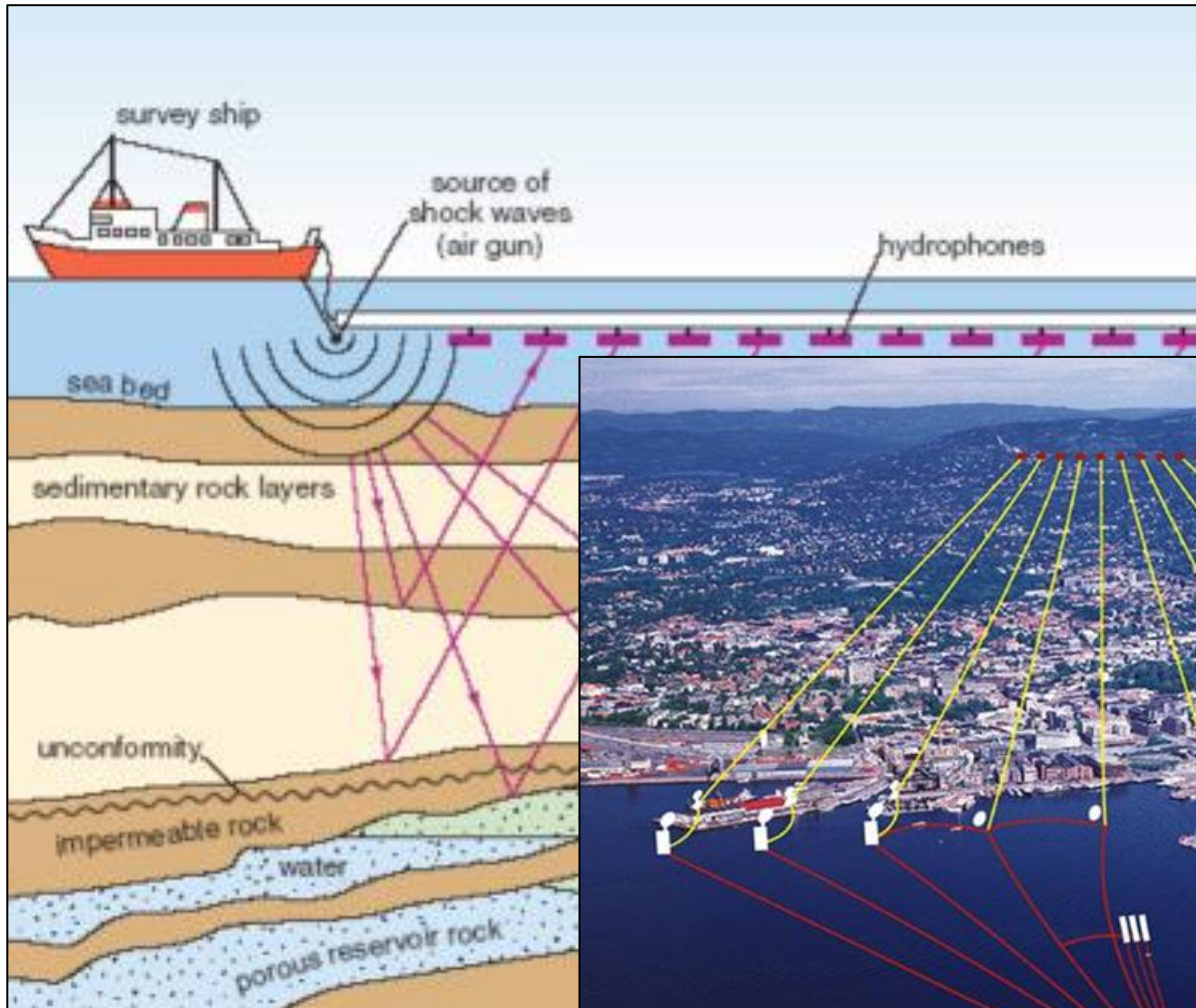




Each 20km line:
 50 receivers
 3,200 + 384 source points

Whole survey:
 175 lines
 8,750 receiver positions
 627,200 source points

Seismic survey basics





The seismic process
1. Access



The seismic process

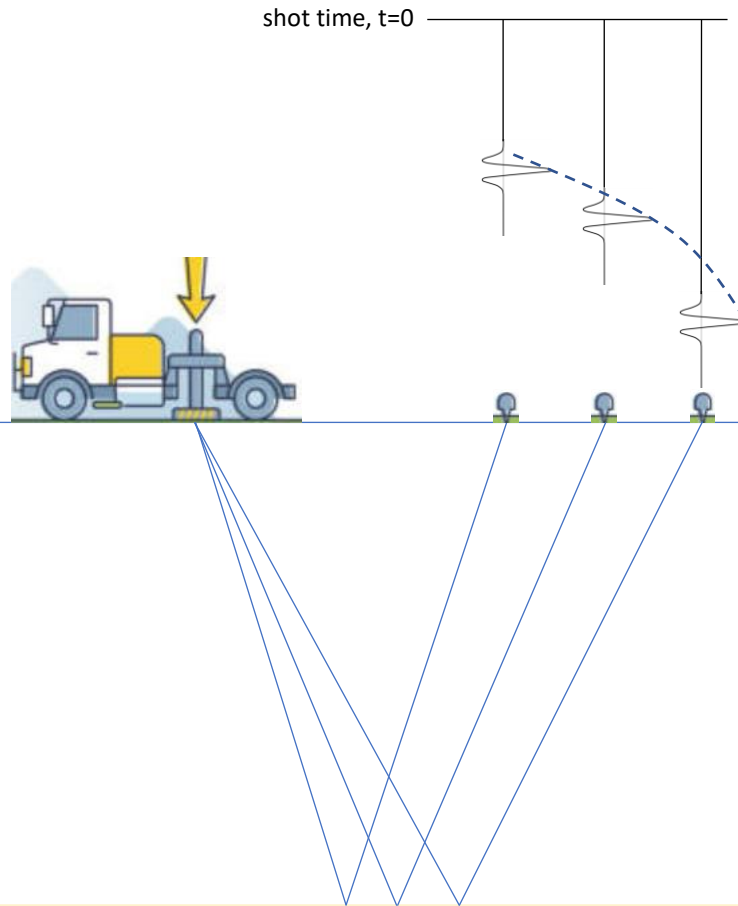
1. Access



The seismic process
1. Access



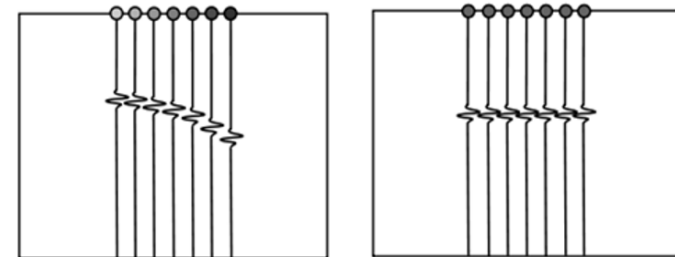
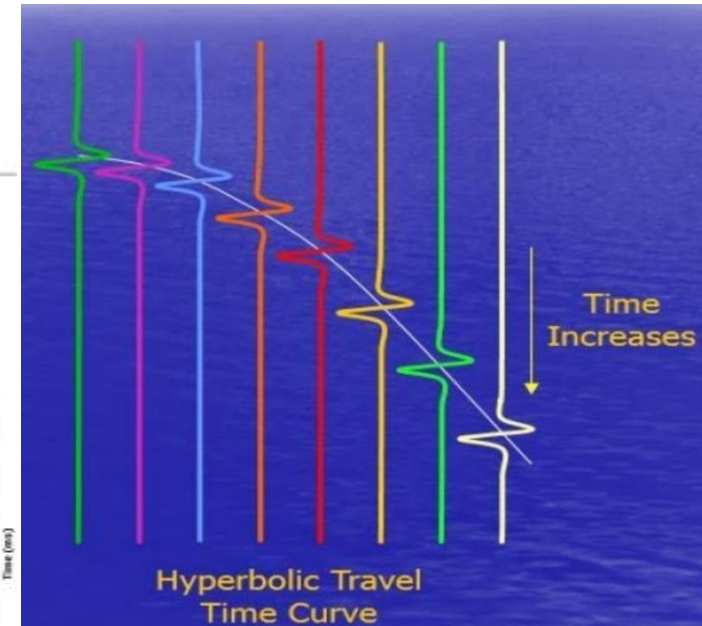
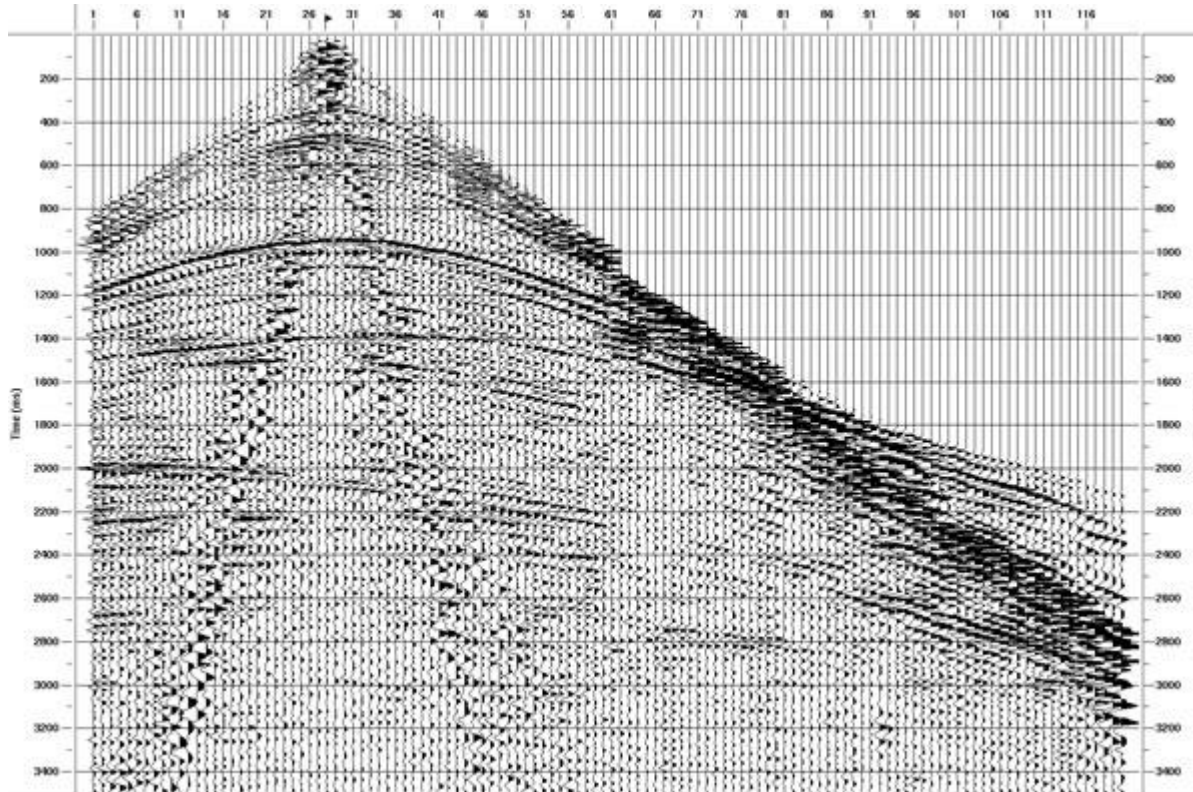
Corrections, corrections!



Corrections, corrections!

Normal Moveout (NMO)

Makes flat reflectors look curved



The seismic process

2. Survey/positioning



The seismic process
2. Survey/positioning



The seismic process
2. Survey/positioning

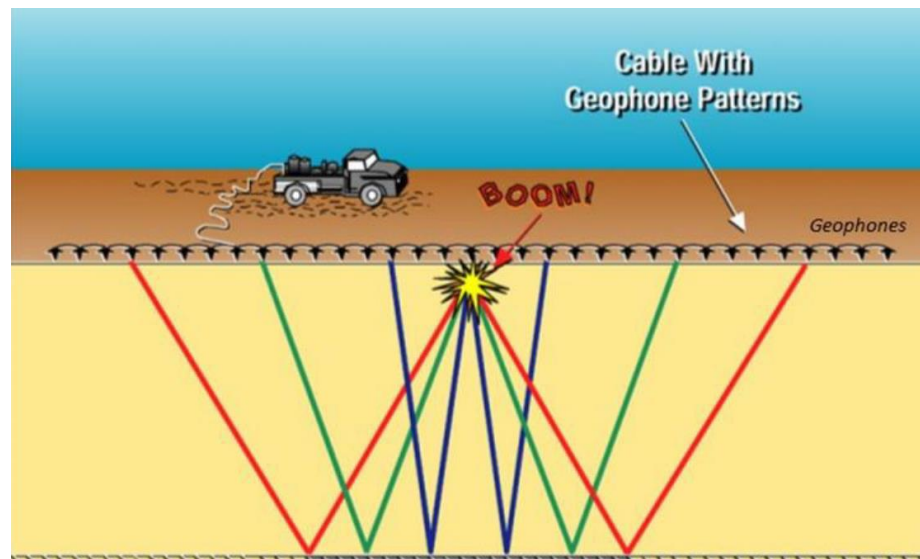


The seismic process

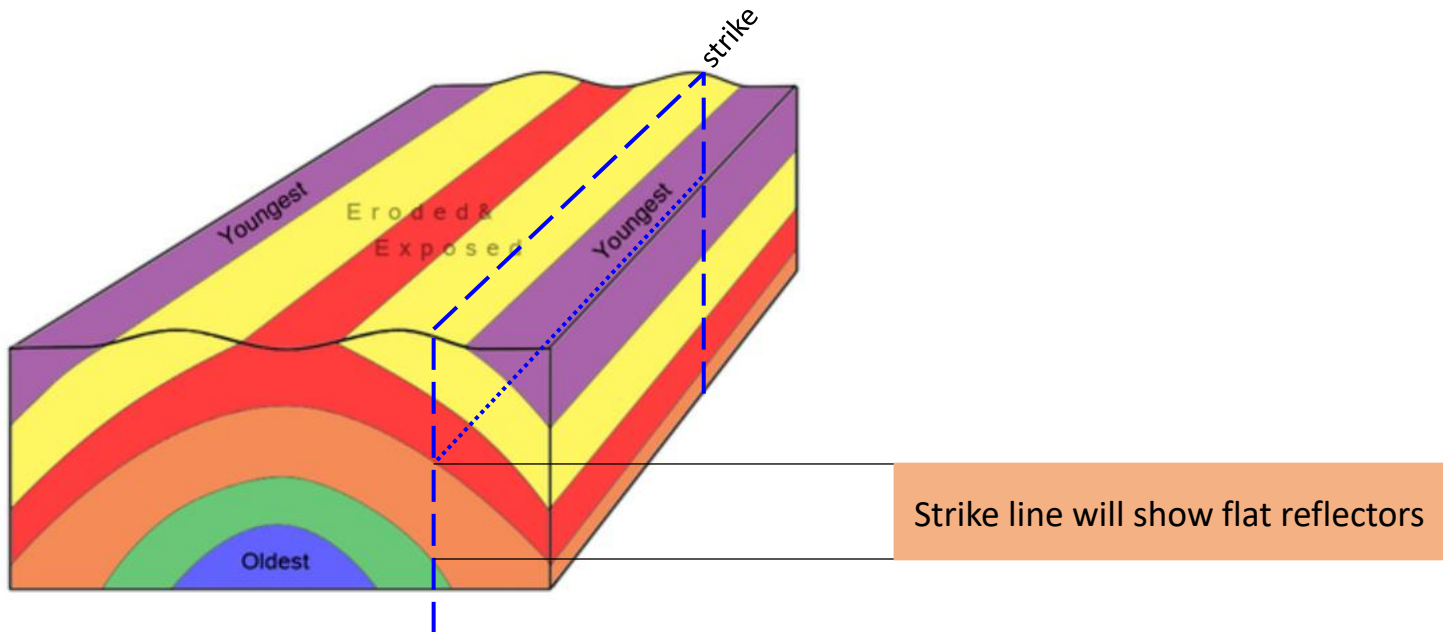
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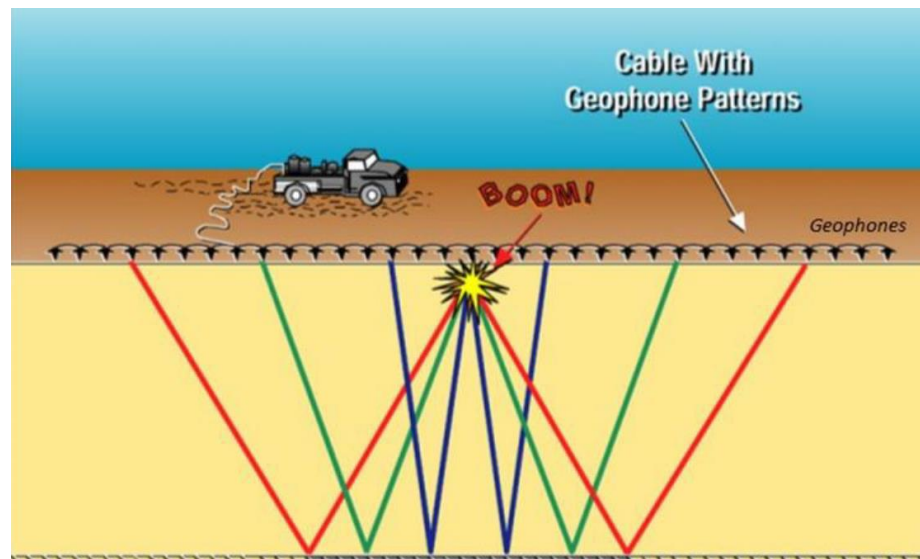
2D & 3D



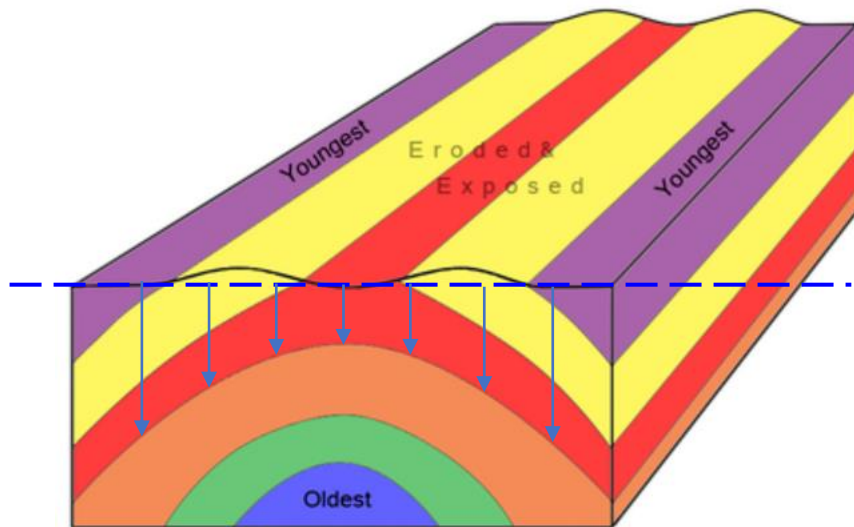
2D – single line, source & receivers on same line (single azimuth)



2D & 3D

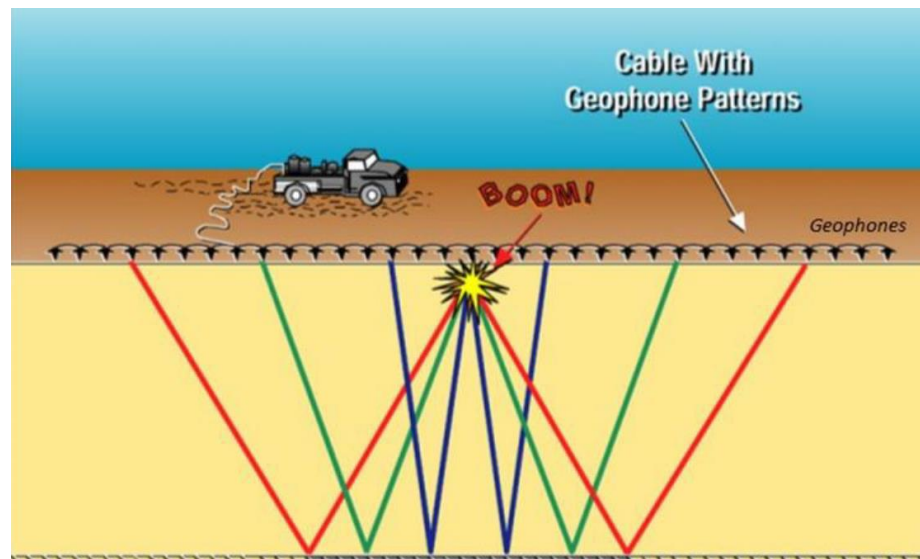


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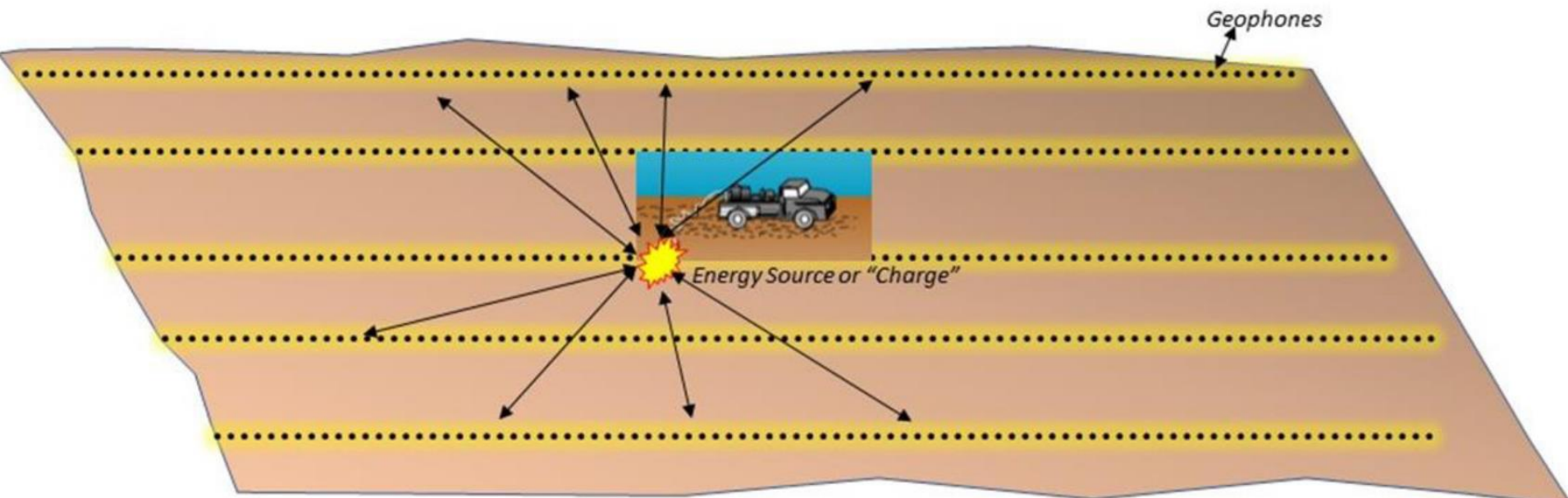


Dip line will show curved reflectors

2D & 3D



2D – single line, source & receivers on same line (single azimuth)



3D – multiple lines, multiple azimuths, images dip and strike

What 2D looks like...





What 3D looks like...



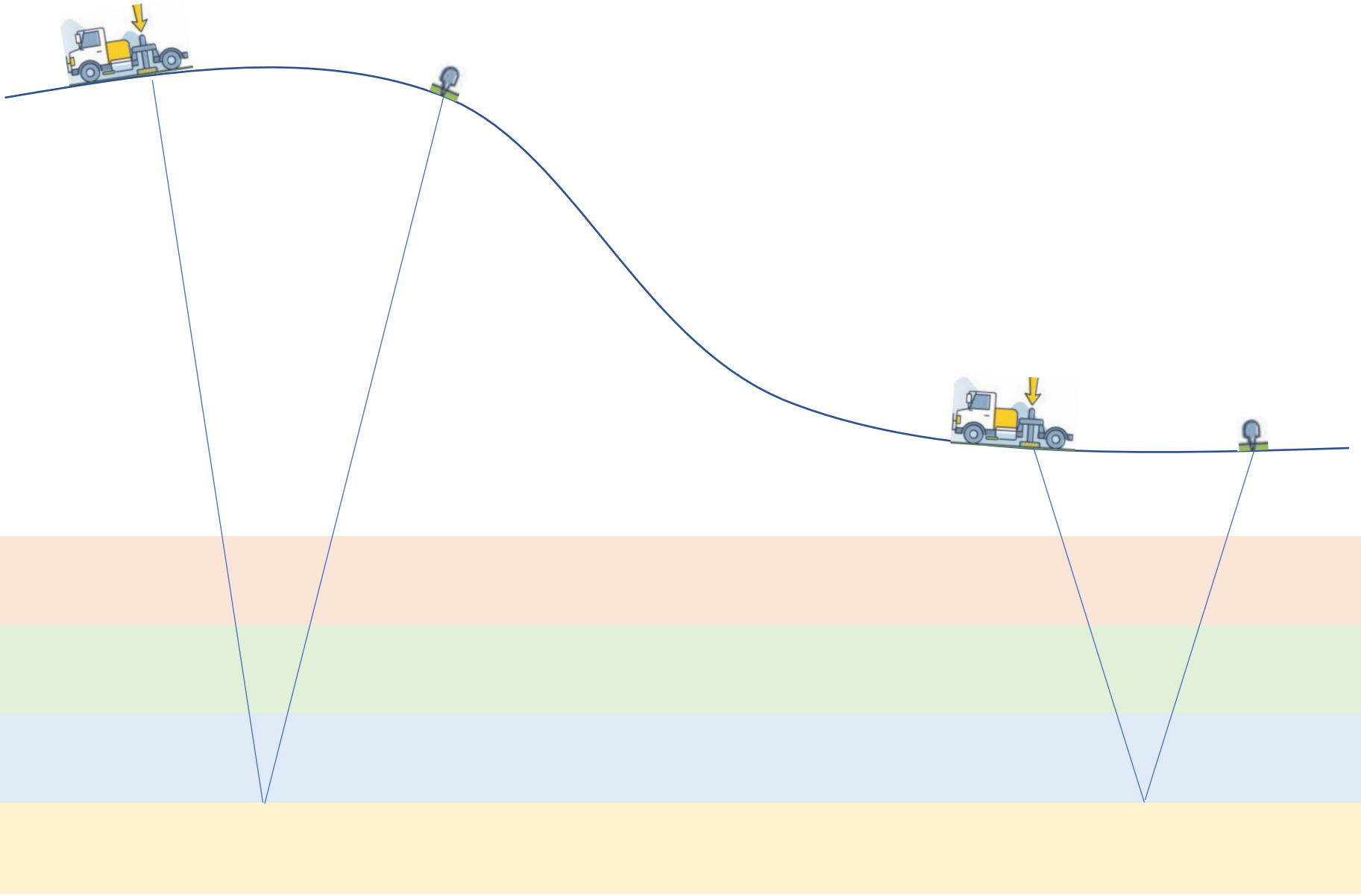




Aerial image of seismic lines about 45 kilometres east of Broome. DAMIAN KELLY

Corrections, corrections!

Elevation (or tide in marine surveying)



The seismic process

3a. Layout (receiver)



The seismic process

3a. Layout (receiver)



The seismic process
3a. Layout (receiver)



The seismic process
3a. Layout (receiver)



The seismic process

3b. Layout (source; drilling & loading)



The seismic process

3b. Layout (source; drilling & loading)



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3b. Layout (source; drilling & loading)

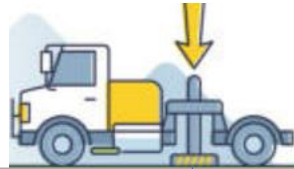


Corrections, corrections!

Velocity

Distance = velocity x time

Crust not homogenous!



v 1

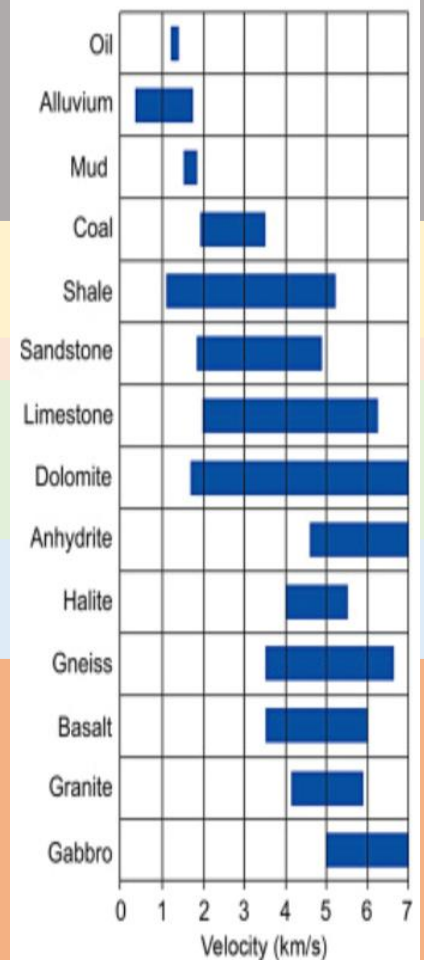
v 2

v 3

v 4

v 5

v 6

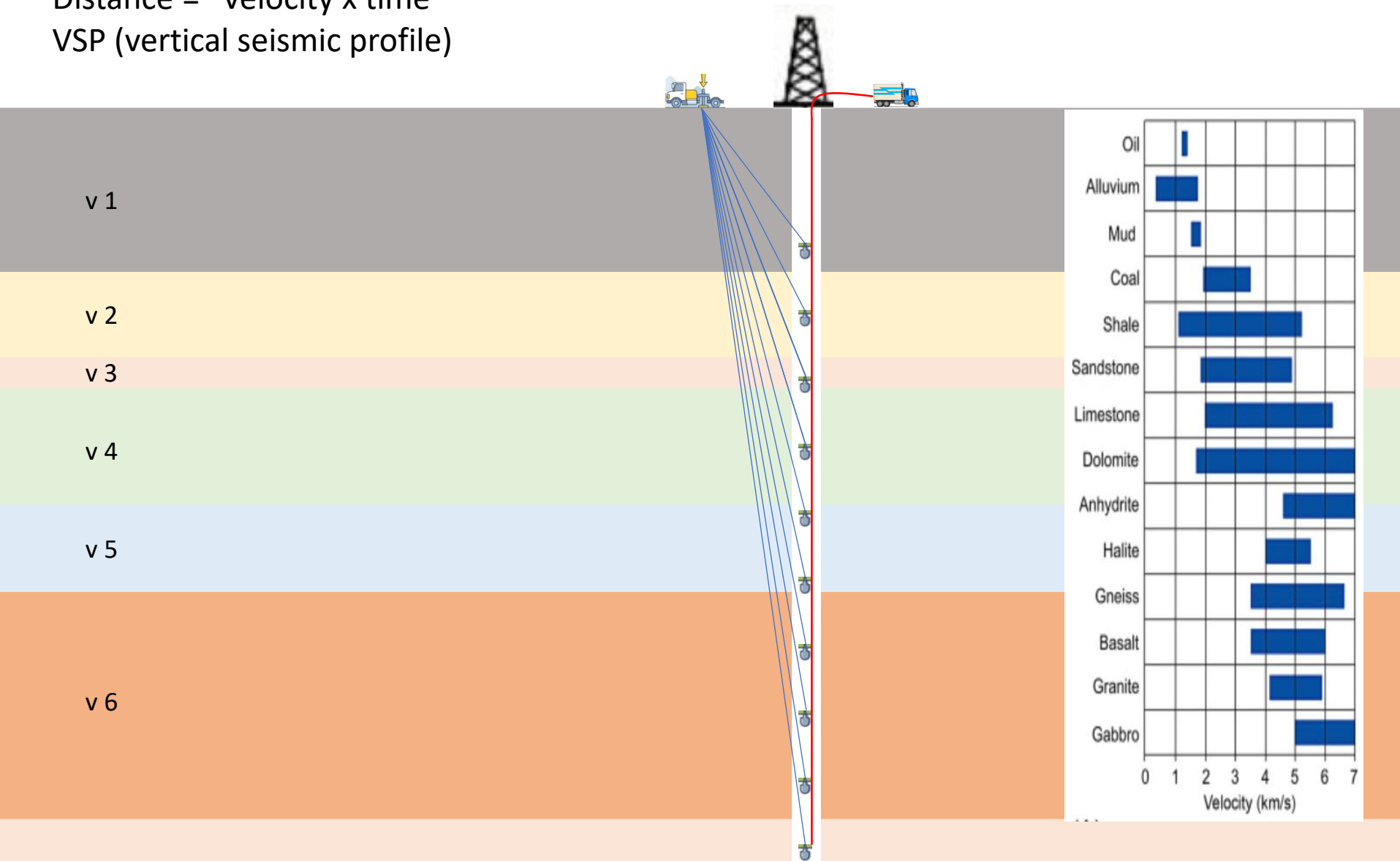


Corrections, corrections!

Velocity

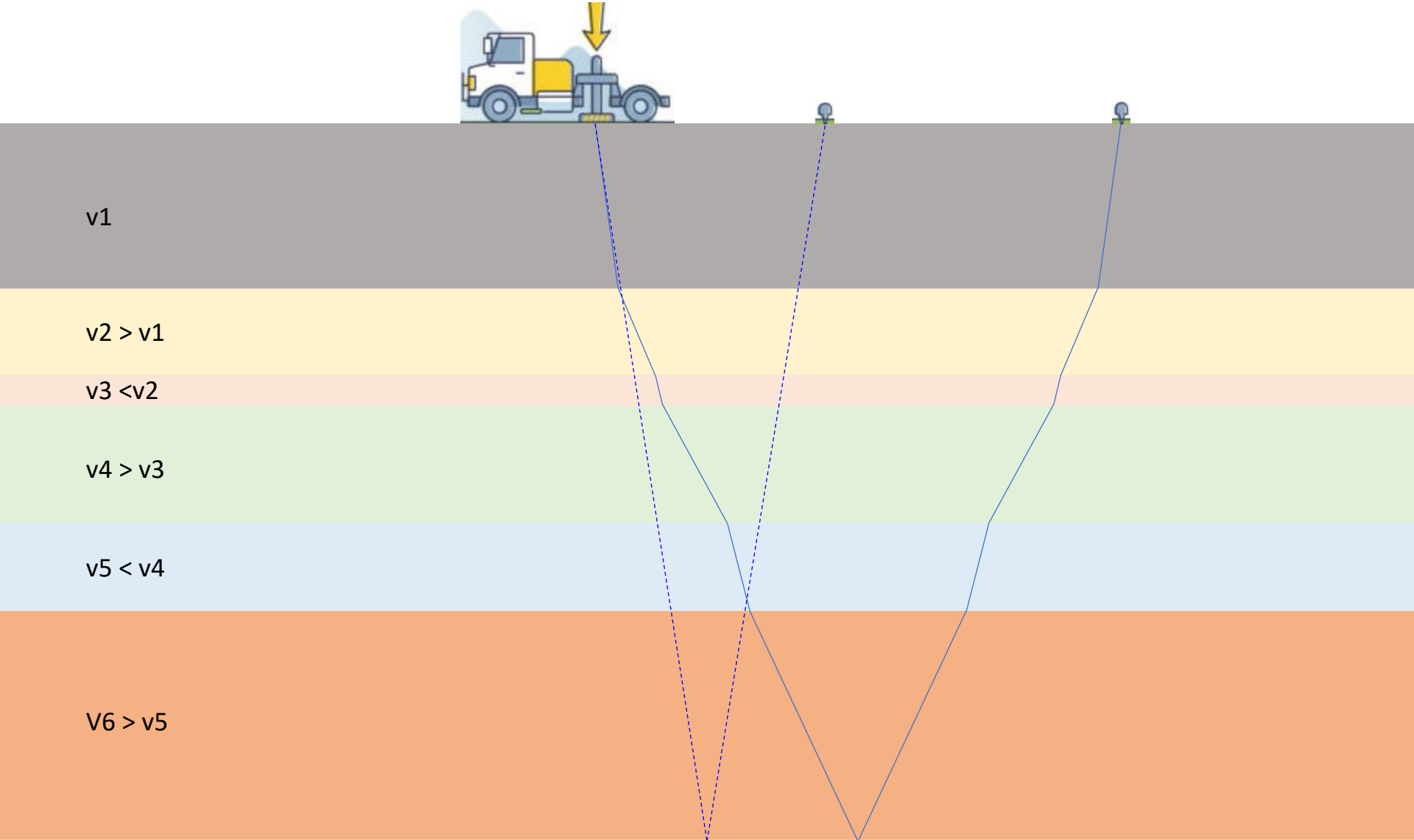
Distance = velocity x time

VSP (vertical seismic profile)



Corrections, corrections!

Refraction



The seismic process

4. Recording



The seismic process
4. Recording



The seismic process

4. Recording



The seismic process

4. Recording



The seismic process

4. Recording



The seismic process

4. Recording



The seismic process

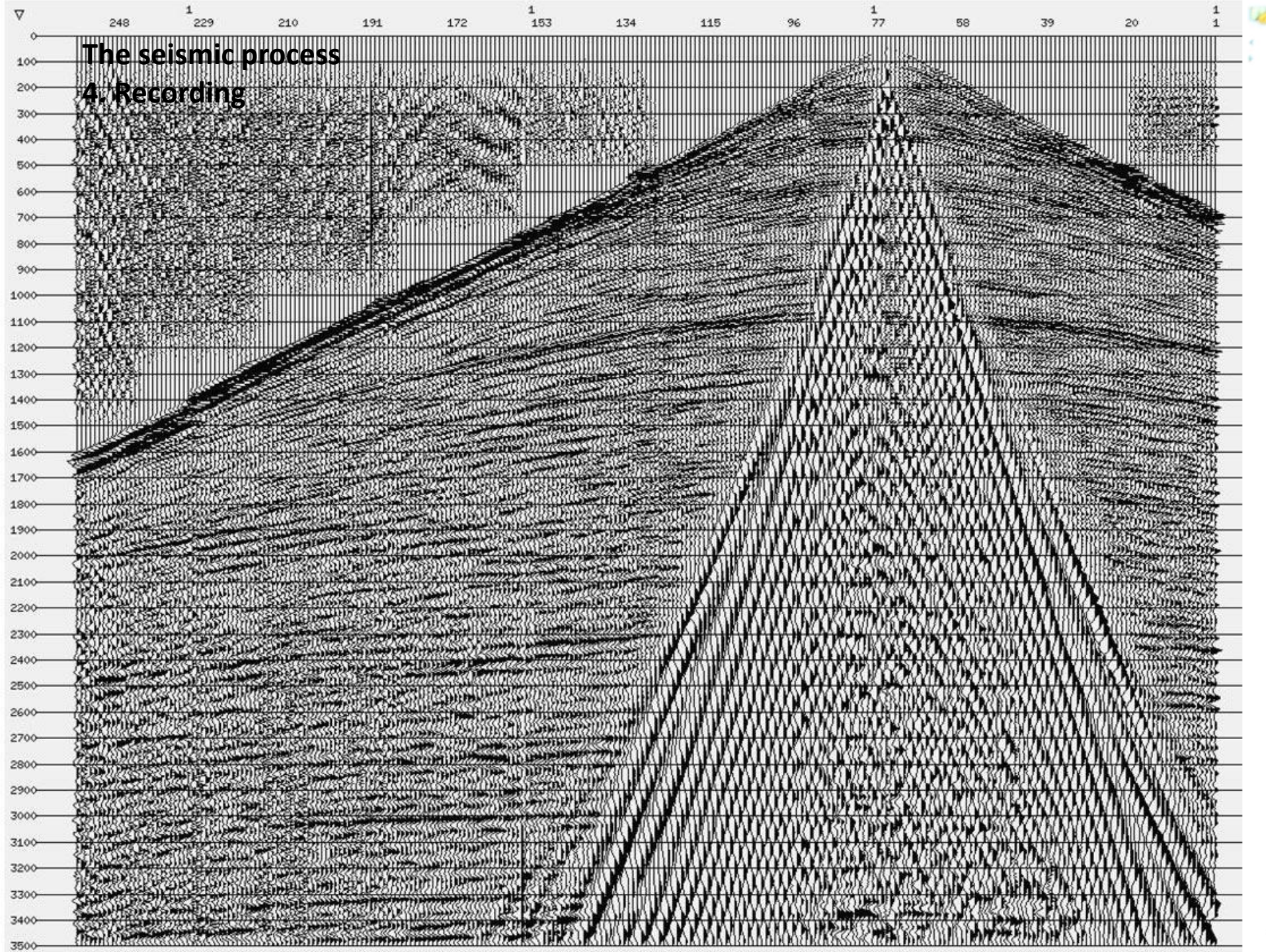
4. Recording



The seismic process

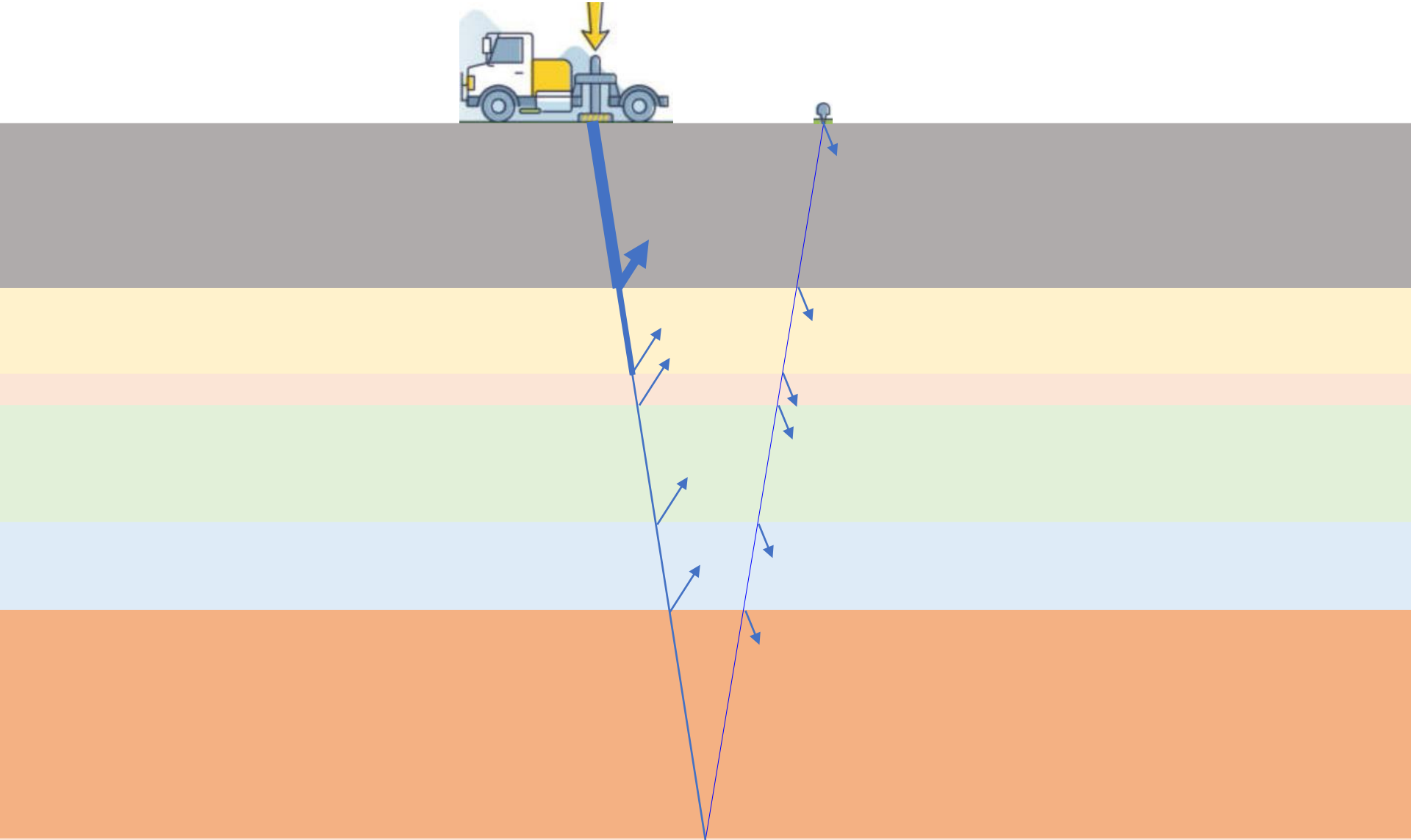
4. Recording





Problems, problems.....

Attenuation (high reflectivity layers)



Problems, problems.....

Attenuation of high frequencies

$$v = f \lambda$$

For a given v , high frequency = short wavelength

low frequency = long wavelength

Resolution of an image $\propto$ wavelength

Shorter wavelength (high frequency) = better resolution

Seismic sources produce a broadband signal; vibroseis, the most controllable, e.g. 4-80 Hz

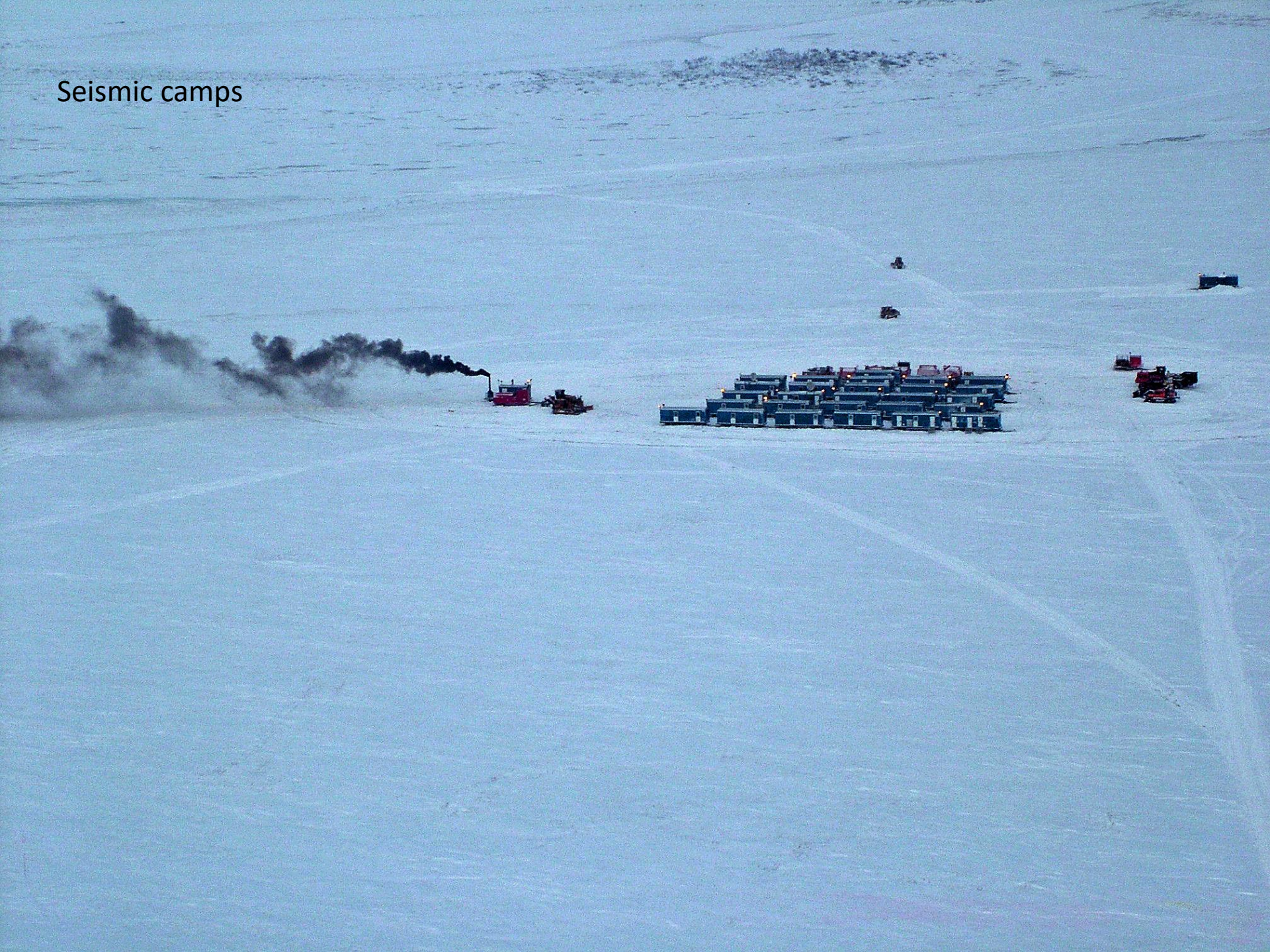
With a broadband signal travelling through a medium, the high frequencies attenuate first.

So resolution degrades with distance.

So the deep reservoir rocks we want to see are the least well resolved!



Seismic camps







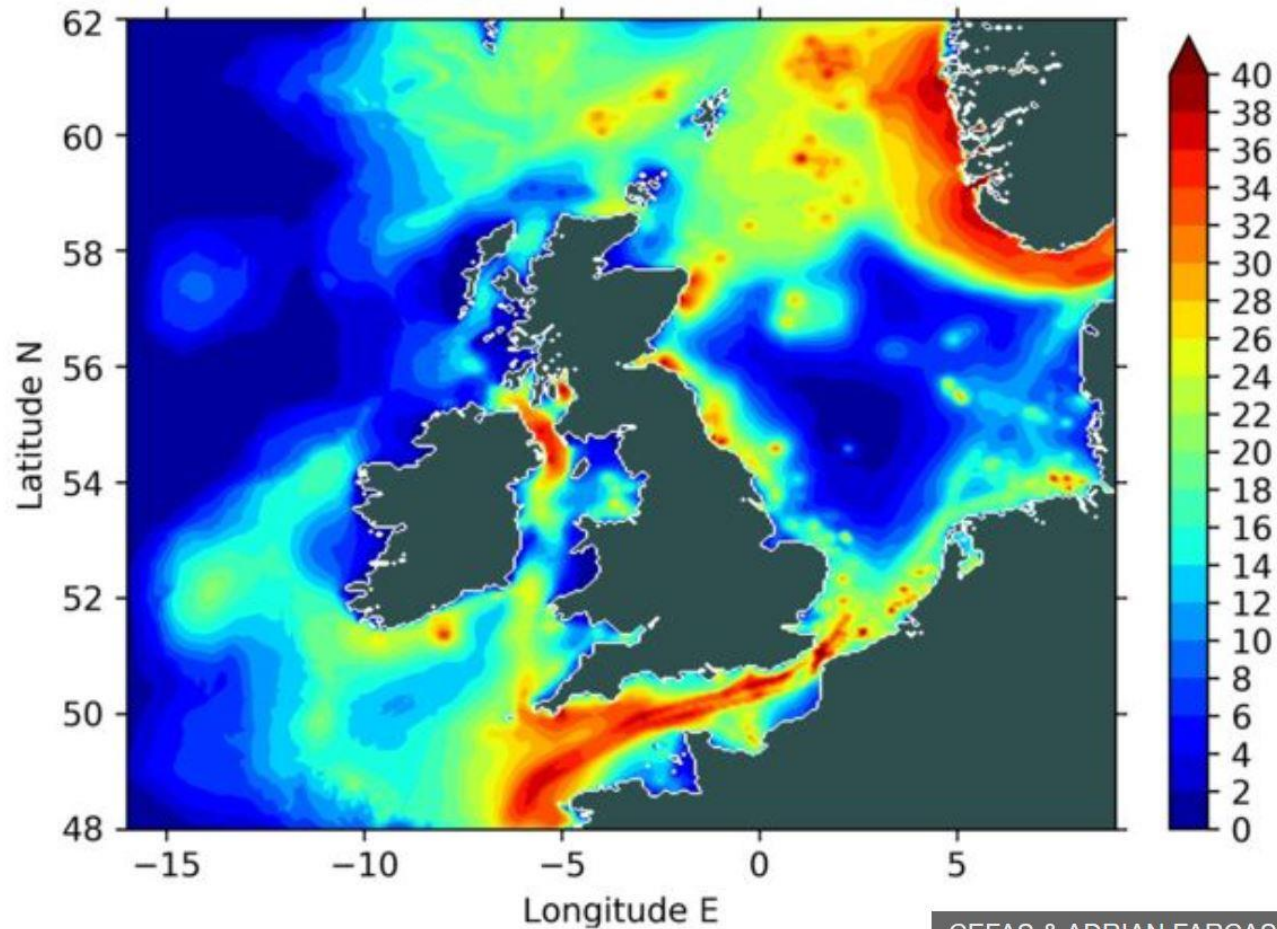
Problems, problems.....

Noise

Natural - seismic activity, waves, wind, fauna, reservoir sloshing

Cultural – human activities; traffic, industry, agriculture

System noise – ground roll, electronics



CEFAS & ADRIAN FARCAS

A map of sea noise around the UK - red the noisiest and blue the quietest

Problems, problems.....

Noise

Natural - seismic activity, waves, wind, fauna, reservoir sloshing

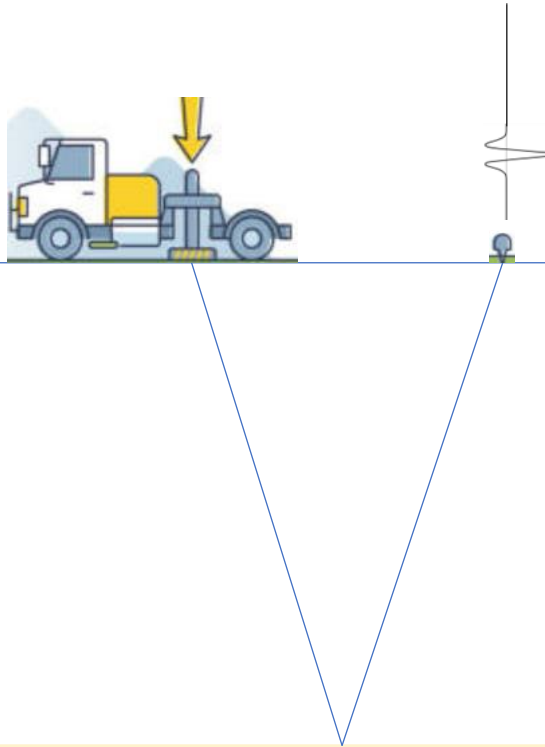
Cultural – human activities; traffic, industry, agriculture

System noise

Noise + signal are recorded

Signal:noise ratio

Increase signal through repetition – fold (number of seismic traces from one point)



Problems, problems.....

Noise

Natural - seismic activity, waves, wind, fauna, reservoir sloshing

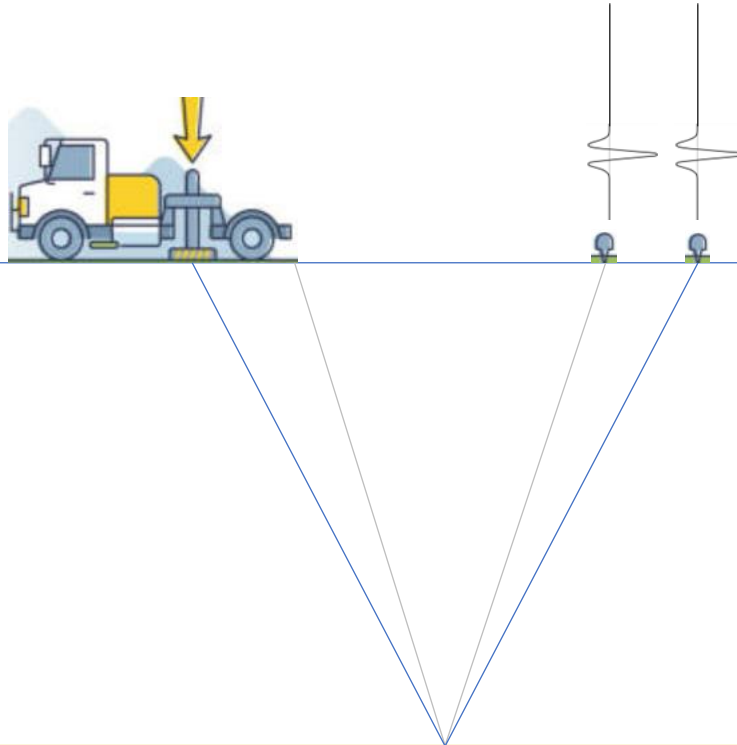
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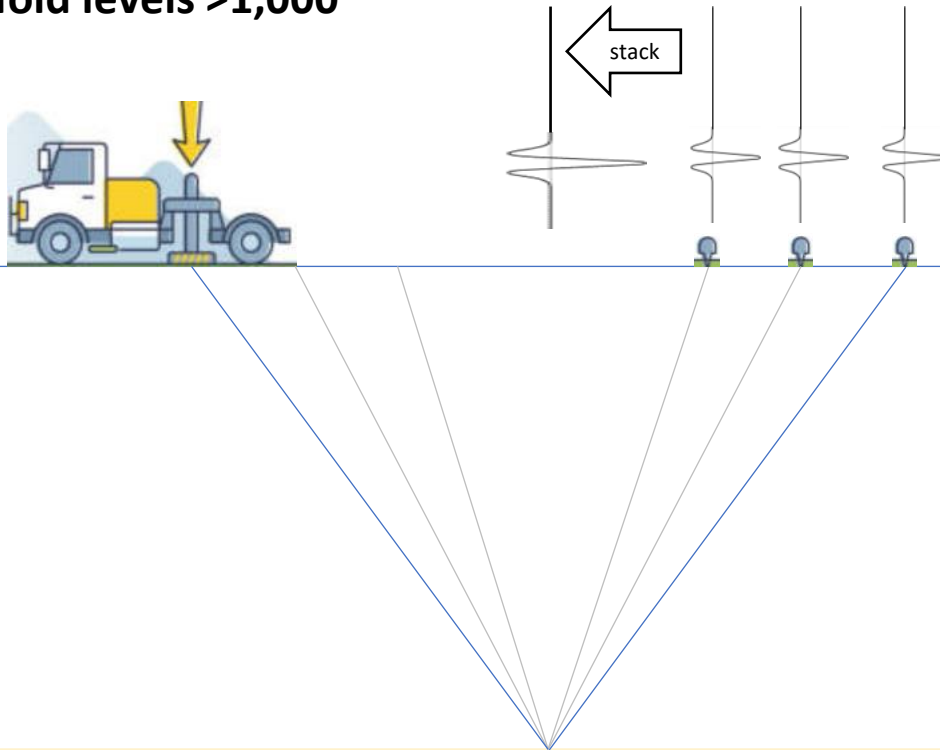
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Typical modern fold levels >1,000



Problems, problems.....

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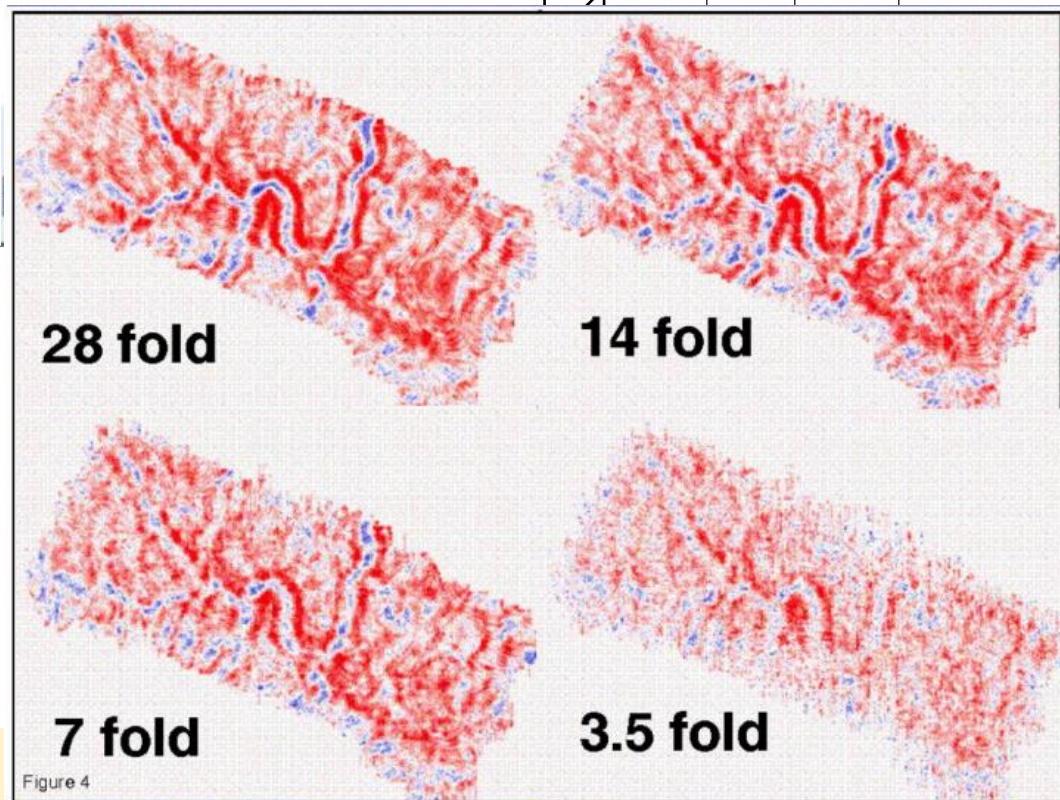
System noise – ground roll, electronics

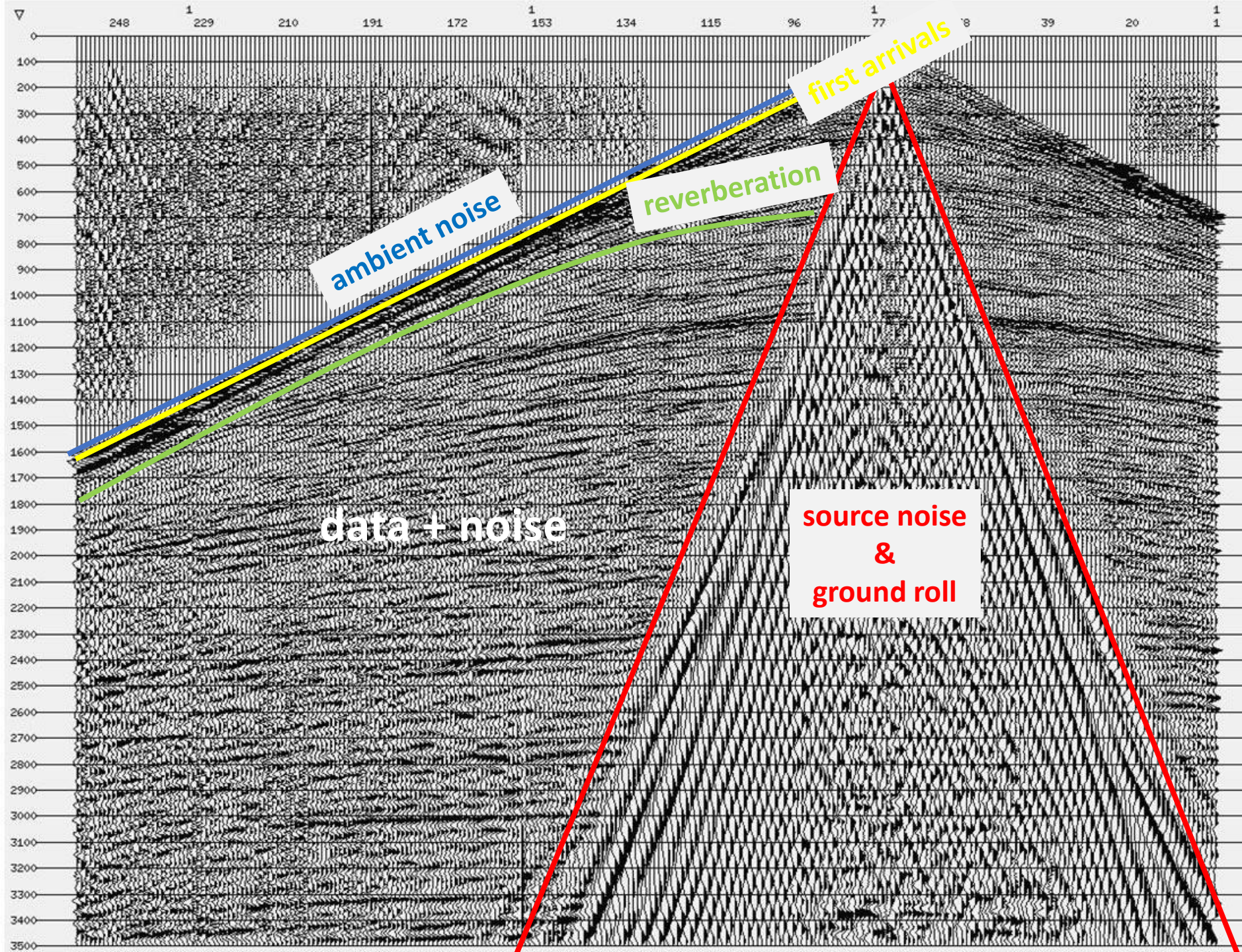
Noise + signal are recorded

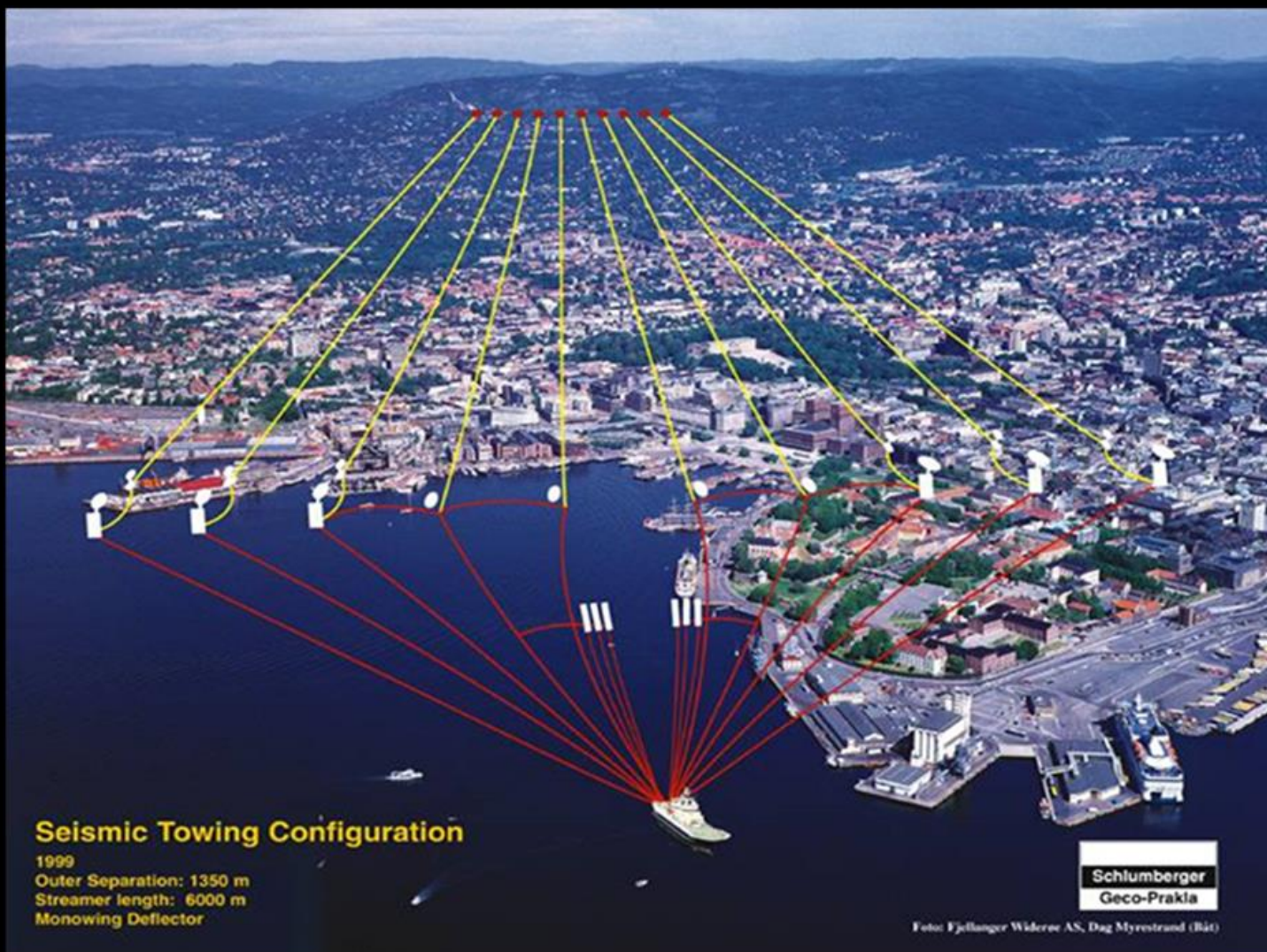
Signal:noise ratio

Increase signal through repetition – fold (number of seismic traces from one point)

Typical modern fold levels >1,000







Seismic Towing Configuration

1999

Outer Separation: 1350 m

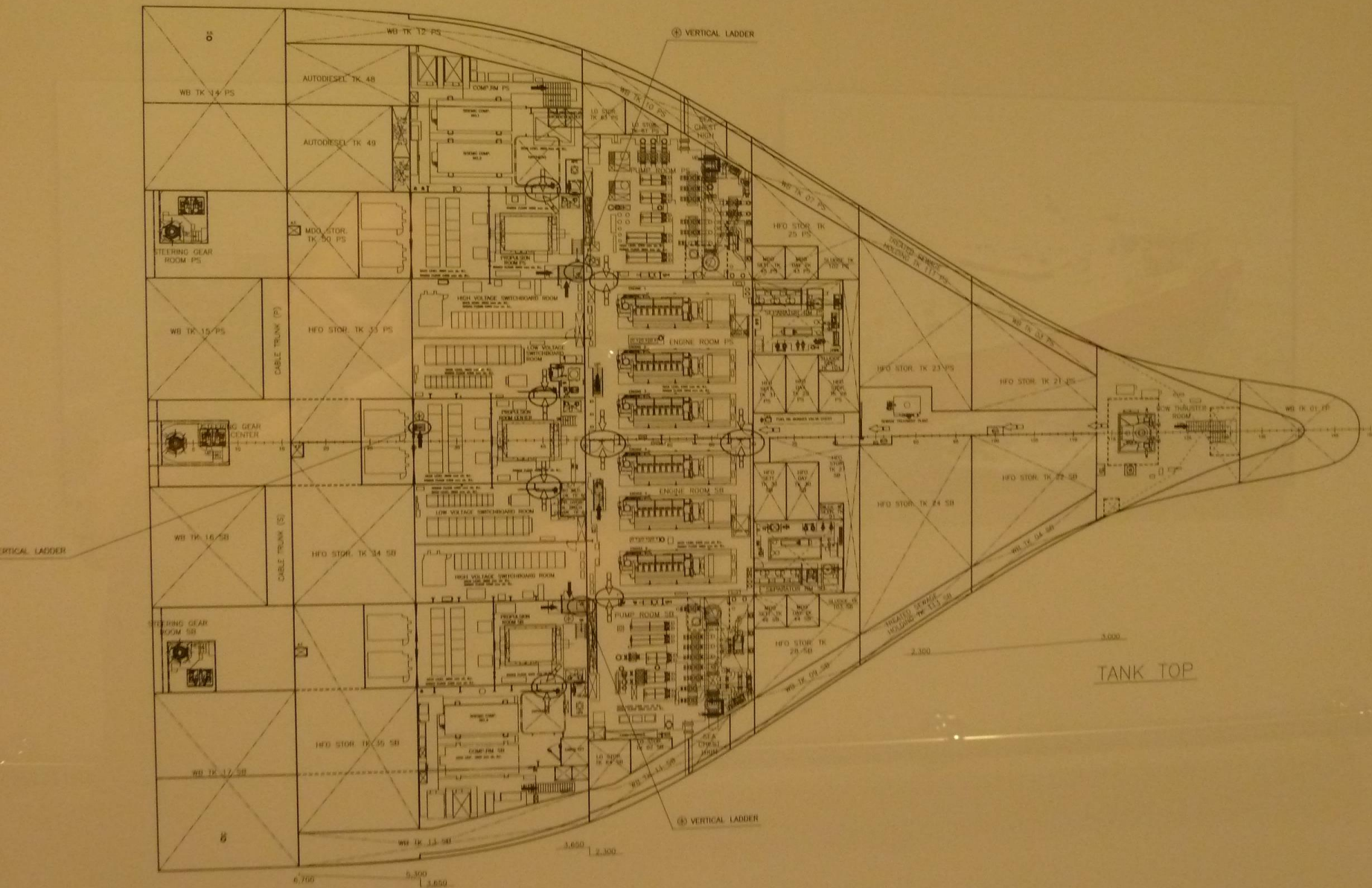
Streamer length: 6000 m

Monowing Deflector

Schlumberger
Geco-Prakla

Foto: Fjellanger Widerøe AS, Dag Myrrestrand (Båt)











12
15s
2ms
30m

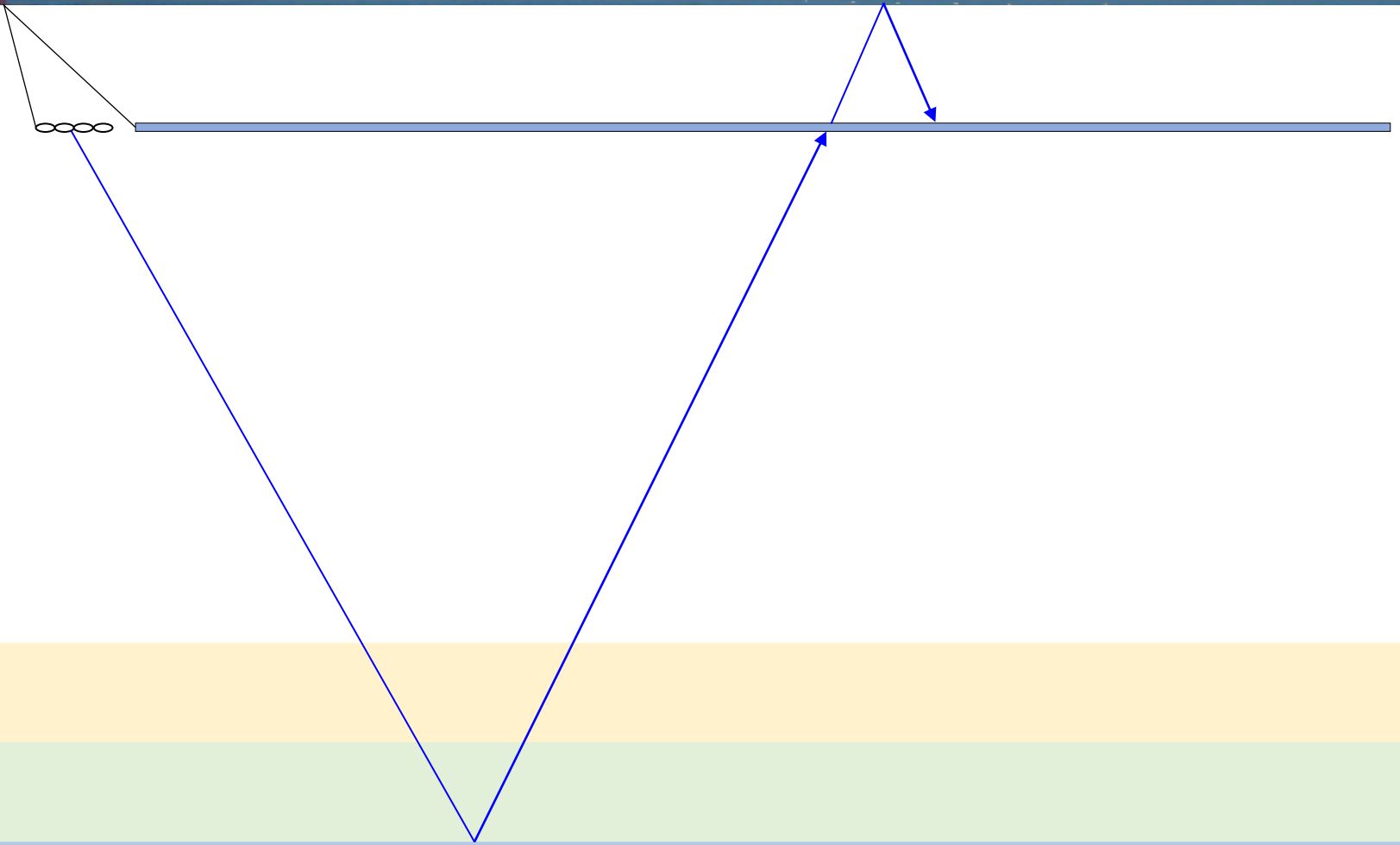


12
15s
2ms
30m



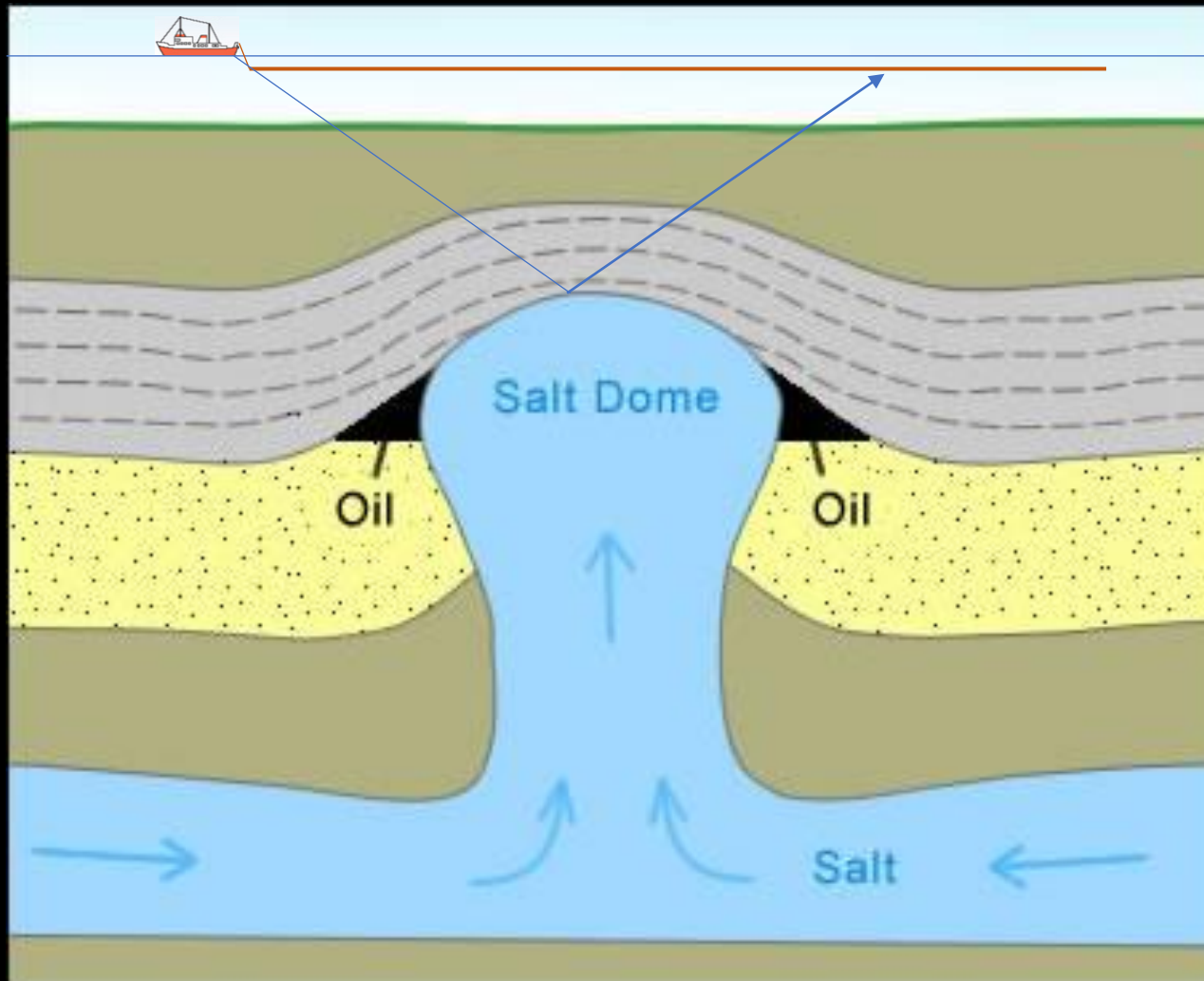


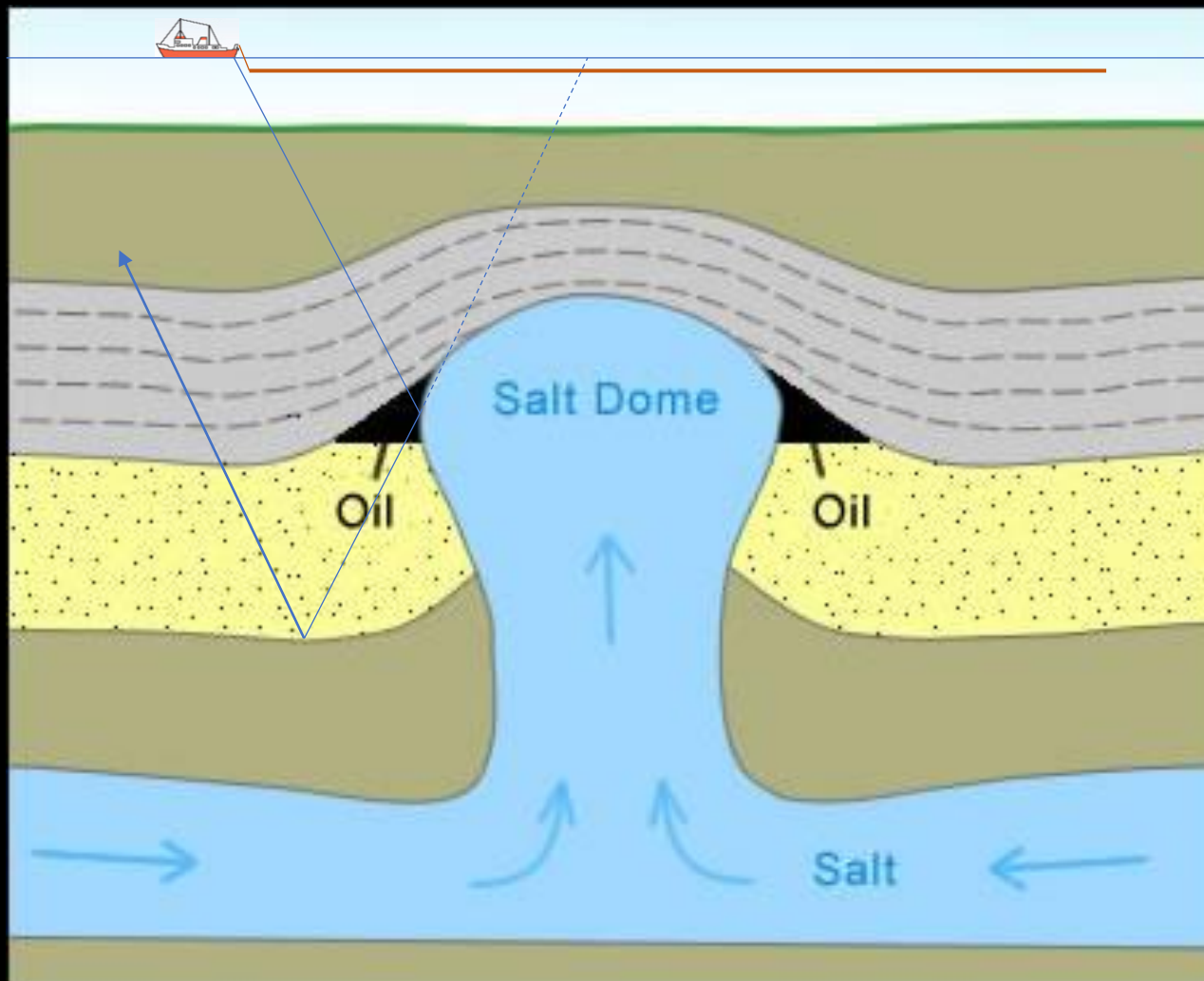
Problems, problems.....
Ghosting

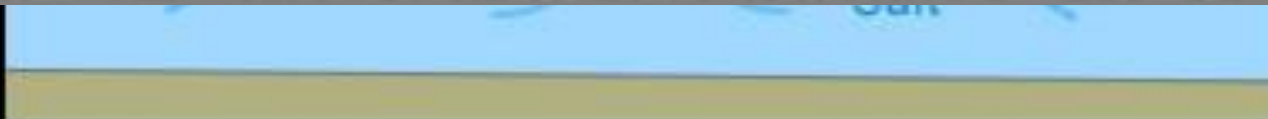
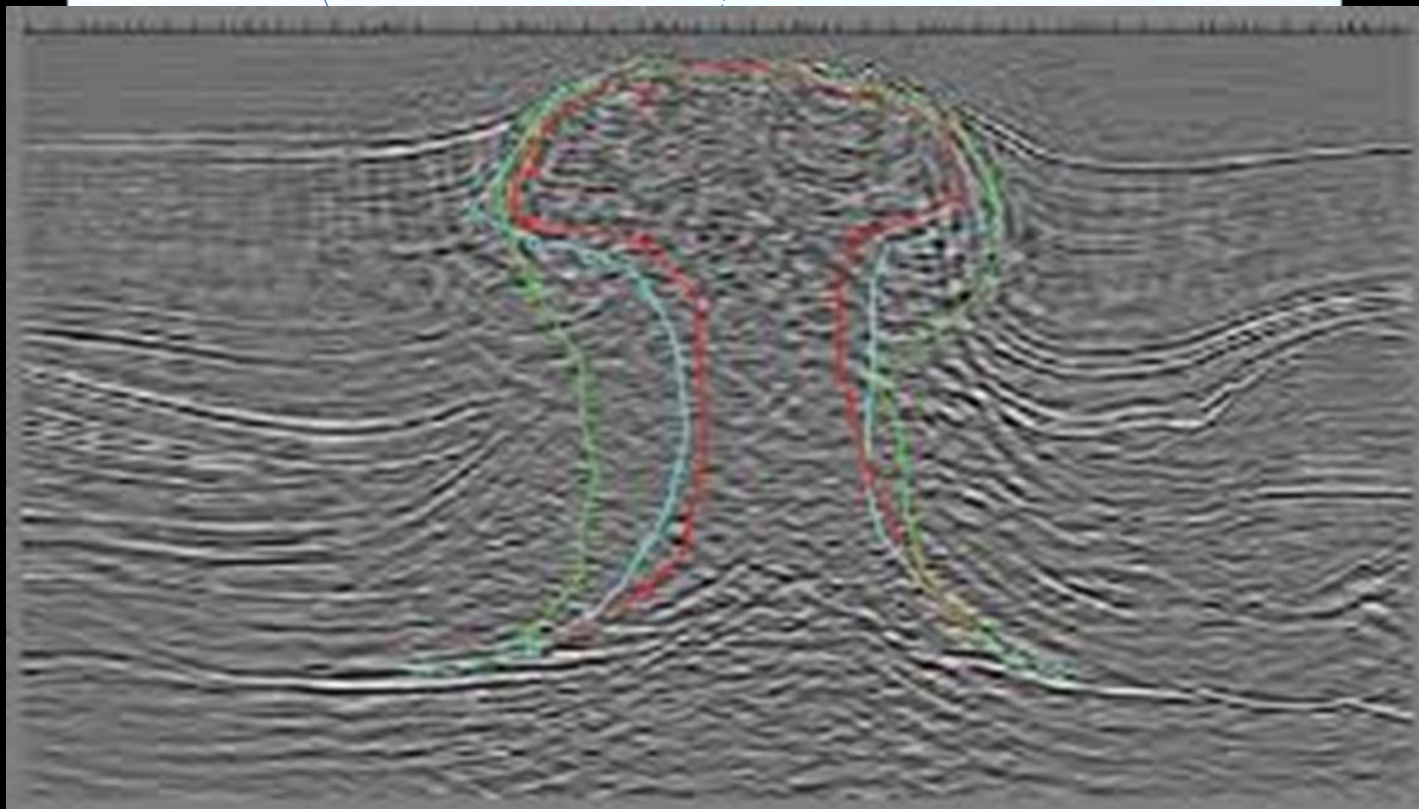
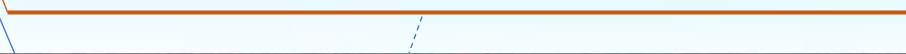




Problems, problems.....







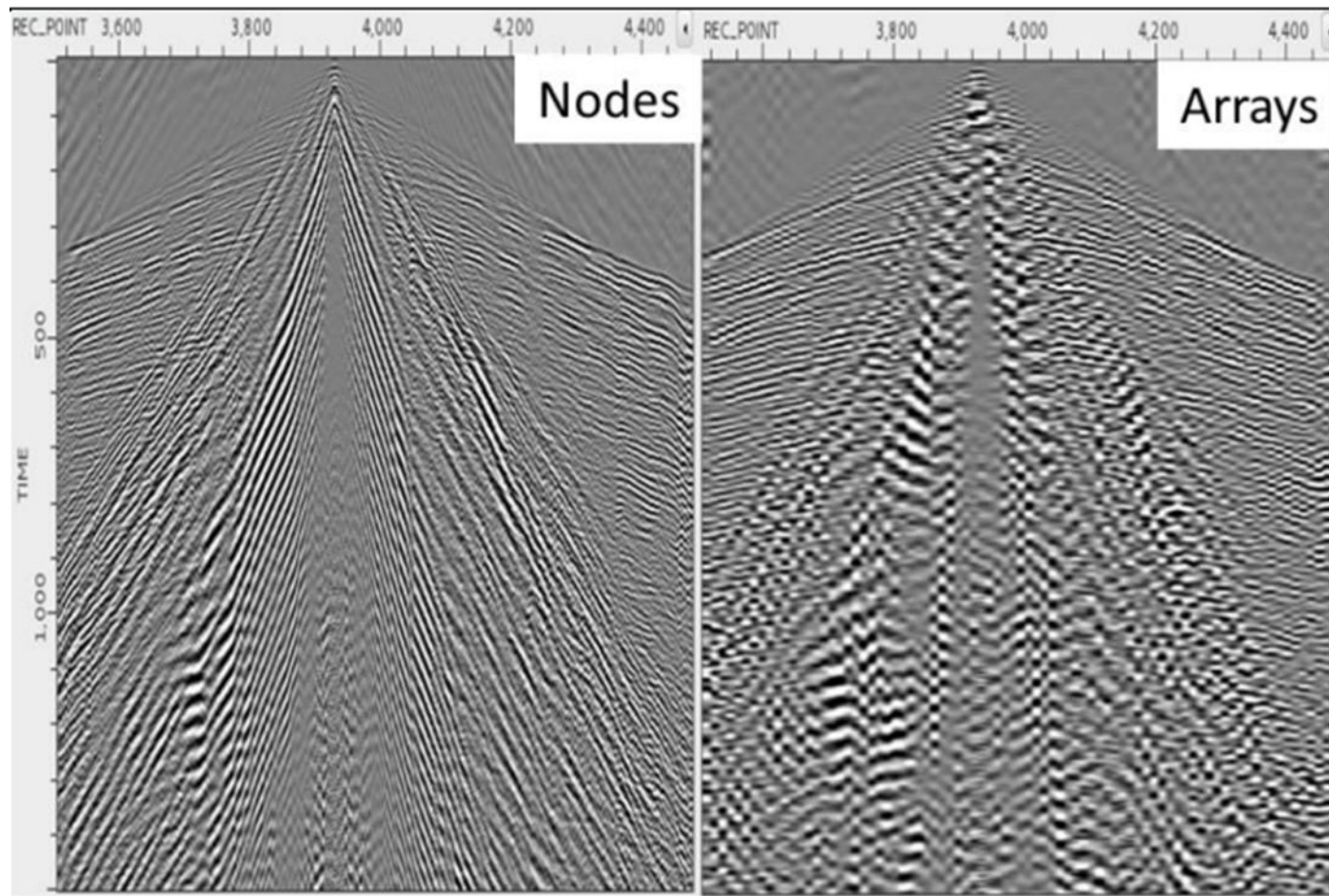


The 21C way



The 21C way





BP_Atlantis_OBN 2019

376.4 m
1181.0 m
204.0 °

-3.0 °P

195.9 °

4.0 °R

1309.1 m
*** m
*** m

0.0 T

0.0 T



magseis fairfield

OCEANEERING

LINE 2665
STAT 1370

786992

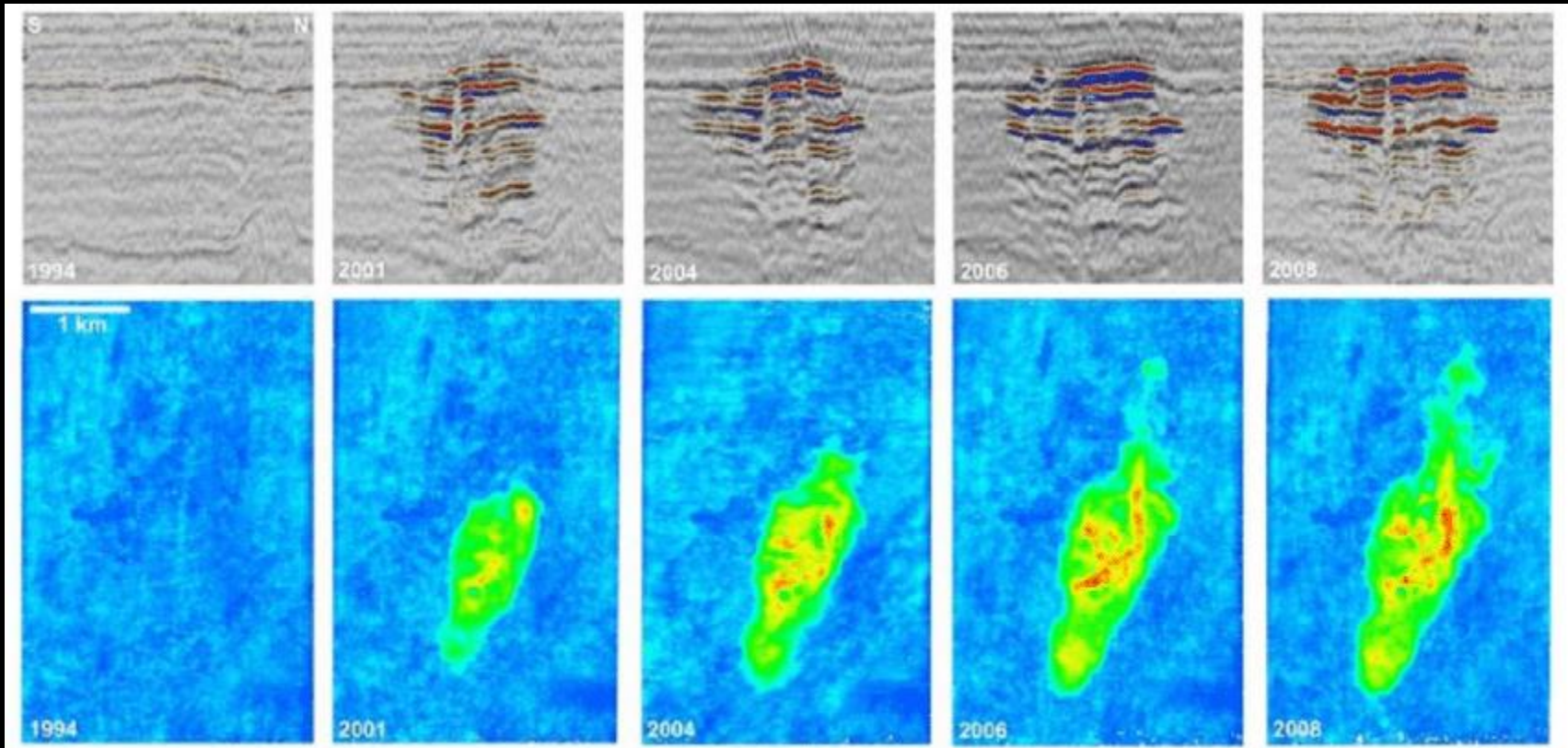
ROV 30242
DIVE 6

MIL 229

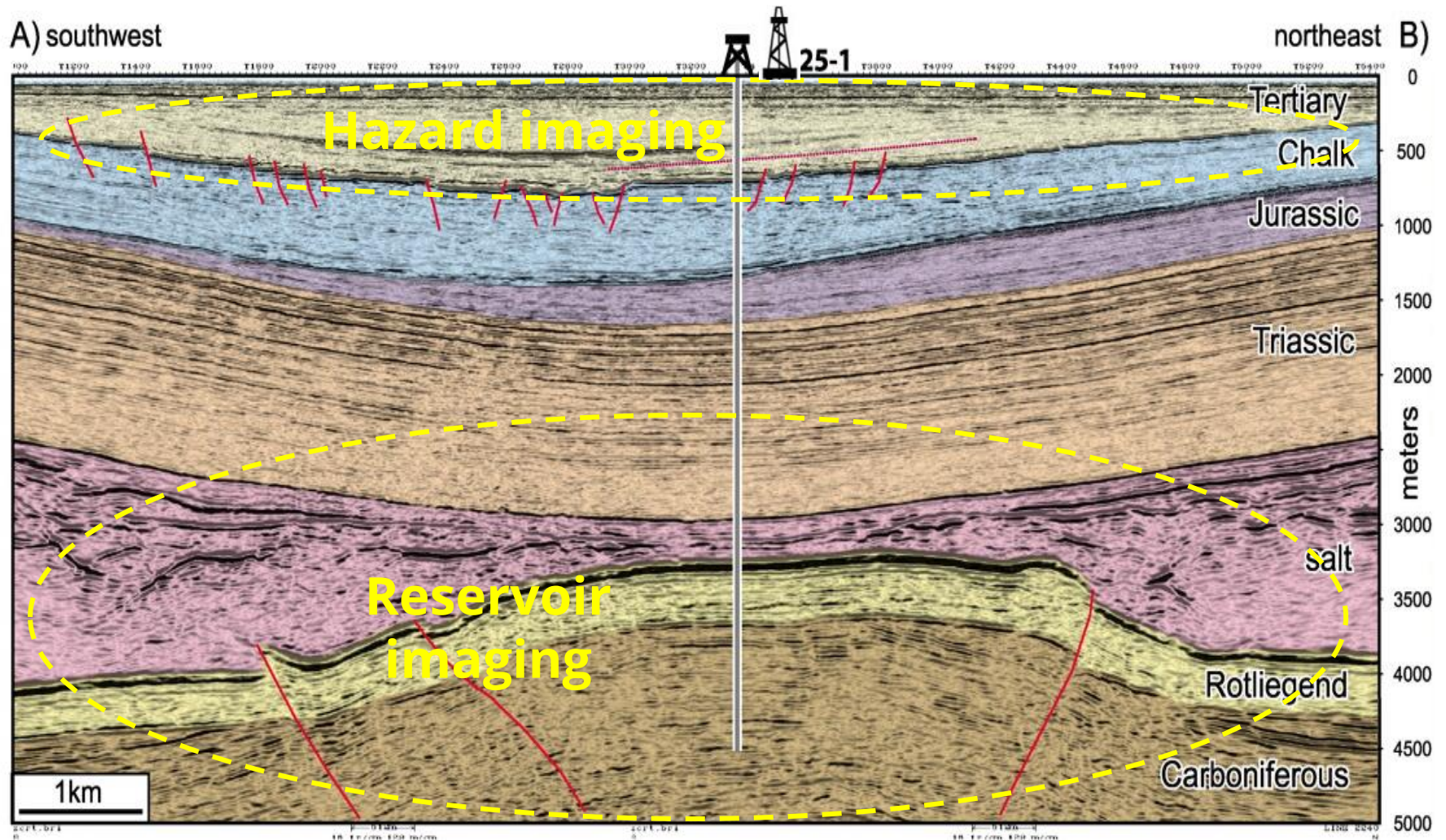
2/2/2019 2:50:37 PM



4D seismic (3D repeated over time)
Monitors the fluids in rock over time
Sleipner CCS project Norway



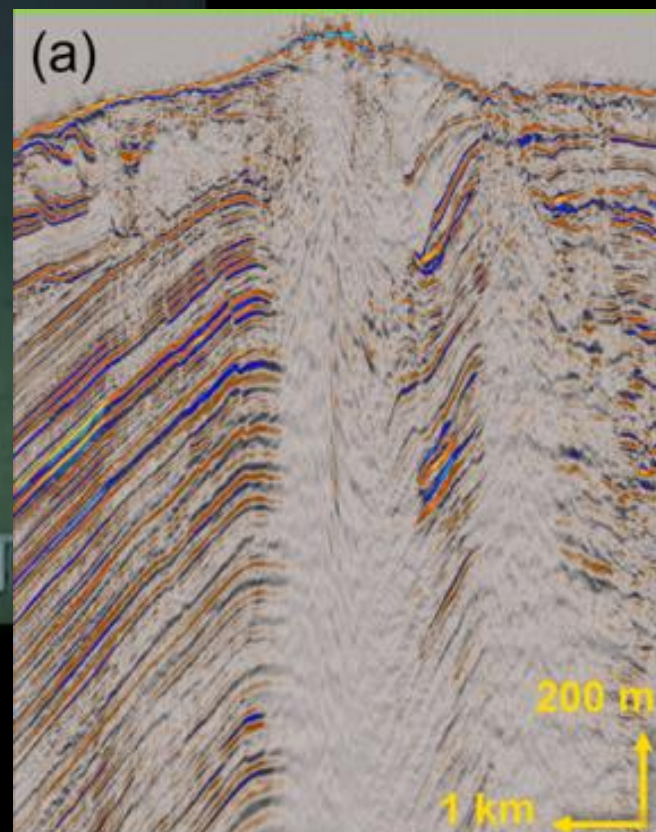
Shallow hazard surveys



19/05/19 11:32:08 E:517974.30 N 4443395.40
HDG: 318.2 Depth:168.4 Alt: 1.3
SP17
GSE-WIF-19-037
Grid Survey Line 20, Chirag 7



iT





Summary

The seismic process

- Source
- Receiver
- Access
- Positioning
- Recording
- Processing
- 2D, 3D, 4D

Problems

- Normal moveout
- Surface elevation
- Velocities
- Refraction
- Attenuation
- Noise
- Ghosting
- Geology (salt, karst)



Thank you
and
good night!

