Università di Trieste
LAUREA MAGISTRALE IN GEOSCIENZE
Curriculum Geofisico
Curriculum Geologico Ambientale

Anno accademico 2018 – 2019

Geologia Marina

Parte I

Modulo 2.2 Metodi indiretti: Rilievi acustici e sismica a riflessione

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Summary

- INTRODUCTION

The Seismic method is the powerful geophysical techniques for imaging the Earth's interior.

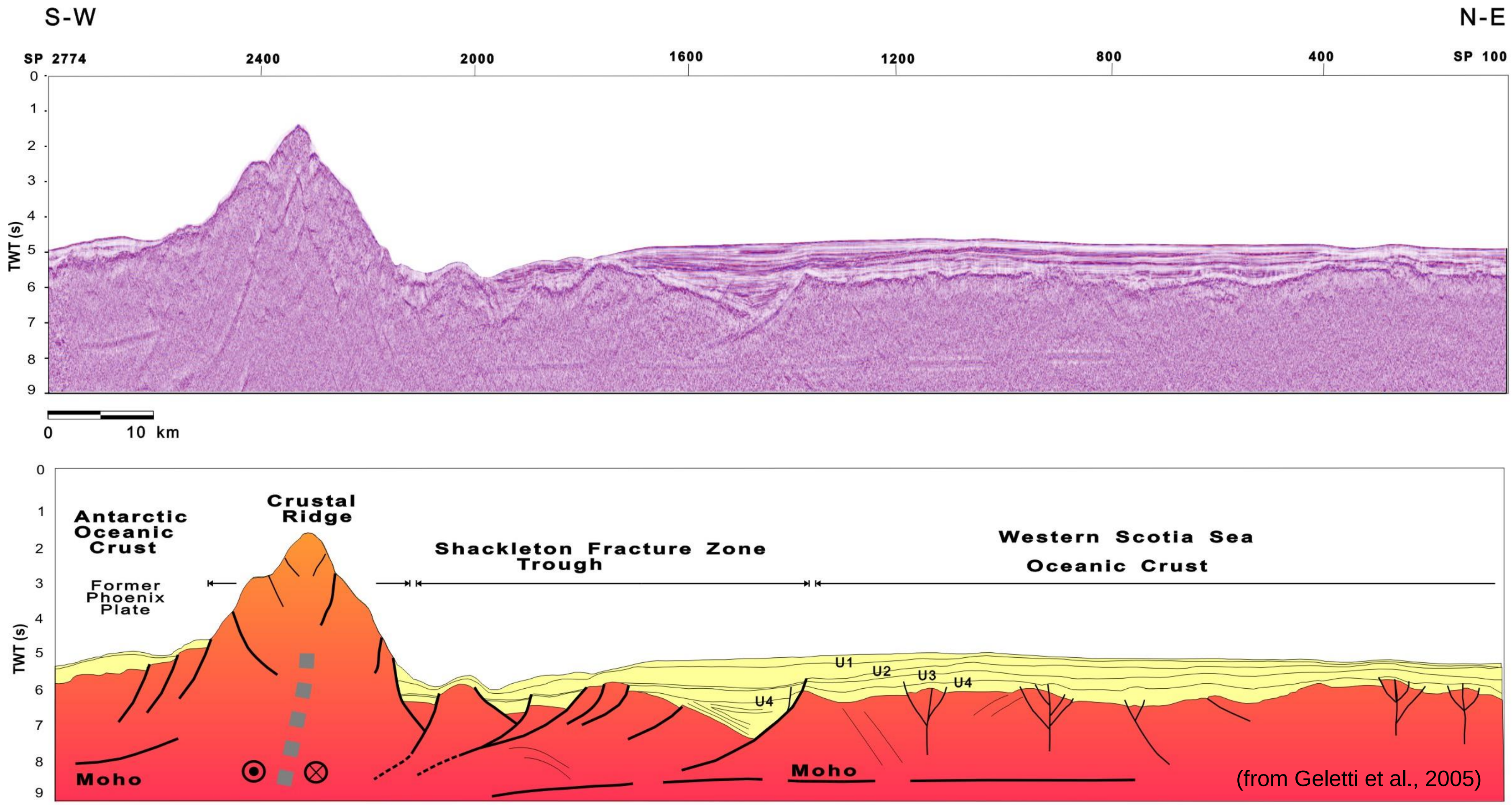
This artificial source method involve the generation of seismic waves whose propagation velocities and transmission paths through the subsurface are mapped to provide information on the distribution of geological boundaries at depth.

An alternative method of investigation subsurface geology is, of course, by drilling boreholes, but these are expensive and provide information only at discrete locations. Nevertheless, seismic surveying does not dispense with the need for drilling because it can give a geological meaning to the seismic reflectors.

Seismic Reflection Interpretation

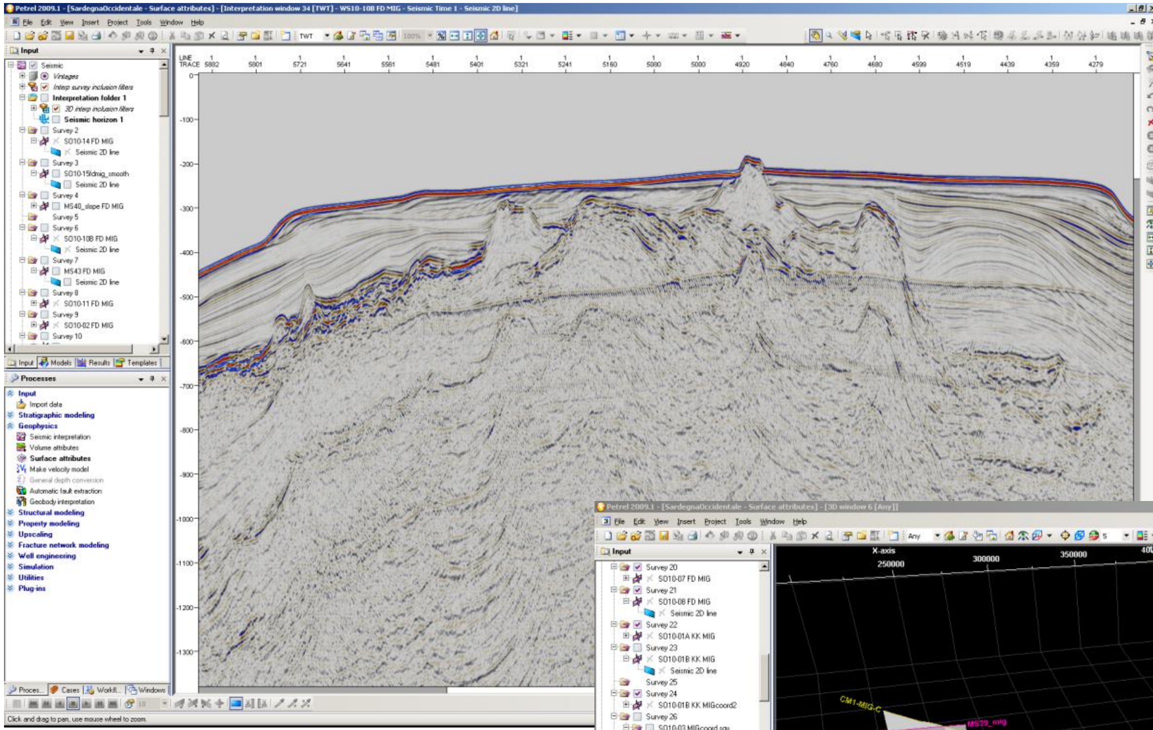
- Fundamental in applied research to geosciences
- Provides information regarding:
  - geometries of stratigraphic sequences
  - geometries of structural and tectonic elements
  - velocity of seismic waves
  - lithological characteristics

The seismic interpretation attributes geological meaning to geophysical data and produces reconstructions of:
2D sections, structural maps, fault systems, slumping and geo-hazard etc.

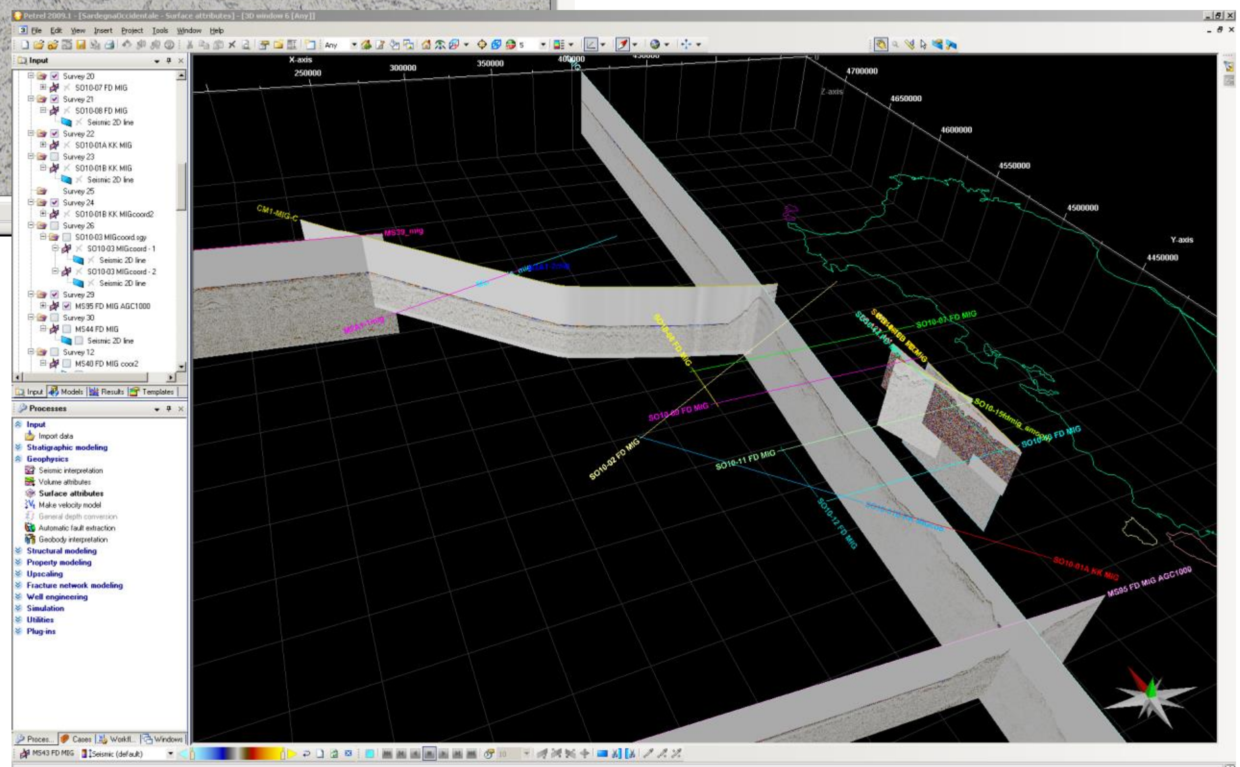


Crustal seismic section: example of seismic interpretation

Interpretation software



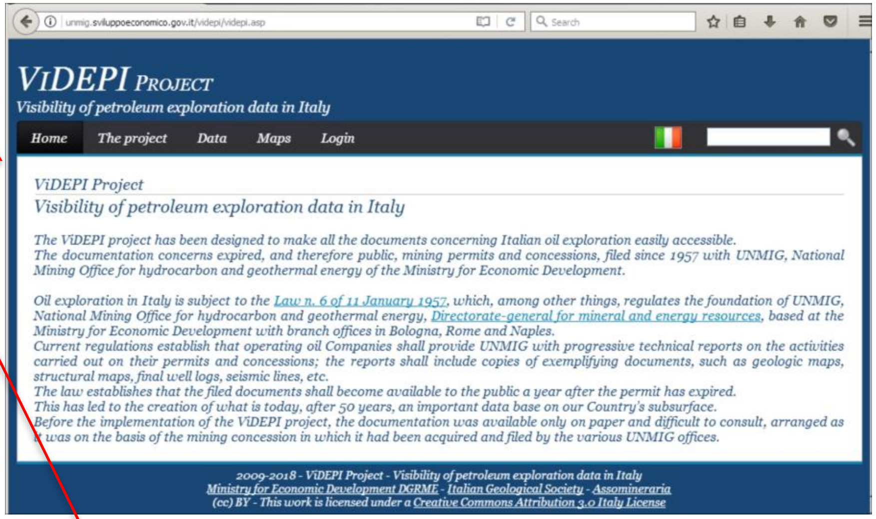
Seismic section

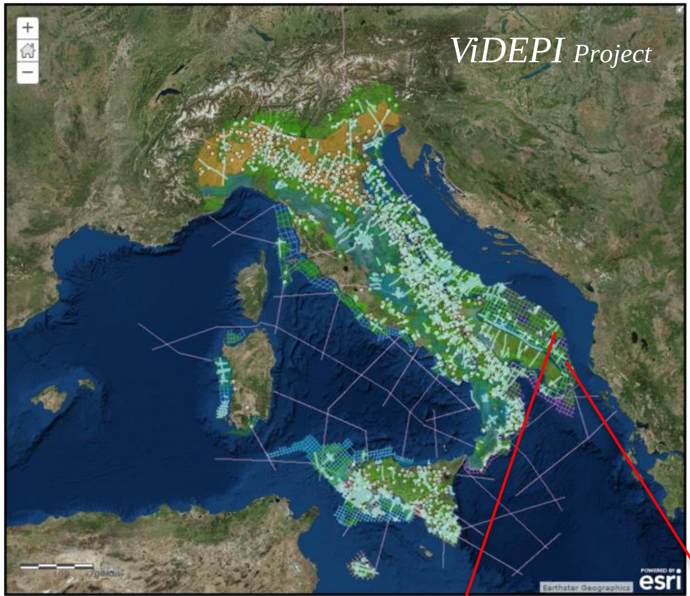


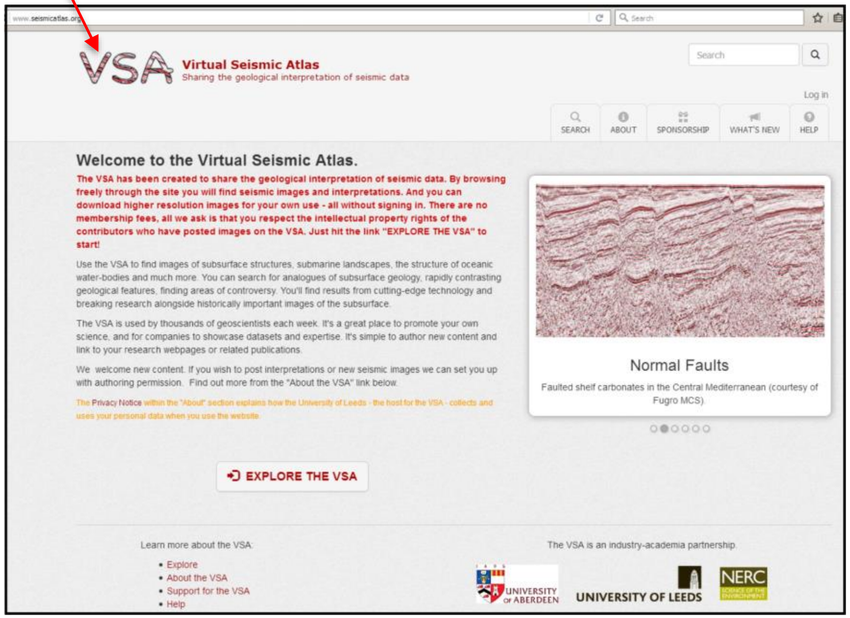
Position map of 2D seismic survey by an interpretation software

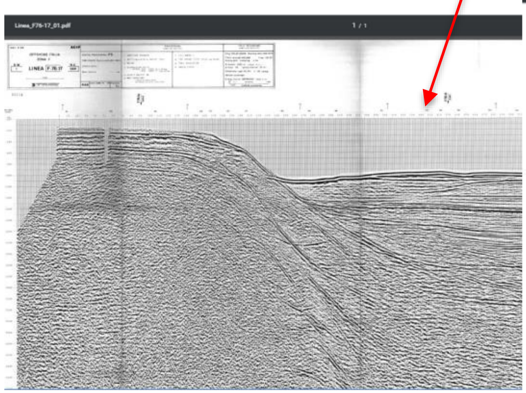
Seismic data websites:

- http://unmig.sviluppoeconomico.gov.it/videpi/
- http://see-atlas.leeds.ac.uk:8080/home.jsp

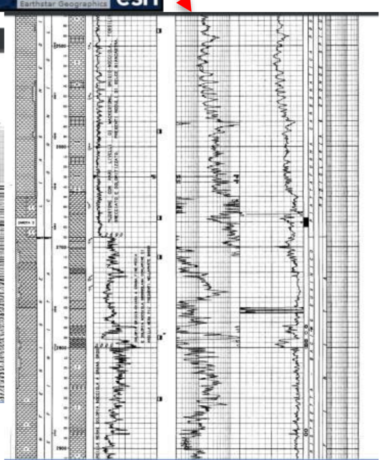


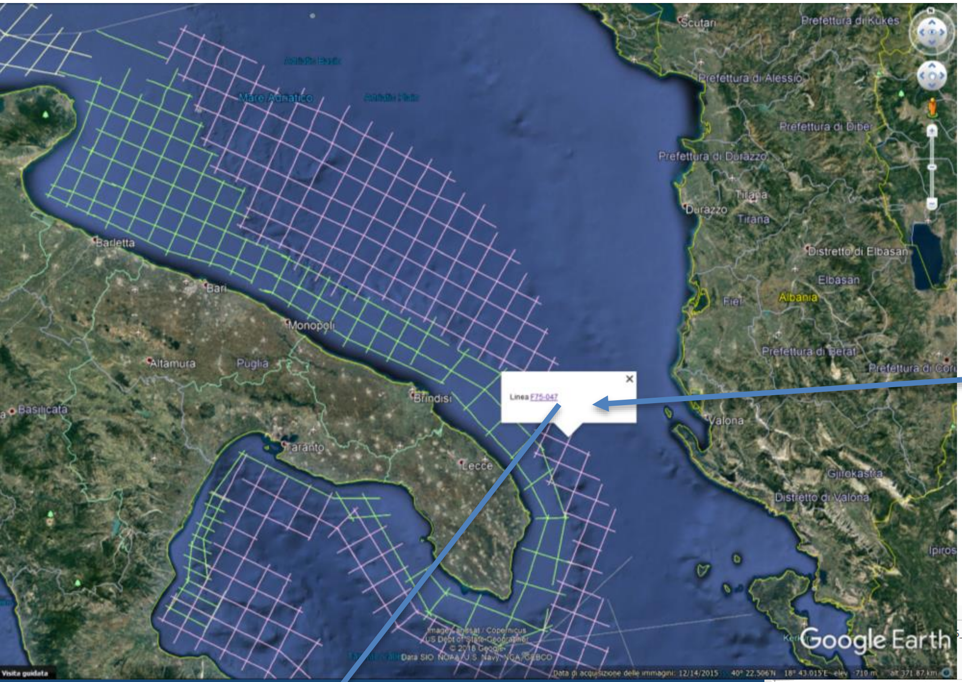






well





ViDEPI Project
Visibility of petroleum exploration data in Italy

Home | The project | Data | Maps | Login

Geographic consultation

Download KML files

In questa pagina sono presenti i collegamenti ad alcuni file in formato kml utilizzabili con il programma Google Earth.

KML files

1. *Reconnaissance seismic campaigns of the offshore areas*
   - *Zona B*
   - *Zona C*
   - *Zona D*
   - *Zona E*
   - *Zona F*
   - *Zona G*
2. *CROP Atlas Project, seismic reflection profiles of the italian crust*
3. *Seismic lines acquired in expired mining permits and concessions*
4. *Expired mining permits and concessions*
5. *Wells*

To carry out a geographic search, you need to download Google Earth program on your pc.
Click on earth.google.com/intl/en to install Google Earth.
Go to support.google.com/earth/?hl=en to learn how to use the program.
To view all the expired mining permit and concessions and wells, move the cursor to the right on the time bar.
The form and location of the elements is purely indicative, they are supplied only to inform users of the presence of data in a area.

2009-2018 - ViDEPI Project - Visibility of petroleum exploration data in Italy
Ministry for Economic Development DGRME - Italian Geological Society - Assomineraria
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ViDEPI Project
Visibility of petroleum exploration data in Italy

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Siesmic lines
Seismic exploration ZONA F
Linea F75-047
Back to previous page

1. *Linea_F75_47_01 (1.838 Kb)* *See on Google Maps*
2. *Linea_F75_47_02 (1.595 Kb)* *The view on Google Maps is not an authority and only has an informative character*

Note:
The image files of seismic lines are in raster format, to view them you have to download the complete pdf file, it may take some time.

2009-2018 - ViDEPI Project - Visibility of petroleum exploration data in Italy
Ministry for Economic Development DGRME - Italian Geological Society - Assomineraria
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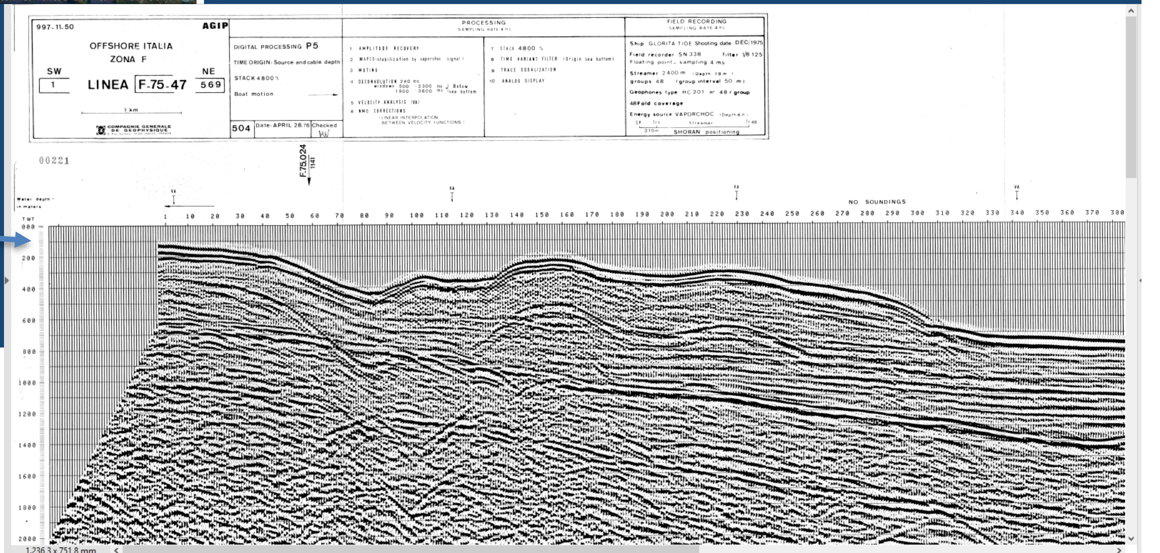
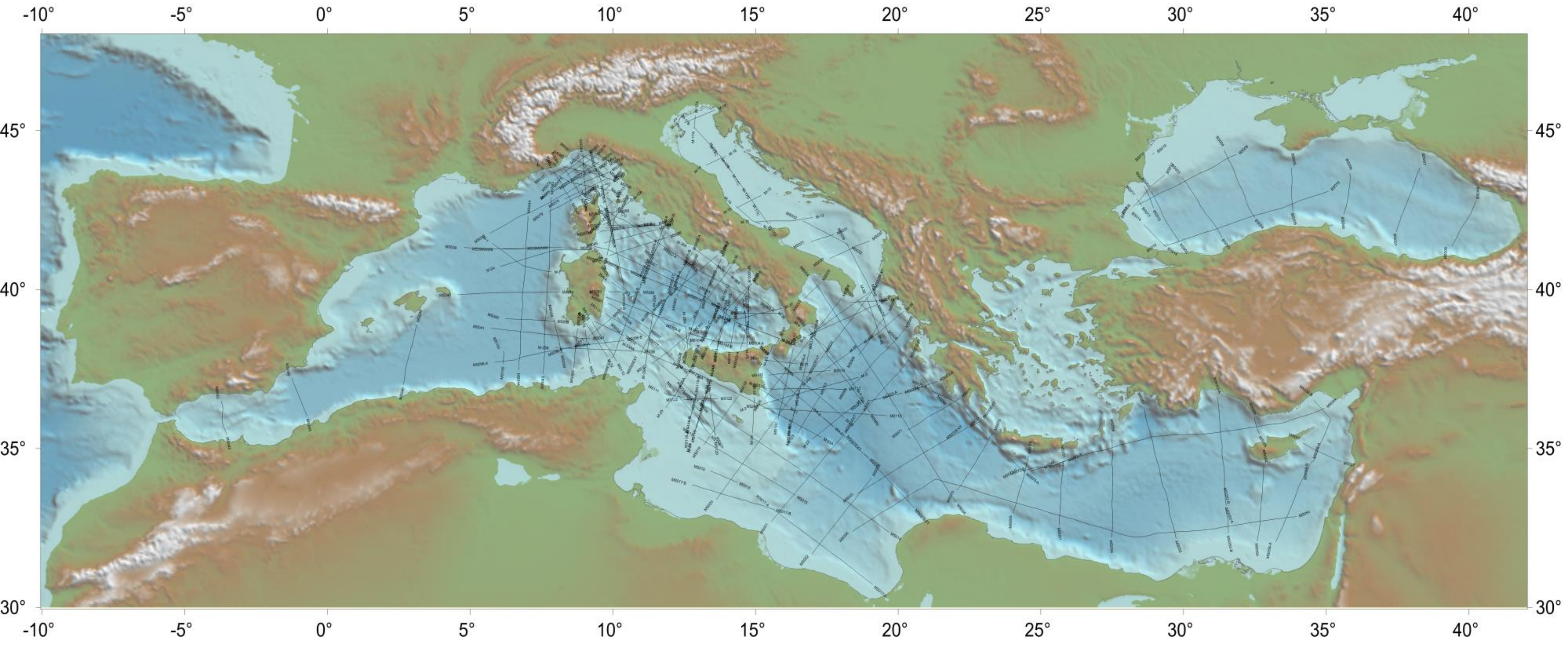
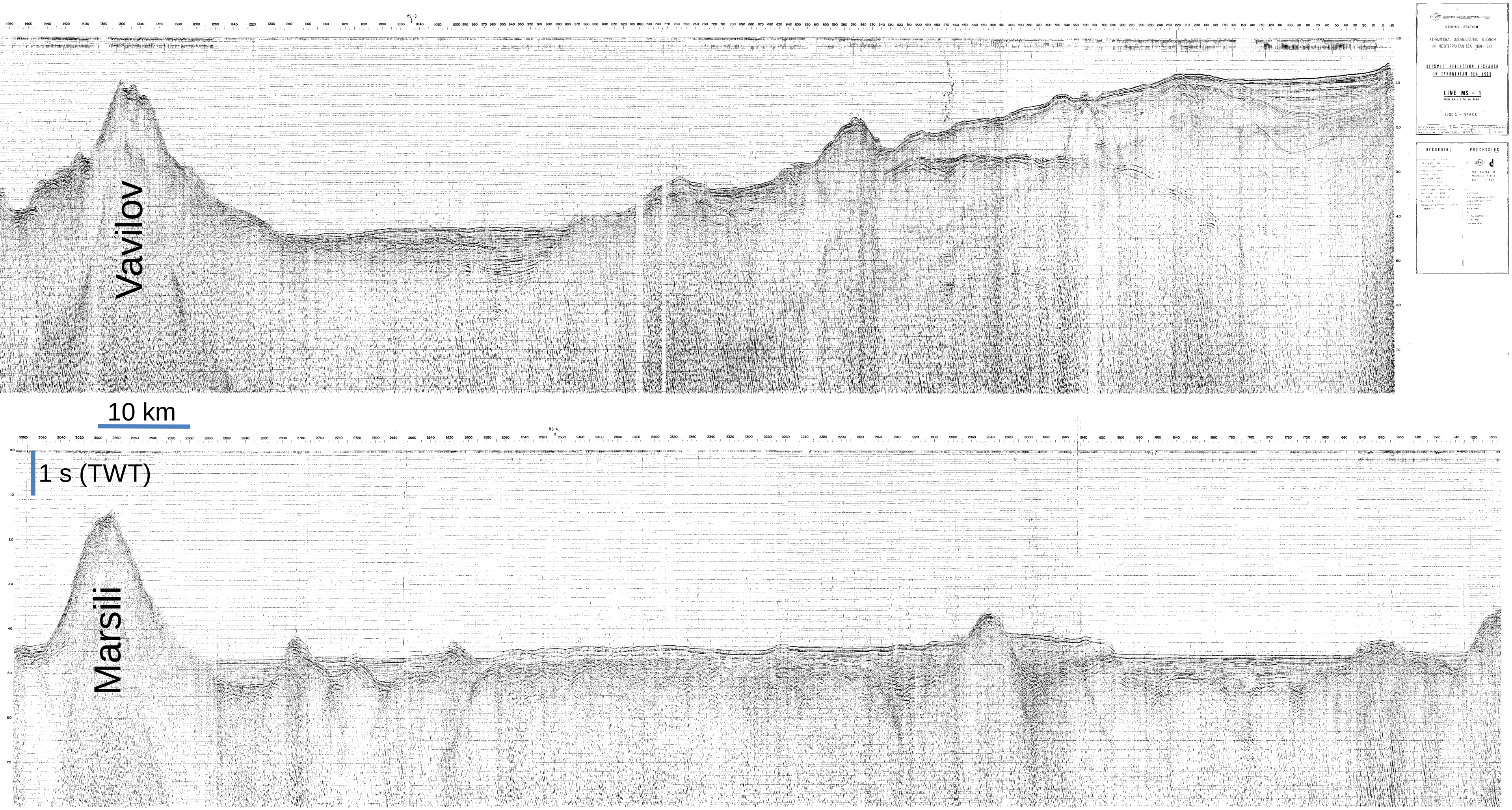


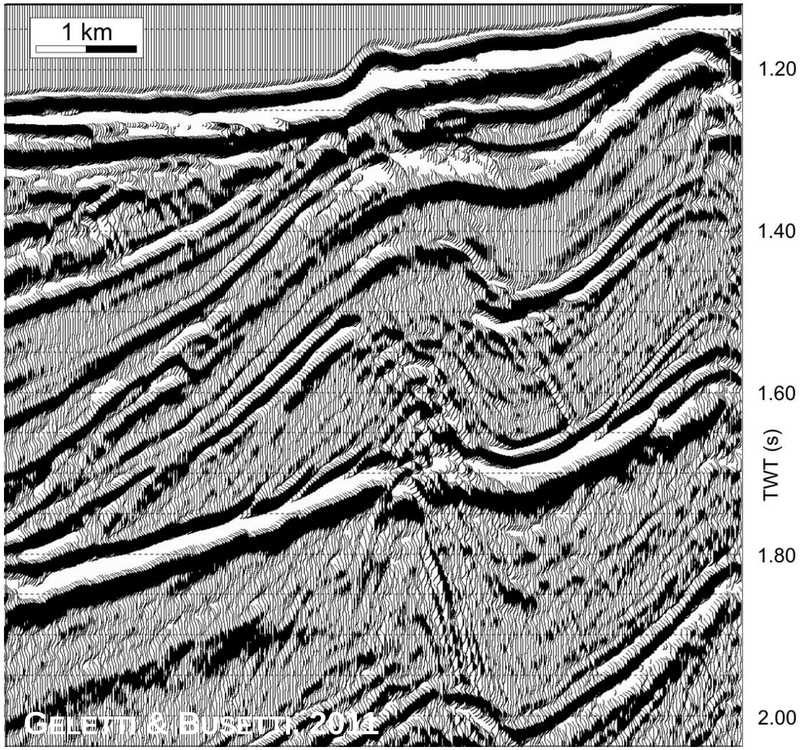
ViDEPI dataset



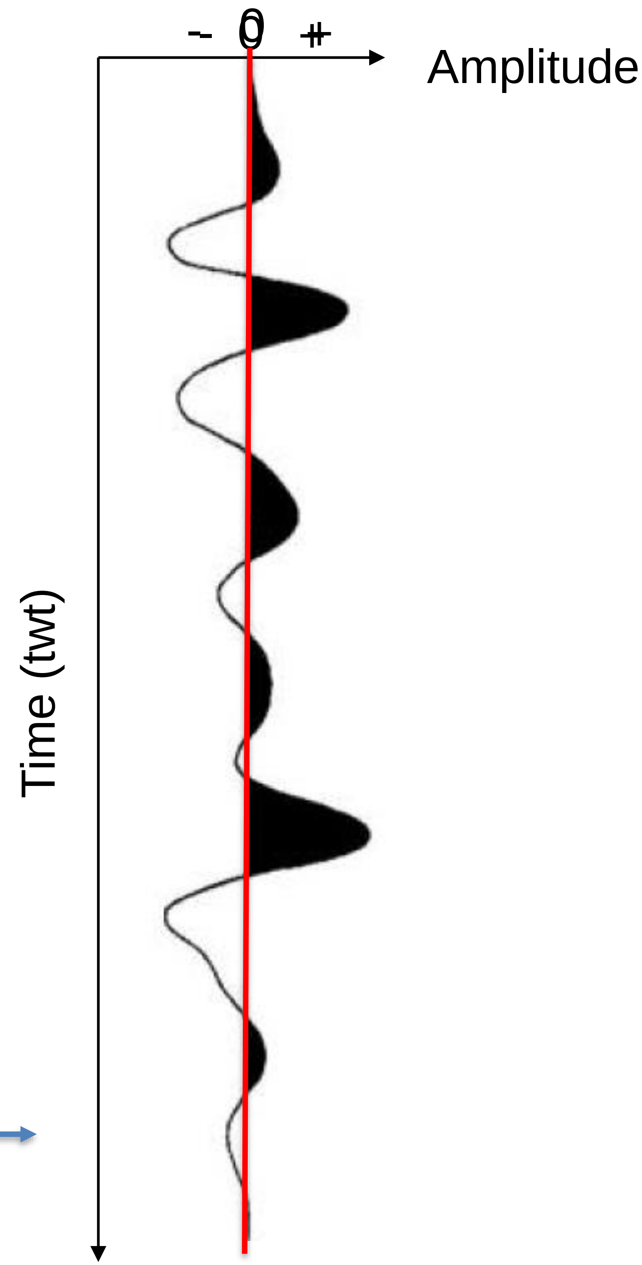
Position map of the seismic profiles of the Italian geophysical exploration projects MS and CROP acquired in 1969 – 1982 and 1991-1995 respectively



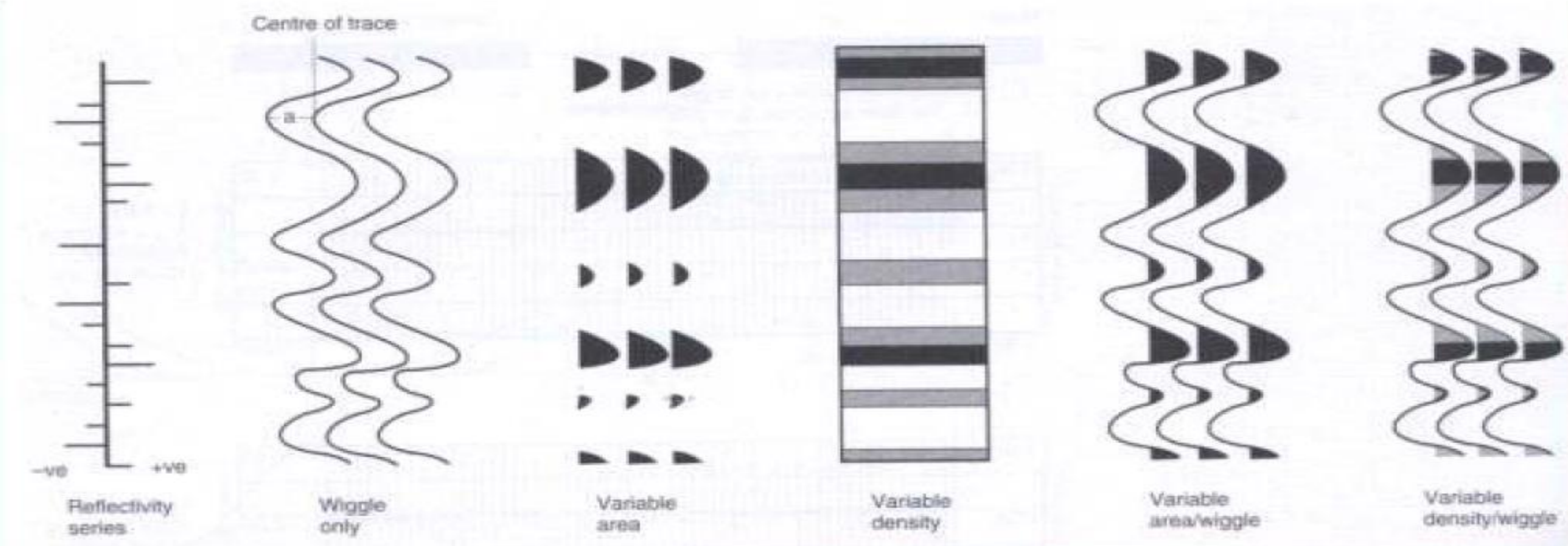
Examples of vintage crustal seismic sections MS 1 acquired in Tyrrenian Sea in 1969



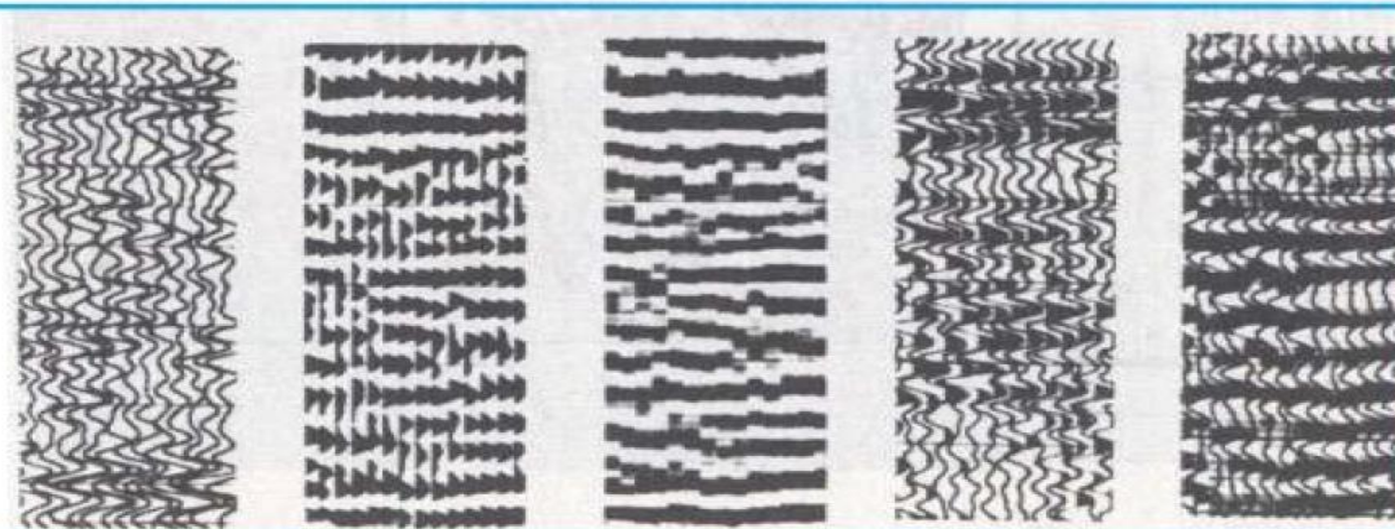
Example of a part of seismic line displayed in wiggle/variable area. On the right is shown a single trace that constitutes the section above (seismogram)

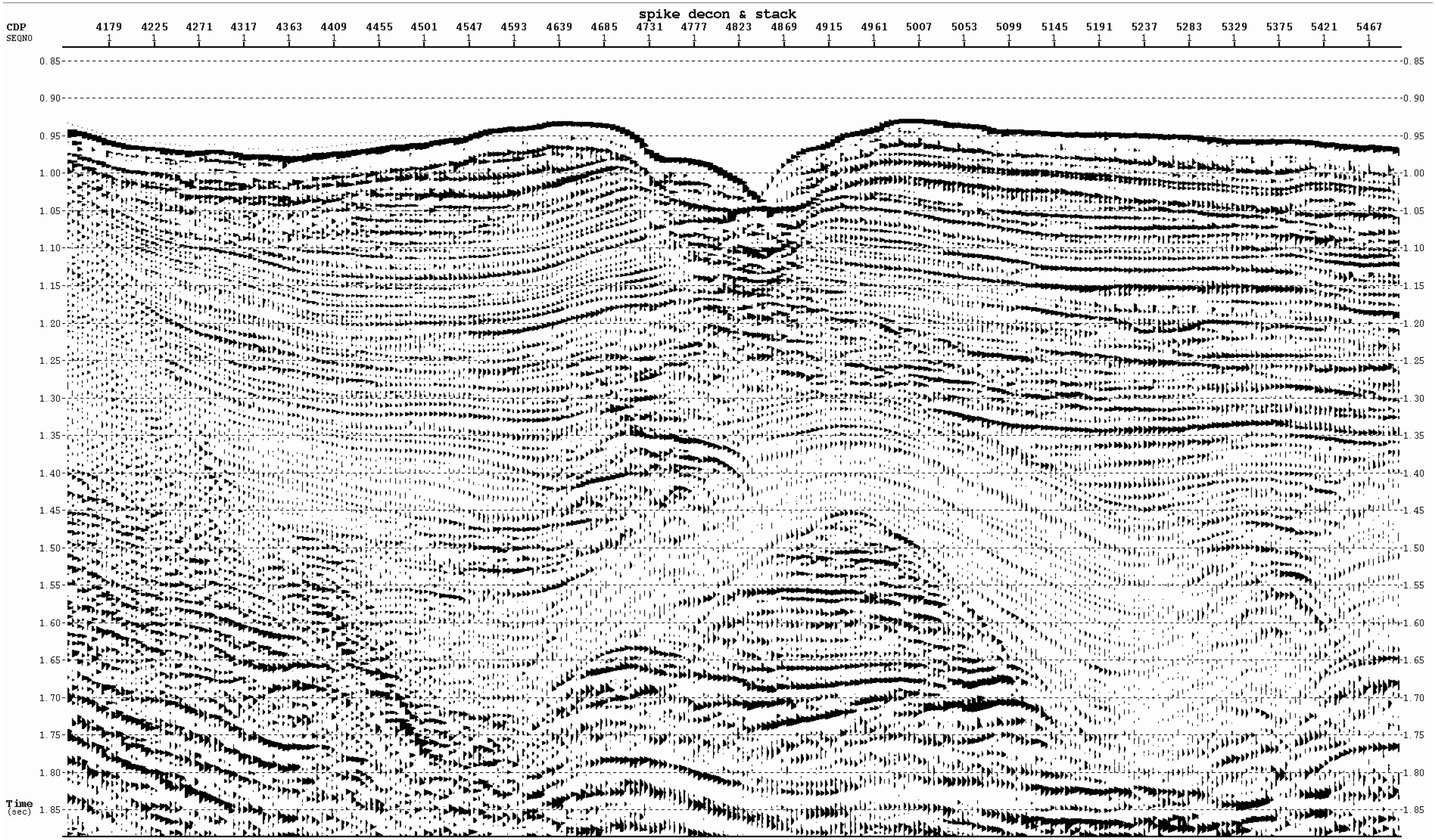


Seismogram: this is an example of a single trace of a seismic profile as shown in the figure above

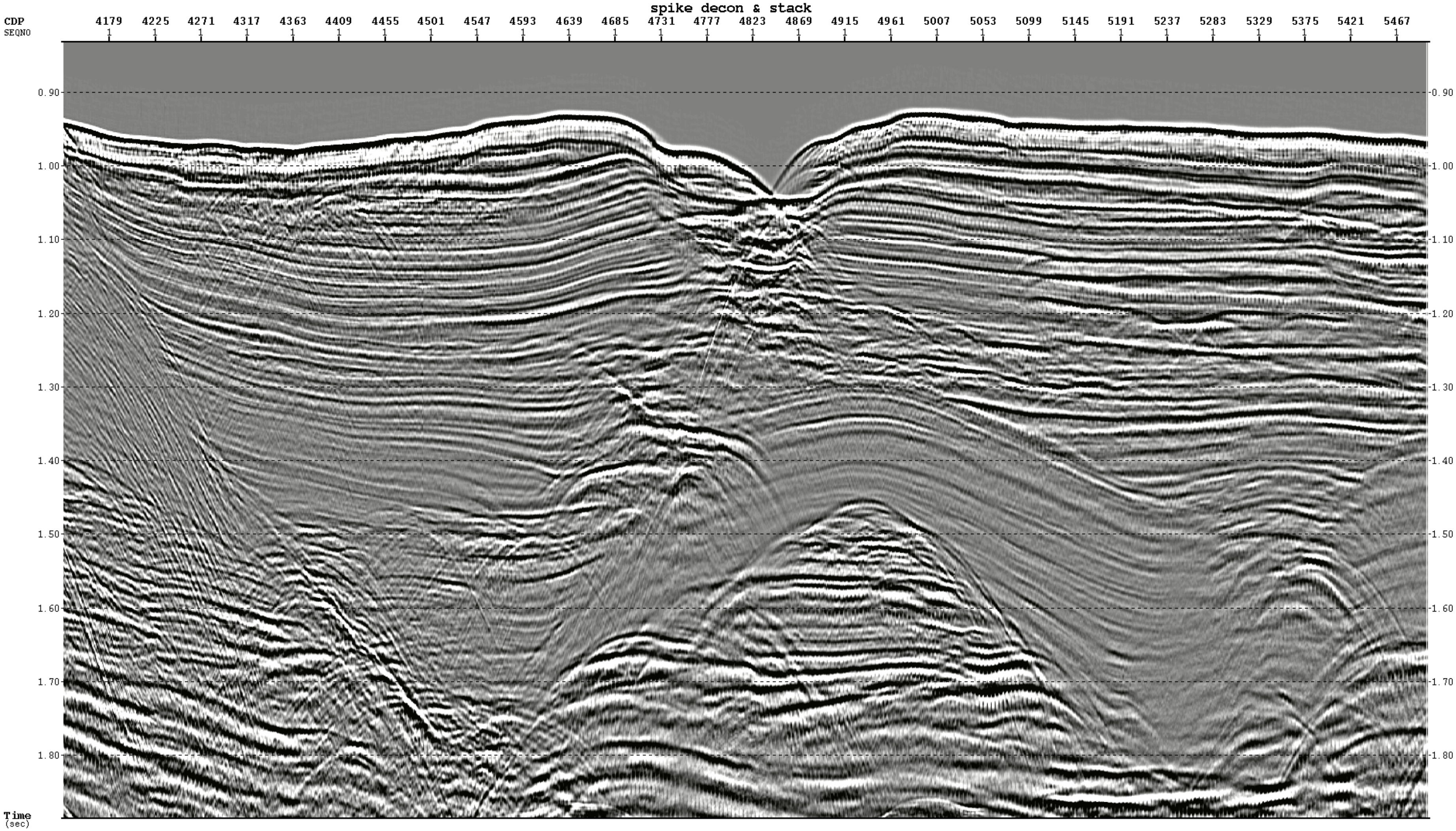


Seimic trace display

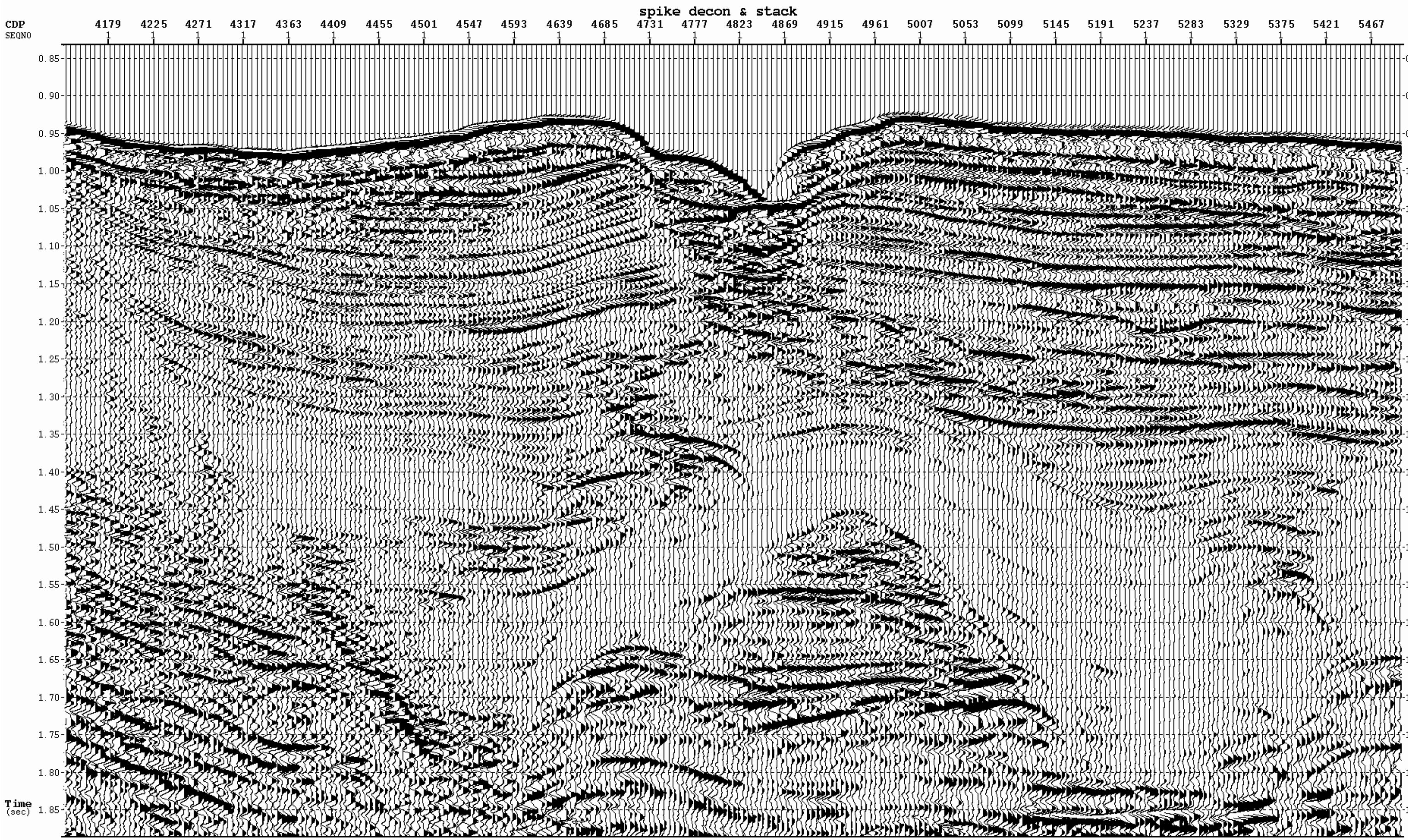




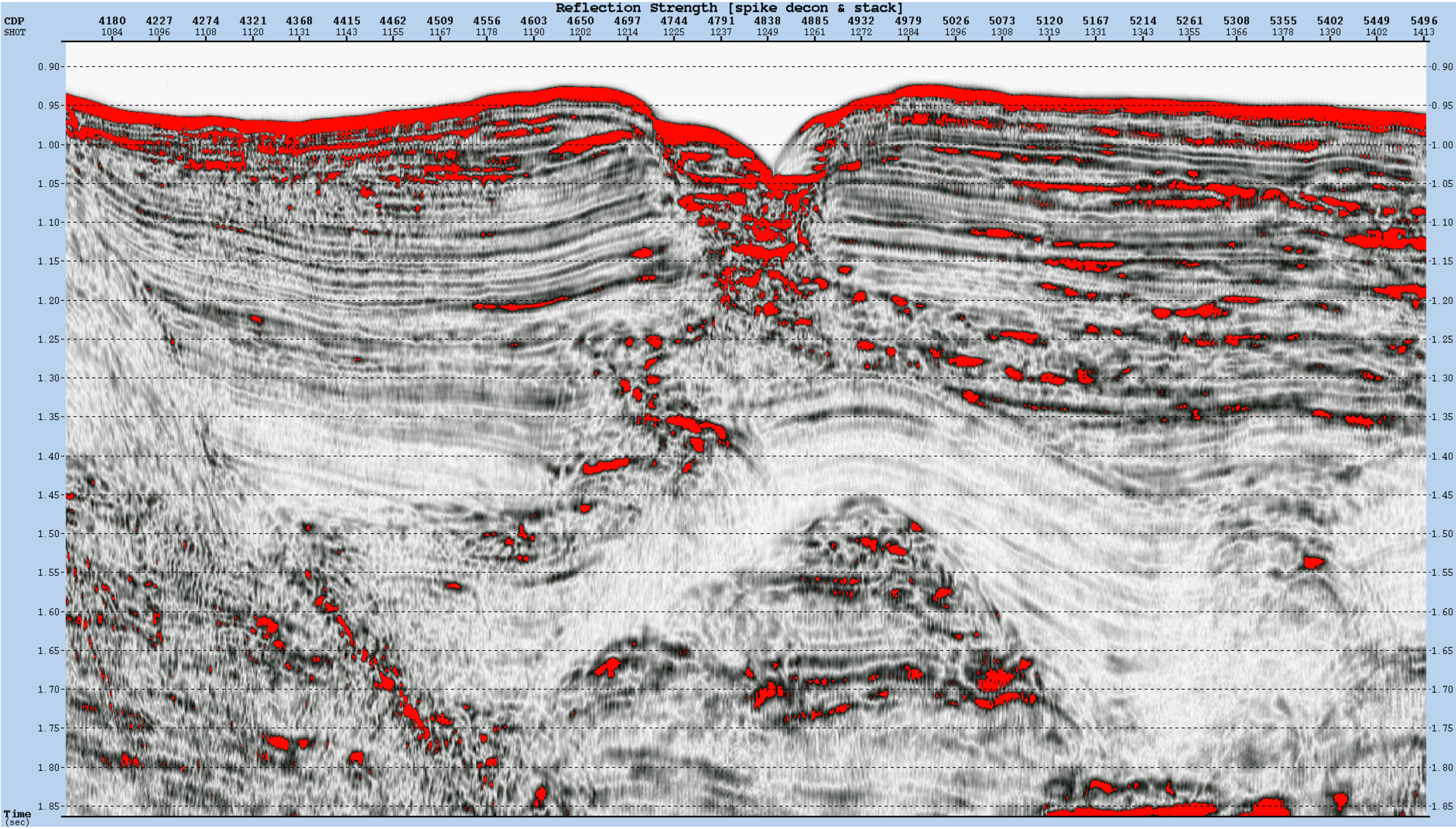
Seismic section displayed in “variable area”



Seismic section displayed in “variable density” in grey scale



Seismic section displayed in “wiggle + variable area”

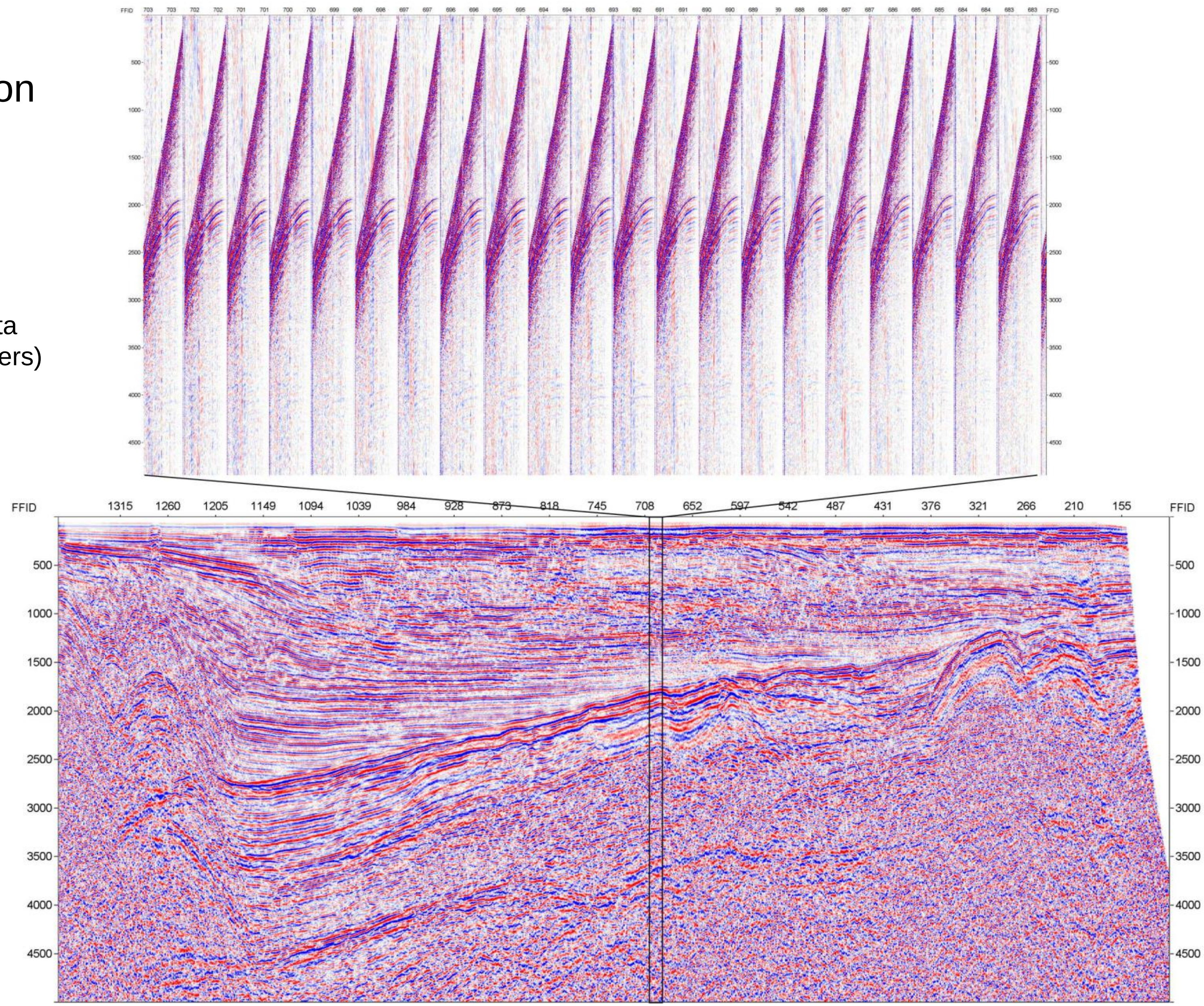


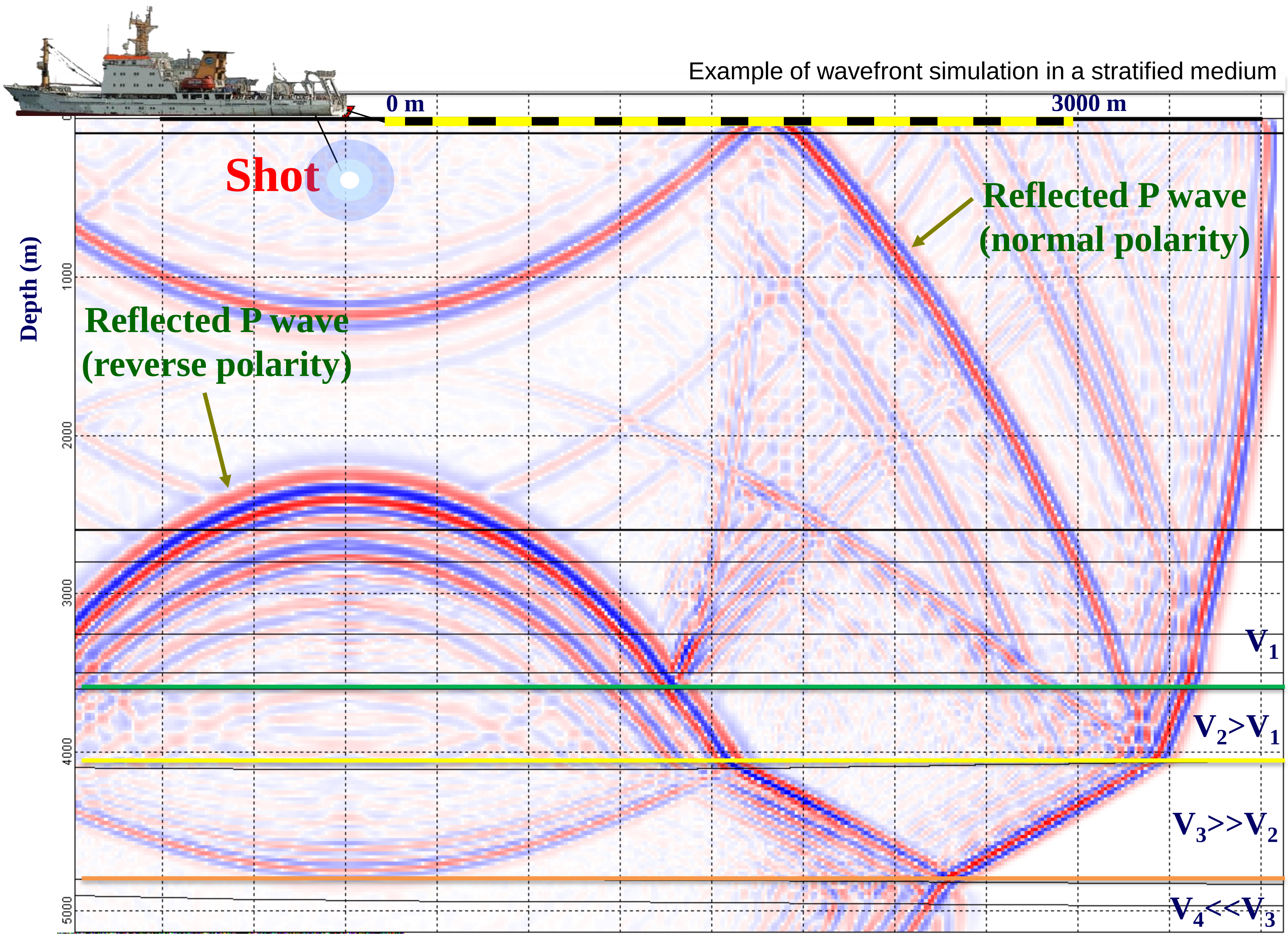
Seismic section displayed in grey scale variable density with the “enhanced reflections” in red colour

MultiChannel Seismic reflection data (MCS)

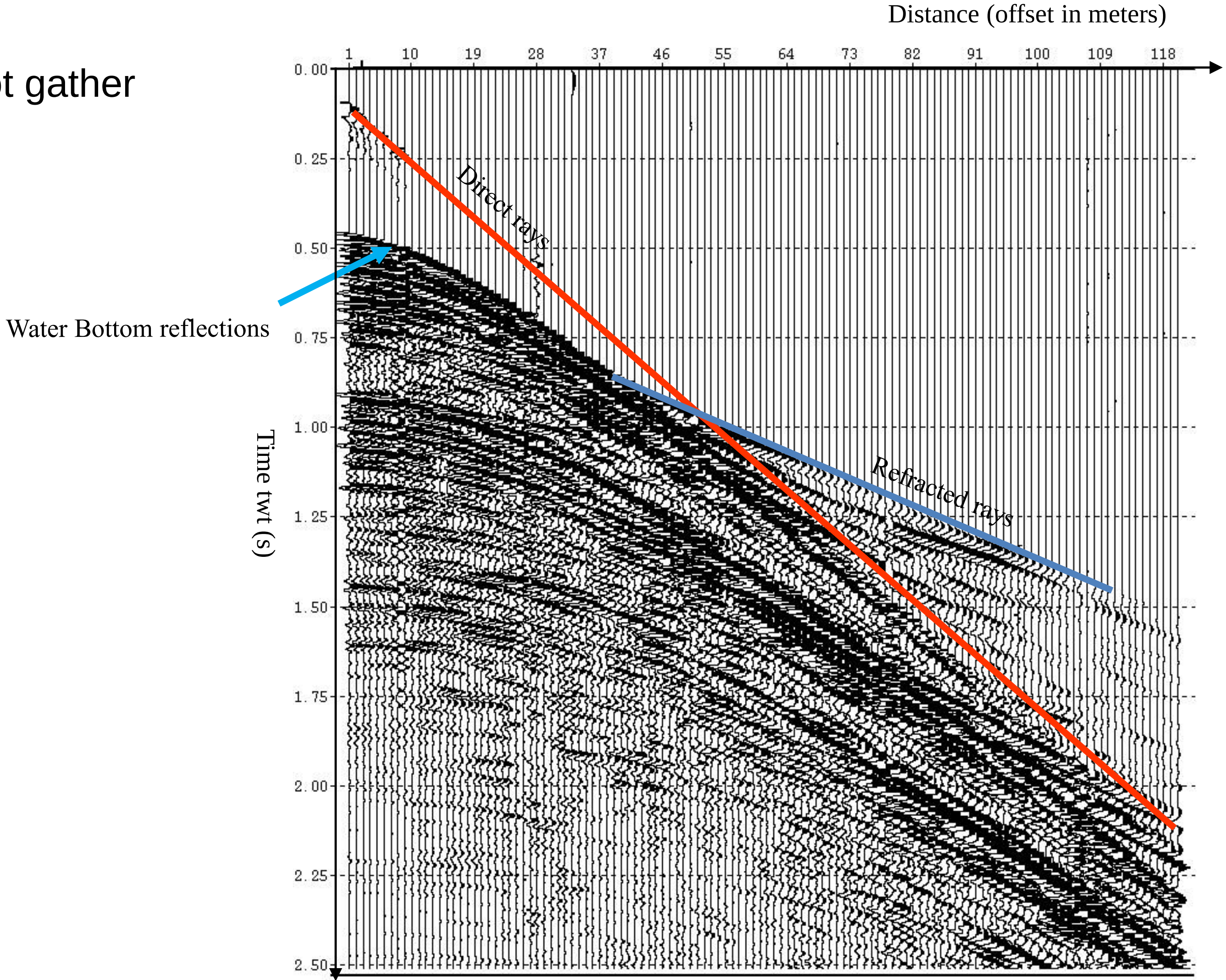
Raw data
(shot gathers)

Processed data
(stack section)




Example of wavefront simulation in a stratified medium
0 m
3000 m
Shot
Reflected P wave
(normal polarity)
Reflected P wave
(reverse polarity)
Depth (m)
1000
2000
3000
4000
5000
V1
V2>V1
V3>>V2
V4<<V3

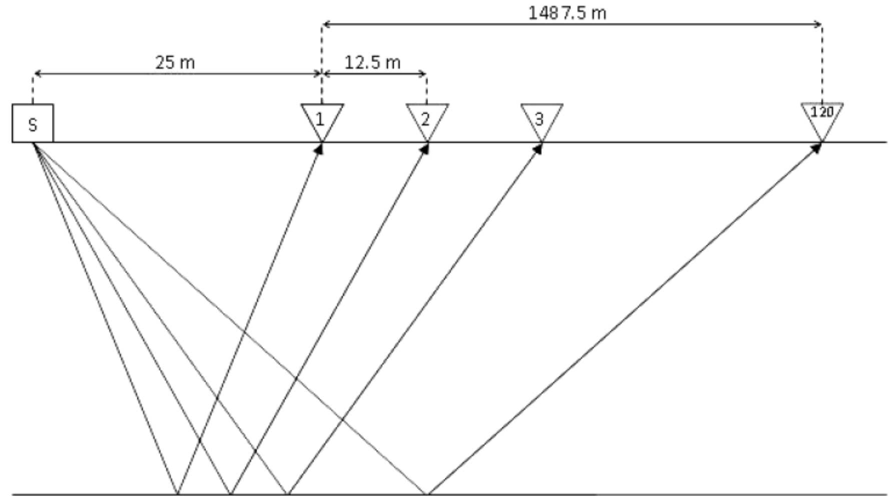
Shot gather


Distance (offset in meters)
1
10
19
28
37
46
55
64
73
82
91
100
109
118
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
Time twt (s)
Direct rays
Refracted rays
Water Bottom reflections

Example of «processing flow chart» that define two different output: Pre-Stack Time Migration (PSTM) and Pre-Stack Depth Migration (PSDM). This sequence has been applied to «crustal data» with «long offset streamer».

The main steps are the following:
Reformating
Editing
Sorting
Gaining
Deconvolution
Velocity analysis
NMO correction and stacking
Migration

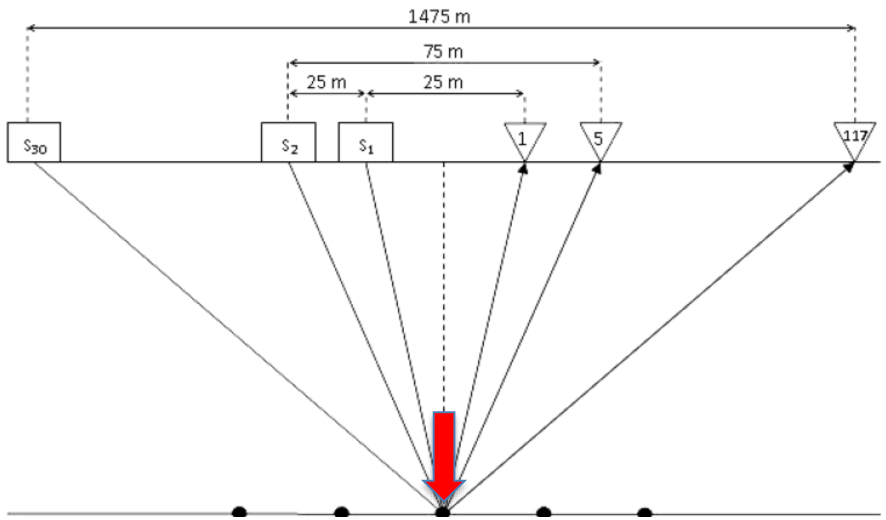
Shot gather



to

Example of Sorting

CDP gather



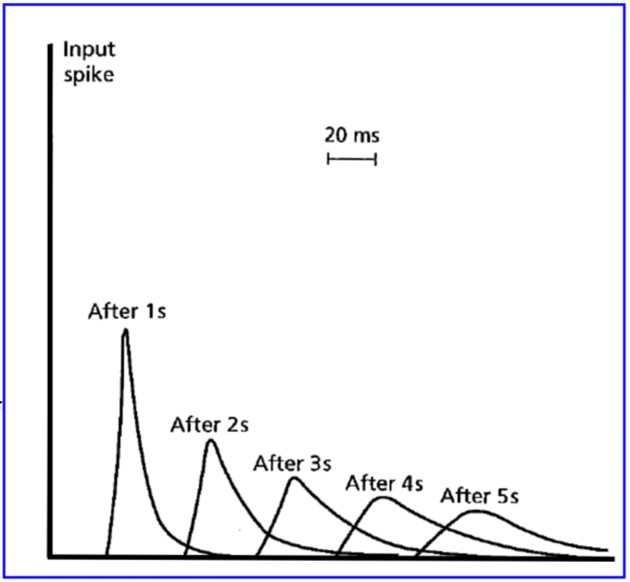
Common Depth Point (CDP)

$$\text{Fold} = \frac{\text{n. Channel x Group int.}}{\text{2 x Shot int.}}$$

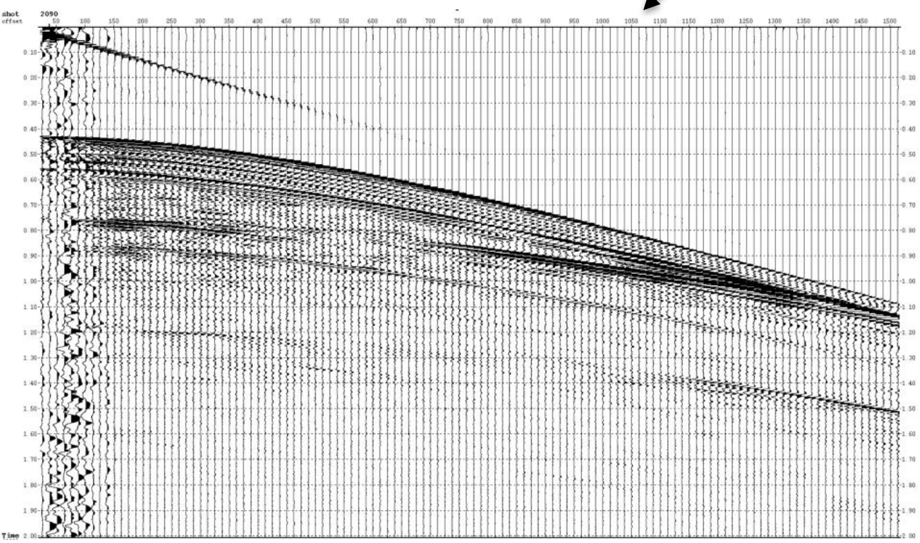
$$\text{Fold} = \frac{120 \times 12.5}{2 \times 25} = 30$$

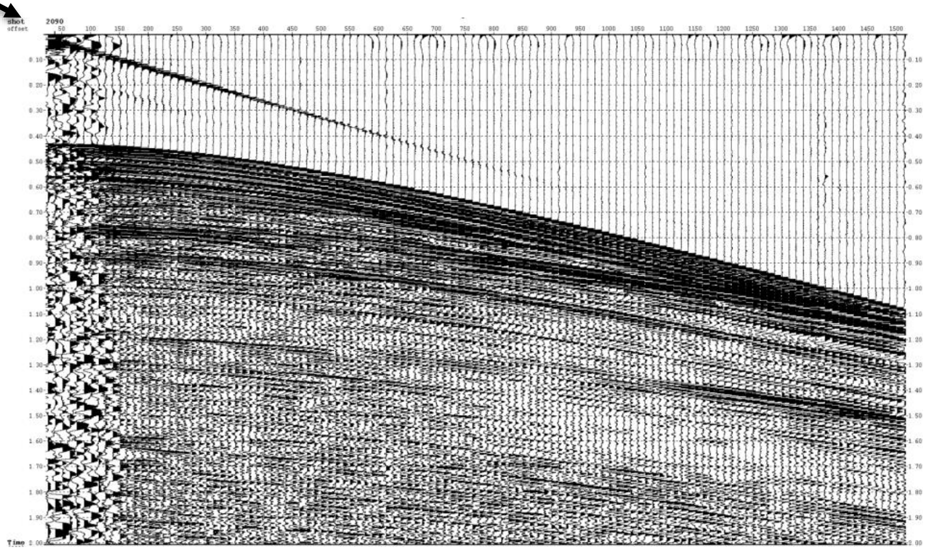
Gain correction

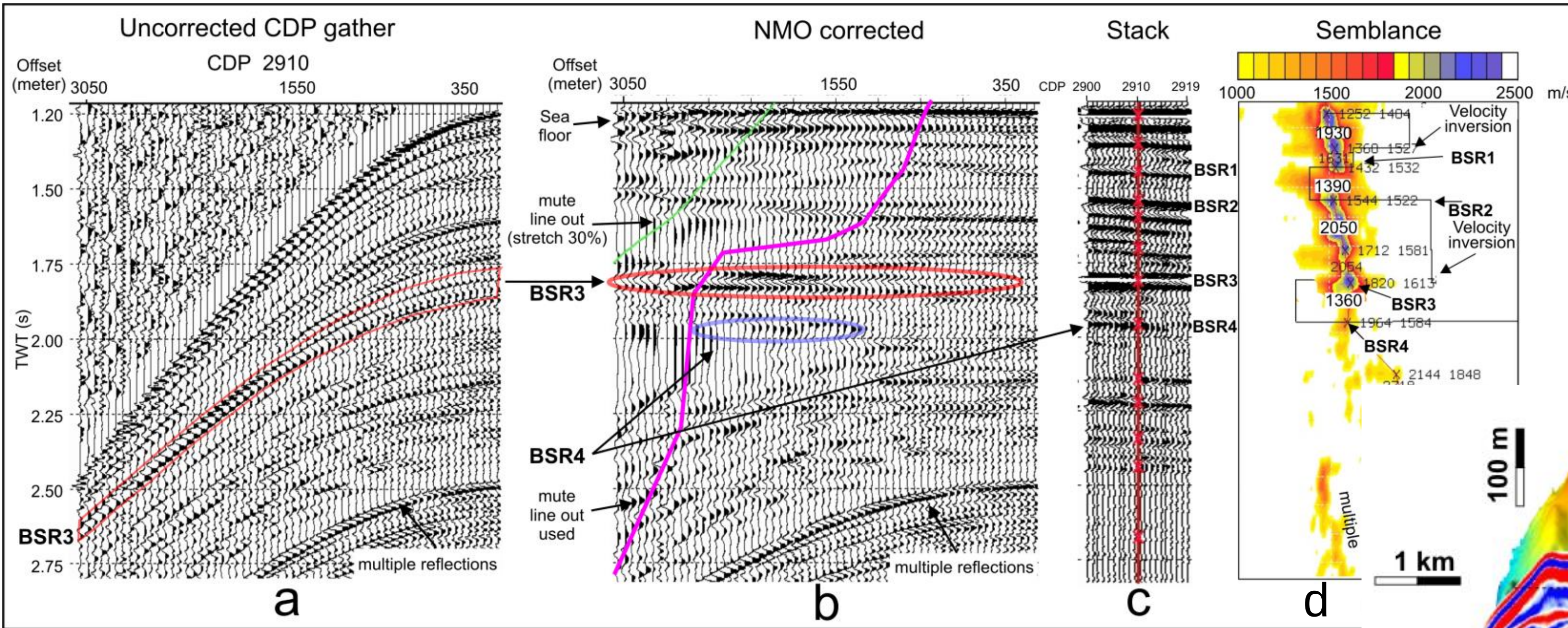
The progressive change of shape of an original spike pulse during its propagation through the ground due to the effects of absorption. (After Anstey, 1977)

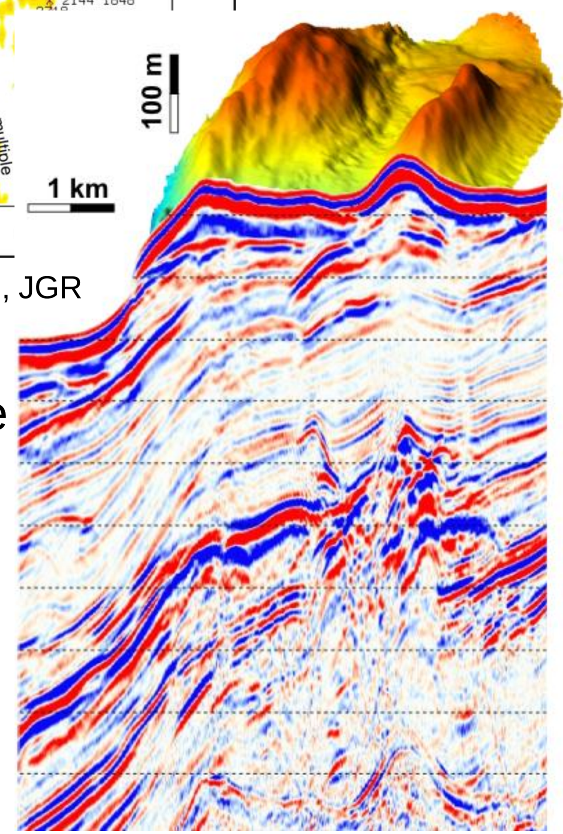


A shot before and after gain correction.









Some of the processing steps

From Geletti & Busetti 2011, JGR

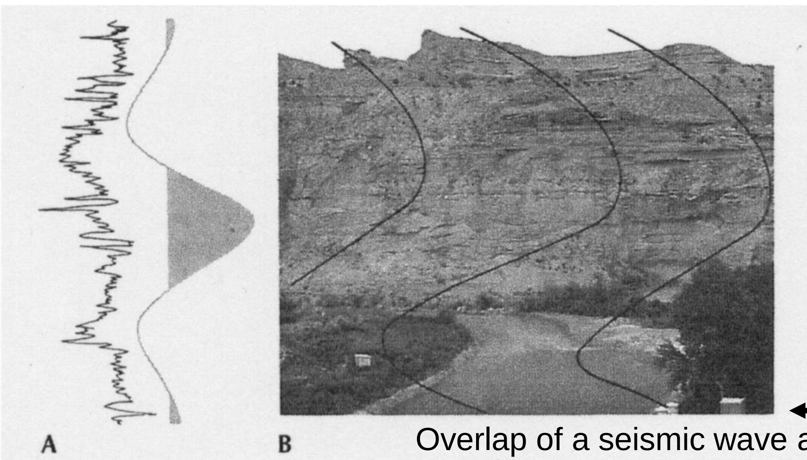
Processing flow

a) CDP gather (after Sorting operation);
b) NMO correction with the velocity function picked in d;
c) Stack on 20 CDP gathers after NMO correction;
d) Semblance with velocity function picked;
e) Migrated section & MB swath bathymetry

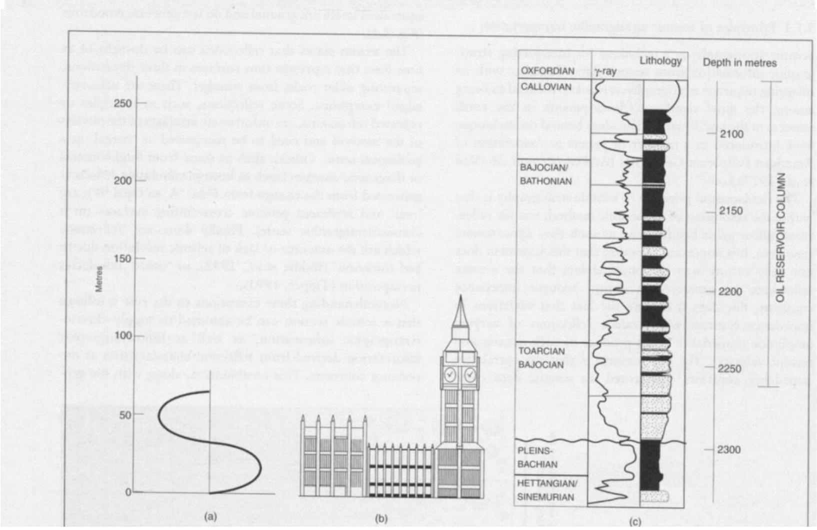
Seismic resolution

Vertical resolution   Lateral resolution

Examples of seismic wave resolution

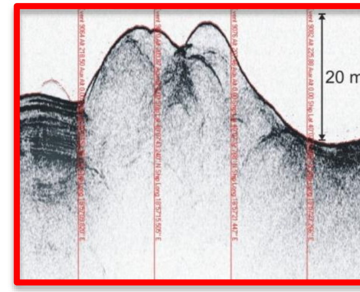


Overlap of a seismic wave and: A) a sonic log, B) a photo of a rock face of about 40 m

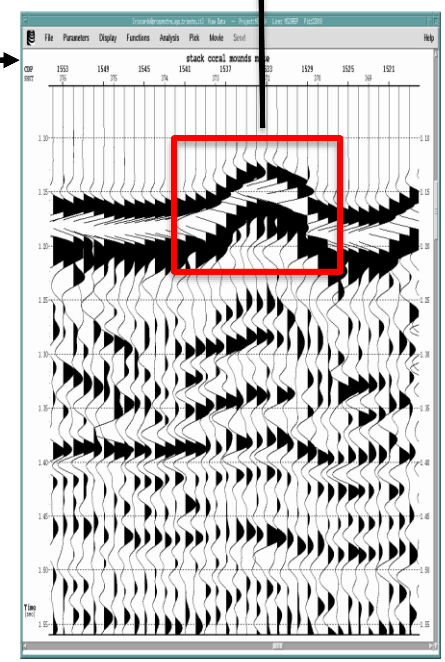


Comparison between a seismic wave and: b) Big Ben of London, c) a well data

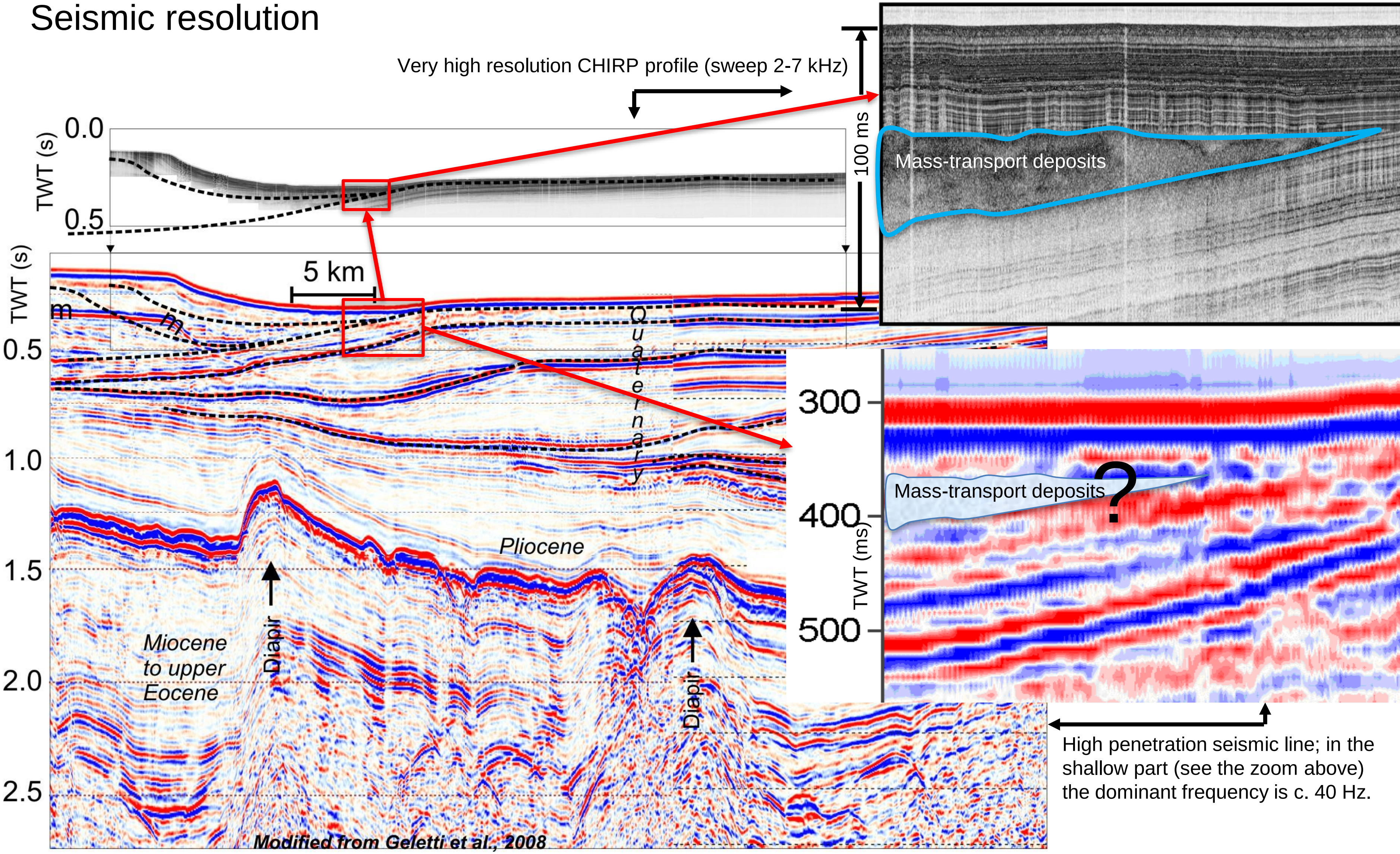
Very high resolution acoustic profile



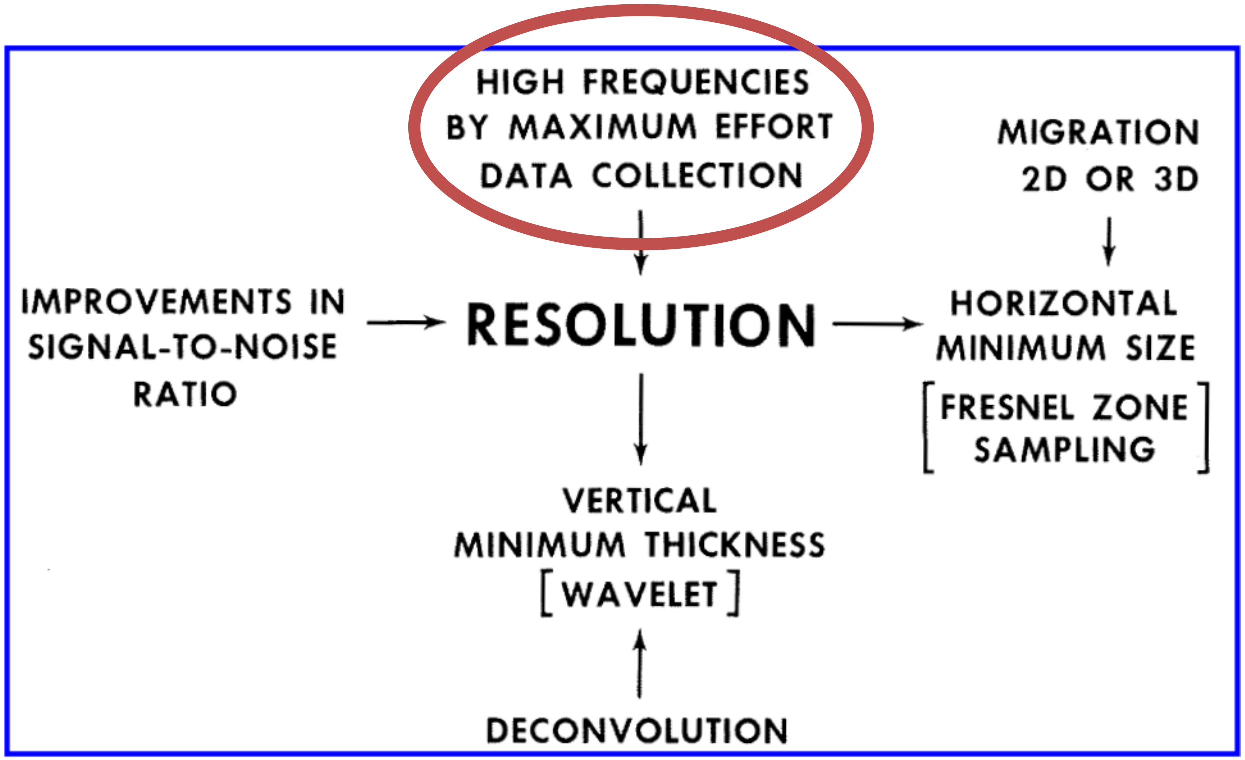
Low resolution seismic profile (crustal data)



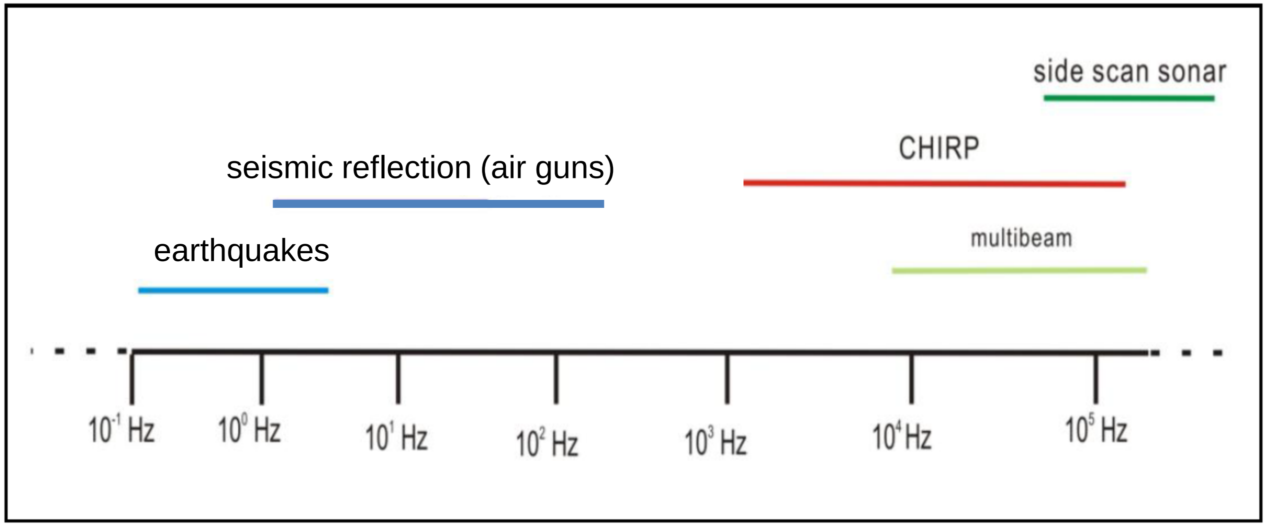
Seismic resolution

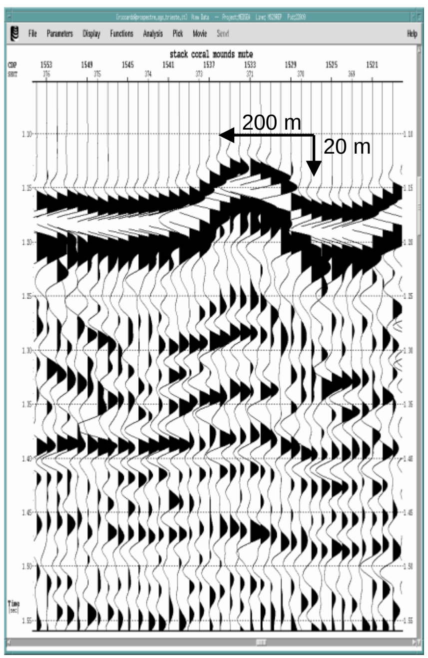


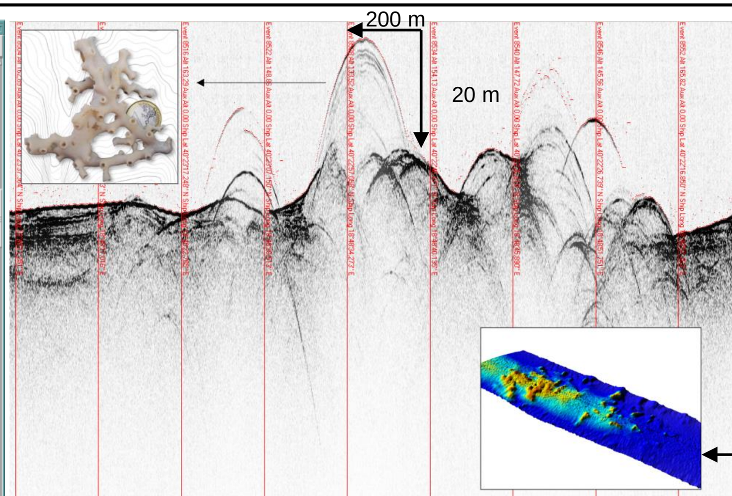
High penetration seismic line; in the shallow part (see the zoom above) the dominant frequency is c. 40 Hz.

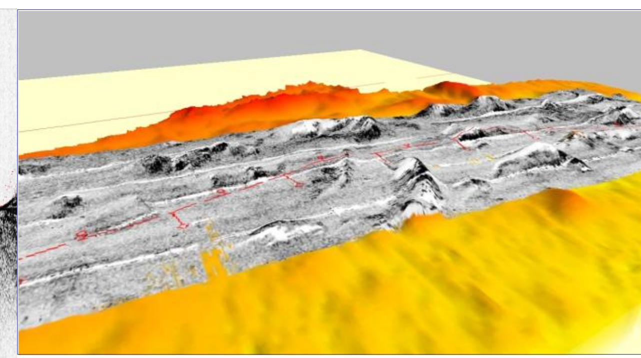


Factors affecting horizontal and vertical seismic resolution









Swath bathymetry: Side Scan Sonar (above) & MultiBeam (left) data

CHIRP profile (Very High Resolution)

High penetration seismic line (low resolution)

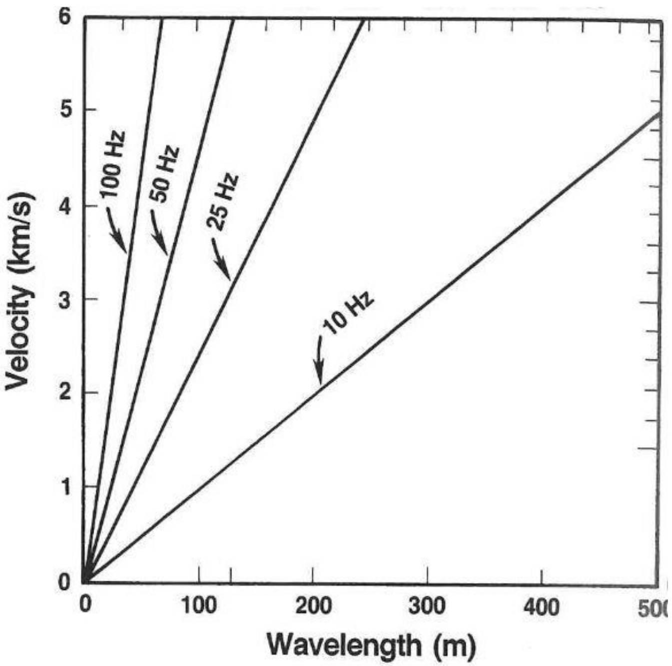
Seismic resolution

Vertical Resolution

$$\lambda/4 = v/4f$$

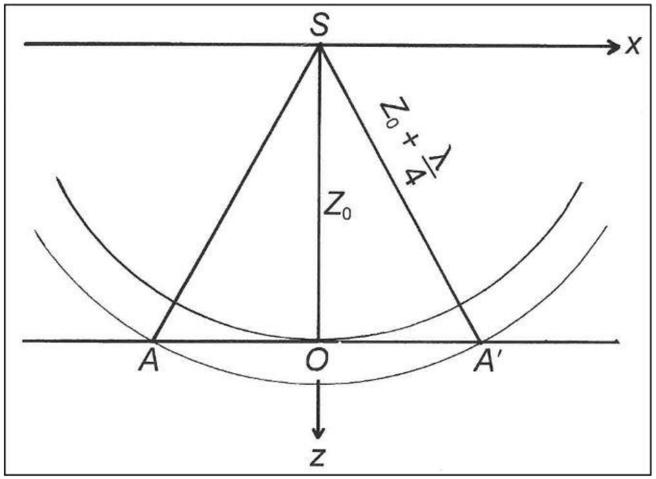
v (m/s)	f (Hz)	$\lambda/4$ (m)
2000	50	10
3000	40	18
4000	30	33
5000	20	62

Threshold for vertical resolution

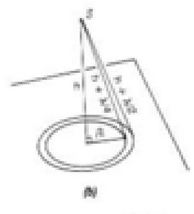


The relationship between velocity (*v*), dominant frequency (*f*) and wavelegth (λ = *v/f*).

Lateral Resolution



Definition of the Frensnel zone AA'



$$r = (v/2)\sqrt{t_0/f}$$

t_0 (s)	v (m/s)	f (Hz)	r (m)
1	2000	50	141
2	3000	40	335
3	4000	30	632
4	5000	20	1118

Threshold for lateral resolution
(t0 = 2z/v, r=OA)

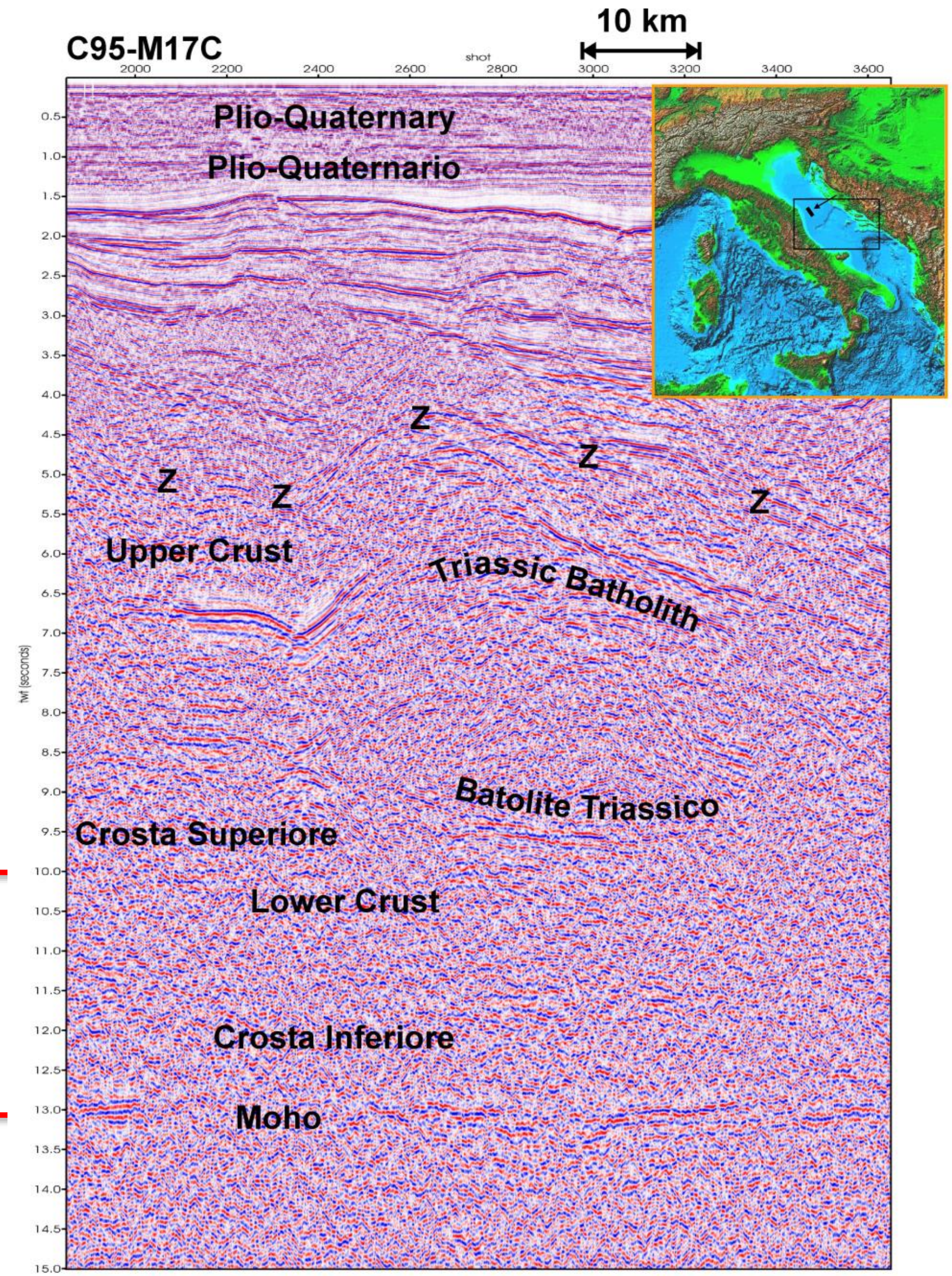
Seismic resolution

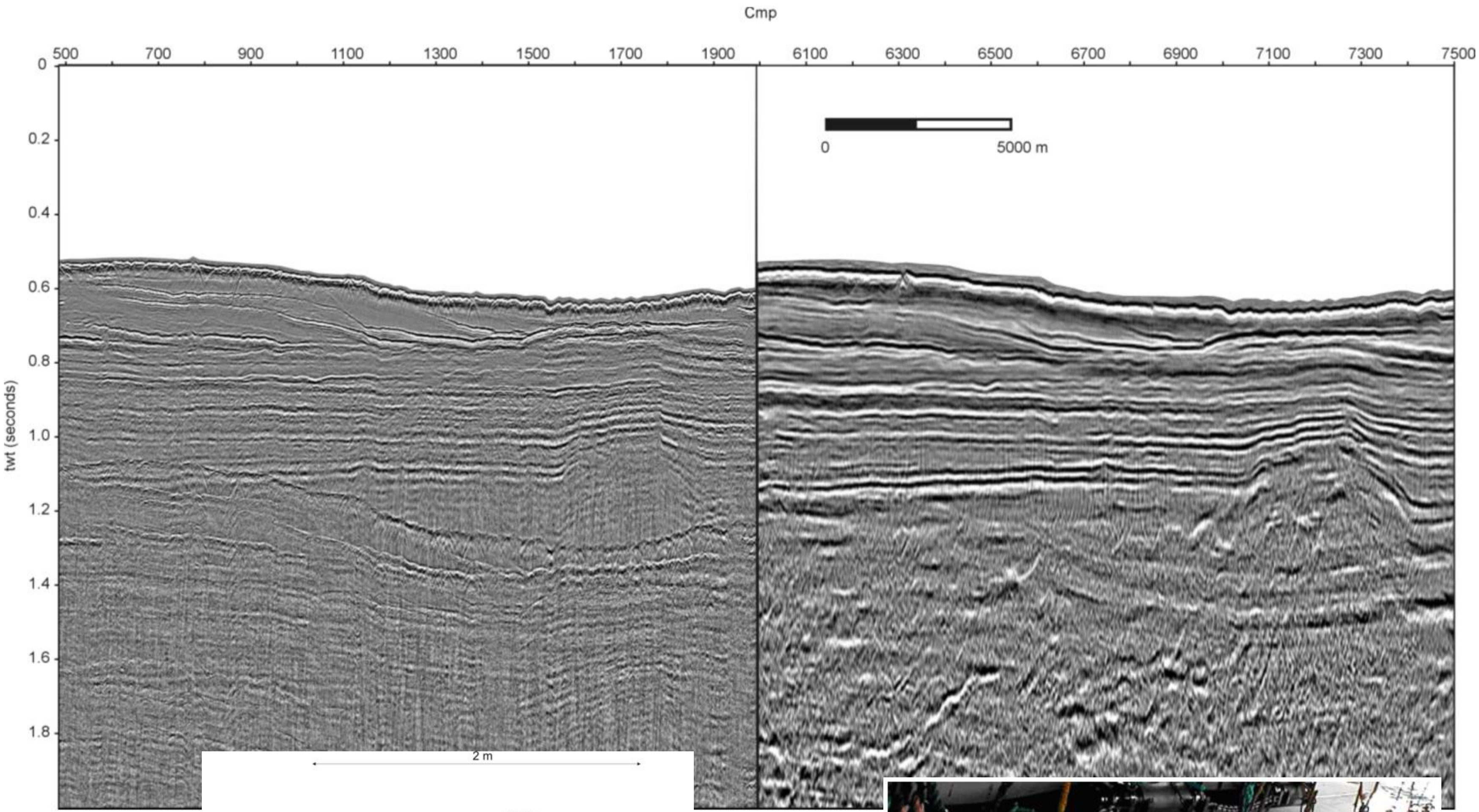
Example of high penetration (low resolution) multichannel seismic reflection profile (CROP project) in Central Adriatic Sea.

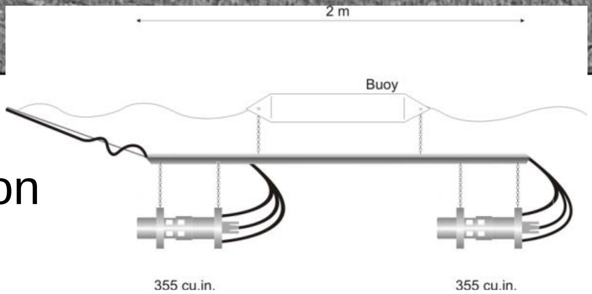
30 km depth

Vertical resolution = 75 m
Lateral resolution = 4840 m
(v=6 km/s; f = 20 Hz)

40 km depth

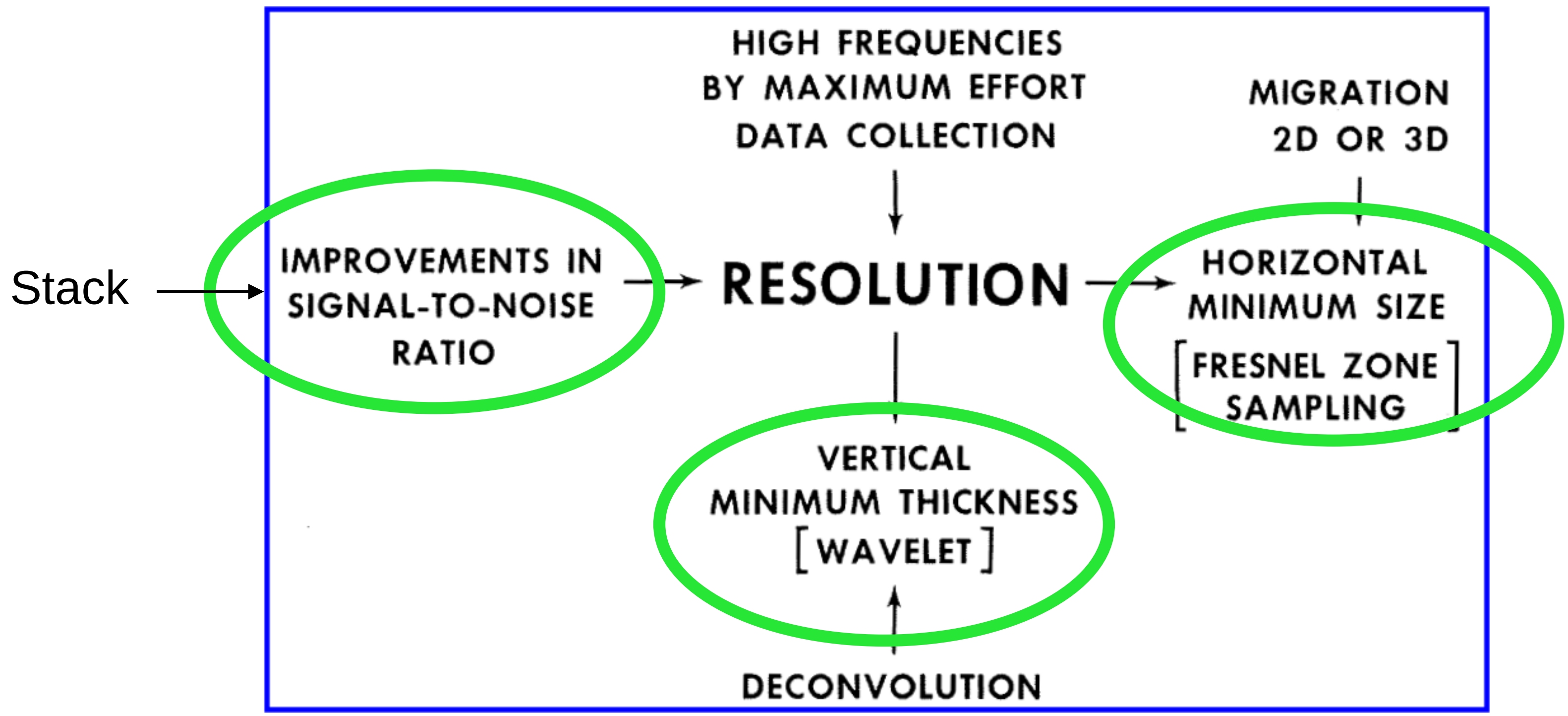






Seismic resolution

Examples of two seismic sections acquired by different sources: (left) by 2 GI guns (11,6 l); (right) by an array of 16 air guns (70 l)

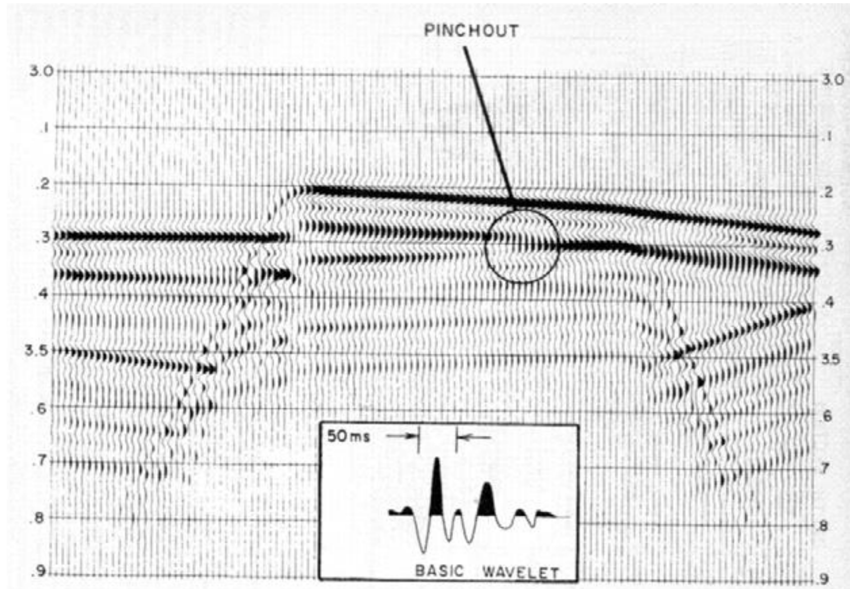


Factors affecting horizontal and vertical seismic resolution: processing solution

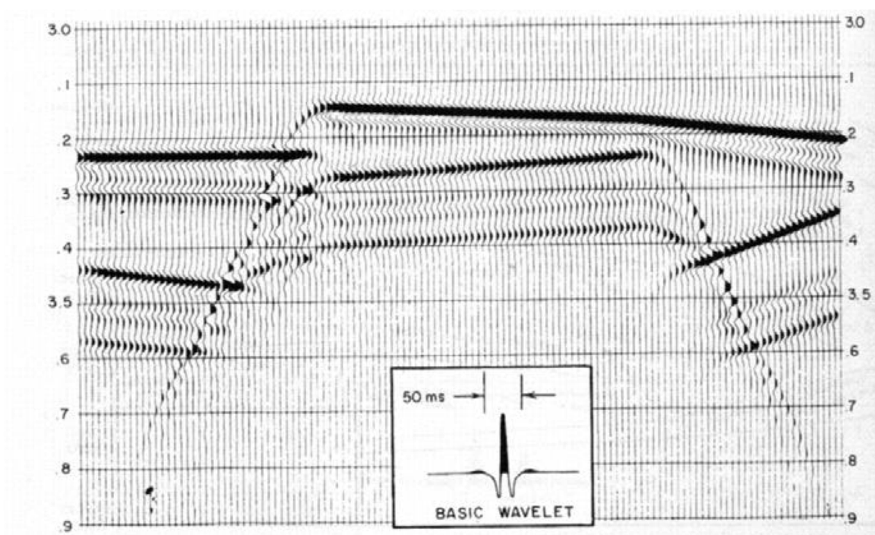
Vertical resolution

Deconvolution

Example of the effect of the deconvolution on the definition of seismic data (synthetic data). The deconvolution "shrinks" the wavelet as shown in the figure (synthetic data)

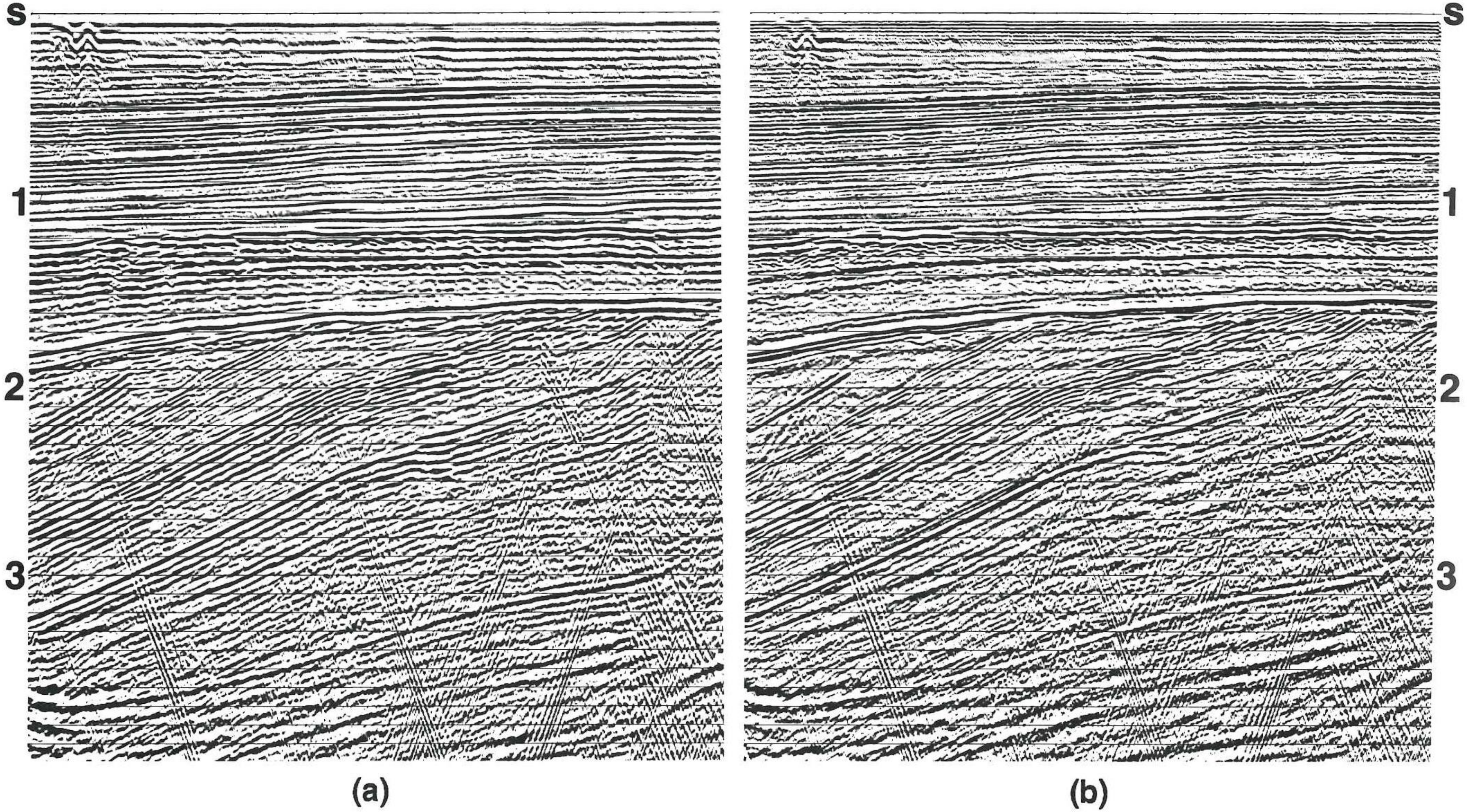


Before the deconvolution



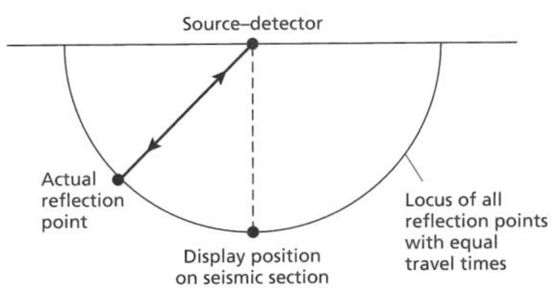
After the deconvolution

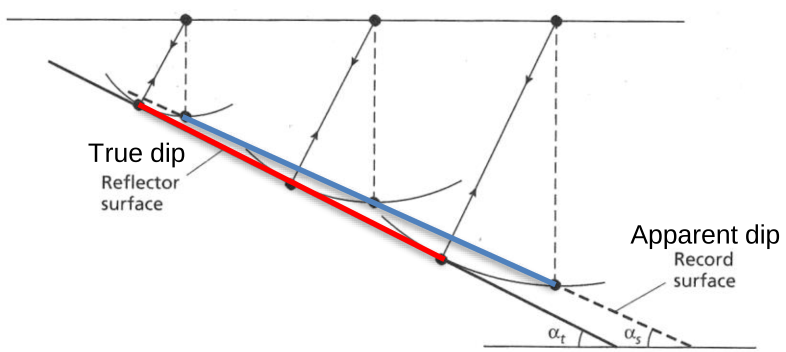
Vertical resolution



Seismic stack section a) before and b) after deconvolution (Yilmaz, 2001)

Lateral resolution



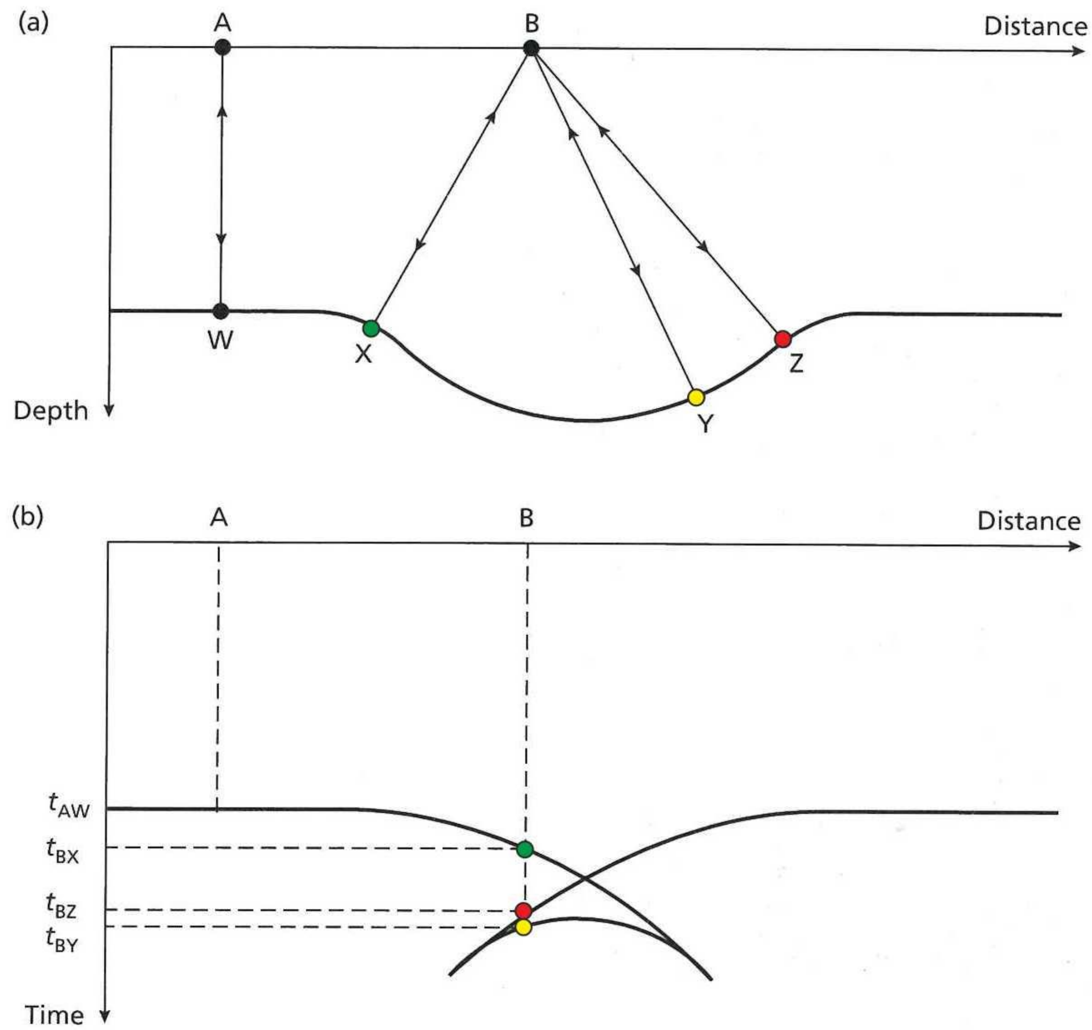


Migration

- Consider a source-detector (s-d) on the surface of a medium of costant seismic velocity. For a given reflection time, the reflection point may be anywhere on the arc of a circle centred on the s-d position. On a non migrated seismic section the point is mapped to be immediately below the s-d.

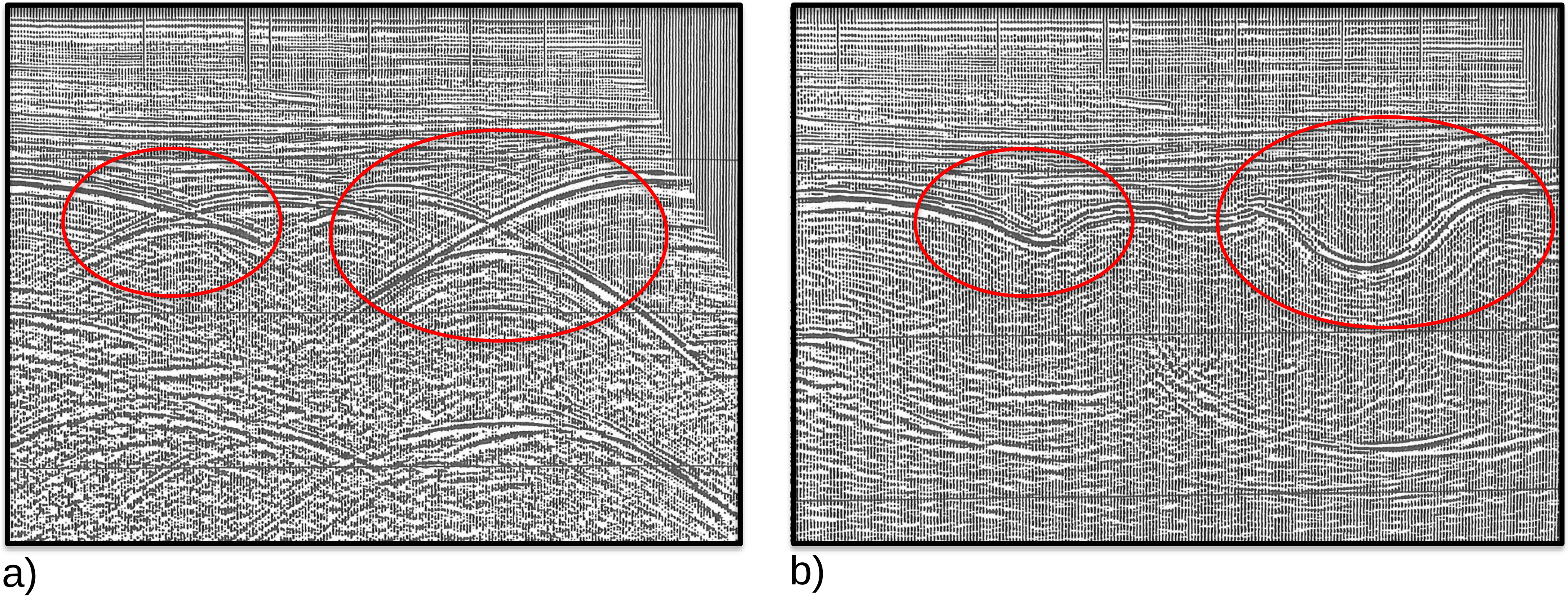
- A planar-dipping record surface derived from a non-migrated seismic section (blu line) and its associated reflector surface (red line).

Lateral resolution



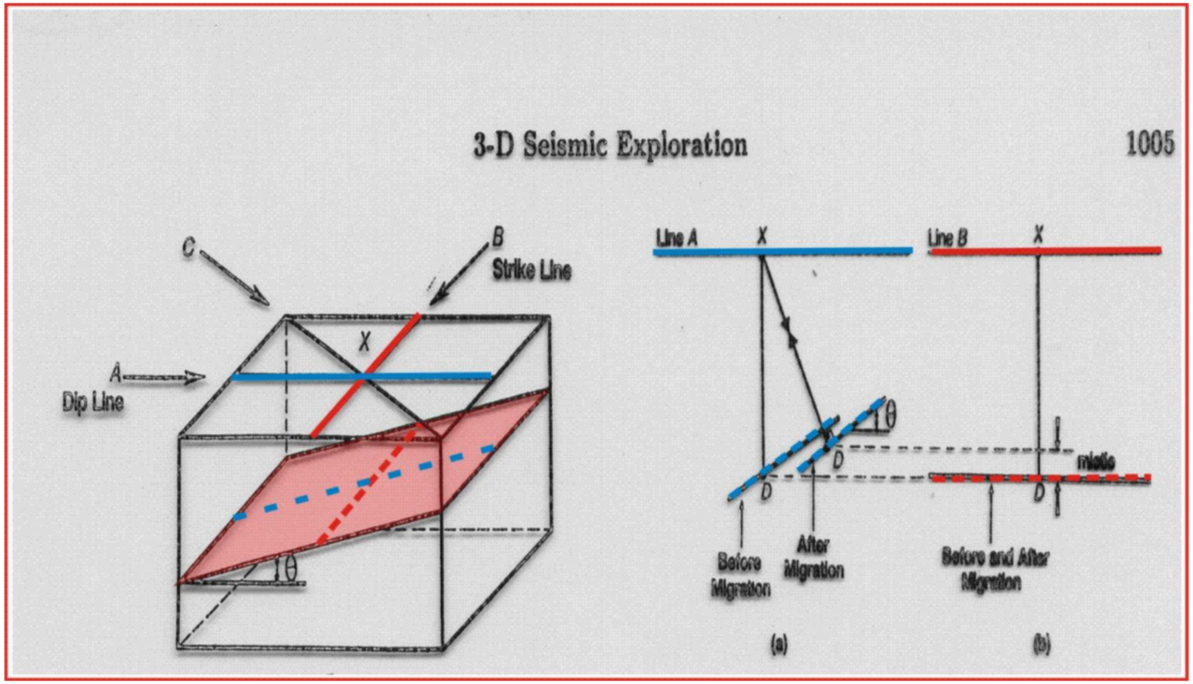
a) A sharp synclinla feature in a reflecting interface, and
b) (b) the resultant «bow-tie» shape of the reflection event on the non-migrated seismic section.

Lateral resolution: migration



Example of seismic reflection profile across two buried channels (a) non-migrated section with the presence of «bow-tie» effect (red ellipses) and b) after migration

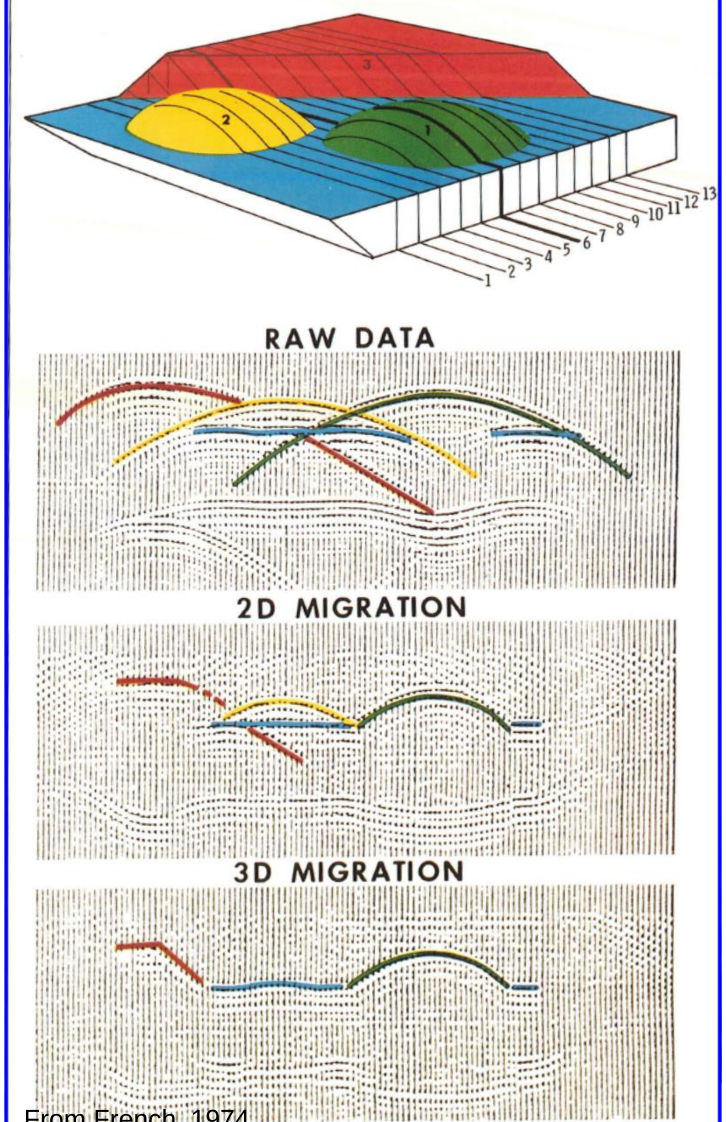
2D migration



2D migration is an imperfect process on the «strike line»

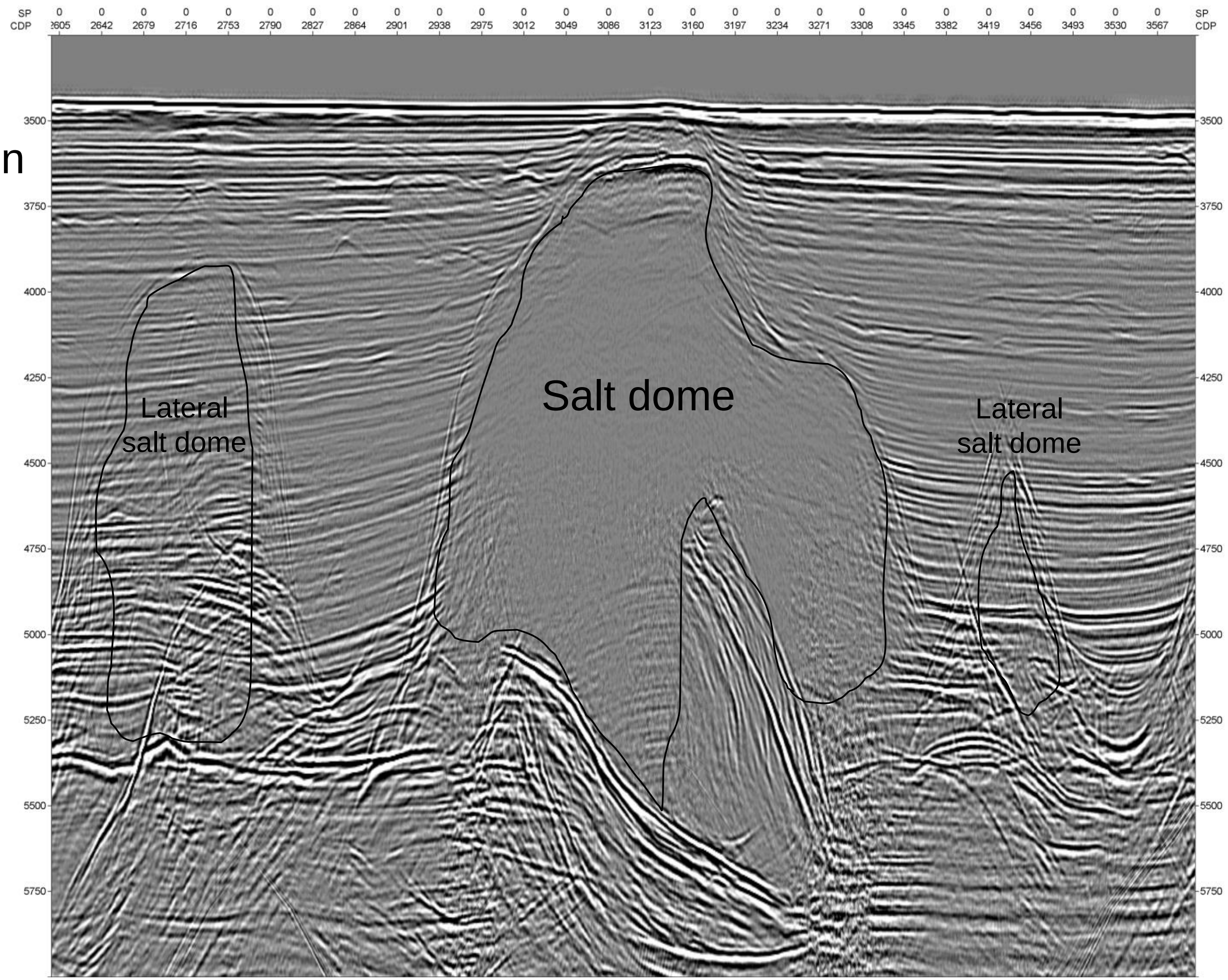
2D and 3D migration

The image shows an example of a 3D geological model with two anticlinals (green and yellow object) and a direct fault (red and blue objects).
The seismic data along line 6 shows the comparative effects of 2D and 3D migration (from French, 1974).
Only 3-D migration is able to provide a seismic profile faithful to the real situation of pending layers.
However, the 2-D migration provides an often satisfactory result for interpretation.



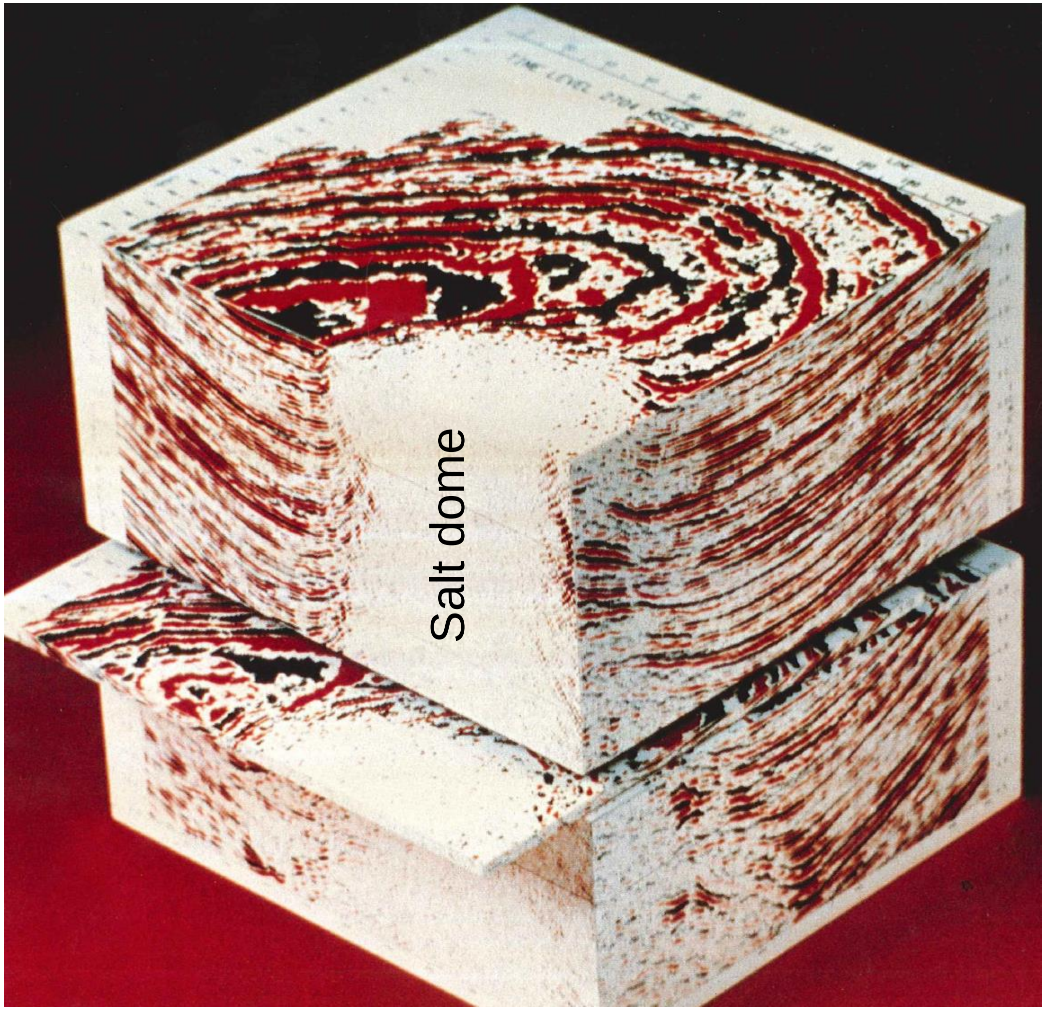
From French, 1974

2D migration

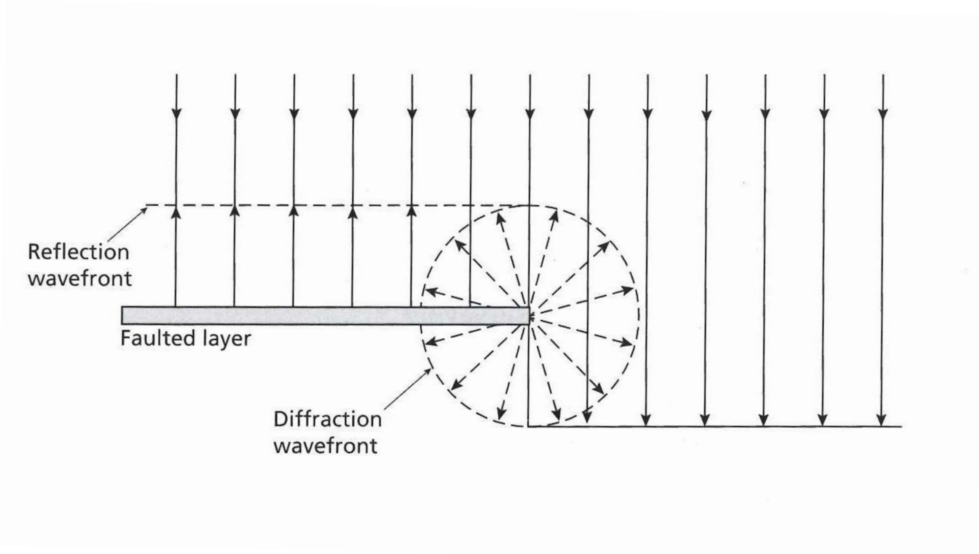


Example of 2D migrated seismic profile with the presence of salt domes, some of which are lateral to the vertical plane of the section.

3D migration

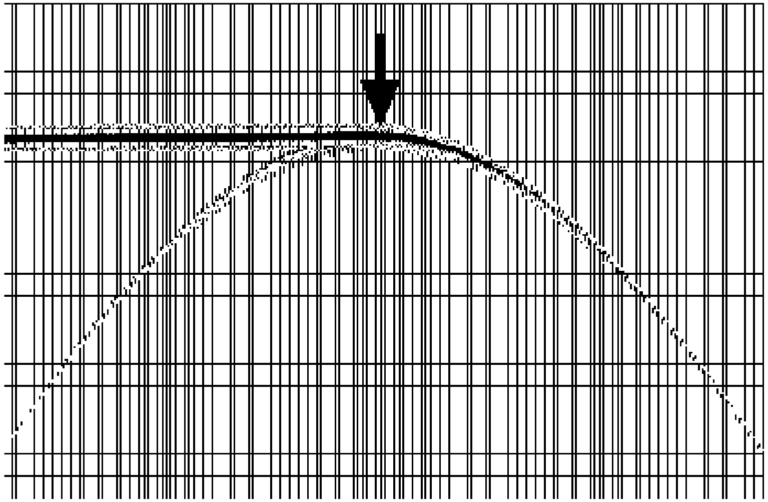


Example of "3D cube" from Brown (1986)

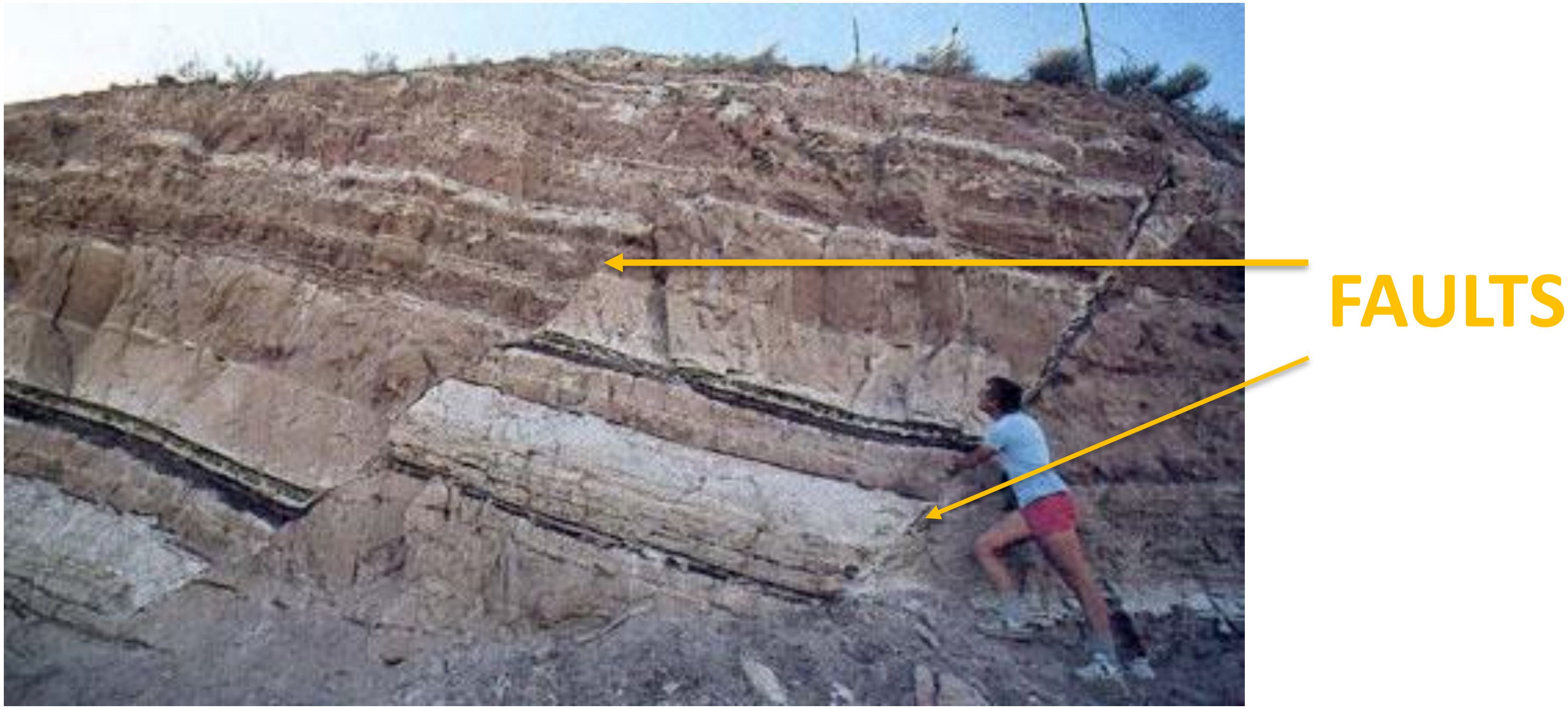


Migration: diffraction collapse

Diffraction
from faulted layer

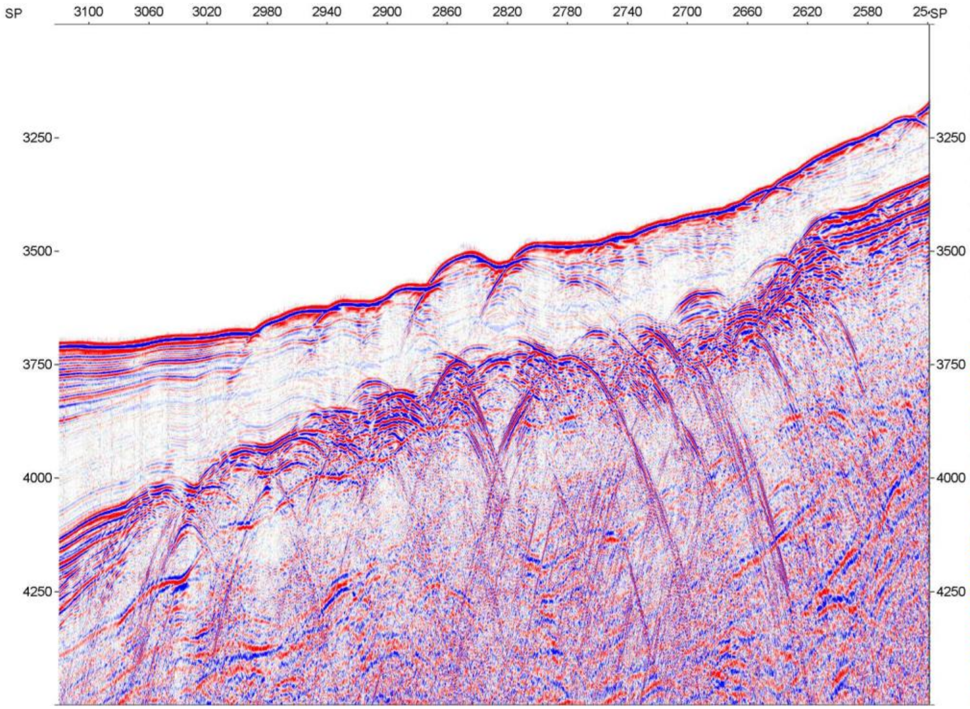


In general, the different depositional / erosional and tectonic events occurring during the geological evolution of an area, determine irregularities along the stratigraphic horizons (reflectors) due to fractures, erosion, sedimentary accumulations, etc. These represent points of inhomogeneity that originate diffractions. Below there is a synthetic seismic section with the diffraction caused by a fault for example.

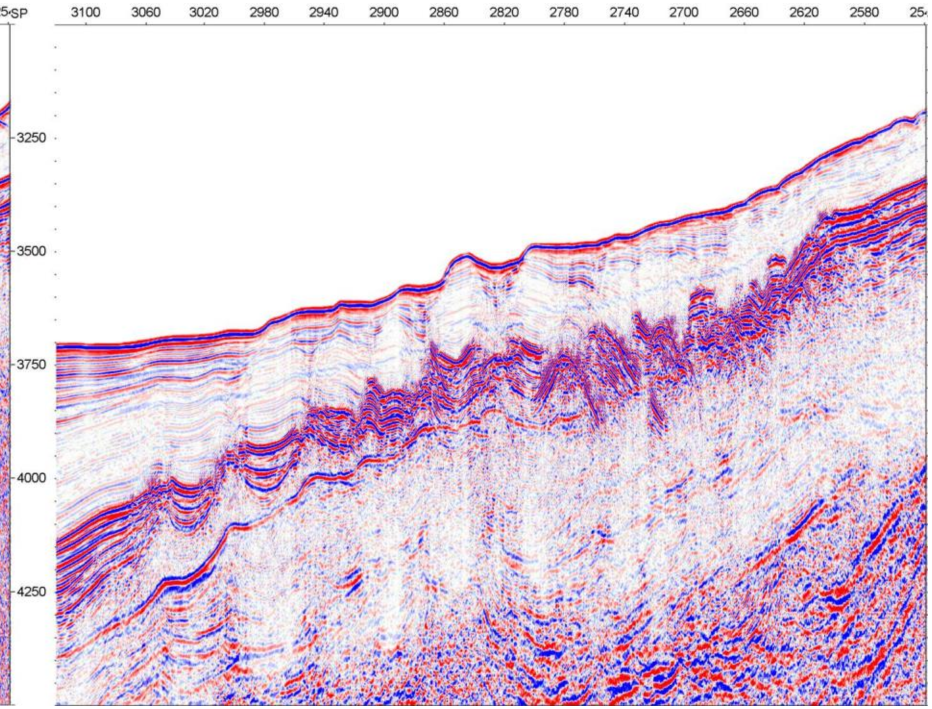


Example of faults in the geological layers.
The faults represent points of inhomogeneity that originate diffractions. You can see the geological layers that are dislocated by the faults

Migration: diffraction collapse

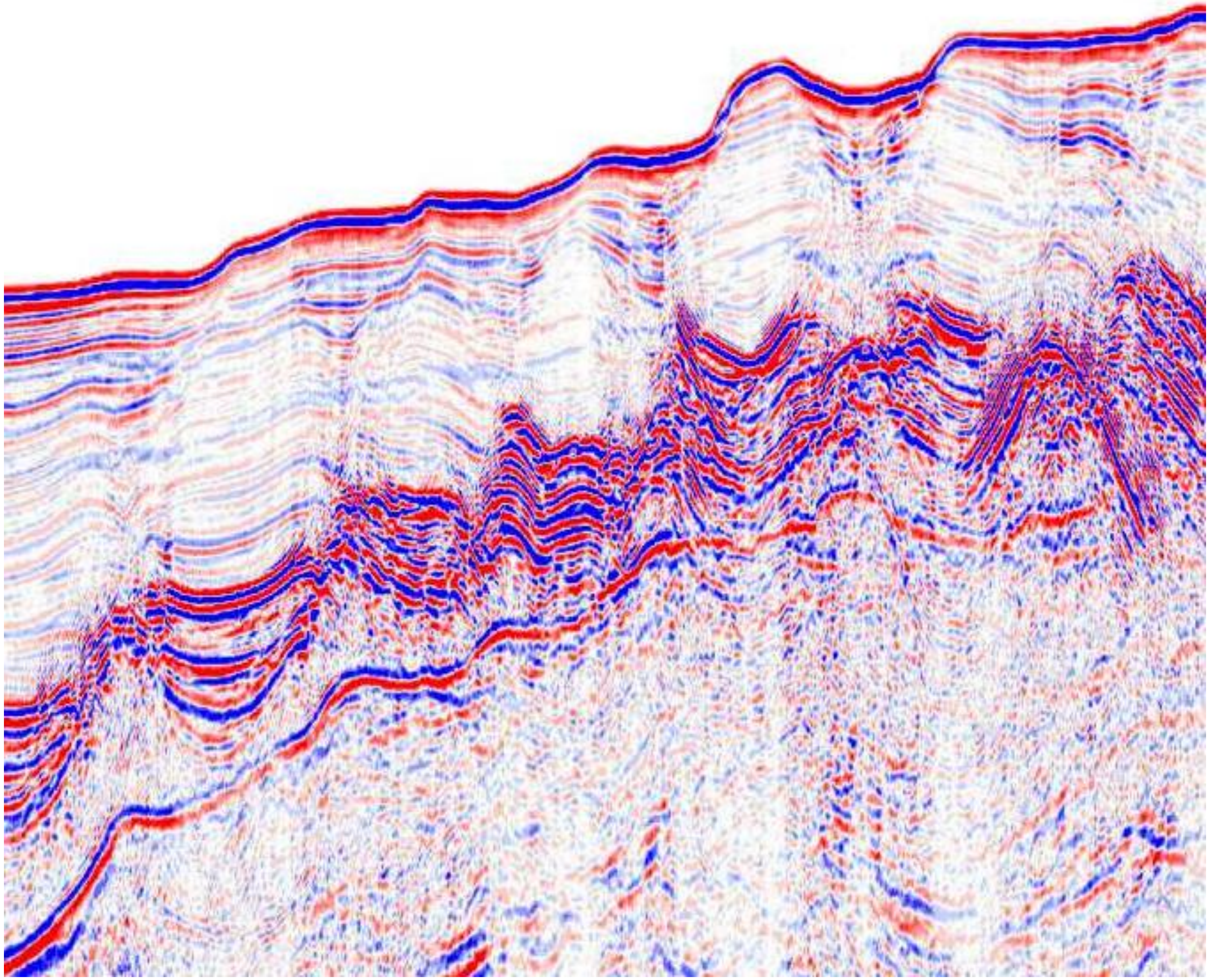


(a)



(b)

Seismic section (a) before and (b) after migration: the diffractions have been collapsed and the faults are evident. The presence of diffractions can sometimes create difficulties of interpretation: the point of breakage of the reflector is not easily identifiable in the non-migrated section. In the case b) the section was migrated and the base of the salt layer is more evident then in stack section a)



Blow up of the previous seismic image

Geologic model
x,y,z

Velocity

Seismic section:
x,y,t

Velocity field of the seismic waves is the parameter that allow to get the geologic model from the seismic section

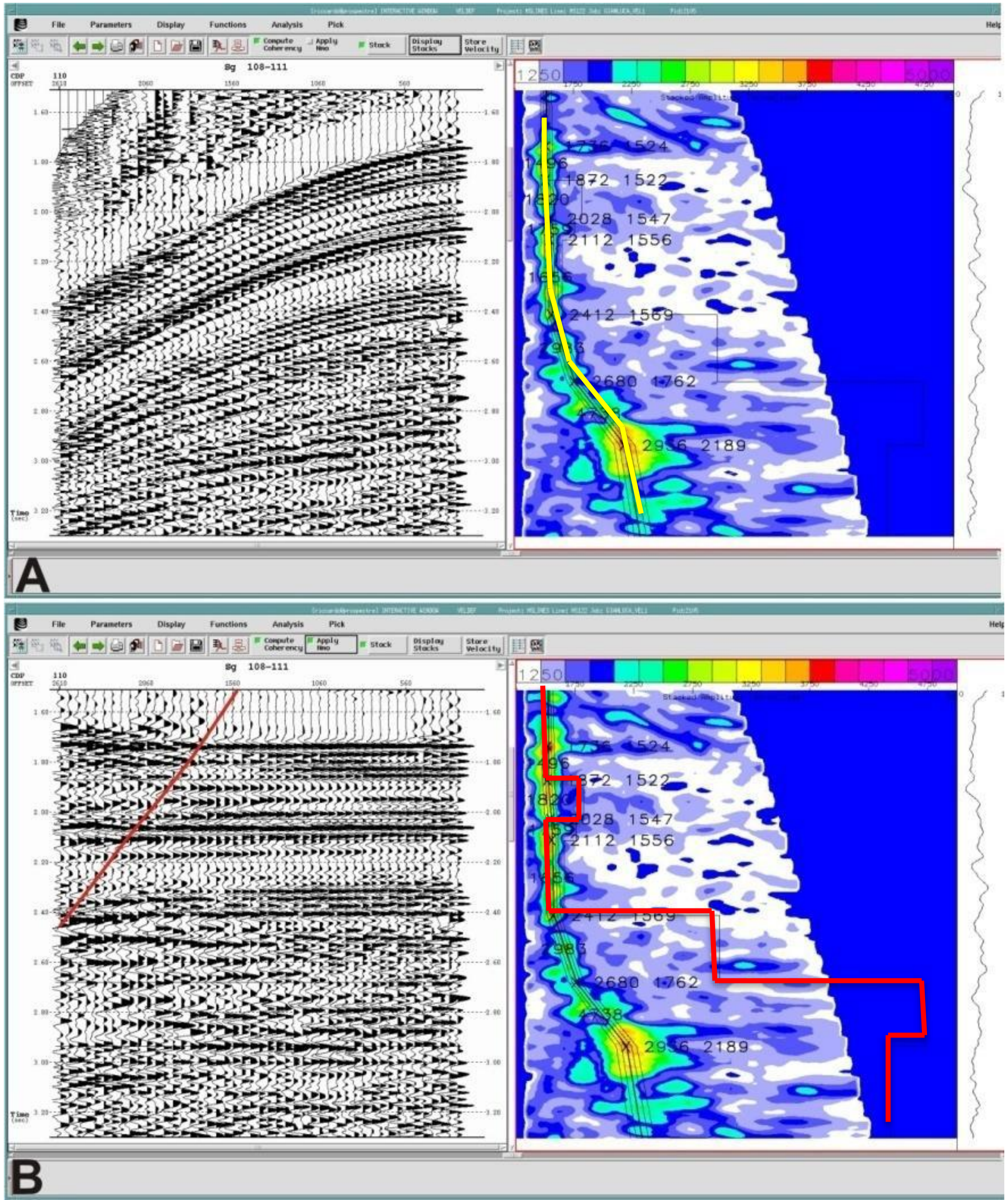
Velocity analysis

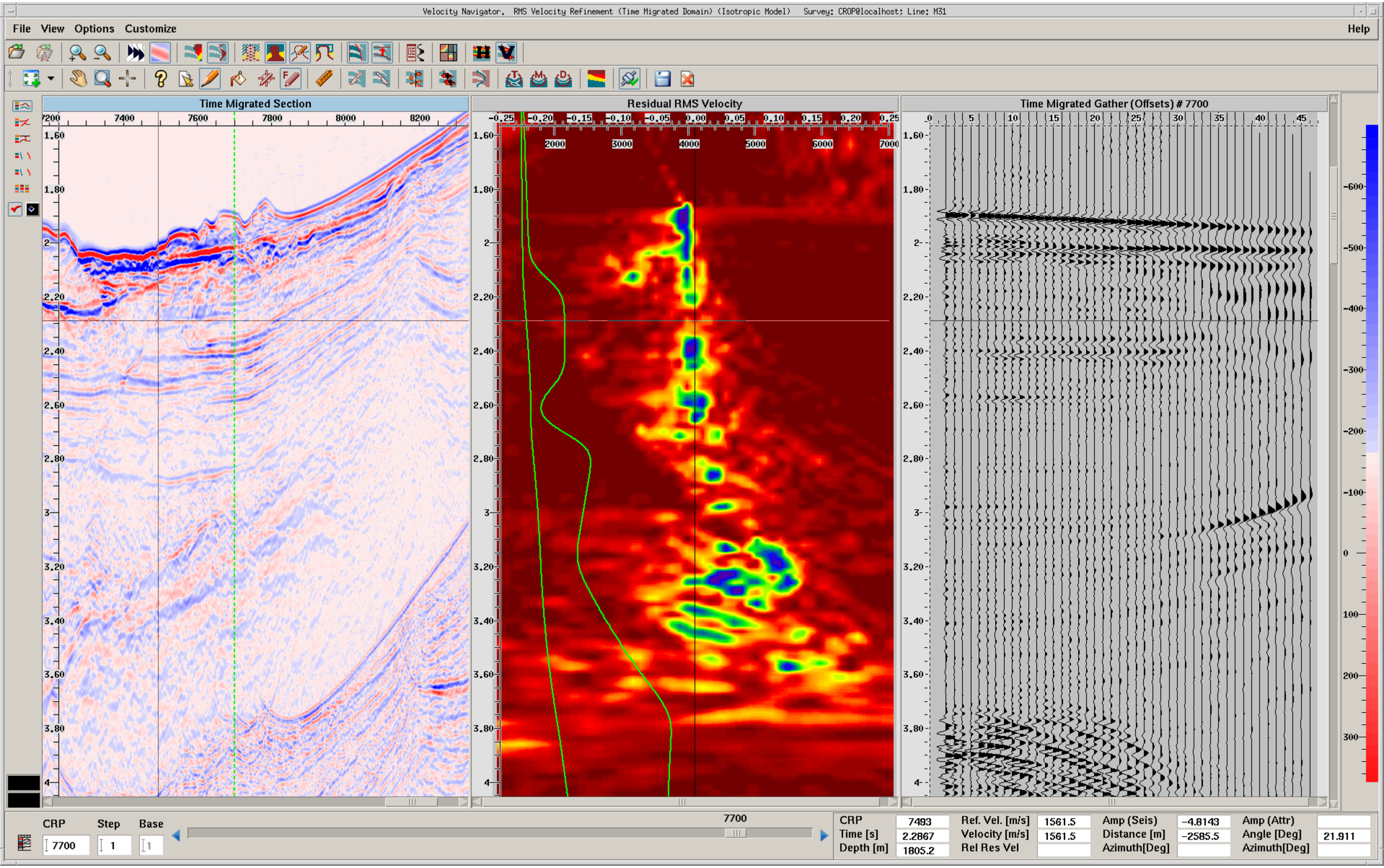
A: a common mid-point trace gather (left) and semblance coherence contour (right).

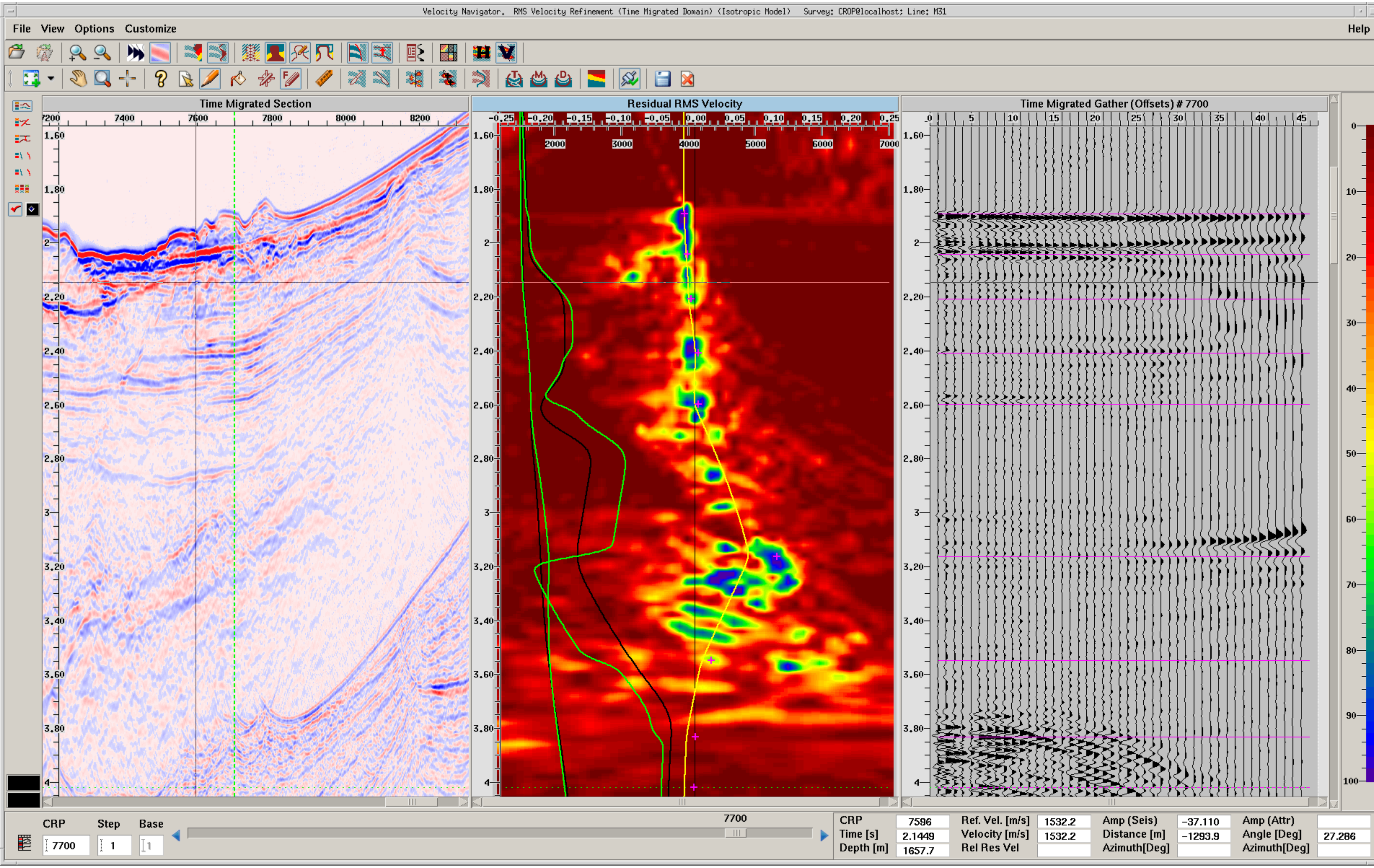
Peaks in coherence give the stacking velocity. (yellow line)

B: The same common mid-point trace gather of A with the normal move-out correction (NMO) after the velocity picking (yellow function). The interval velocity (red function) associated to this stacking velocity it will use in migration process.

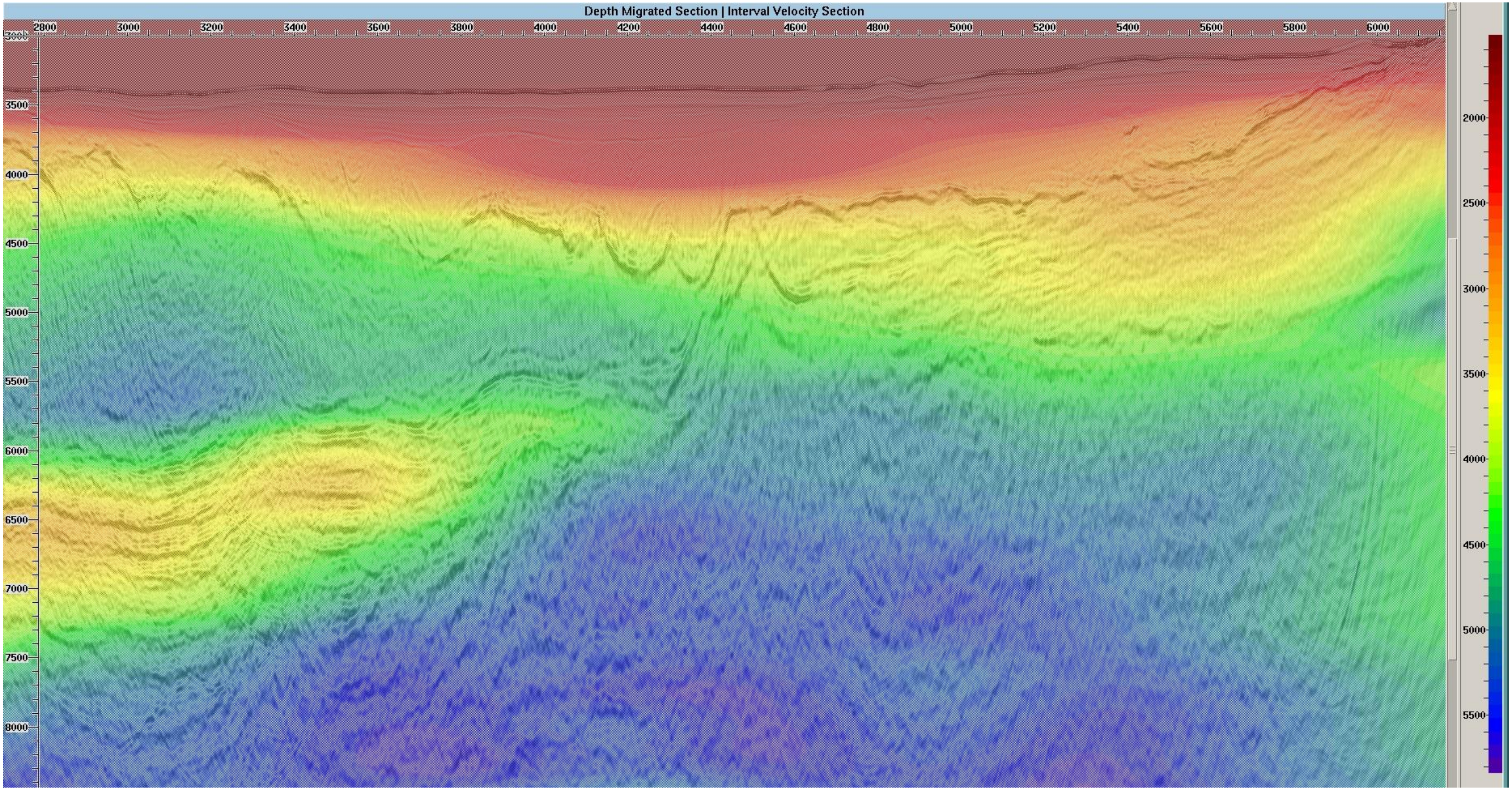
The field velocity section can be obtained from the seismic data using the stack velocities. We are going to flatten the reflections in CDP gather as in the image, picking the maximum coherence in the semblance. In this way velocity functions are obtained which we will interpolate with the others in order to have a section.




Velocity Navigator. RMS Velocity Refinement (Time Migrated Domain) (Isotropic Model) Survey: CROP@localhost; Line: M31
File
View
Options
Customize
Help
Time Migrated Section
Residual RMS Velocity
Time Migrated Gather (Offsets) # 7700
CRP
7700
Step
1
Base
1
7700
CRP
7493
Time [s]
2.2867
Depth [m]
1805.2
Ref. Vel. [m/s]
1561.5
Velocity [m/s]
1561.5
Rel Res Vel
Amp (Seis)
-4.8143
Distance [m]
-2585.5
Azimuth[Deg]
Amp (Attr)
Angle [Deg]
21.911
Azimuth[Deg]

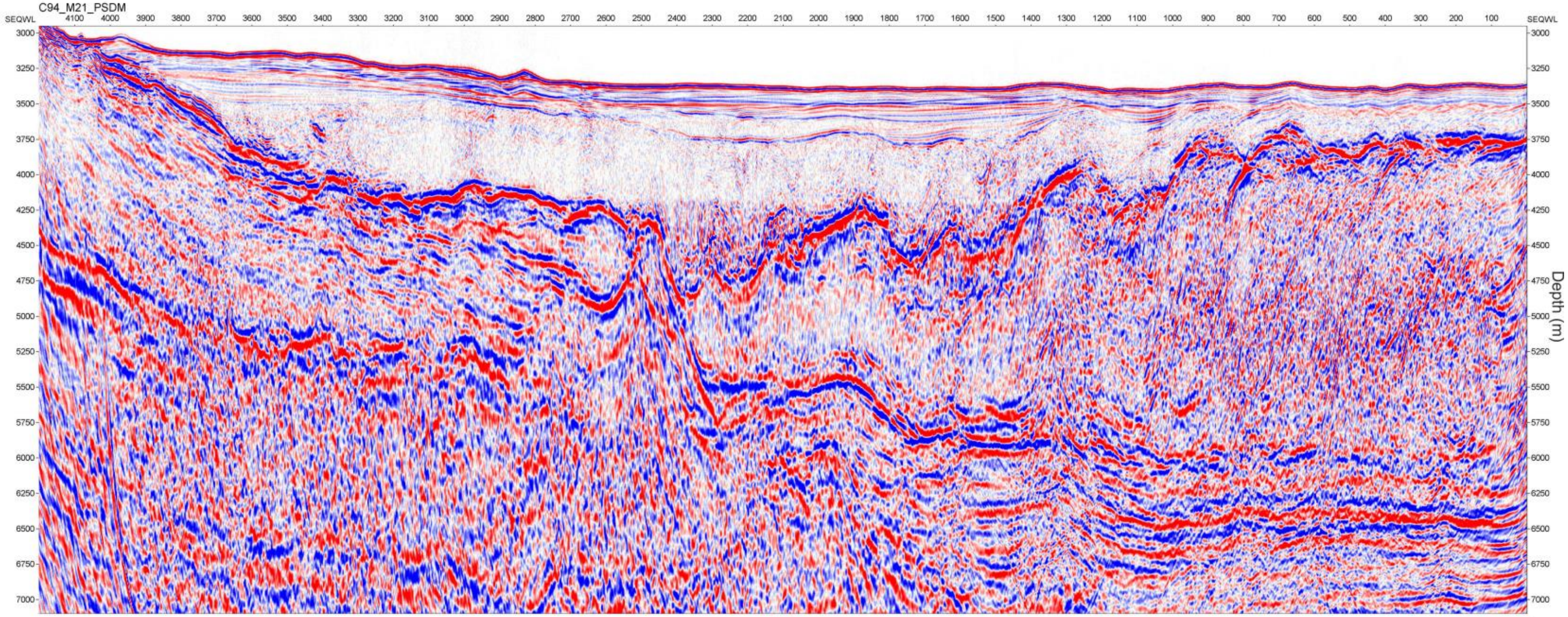

Velocity Navigator. RMS Velocity Refinement (Time Migrated Domain) (Isotropic Model) Survey: CROP@localhost; Line: M31
File
View
Options
Customize
Help
Time Migrated Section
Residual RMS Velocity
Time Migrated Gather (Offsets) # 7700
CRP
7700
Step
1
Base
1
7700
CRP
7596
Time [s]
2.1449
Depth [m]
1657.7
Ref. Vel. [m/s]
1532.2
Velocity [m/s]
1532.2
Rel Res Vel
Amp (Seis)
-37.110
Distance [m]
-1293.9
Azimuth[Deg]
Amp (Attr)
Angle [Deg]
27.286
Azimuth[Deg]

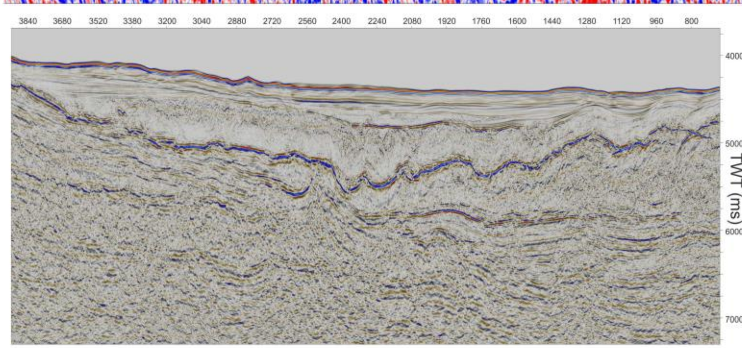
Velocity field and depth migrated seismic section

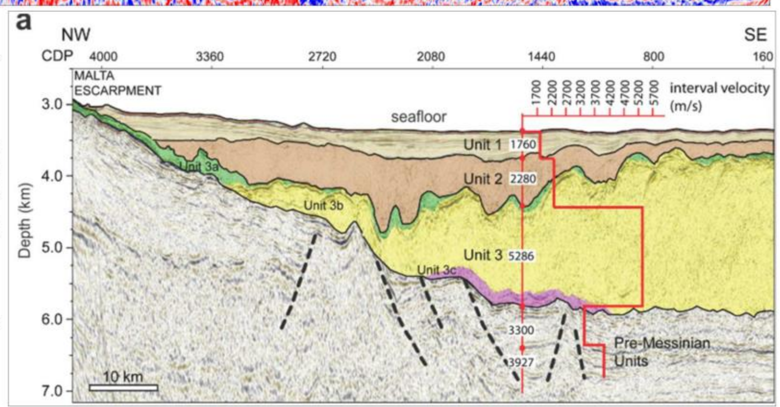


Example of Pre Stack Depth Migrated section with its velocity field superimposed (see next slide for the interpretation)

Depth migrated seismic section







(from Micallef et al., 2018)

Example of Pre Stack Time/Depth Migration section and the interpretation superimposed with velocity function.

Depth migrated seismic section

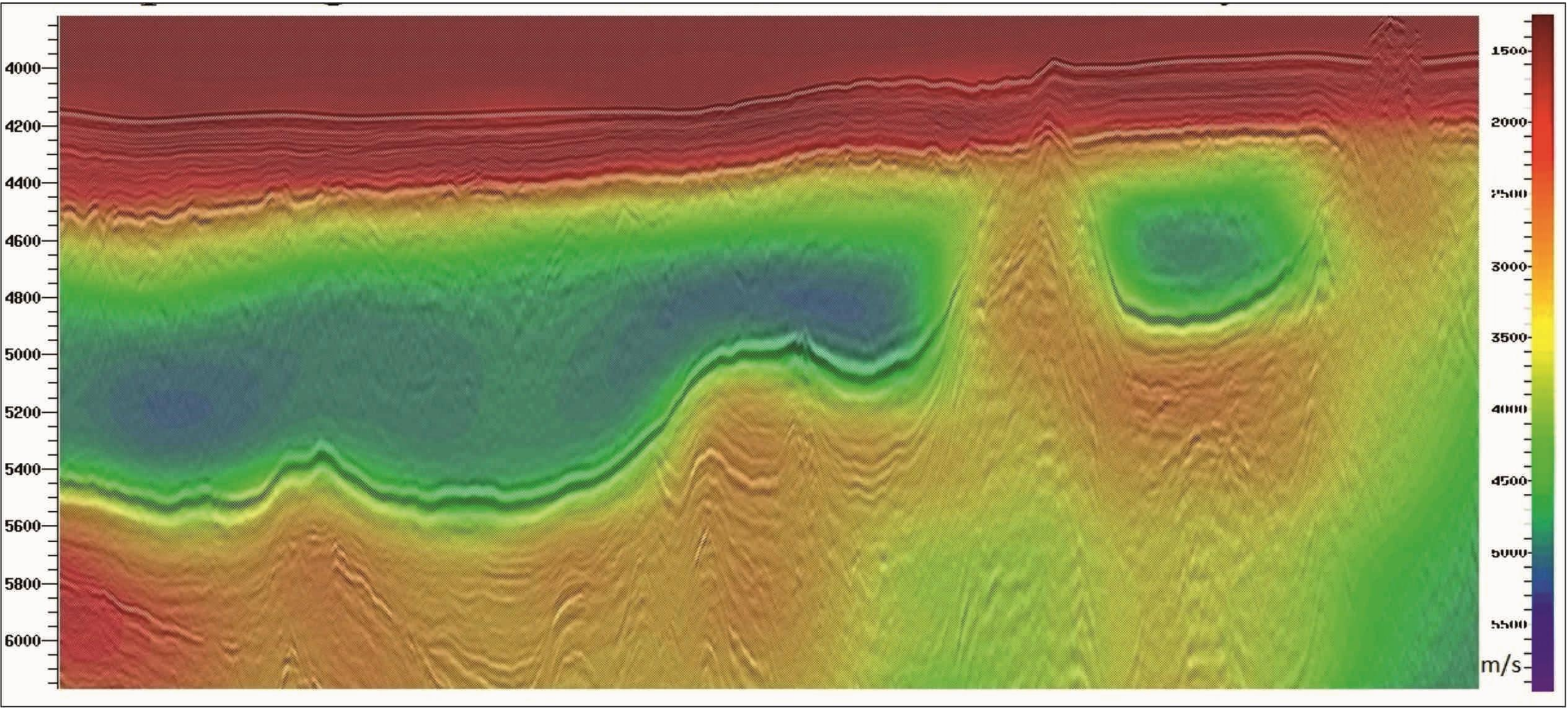
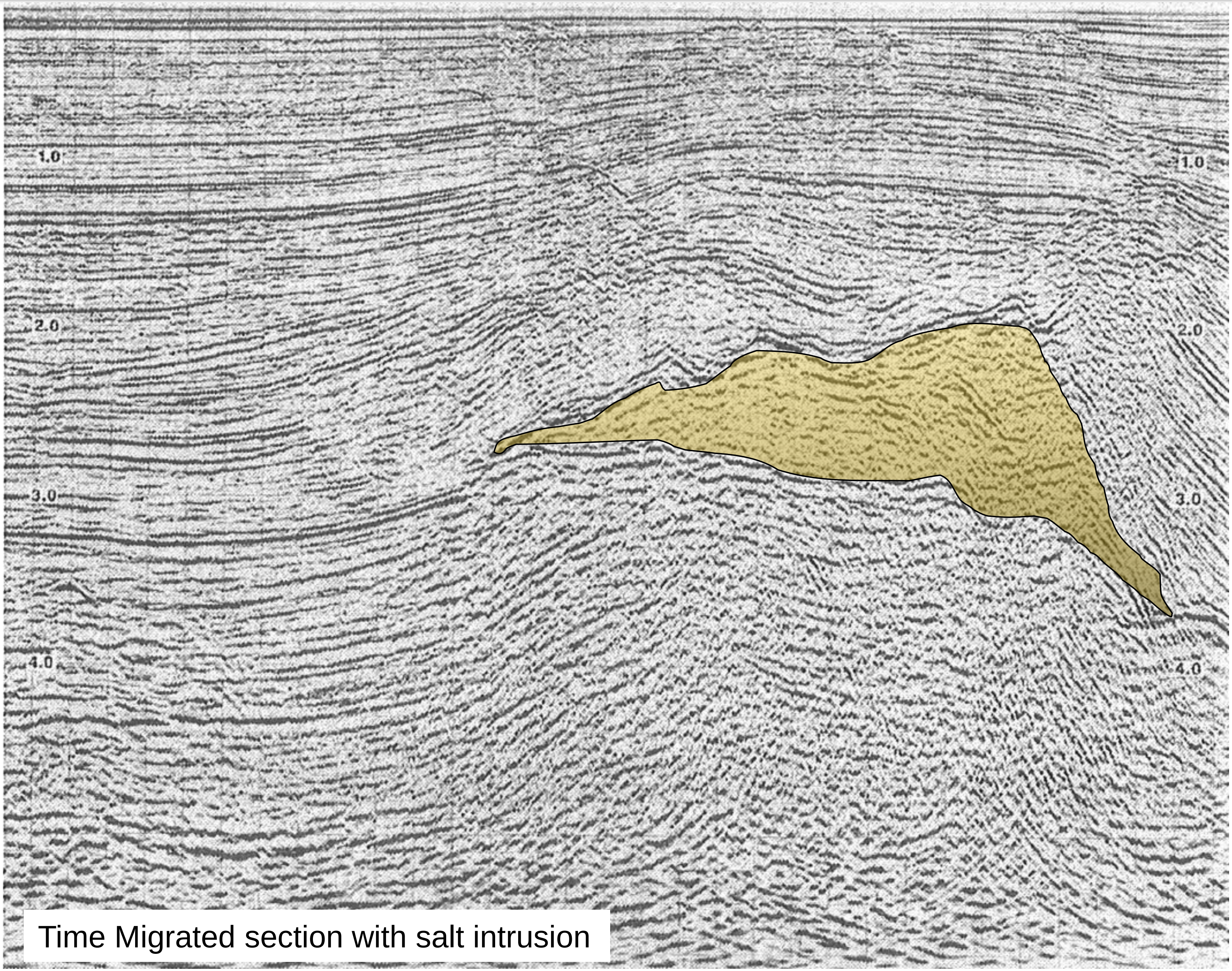
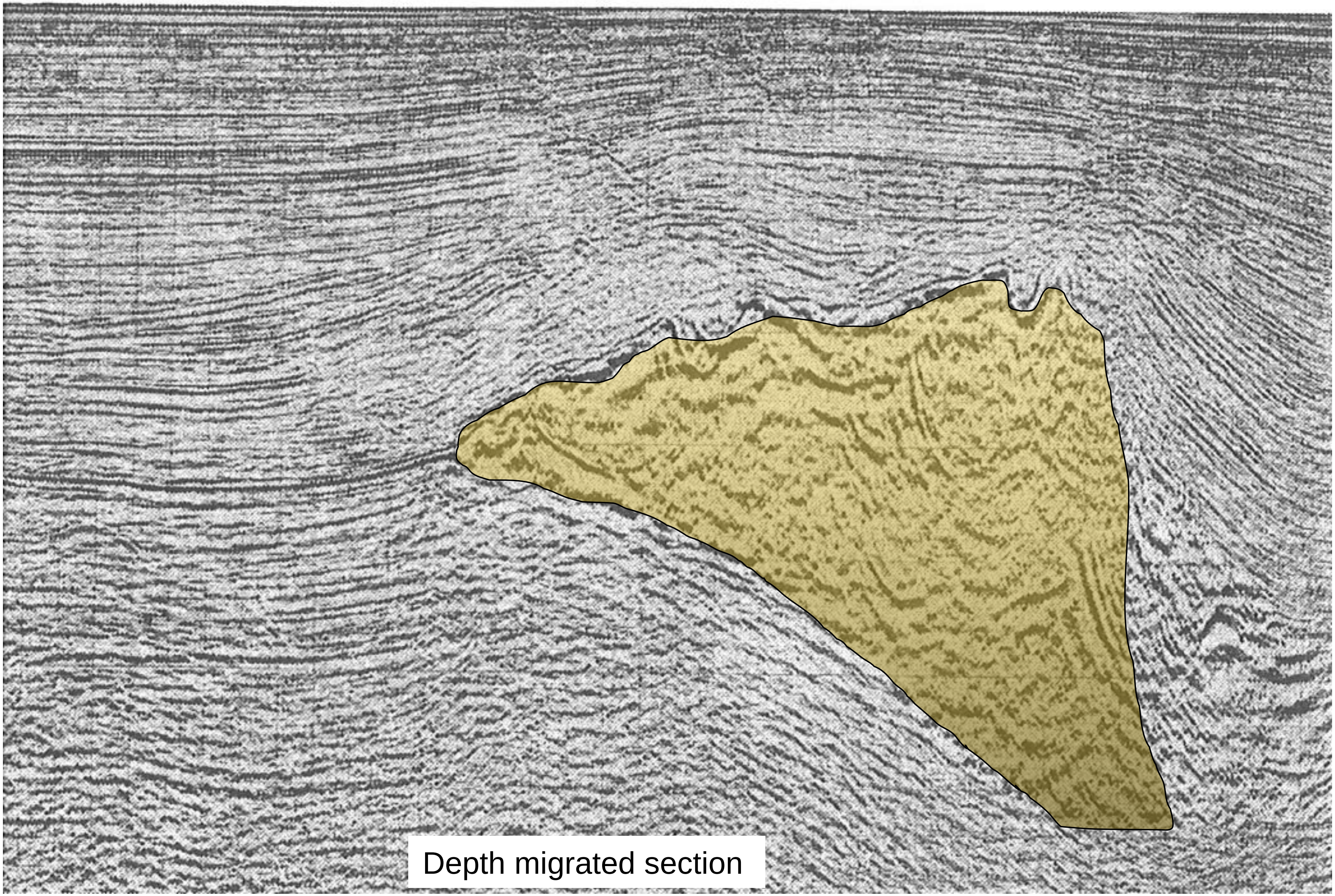


Image of a Pre-Stack Depth Migrated section (PSDM) and its velocity field used to migration (from Saule et al. 2016)

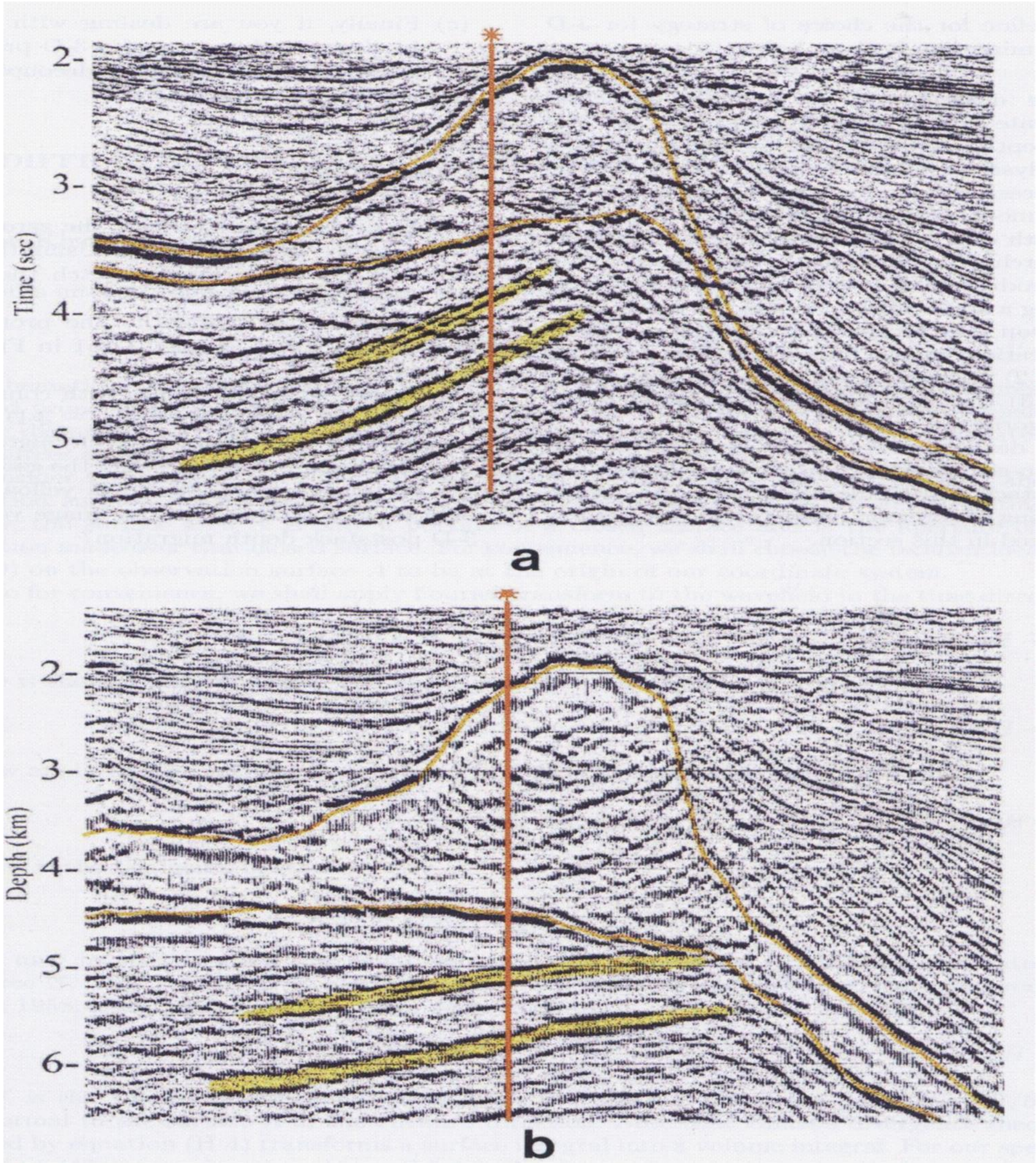
Note the high-velocity layer with a semi-transparent seismic signature with no stratification inside it. This is the Messinian salt layer (halite) in a seismic profile acquired in Ionian Sea.



Time Migrated section with salt intrusion


Depth migrated section

Pull up velocity effect:
example of a salt dome

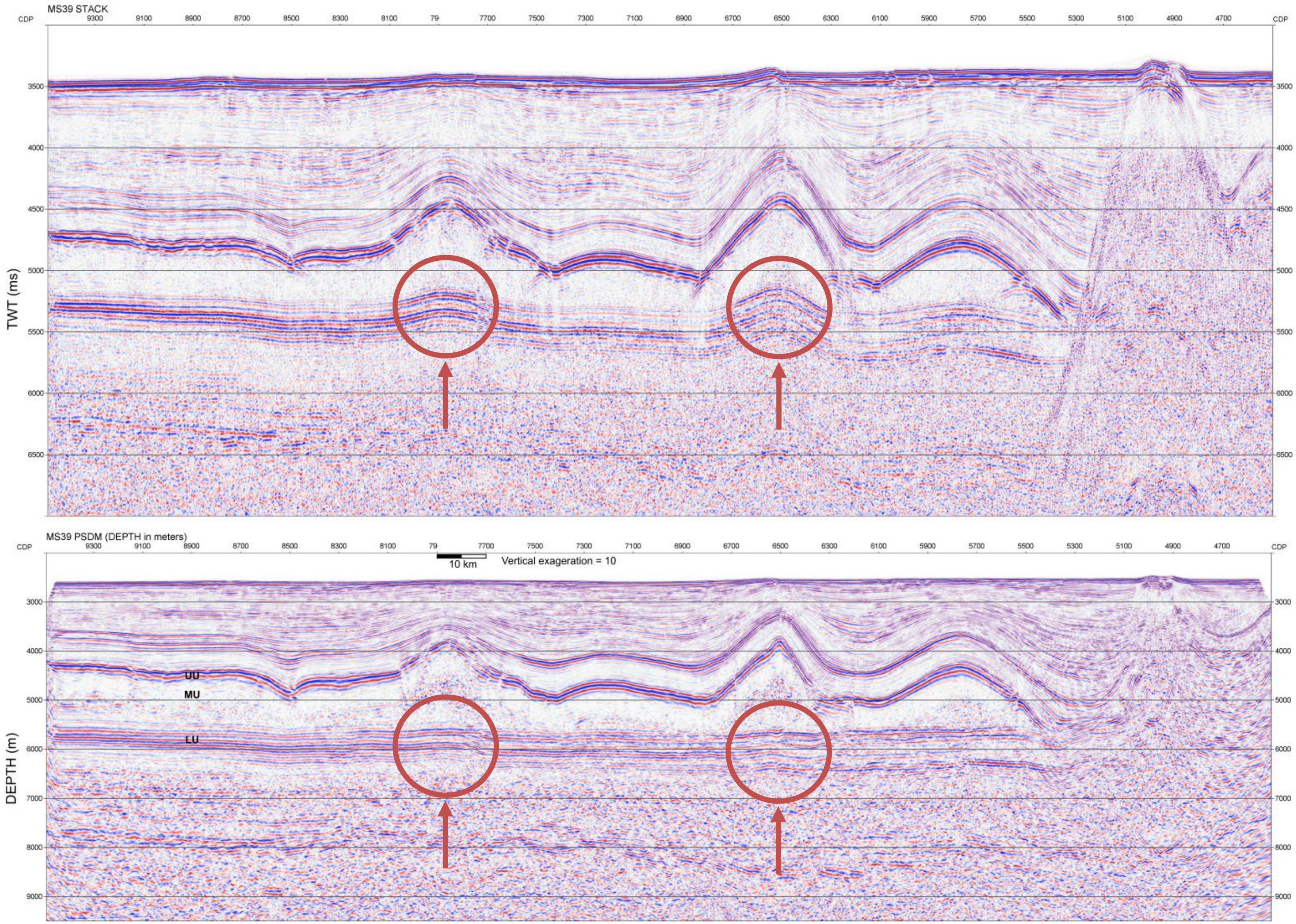


Time migrated section

Depth migrated section

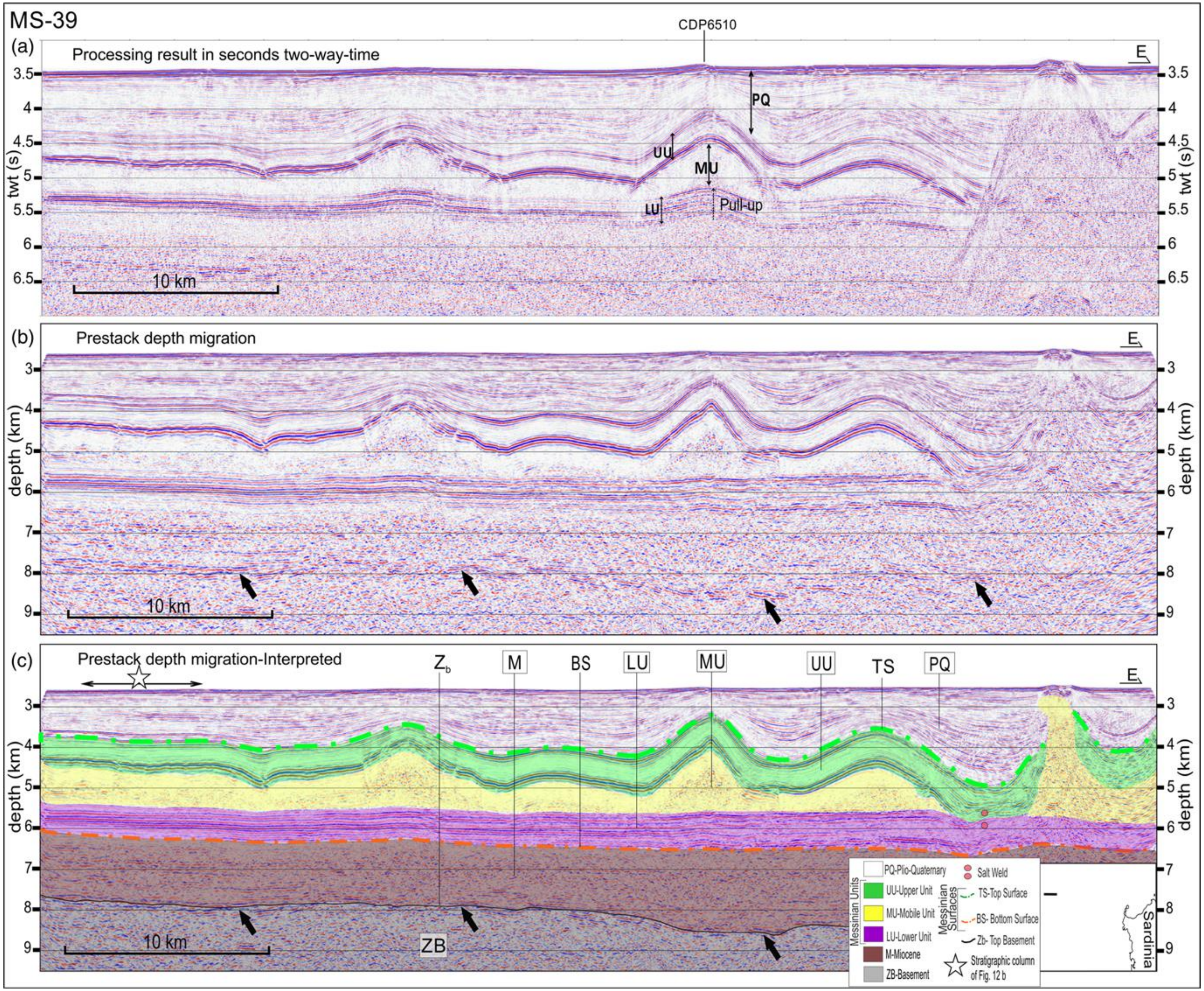
In presence of salt domes, in the seismic section we can observe the pull up velocity effect. This is due to the presence of high-velocity salt dome over the deep reflector in that sector of the profile. When we migrate in depth this effect is corrected with a right velocity function.

Pull up velocity effect

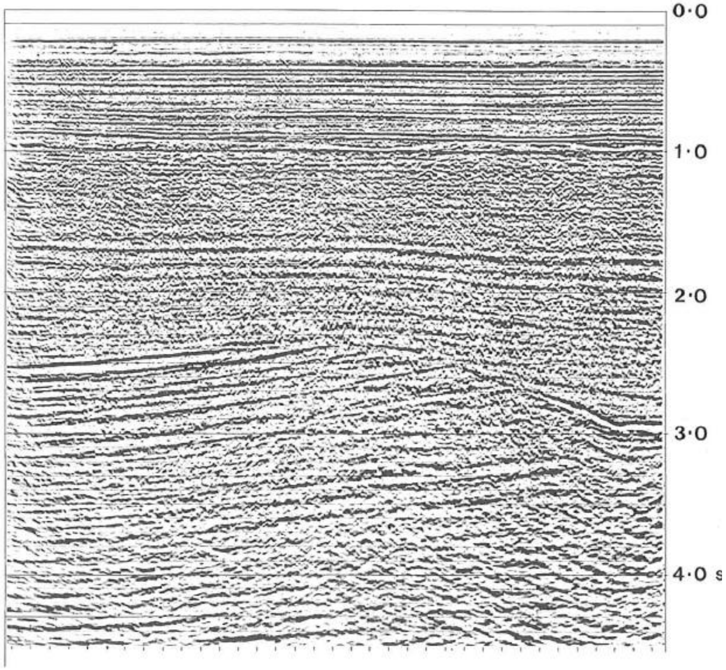


(Above) Result of data processing in time domain: the pull-up event (red circles) of about 200 ms occurs beneath a salt dome and affects the underlying layers. (below) Result of Pre-Stack Depth Migration (PSDM) showing flattened pullup event. (modified from Dal Cin et al. 2016)

Interpretation



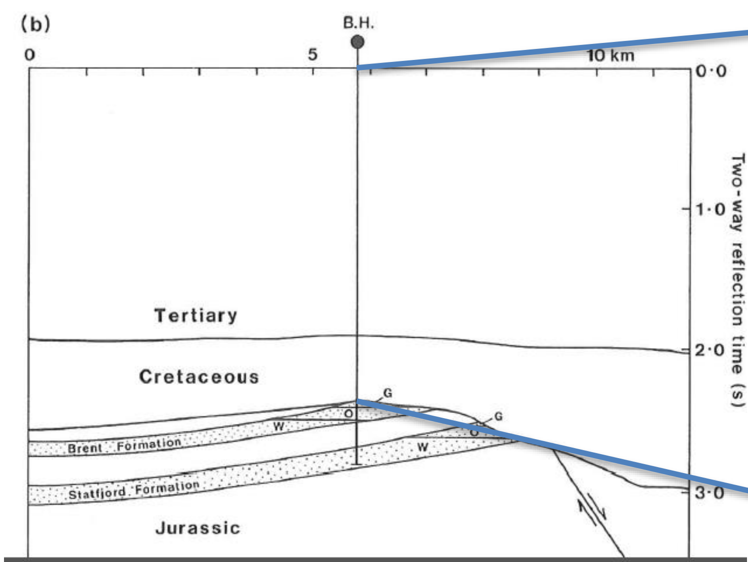
Dal Cin et al., 2016. Petroleum Geosciences

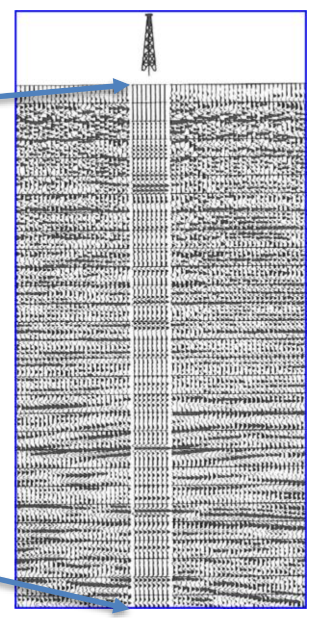


Vertical Seismic Profiling (VSP) in seismic interpretation

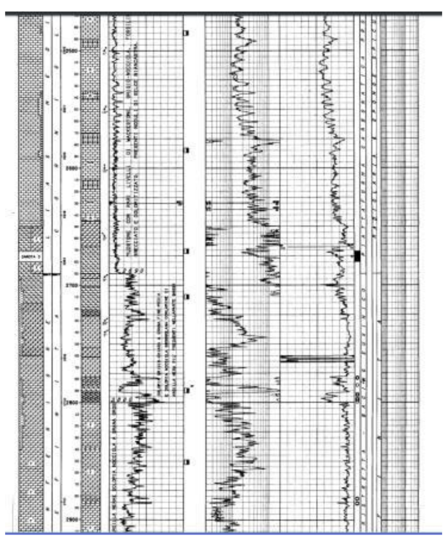
Example of correlation of well data (VSP) with the seismic section for geological interpretation

In some case we have a borehole across the seismic section and we can correlate these two type of data. From this we can therefore give a lithological meaning to the individual reflectors of the seismic profile passing through the well. In the image below and on the right, we can see an example of correlation between the seismic profile and the data obtained from the registration of the VSP in a borehole. The VSP was made after the geologic sampling in the same borehole.



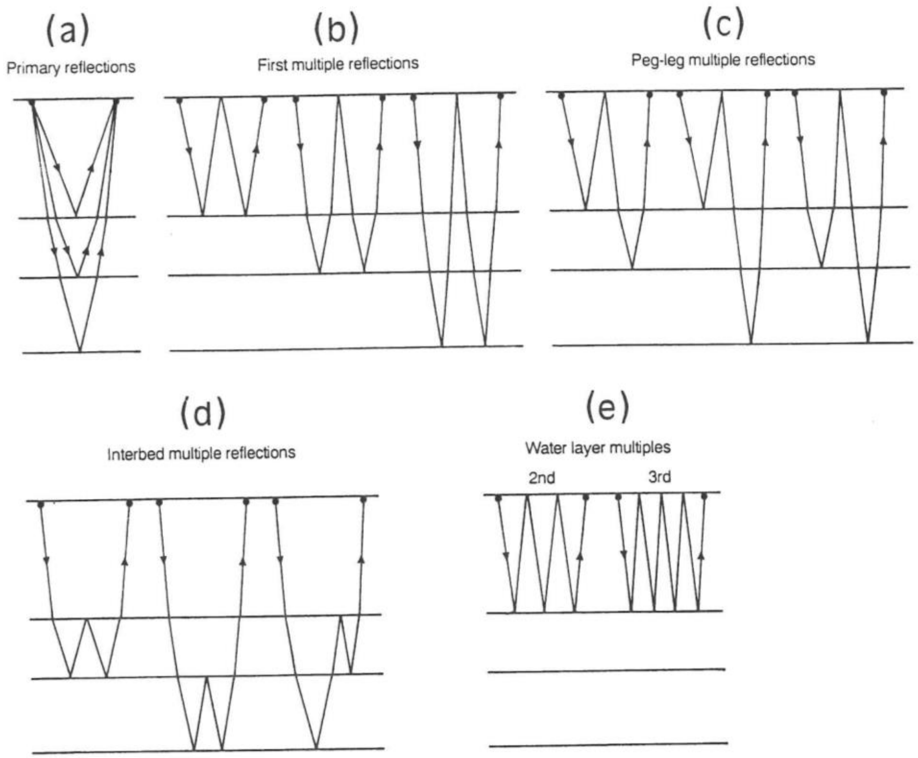


Well



- MULTIPLE REFLECTIONS –

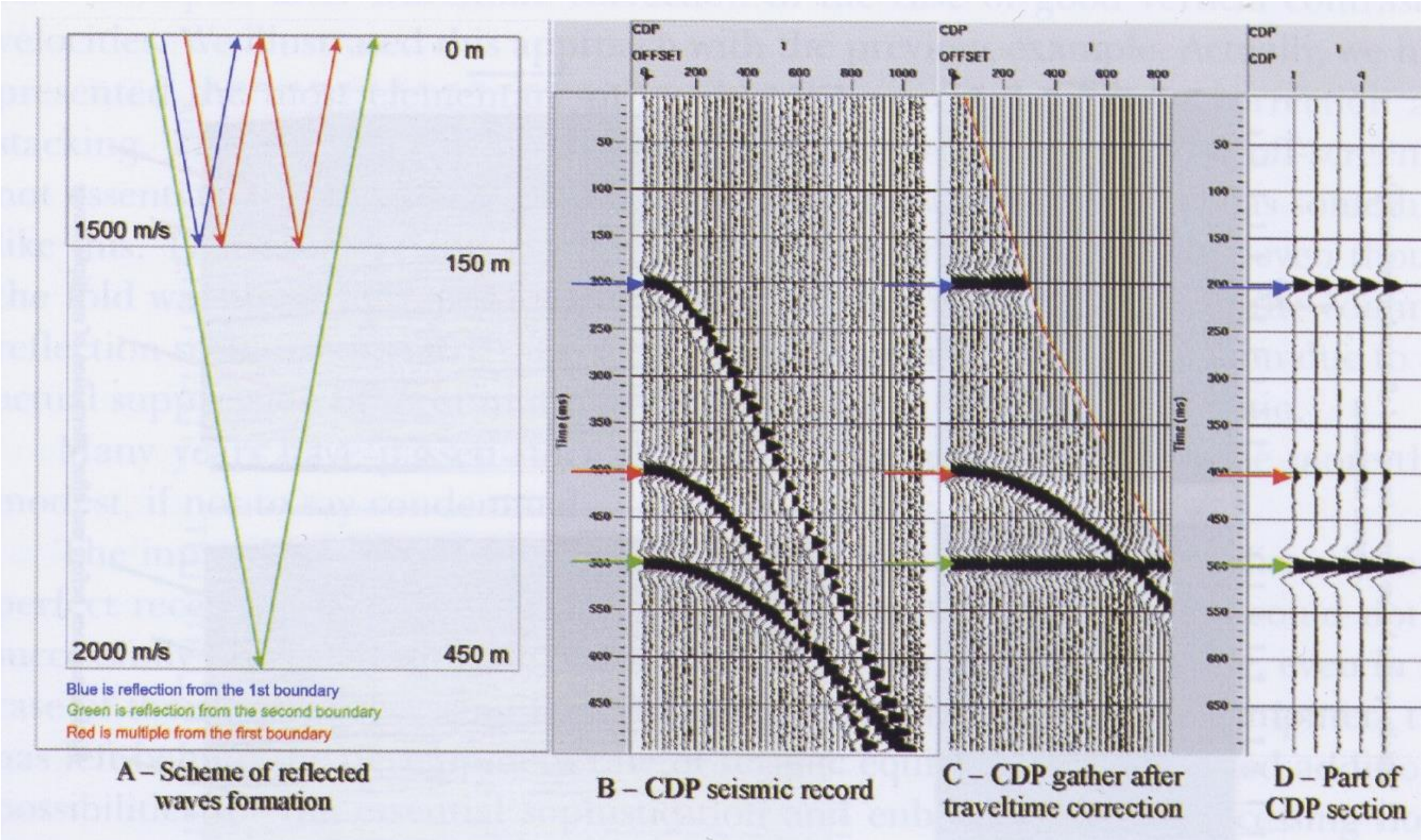
The problem of cherent noise in marine seismic profiles



Long-path multiples appear as distinct events. Short-path multiples are added to primary reflections and tend to come from shallow subsurface phenomena

The marine seismic dataset is often characterized by the presence of multiple reflections that affect the quality of the section itself. The multiple are the coherent noise that it leads to the misinterpretation of real reflective horizons. There are a lot of type of coherence noise, but the first water bottom multiple reflections are the most frequently.

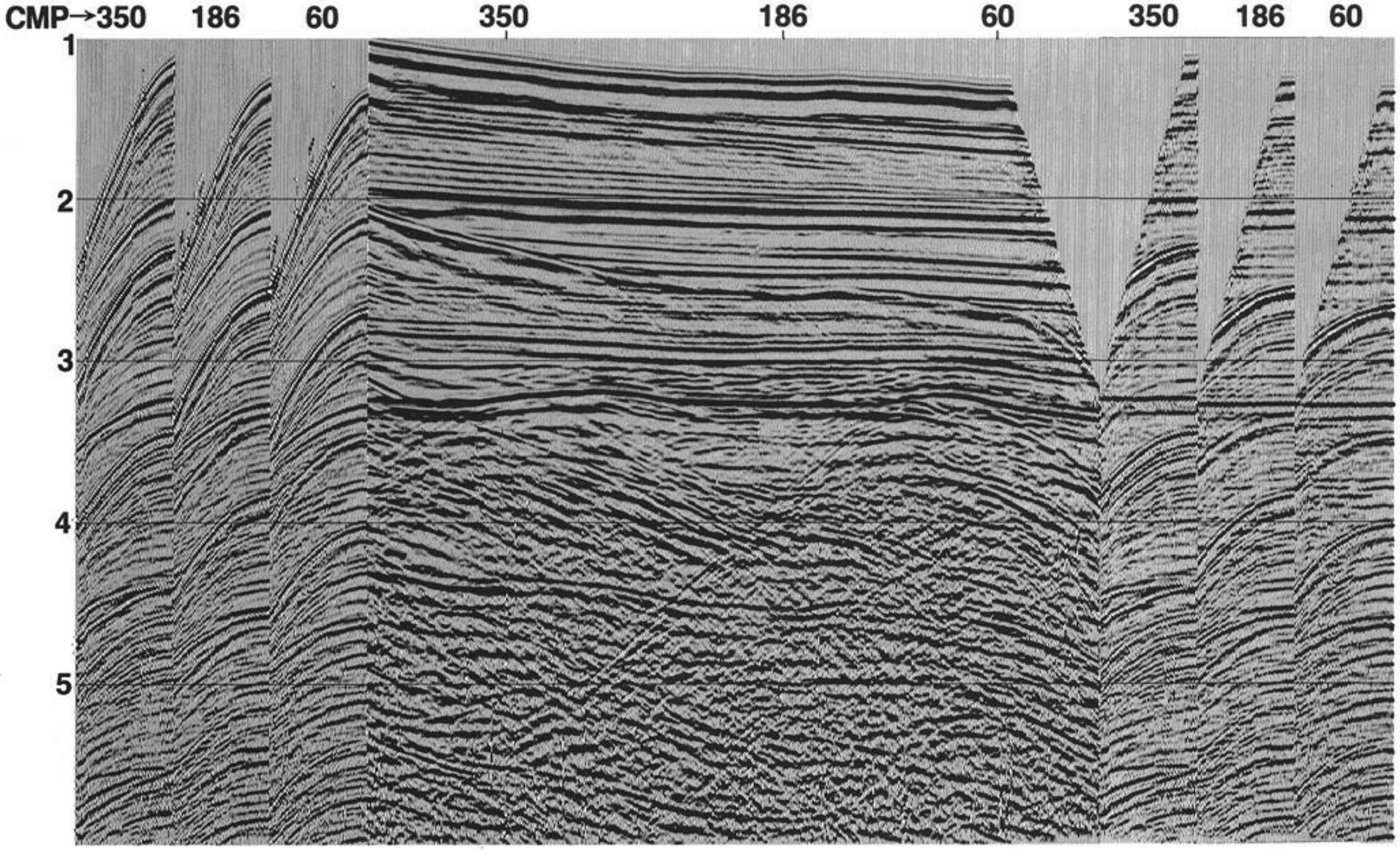
MULTIPLE REFLECTIONS



A – Scheme of reflected waves formation
B – CDP seismic record
C – CDP gather after traveltime correction
D – Part of CDP section

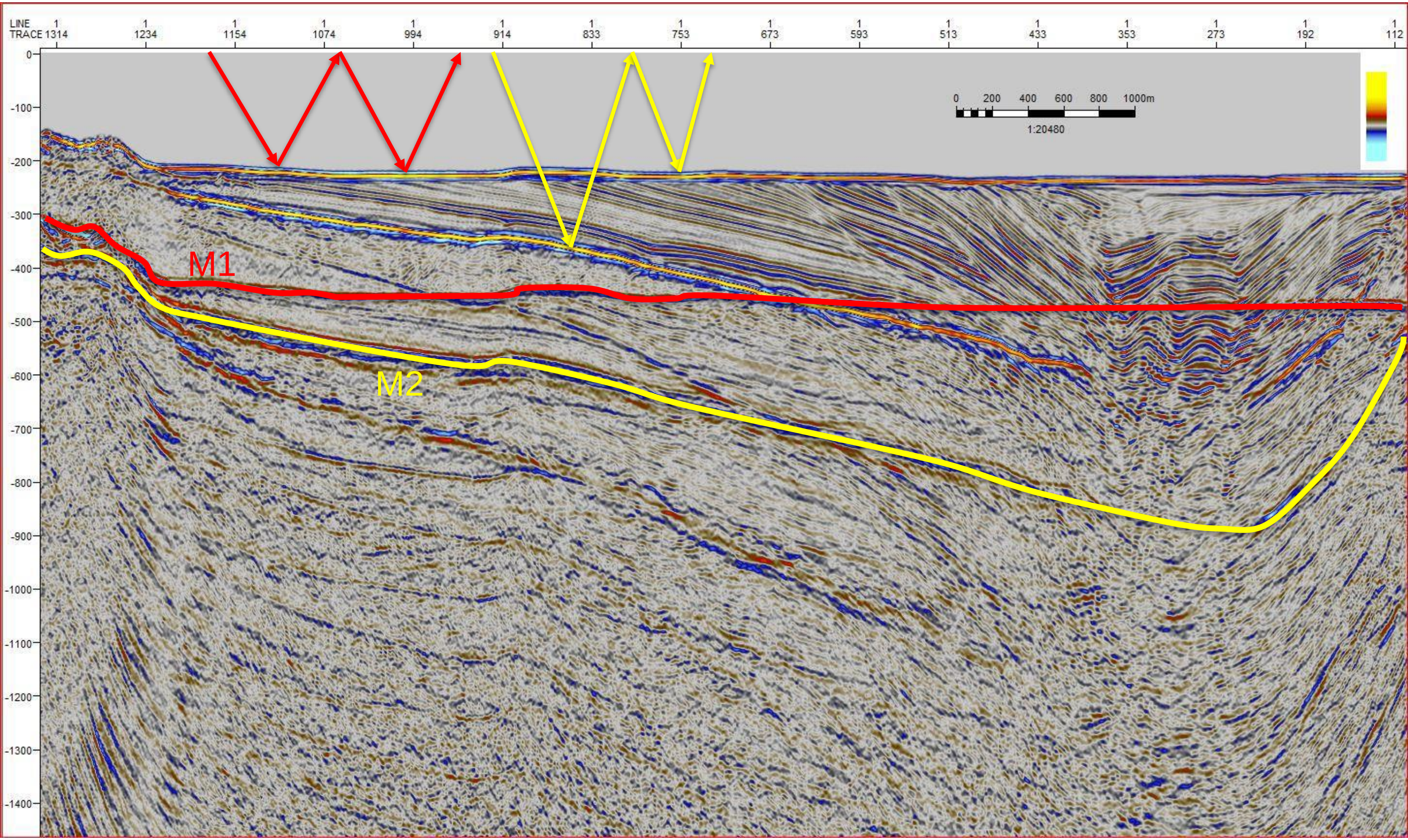
In this slide on the left it shows a schematic model of ray paths of the sea floor reflector (in blue color), a deep reflector at 450 m (in green color) and a multiple ray path in red. On the right there is a cdp gather before and after normal move out correction (velocity correction) and its stack section where you can see that the multiple reflection is attenuated, but no eliminated..

MULTIPLE REFLECTIONS



Three CMP gathers before (left) and after (right) NMO correction.Note that the primaries have been flattened and the multiples have been undercorrected after NMO correction. As a result, multiple energy has been attenuated on the stacked section (center) relative to primary energy (from Yilmaz 2001)

MULTIPLE REFLECTIONS

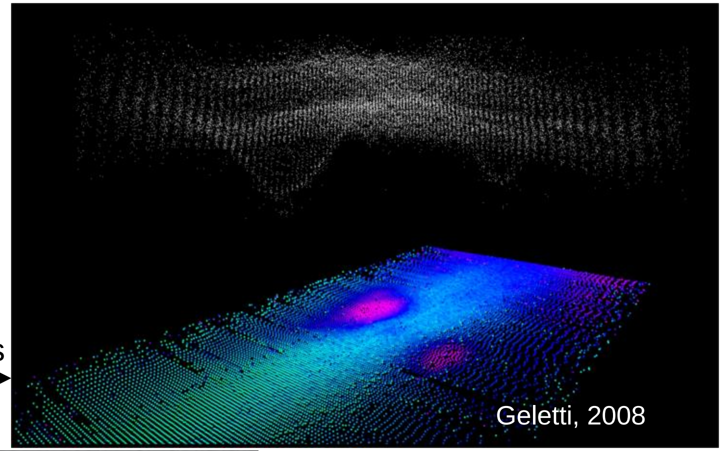


Example of seismic stack section with multiple reflections (M1 and M2)

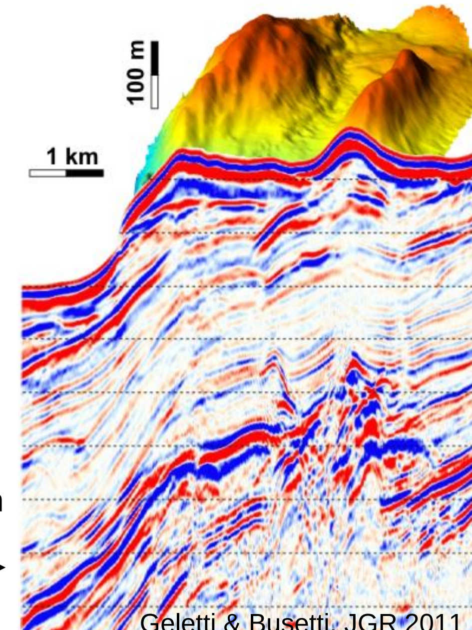
Gas seeping features

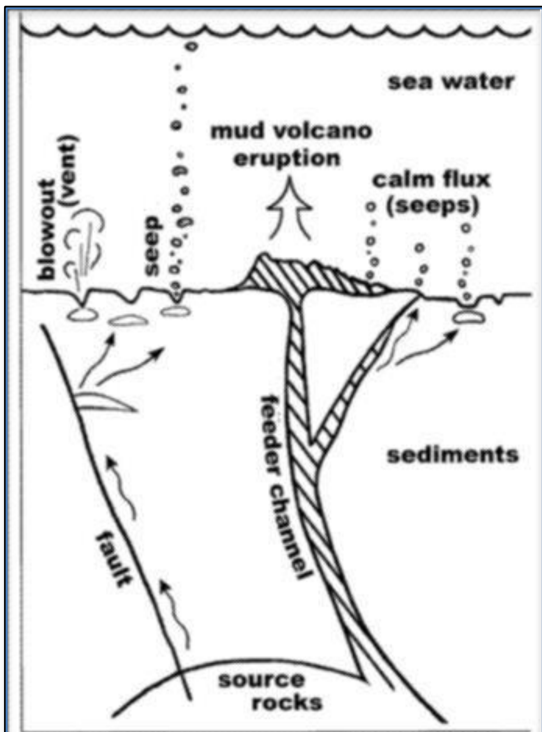
Mud volcanoes and pockmarks

MB data with pockmarks

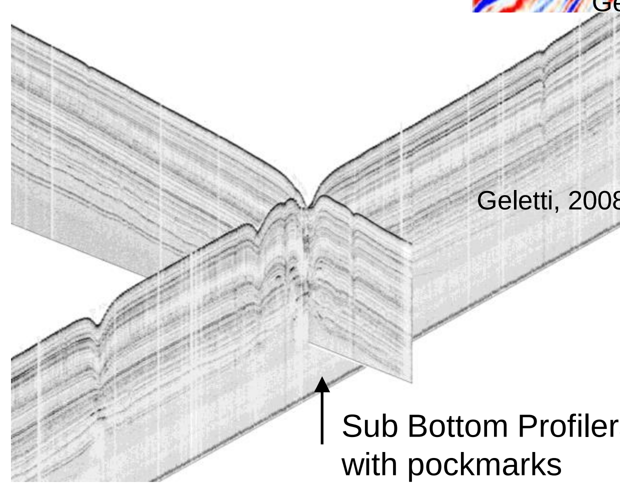


Seismic line & MB image with mud volcano





Schematic model of gas seeping related upward fluid migration

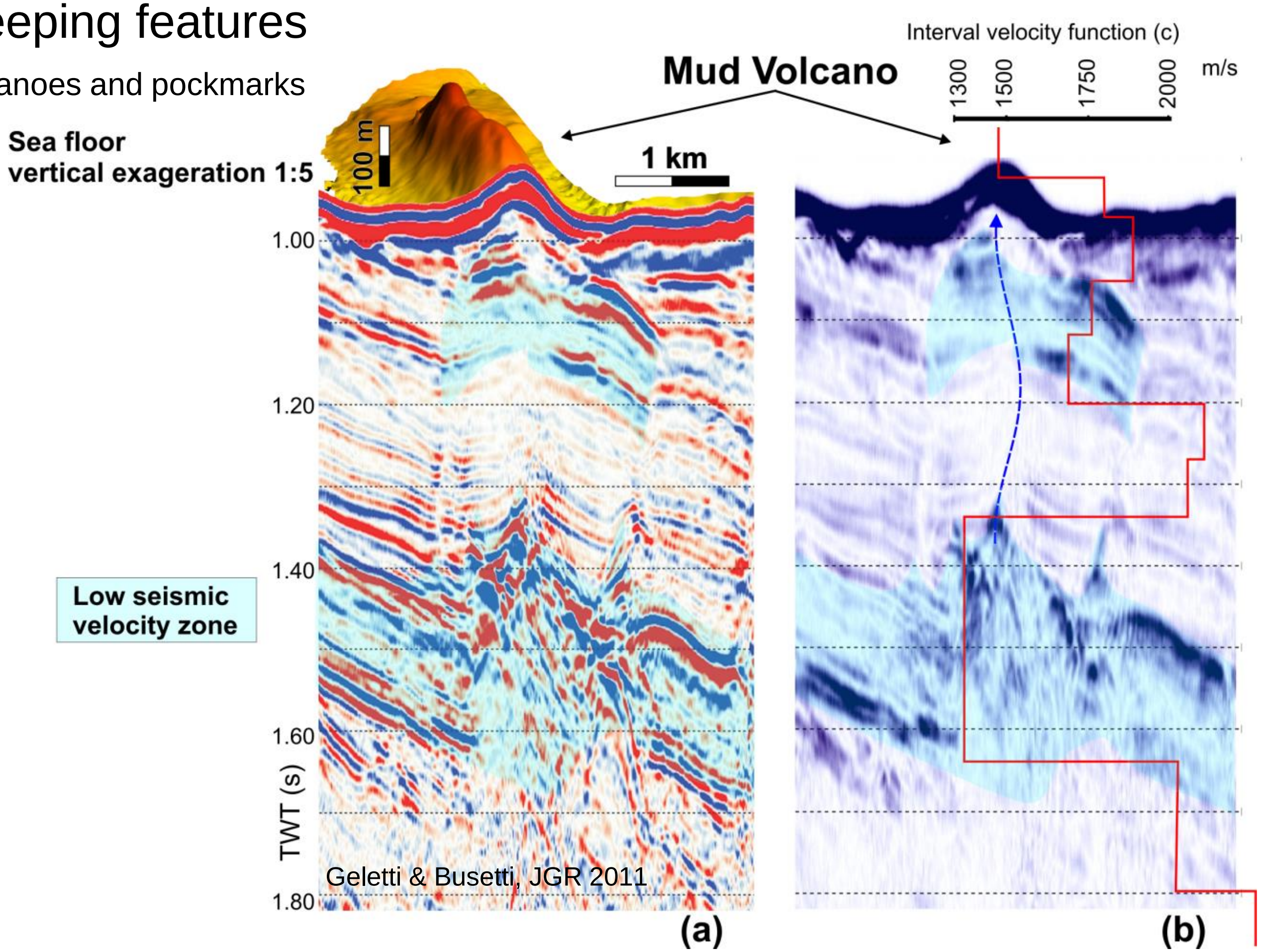


Sub Bottom Profilers (CHIRP) with pockmarks

Some example of gas seeping features. Sea bed fluid flow, also known as submarine seepages, involves the flow of gas and liquids through the seabed. This geological phenomenon has widespread implications in seabed slope instability, drilling hazard, hazards to seabed installations and so on. Seabed fluid flow affects seabed morphology (pockmarks, mud volcanoes). Natural fluid emissions also have a significant impact on the composition of the oceans and atmosphere: methane emissions have important implications for the global climate change.

Gas seeping features

Mud volcanoes and pockmarks

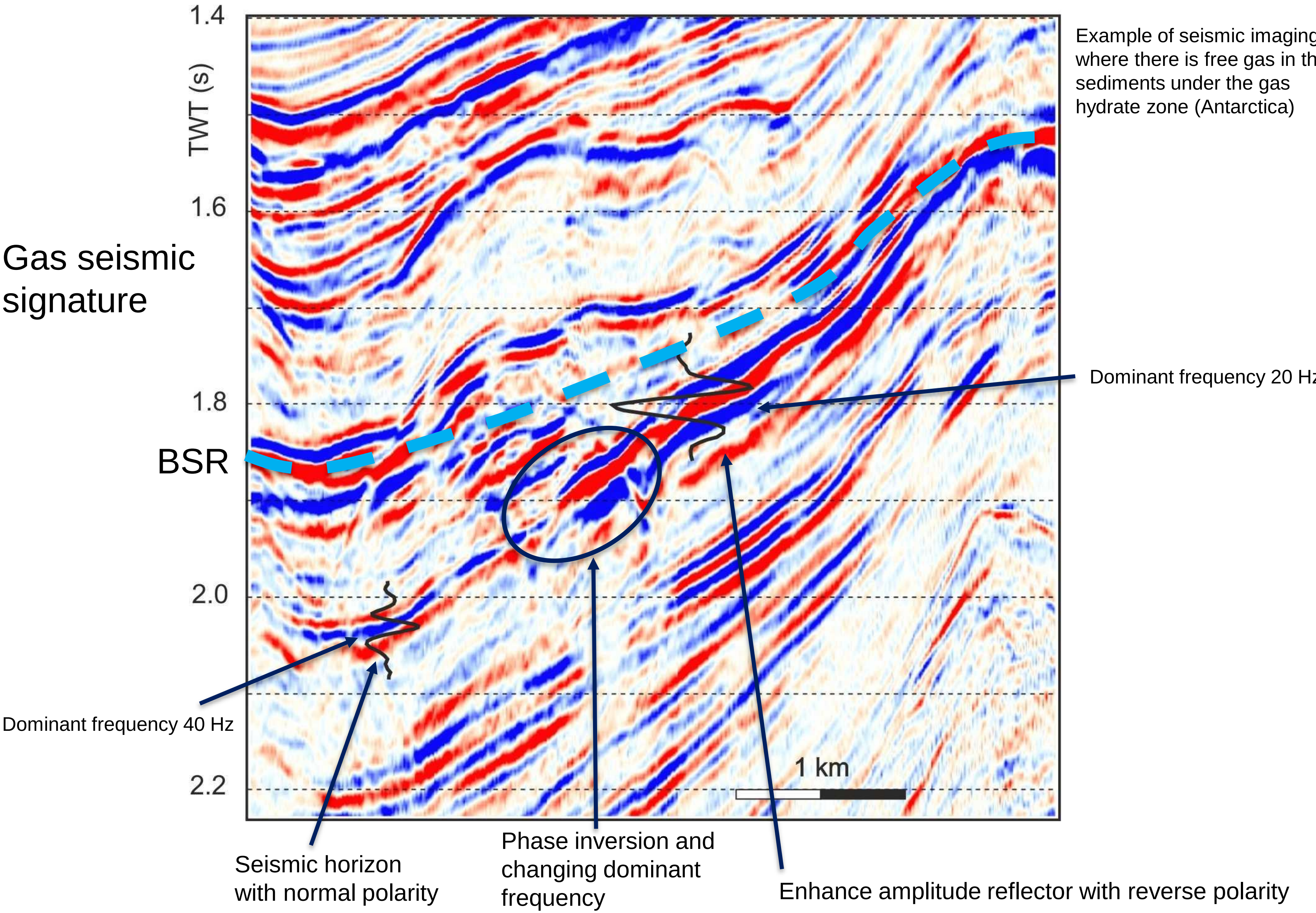


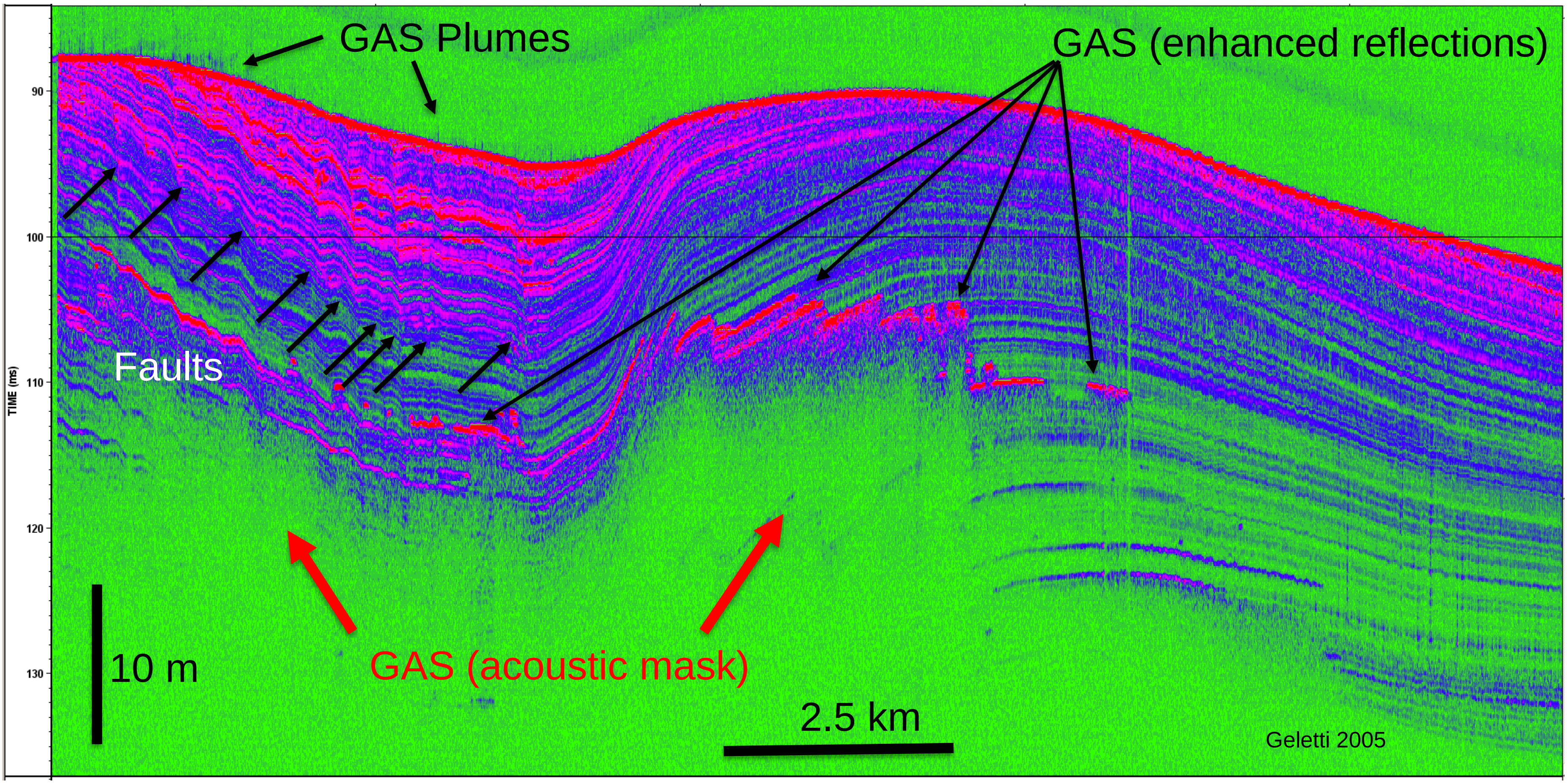
Example of upward fluid migration and the correlated gas seepage features in a seismic profile

(modified from Geletti & Busetti, JGR - 2011)

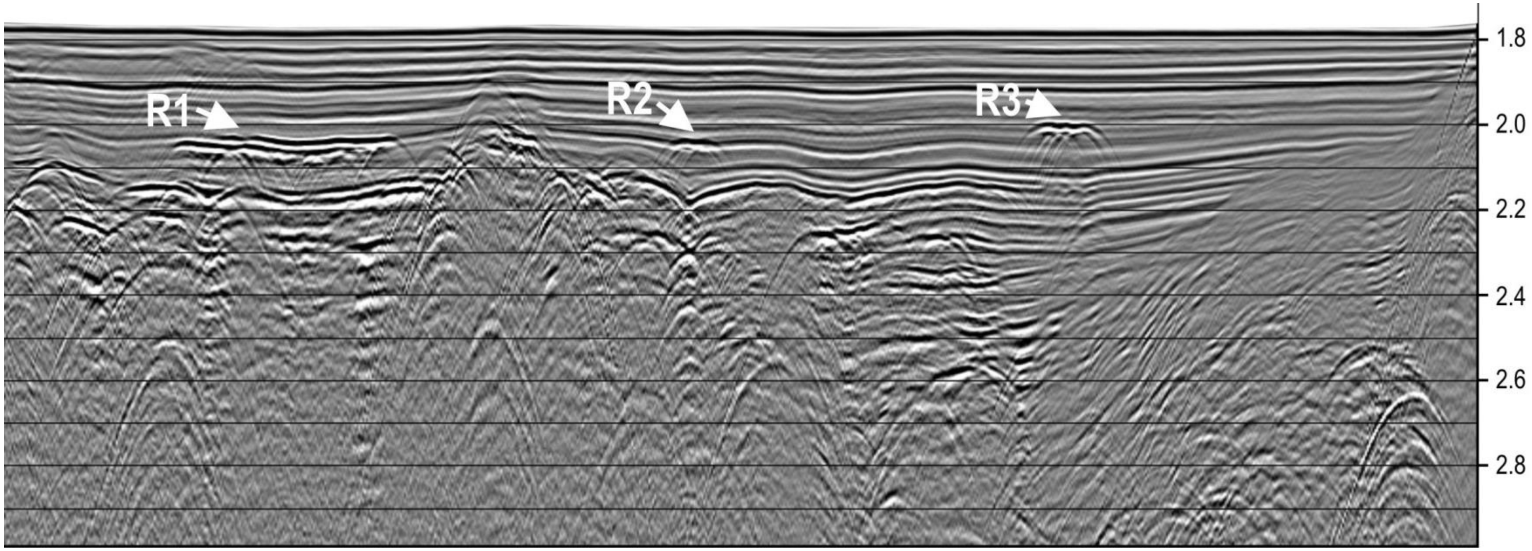
Gas seismic signature

Example of seismic imaging where there is free gas in the sediments under the gas hydrate zone (Antarctica)





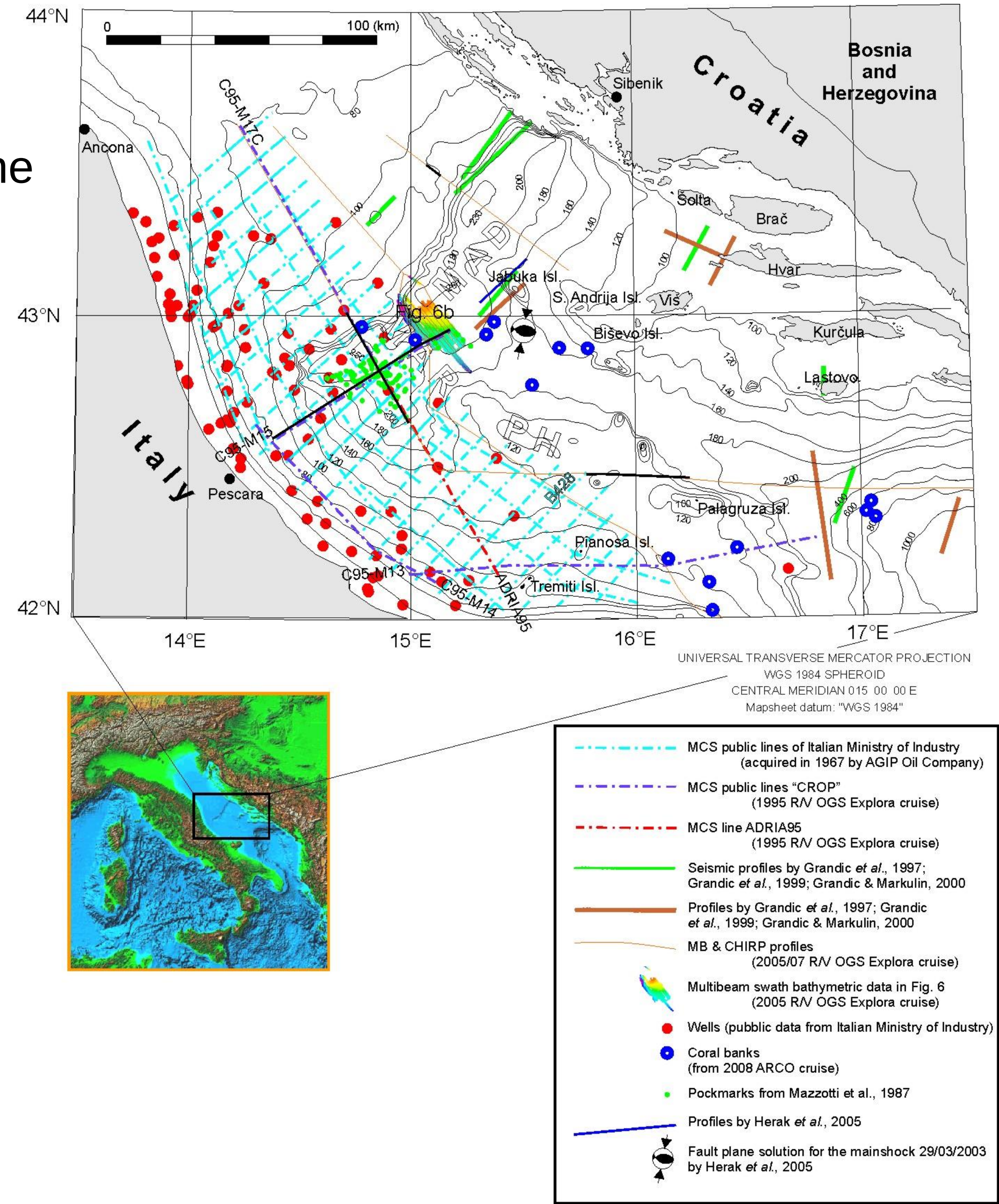
Echosounder CHIRP profile where there are gas evidences

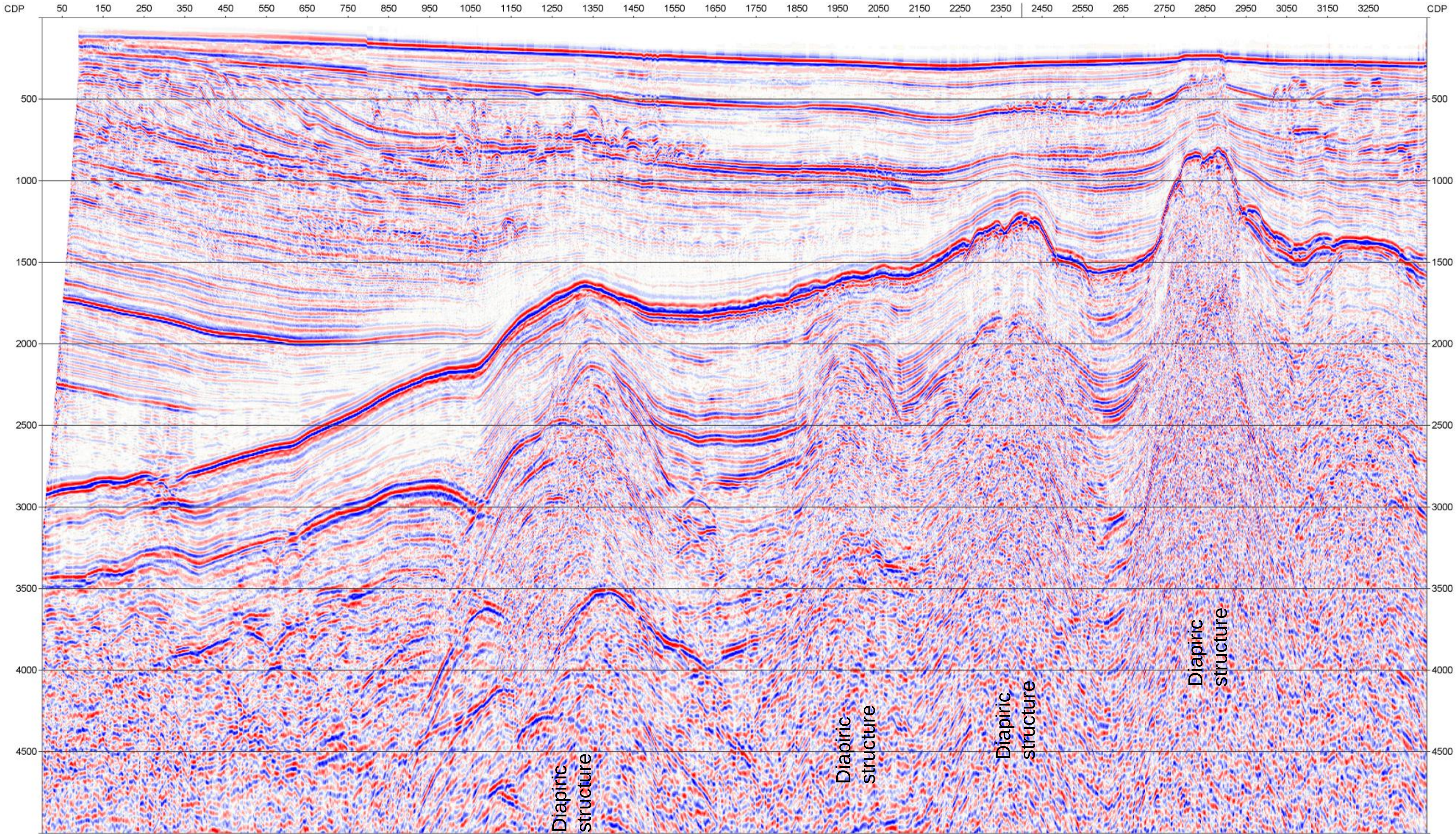


Examples of bright spot (R1, R2 and R3) in a seismic section (no migrated)

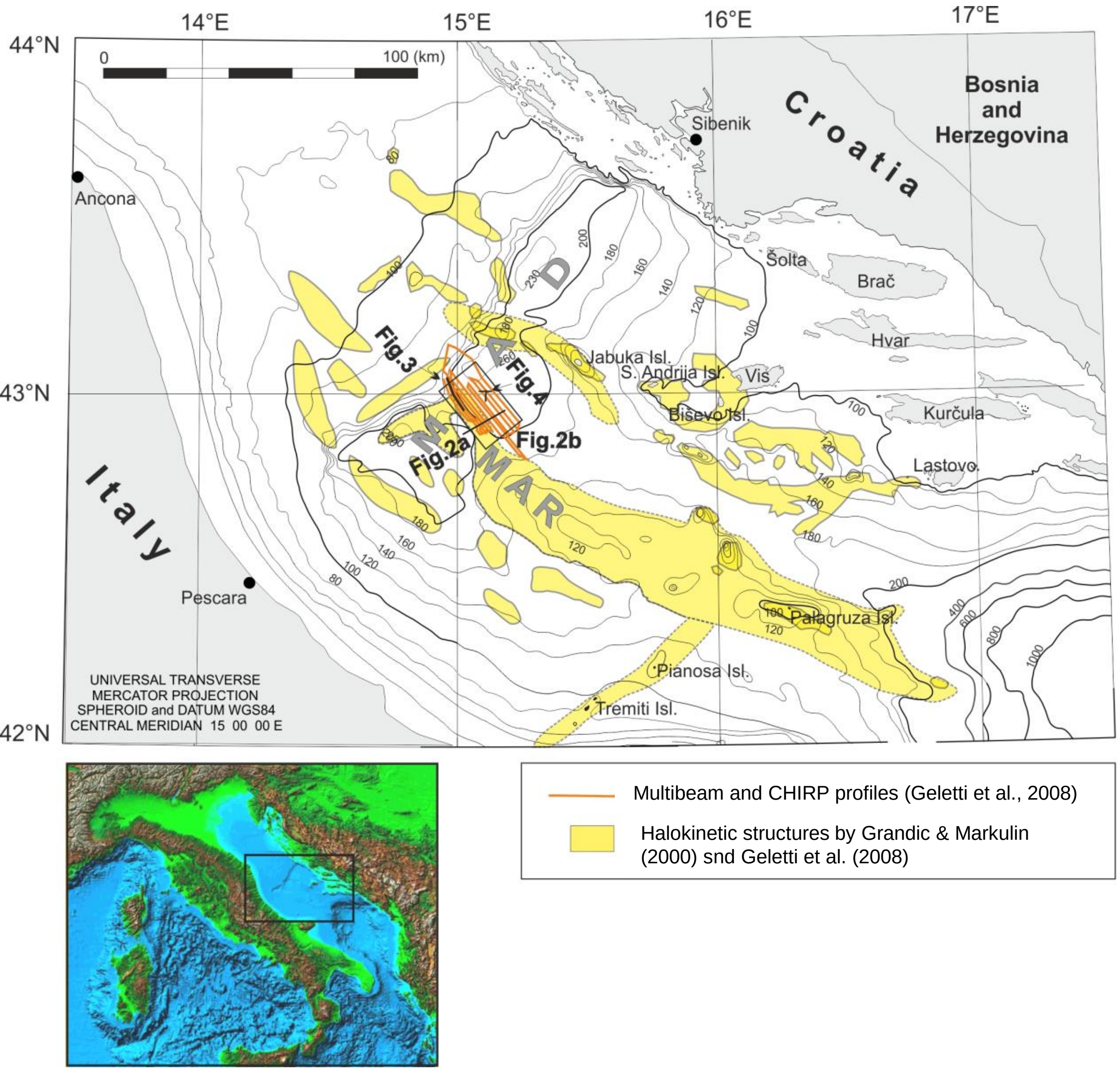
CASE HISTORY - 1: Gas seeps linked to salt structures in the Central Adriatic Sea (Geletti et al., 2008)

The analyses of about 800 km of Chirp sub-bottom profilers and 600 km^2 of Multibeam data acquired during the 2005 and 2007 surveys of the R/V OGS Explora, and their correlation with one new, and several public, multichannel seismic profiles, allow us to propose a relation between the distribution of gas seepages, fracture systems and deep salt features present in the Central Adriatic Sea. Gas seepage is evident from pockmarks on the seabed and in the shallow sub-bottom, where acoustic chimneys and bright spots have been highlighted and analyzed. The Mid-Adriatic Depression (MAD) is a distinct morphological feature in the Central Adriatic Sea elongated in a NE-SW direction. The area is affected by salt doming of Triassic evaporites which cause the two main alignments of the Mid-Adriatic Ridge as far as the Palagruza High and the Jabuka Ridge. These salt tectonics have existed since, at least, Paleogene times and are still active: they characterize sectors with less resistance to deformation produced by successive regional compressive regimes that have affected the area differently during the different geodynamic phases. Gas- seep features are distributed preferentially above and along the fracture systems produced above and around the salt mounds.



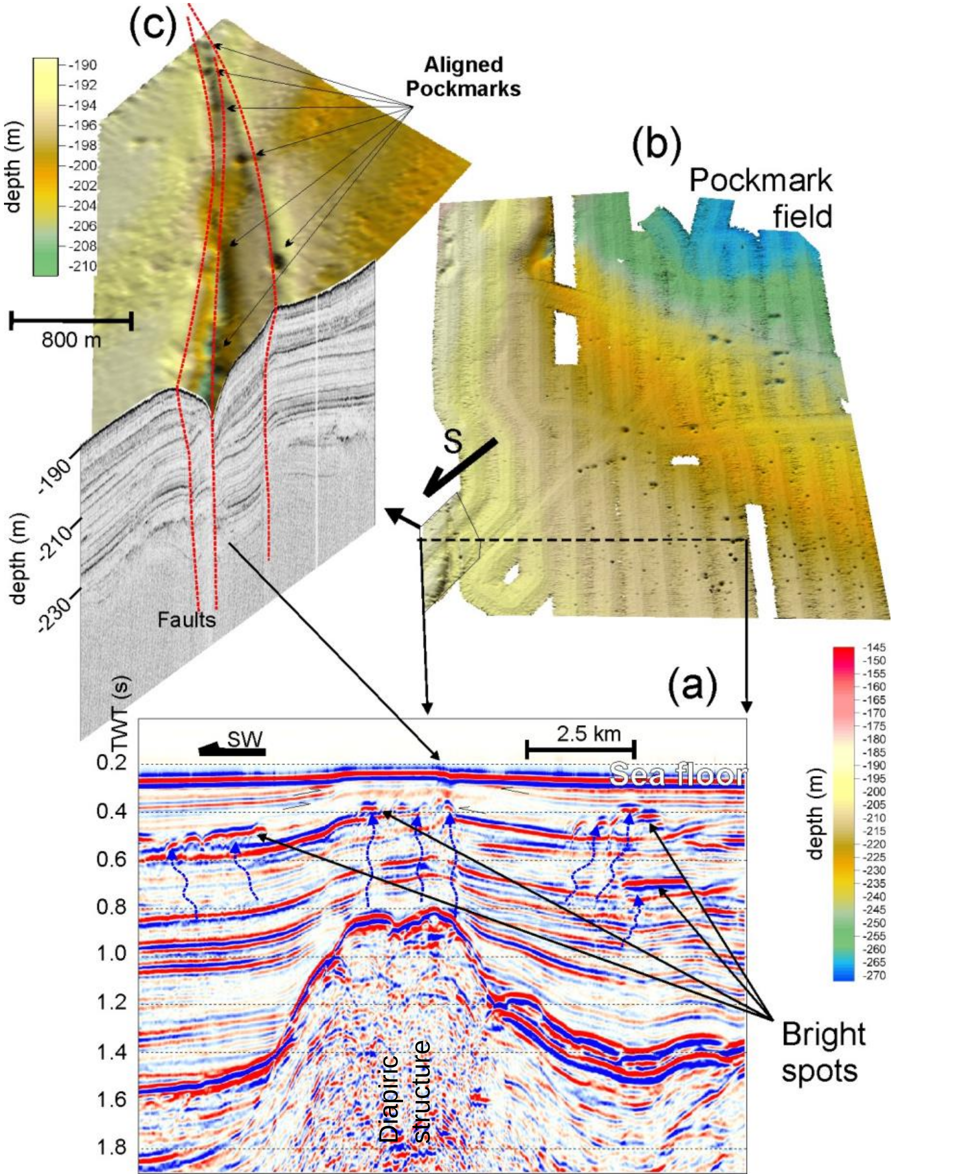


Crustal seismic profile CROP- M15

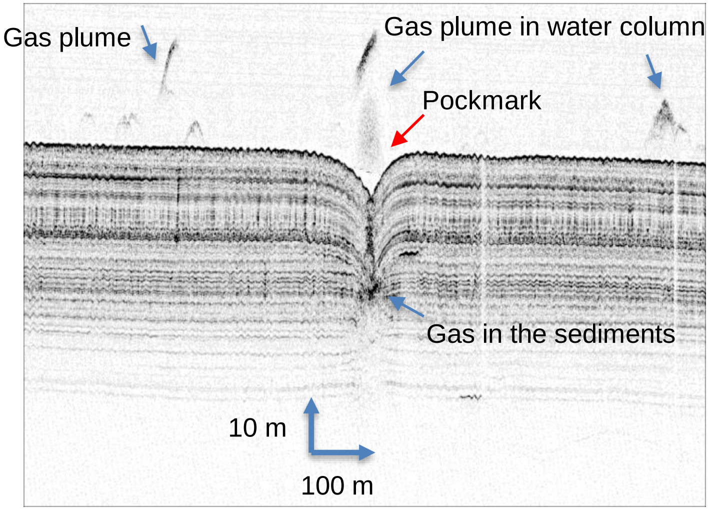


Bathymetric map of the Central Adriatic Sea, affected by gas seeping phenomena. There are mapped the CHIRP and multibeam profiles acquired in 2005 by the R/V OGS Explora (GELETTI *et al.*, 2008), the positions of the figures in the text and the indication of the main halokinetic structures present in the area (modified by GELETTI *et al.*, 2008)

a) Image of the seismic reflection profile with the evidence of bright spots indicating the presence of gas in the Plio-Quaternary sediments, b) multibeam bathymetry (MB) and a pseudo 3D image (c) with CHIRP profile and MB where it is highlighting a system of active faults along which some pockmarks can be identified. The seismic line shows the presence of a deep diapiric structure that also deforms the sea floor



Detail of the CHIRP line with evidence of gas plume



In this slide there are some images of gas/fluid presences within the sediments. On the right, above you see an image of pockmarks on swath bathymetry of multibeam. Below, two chirp profiles. On the left side you see a seismic section where at a deep of 400/450 m there are seismic anomalies below superficial gas evidence in chirp profiles

Seismic section with gas seeps features

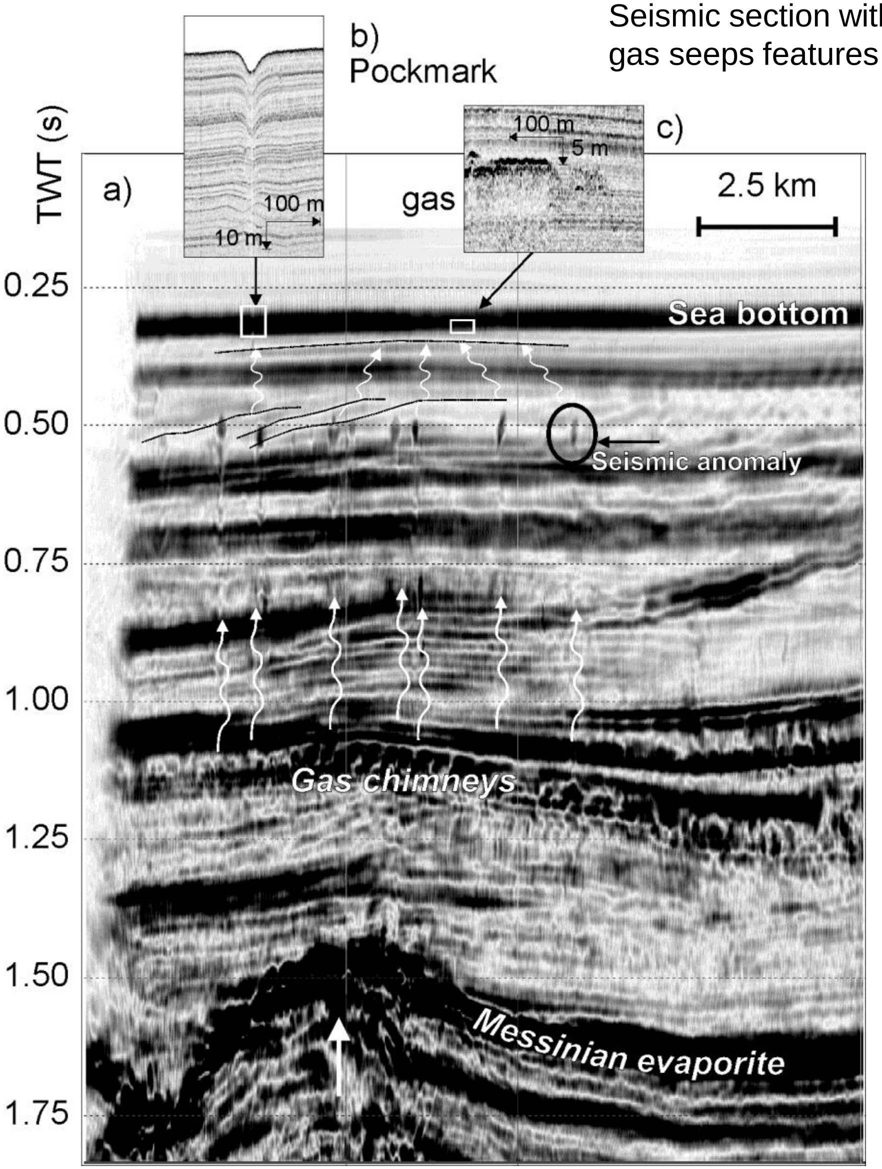
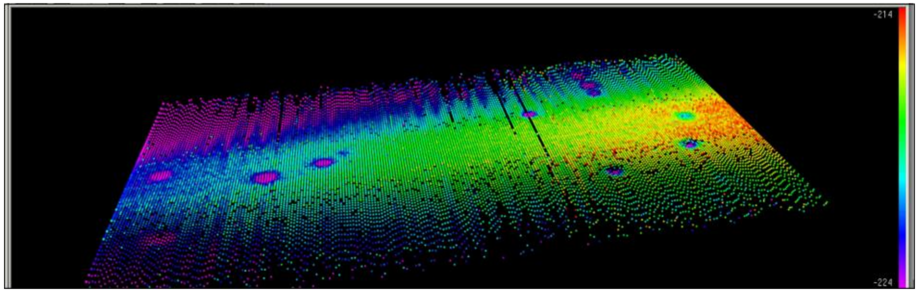
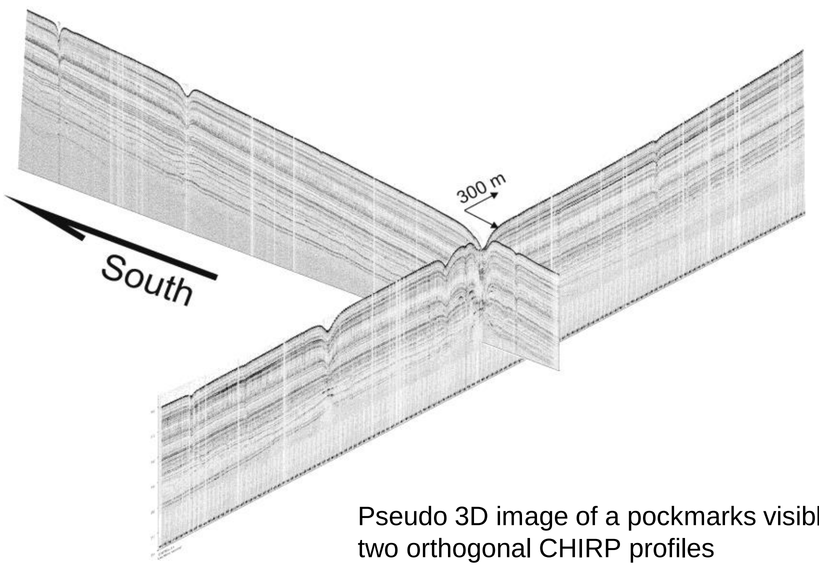
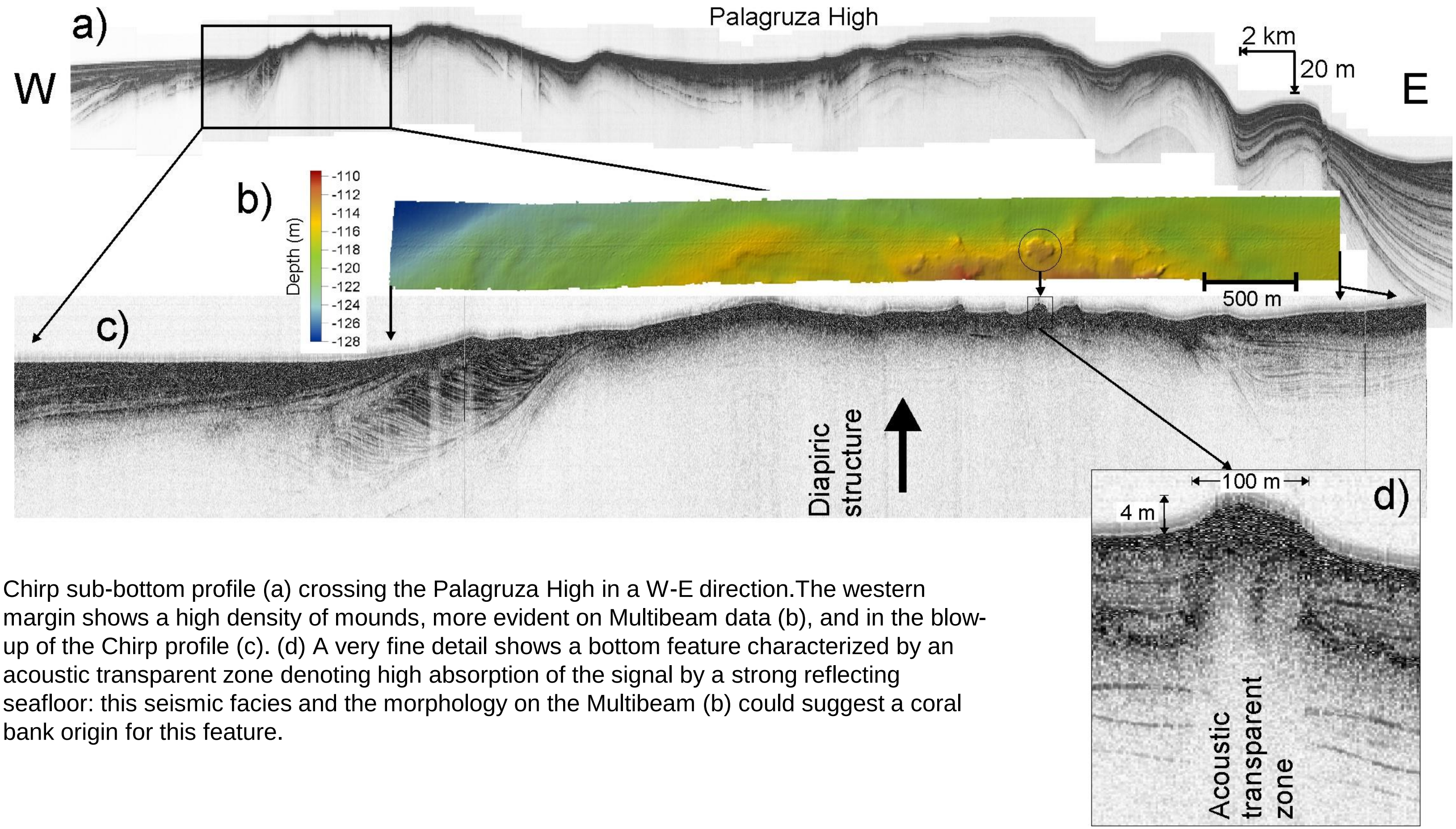


Image of Pockmarks in MB data





Pseudo 3D image of a pockmarks visible on two orthogonal CHIRP profiles

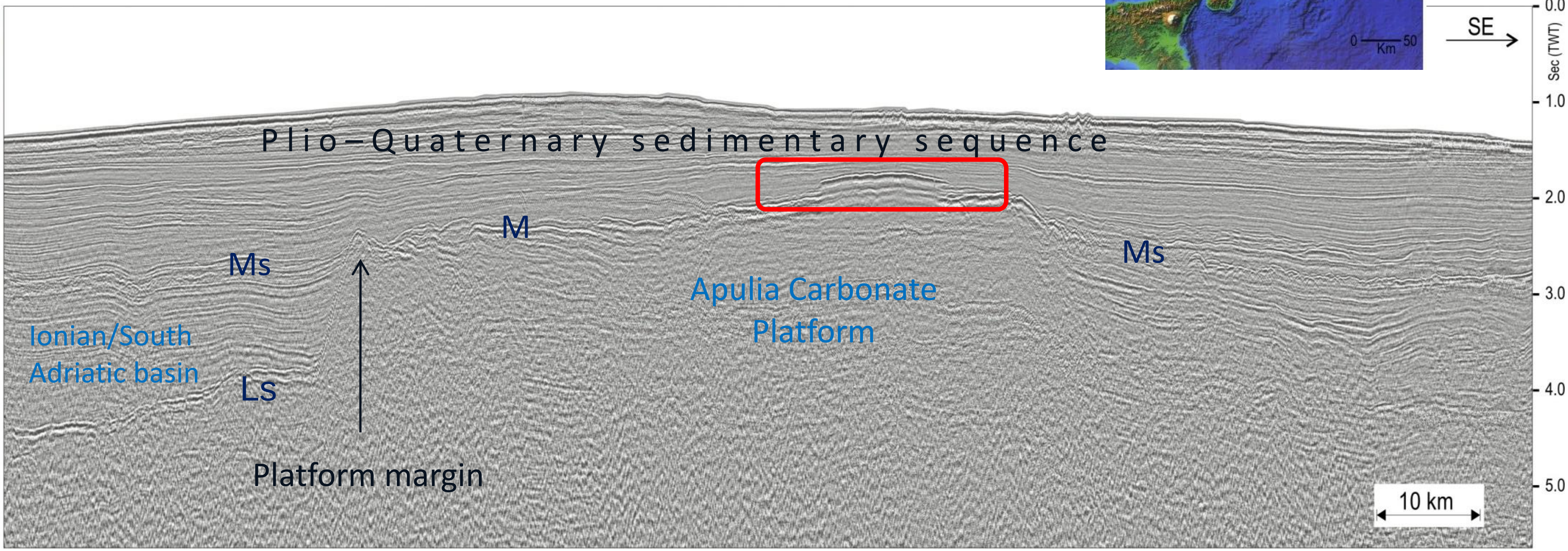


Chirp sub-bottom profile (a) crossing the Palagruza High in a W-E direction.The western margin shows a high density of mounds, more evident on Multibeam data (b), and in the blow-up of the Chirp profile (c). (d) A very fine detail shows a bottom feature characterized by an acoustic transparent zone denoting high absorption of the signal by a strong reflecting seafloor: this seismic facies and the morphology on the Multibeam (b) could suggest a coral bank origin for this feature.

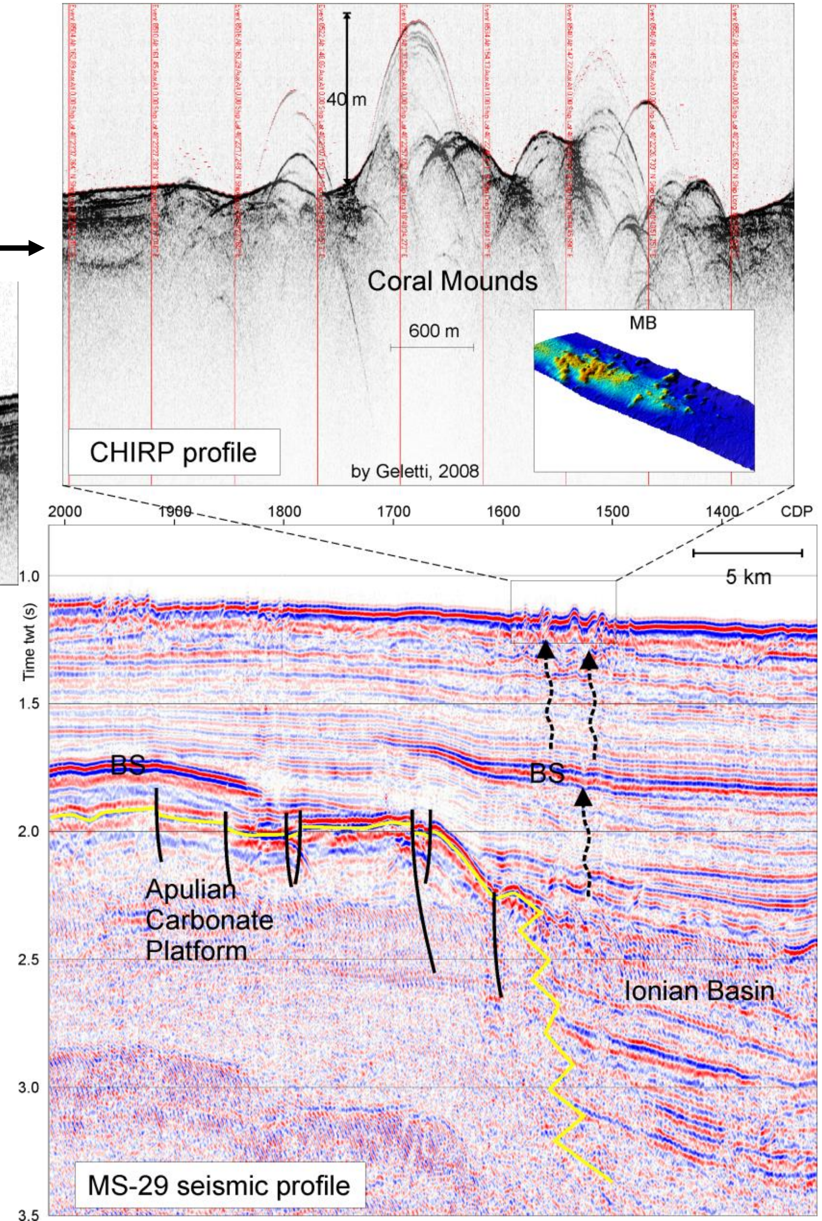
CASE HISTORY - 2: THE OTRANTO CHANNEL

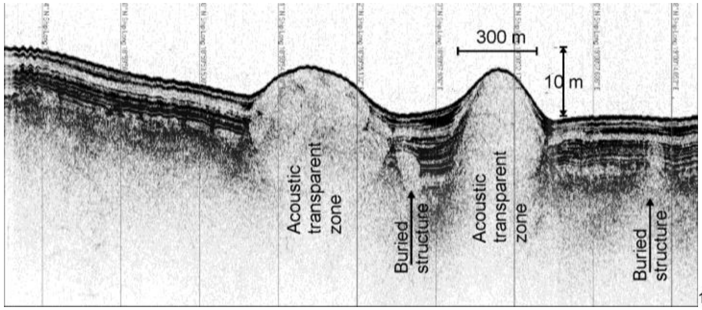
Gas seepages related to deep features in the Otranto Channel (South Adriatic Sea) - OCSS15 project - (**O**tranto **C**hannel ga**S** **S**eepages)

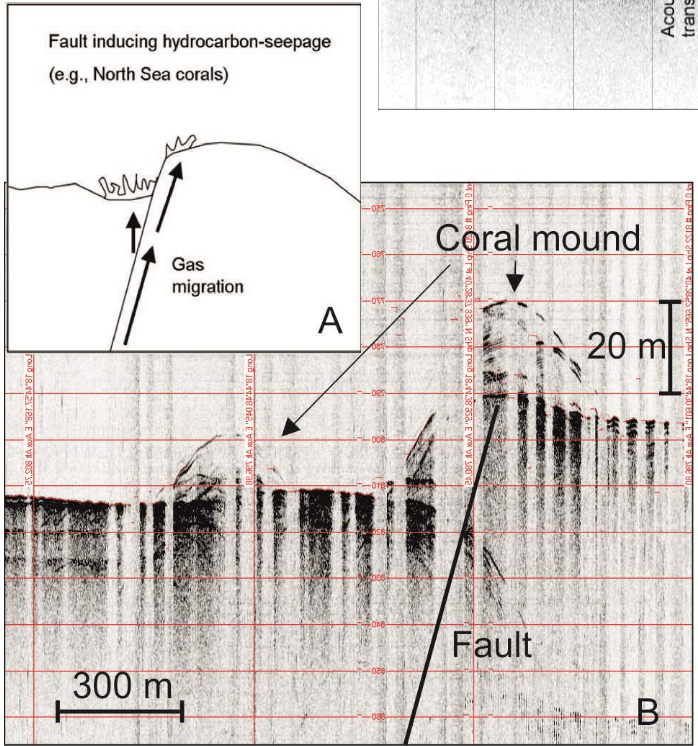
MS-29 seismic profile, Otranto Channel



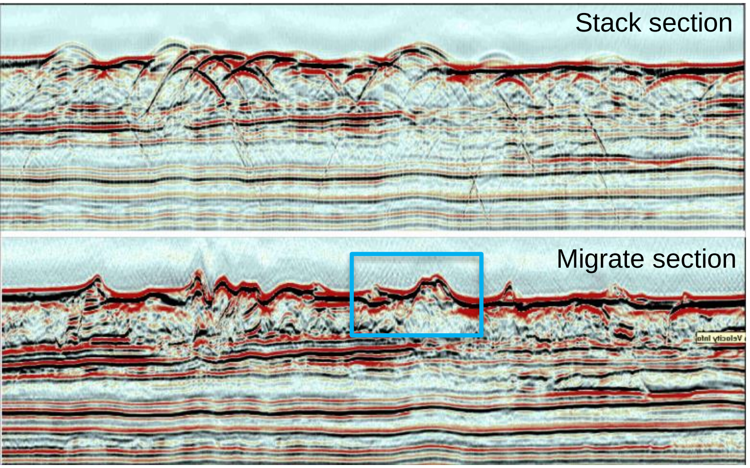
Seabed structures on Chirp profile, Multibeam data (GELETTI, 2008) corresponding to the bottom features previously highlighted on the MS-29 seismic profile (below). Sub-Bottom profile crossing the deep water mound, showing possible sediment drifts deposits with weak layers within the carbonate mound. The internal structures are poorly imaged due to the strong reflectivity of the sea floor. Along the MS-29 seismic profile a micro-fracture system (black arrows) was recognized and associated to differential sediment compaction. The micro-facture web represent the pathway along which the gas migrate from the bright spots (BS) toward the seabed.



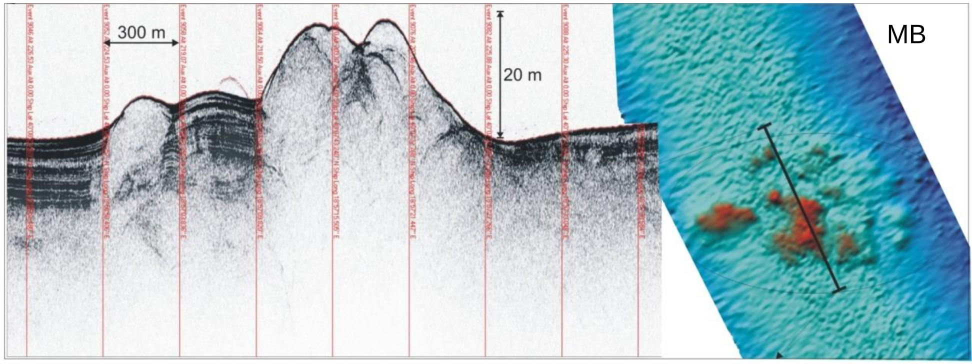




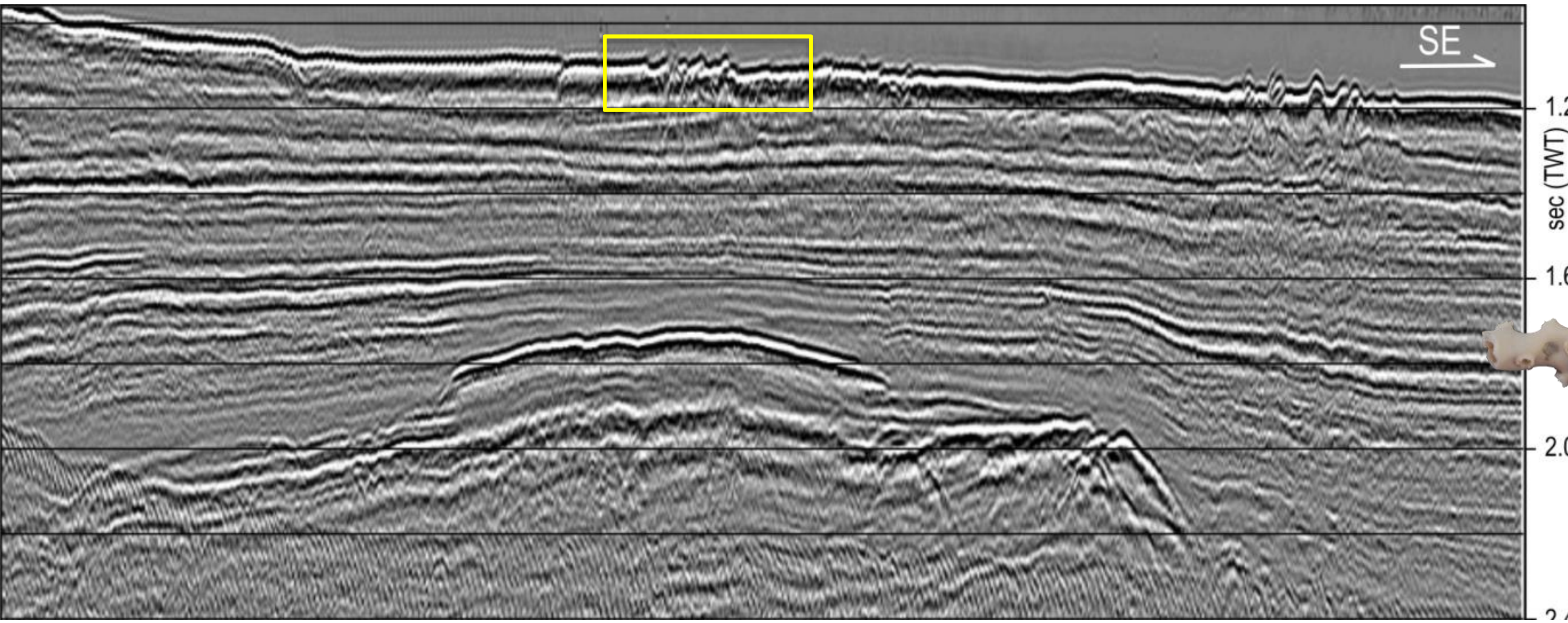
A) Sketch model of fault-linked development of deep-water coral mounds in the North Sea. The arrows indicate nutrient-rich fluid hydrocarbon seepage (from HOVLAND, 2005). B) CHIRP profile acquired during the OCSS15 cruise in the central Otranto Channel zone, showing Coral mounds over a fault

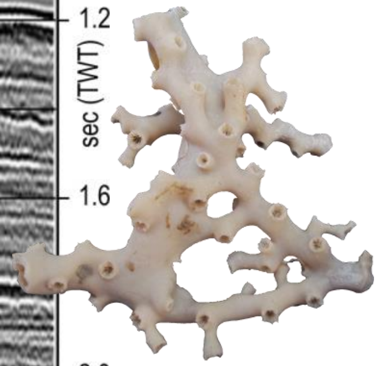


CHIRP profile

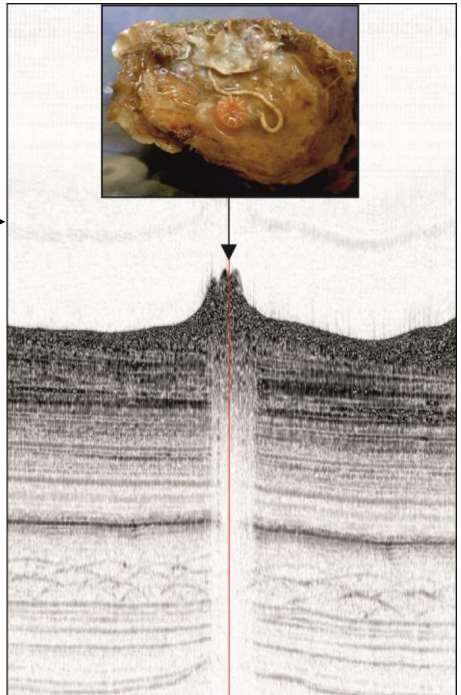


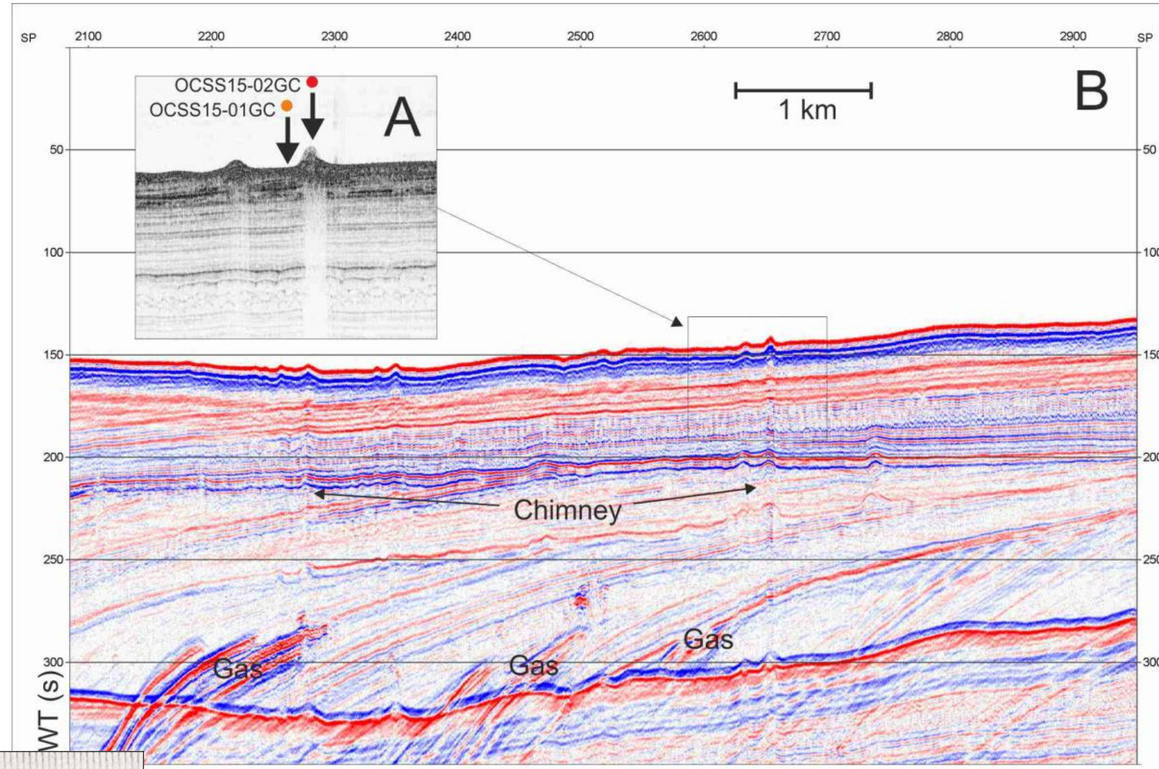
Seabed structures (carbonate mounds) on the seismic profiles (low & medium resolution), CHIRP and Multibeam (MB). (Geletti, 2008; Del Ben et al., 2008; Romeo et al. 2011).



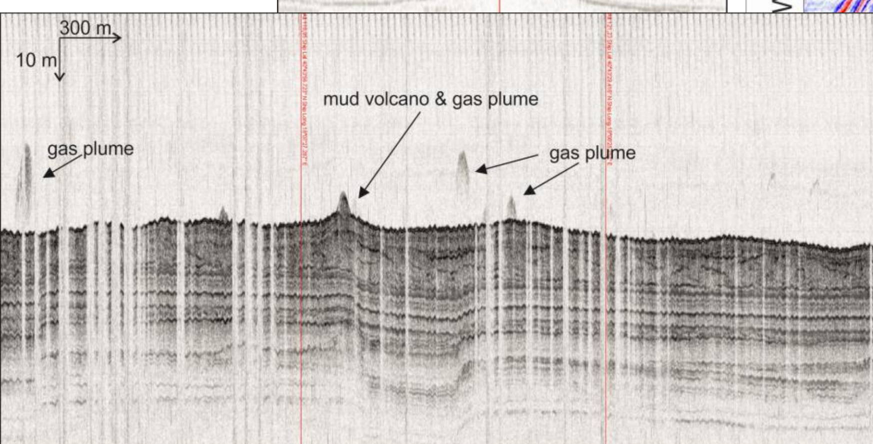


CHIRP profile (OCSS15 cruise) with a mound on which the corals were sampled





A) Chirp profile crossing some of the mud volcanoes calibrated by two gravity corers during the OCSS15 acquisition project. This CHIRP line was acquired on the seismic profile (B) of the same cruise: the sea bottom features are related to gas accumulations evidenced by some inclined bright spots. The image in B is a preliminary seismic stack section.



Detail of the CHIRP line with evidence of gas plumes

Figures from Geletti et al., 2018

Conclusion - 1

The Multi-Channel Seismic Reflection (MCS) method is:

- The most widespread method for the geophysical prospecting of the subsoil, fundamental in the exploration of hydrocarbon reservoir.
- It provides more detailed information than any other non-invasive method on stratigraphy, structure and properties of materials.
- It uses arrival times, amplitude and phase of the echoes from the discontinuity in the elastic properties present in the subsoil to obtain its position and physical properties (acoustic impedance, velocity propagation of seismic waves, elastic parameters, ...).

Disadvantages of the MCS method:

- High costs of data acquisition (R/V OGS Explora ship time - > 15-20 K€ a day)
- Complex signal processing required
- Numerous specialized people needed
- For a survey, numerous permits and authorizations are required

Conclusion - 2

The seismic reflection interpretation attributes geological meaning to geophysical data.
Interpretation provides information on:

- geometry of stratigraphic sequences and structural/tectonic elements
- seismic wave velocity
- Lithological characteristics

Applications for reconstructions of 2D section, structural maps, fault systems, slumping and seismic hazard.
The interpretation is made by a team of geologists / geophysicists / physicists with different skills who work in synergy.

"Interpretation is a combination of both art and science " (Lines and Newrick, 2004)

Questions

1. What is a seismic section?
2. What is the difference between seismic and geological section?
3. What is the vertical scale in a seismic section?
4. Which is the difference between seismic stack section and migrated section?
5. What is a diffraction?
6. What is a «bow-tie» event?
7. What is a multiple reflection?
8. What are the advantages of a migrated section?
9. Which seismic parameter is fundamental in depth migration?
10. Which is the first reflection in a marine seismic section?
11. What is the *acoustic basement*?
12. What is a « bright spot» in a seismic section?
13. What are the seismic characters that identify the possible presence of gas in the sediments?
14. What are the gas seeping structures?
15. What is the best acoustic method to study these structures?

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