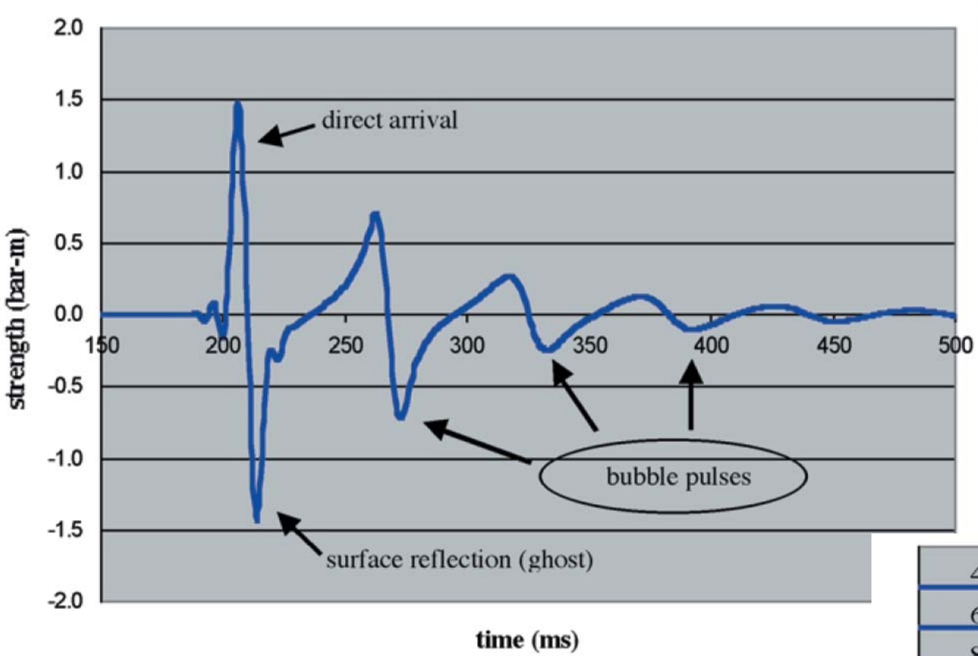
Three critical concerns for marine seismics with portable systems

- Source strength and tuning
- Streamer length
- 2D vs. 3D

Airgun Source

Single airgun

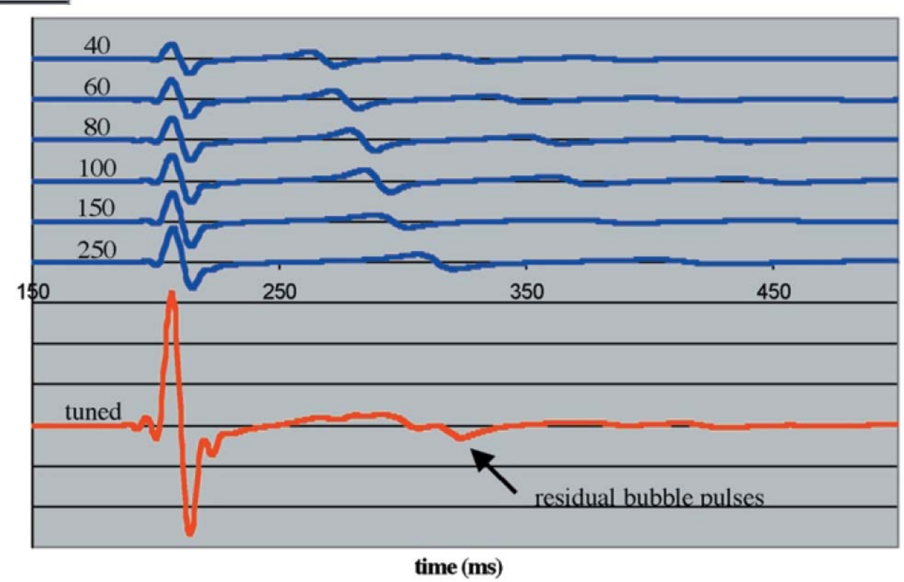


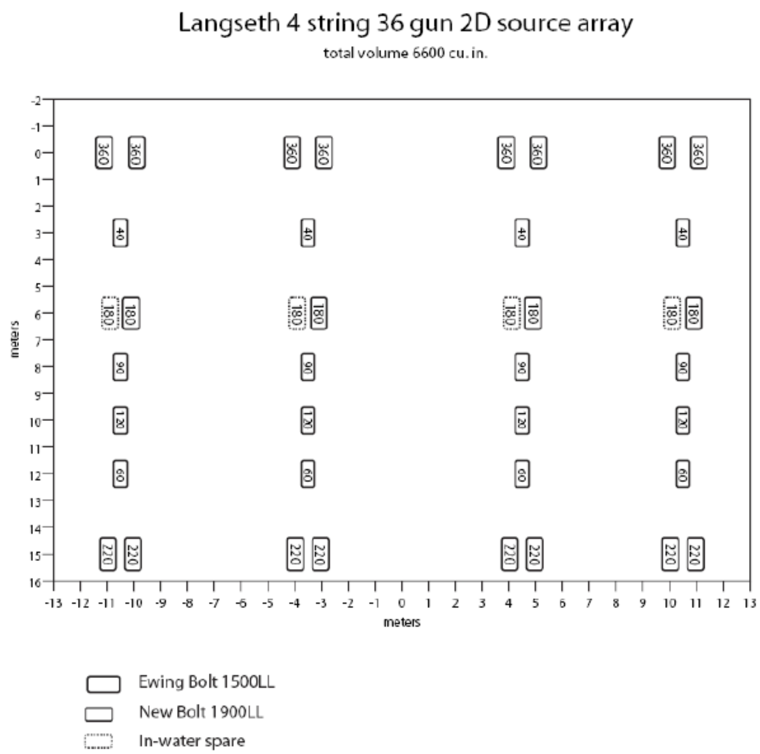
Multiple airguns

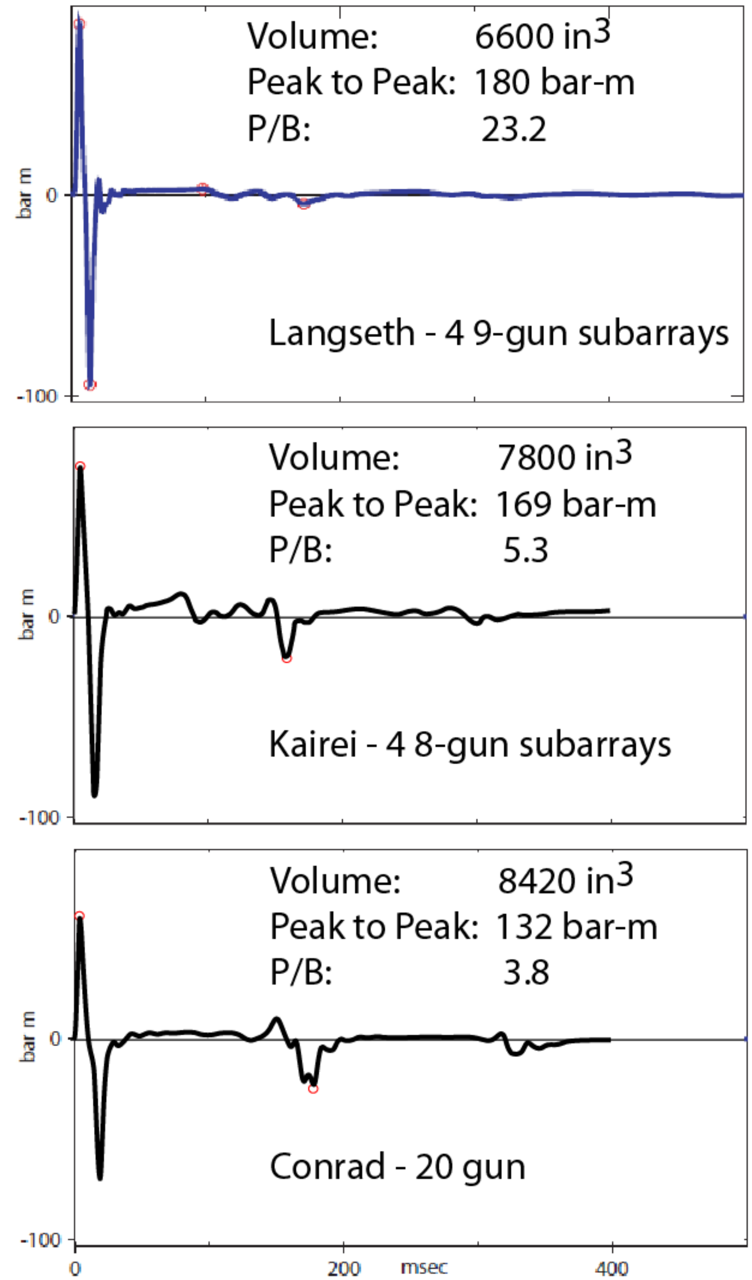
signal strength ∝ volume $^{1/3}$

$1 \times (200\ \text{in}^3)^{1/3} = 5.85$

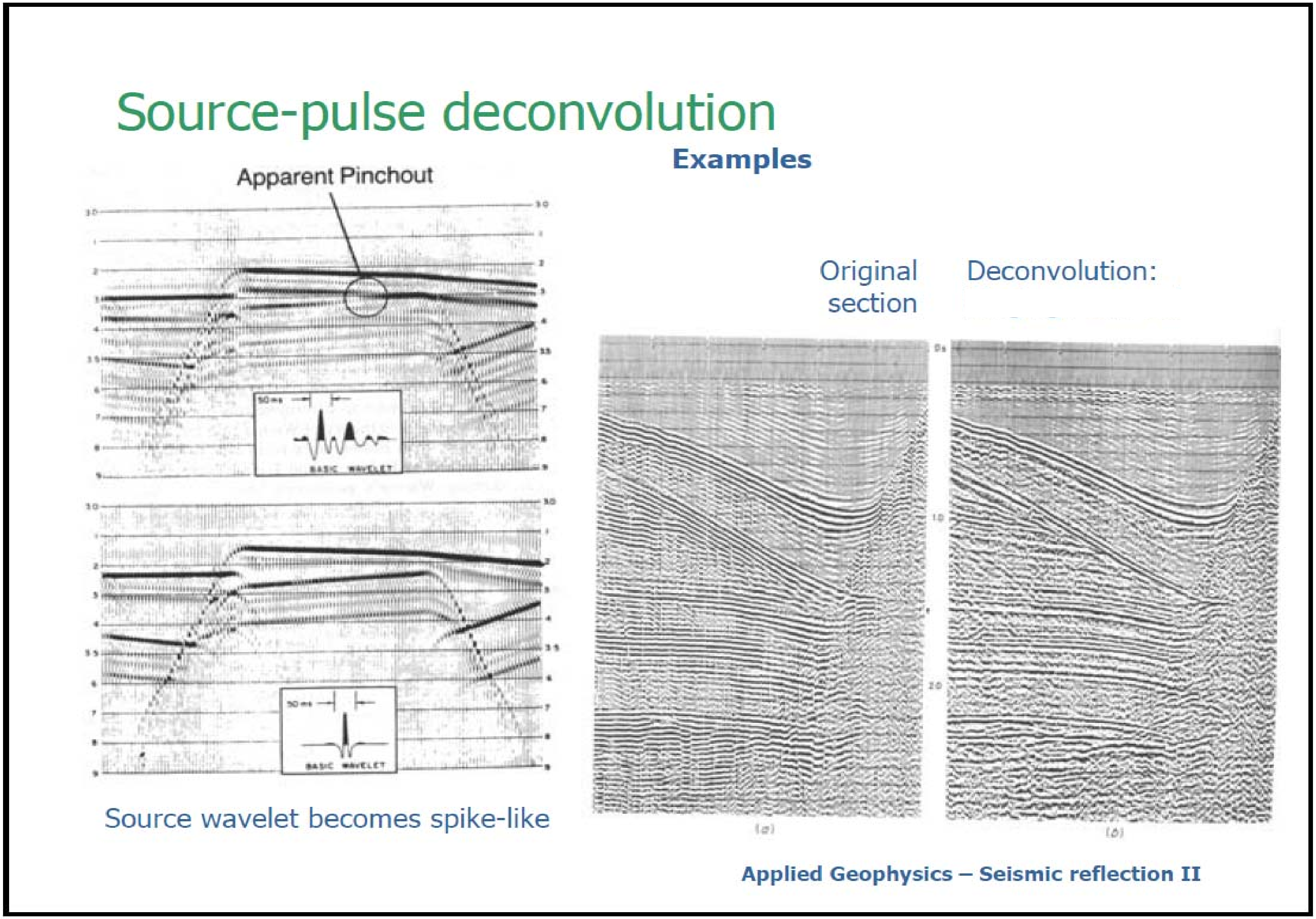
$4 \times (50\ \text{in}^3)^{1/3} = 4 \times 3.69 = 14.76$




Langseth 4 string 36 gun 2D source array
total volume 6600 cu. in.
meters
meters
Ewing Bolt 1500LL
New Bolt 1900LL
In-water spare


Volume: 6600 in3
Peak to Peak: 180 bar-m
P/B: 23.2
Langseth - 4 9-gun subarrays
Volume: 7800 in3
Peak to Peak: 169 bar-m
P/B: 5.3
Kairei - 4 8-gun subarrays
Volume: 8420 in3
Peak to Peak: 132 bar-m
P/B: 3.8
Conrad - 20 gun
bar m
msec

Bubble pulse effects and removal

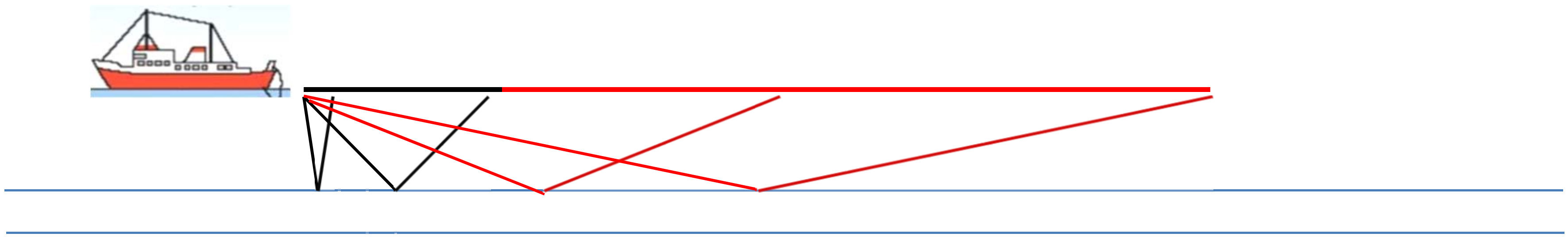


Large, tuned array is critical for seismic imaging and OBSs

- Large signal (peak-to-peak amplitude) requires large number of guns
- Tuning requires large number of guns with various sizes

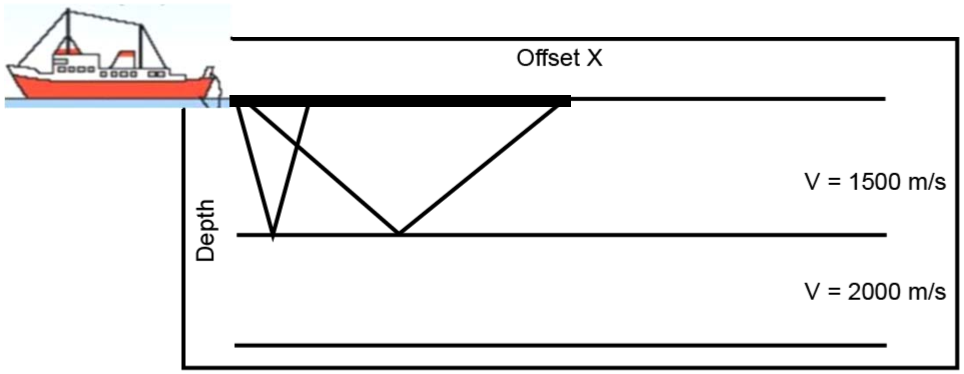
  (with some consideration of their location within the array)

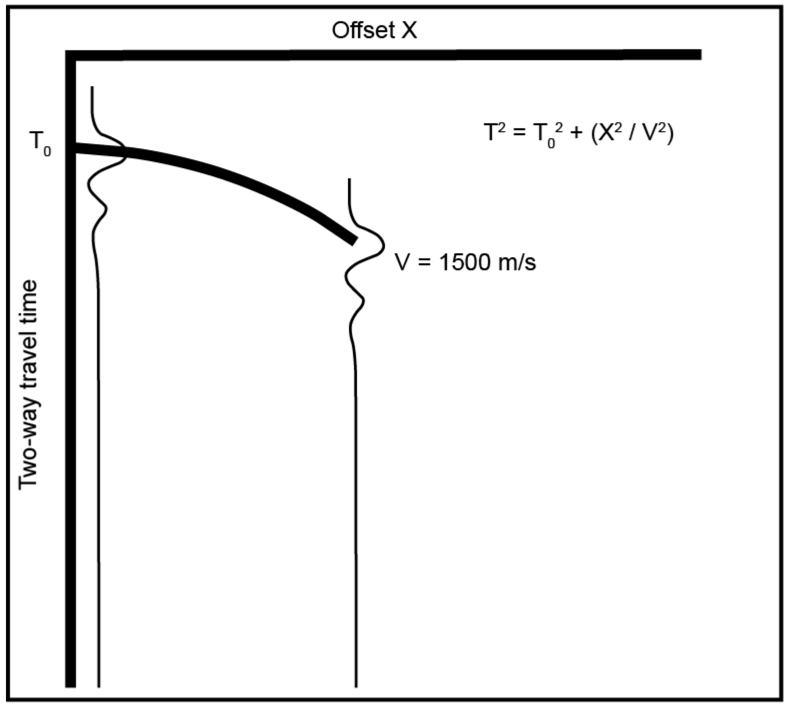
Long offsets (large incidence angles)



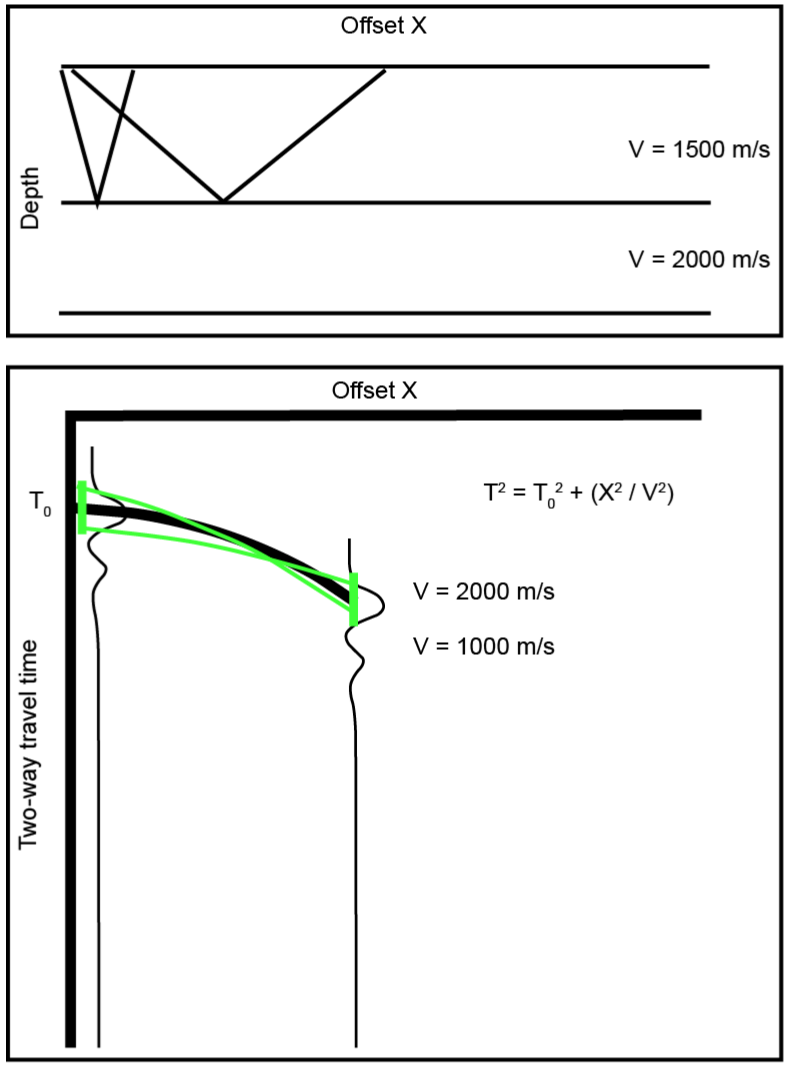
- More traces for stacking   (signal improvement $\propto$ sqrt (n))
- Velocity control
- Multiple suppression
- Amplitude with offset (angle) and rock properties

Velocity Control

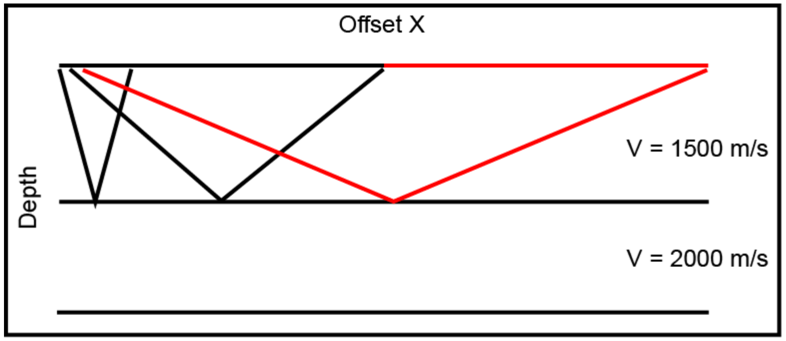


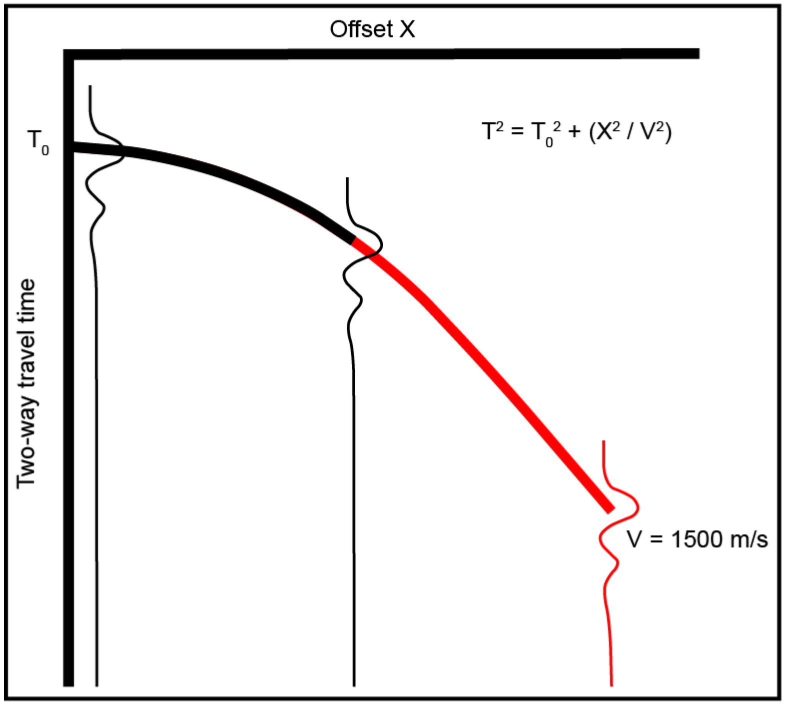


Velocity is a function of signal arrival time and source-receiver offset

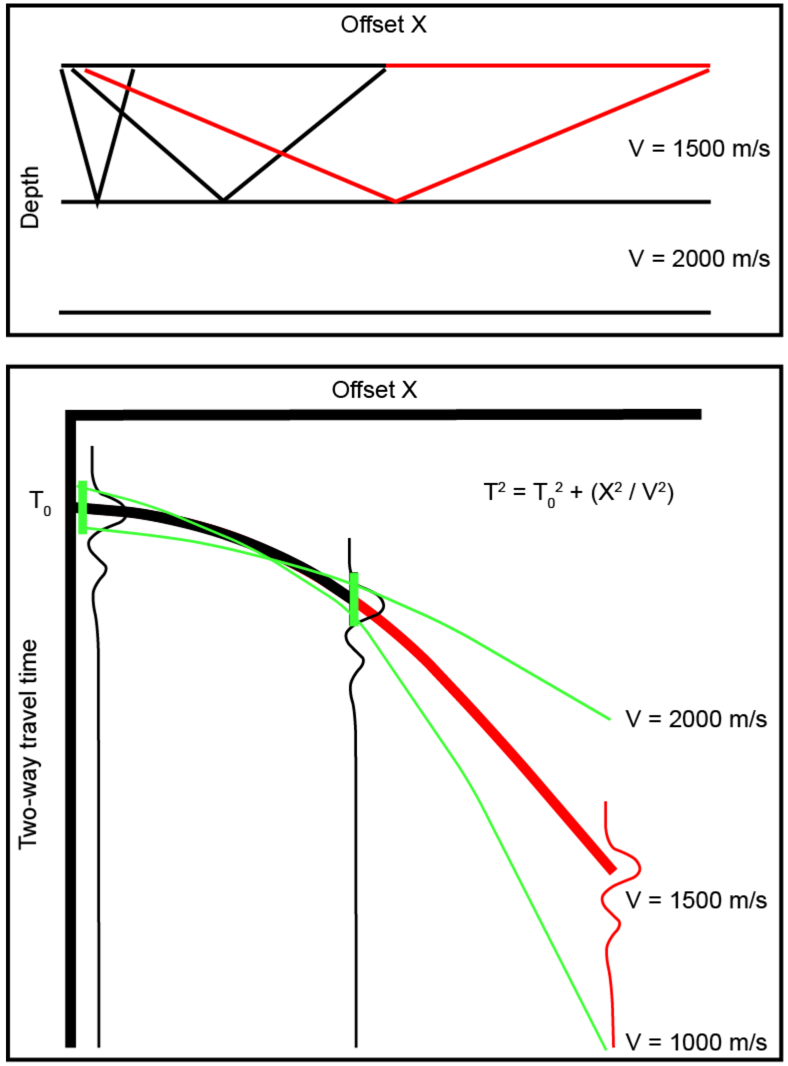


Signal arrival time
is inherently uncertain,
which propagates to
seismic velocity

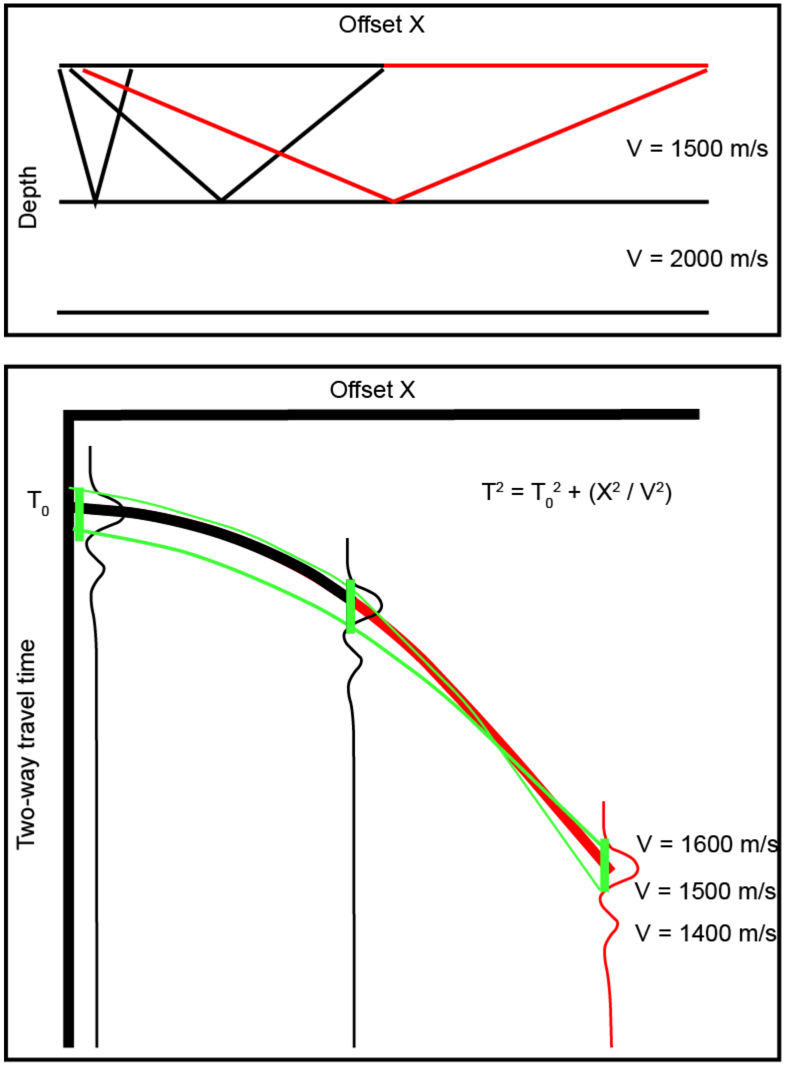




Long source-receiver offsets record rays that travel through more of the medium.

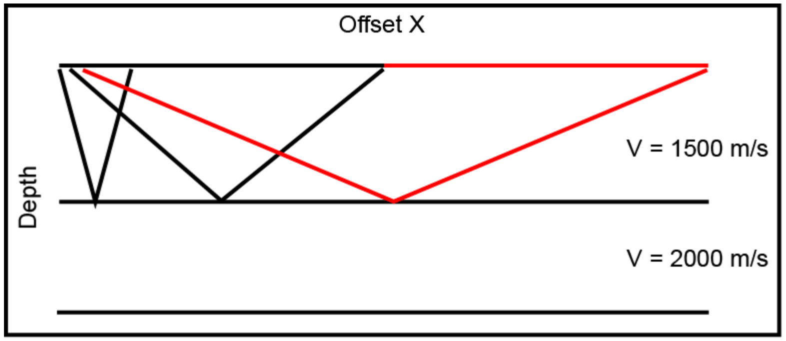


Reflections recorded at longer offsets can constrain traveltime curves that cannot be constrained at short offsets.

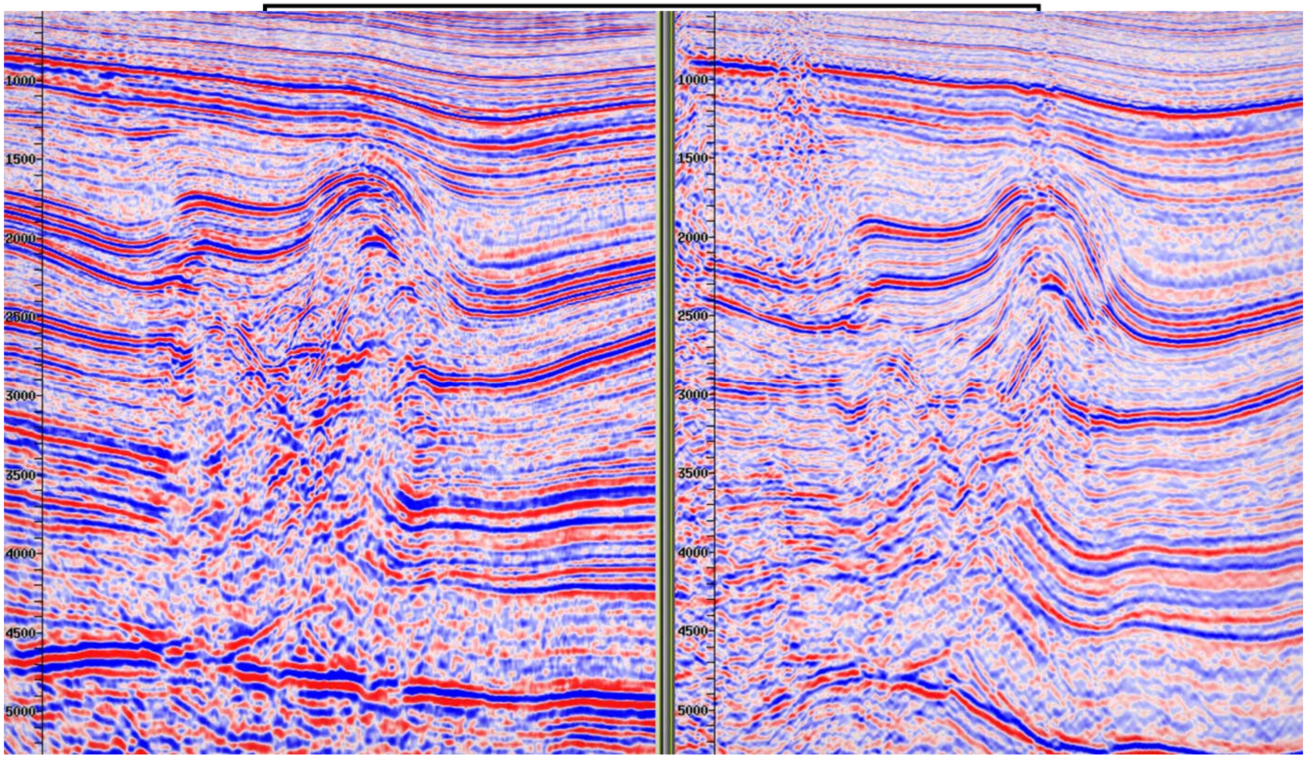


Long offsets constrain the traveltime curve to narrower limits than short offsets thereby also constraining velocity.

Velocity Control for Imaging



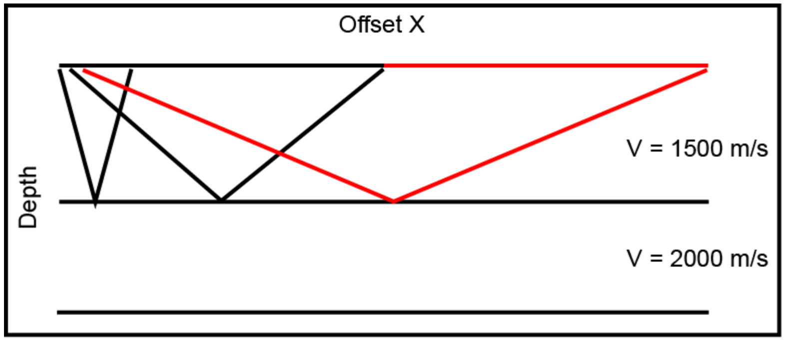
Velocities are critical for imaging, especially with large lateral velocity variations that require prestack depth migration.



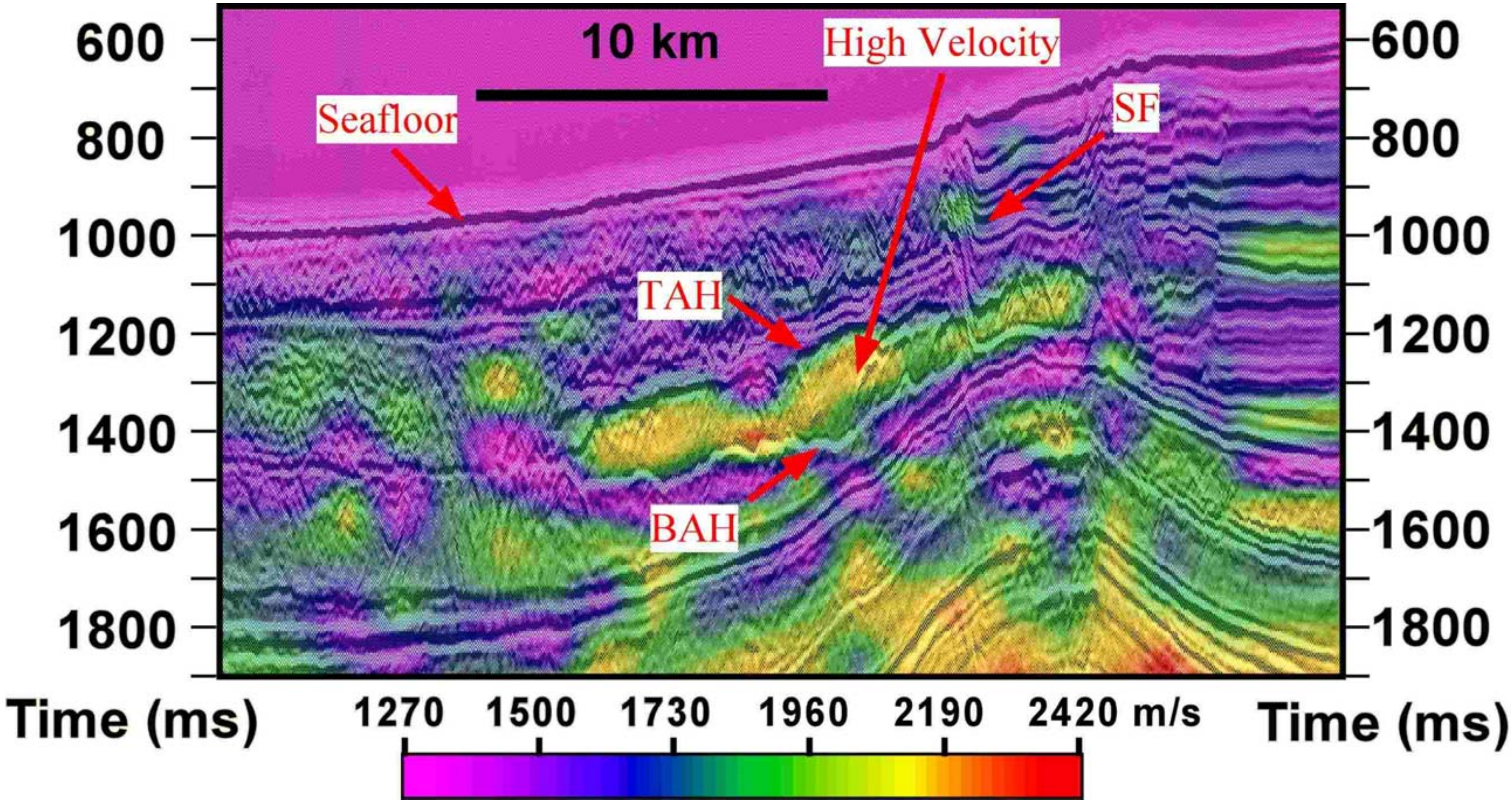
Poor Focus

In Focus

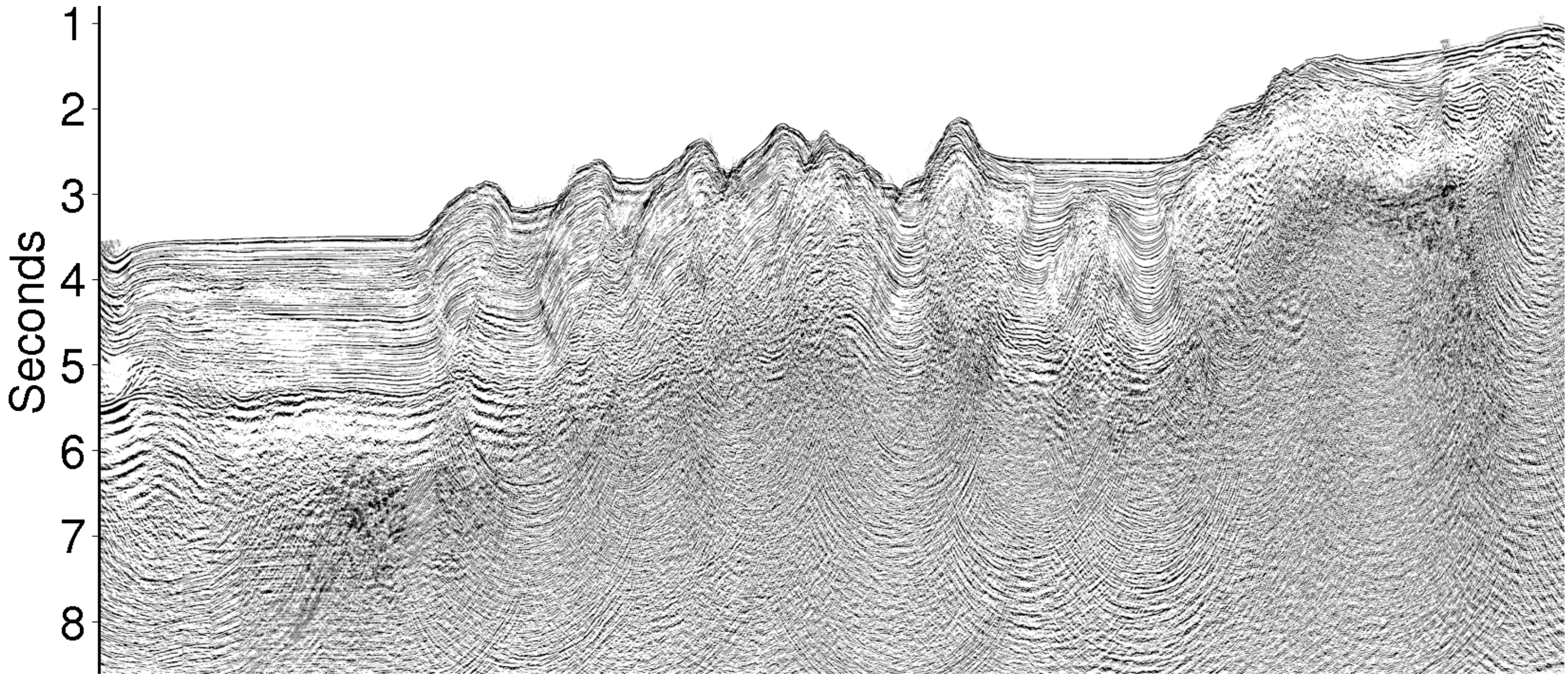
Velocity Control for Interpretation



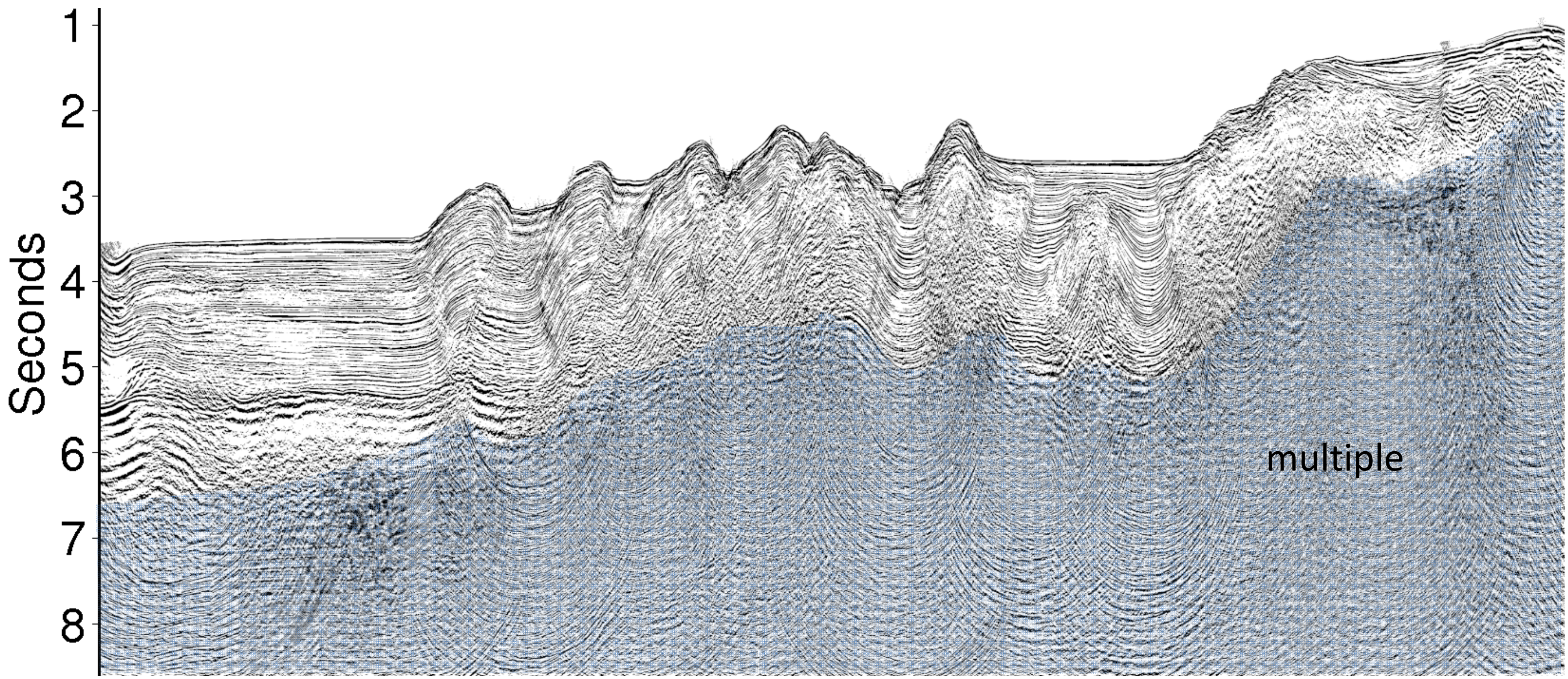
Accurate velocities can be used for interpretation of rock properties.



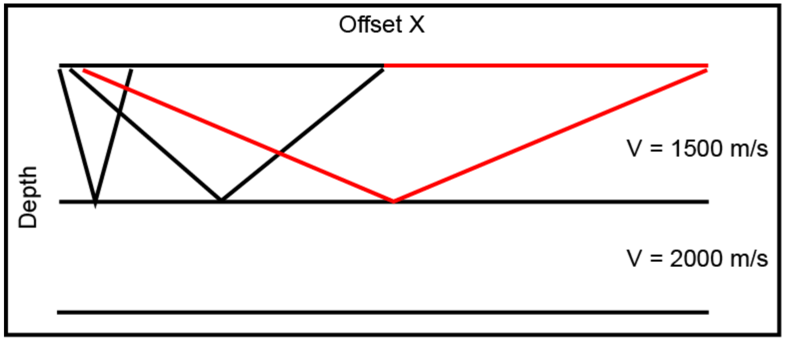
Velocity-Based Multiple Suppression

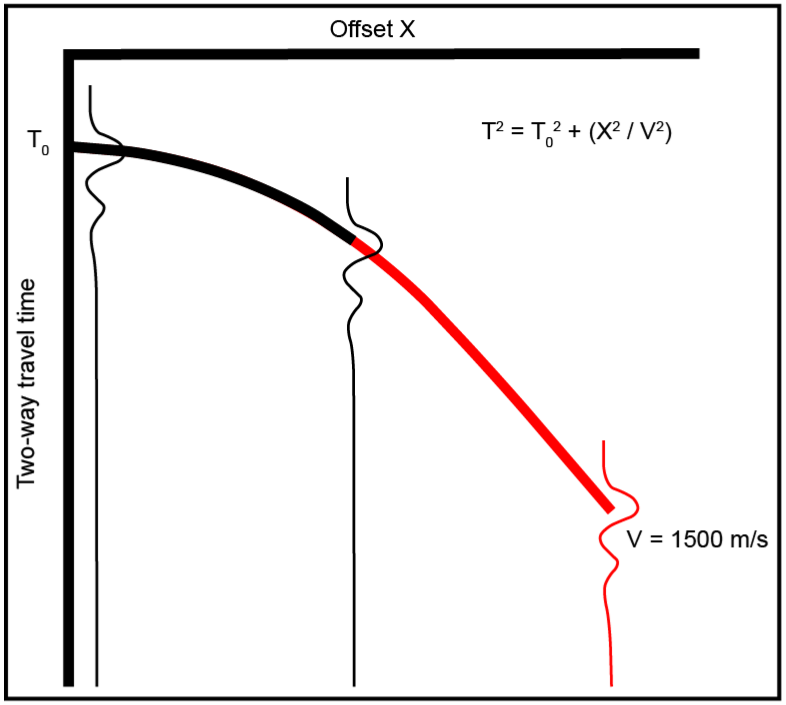


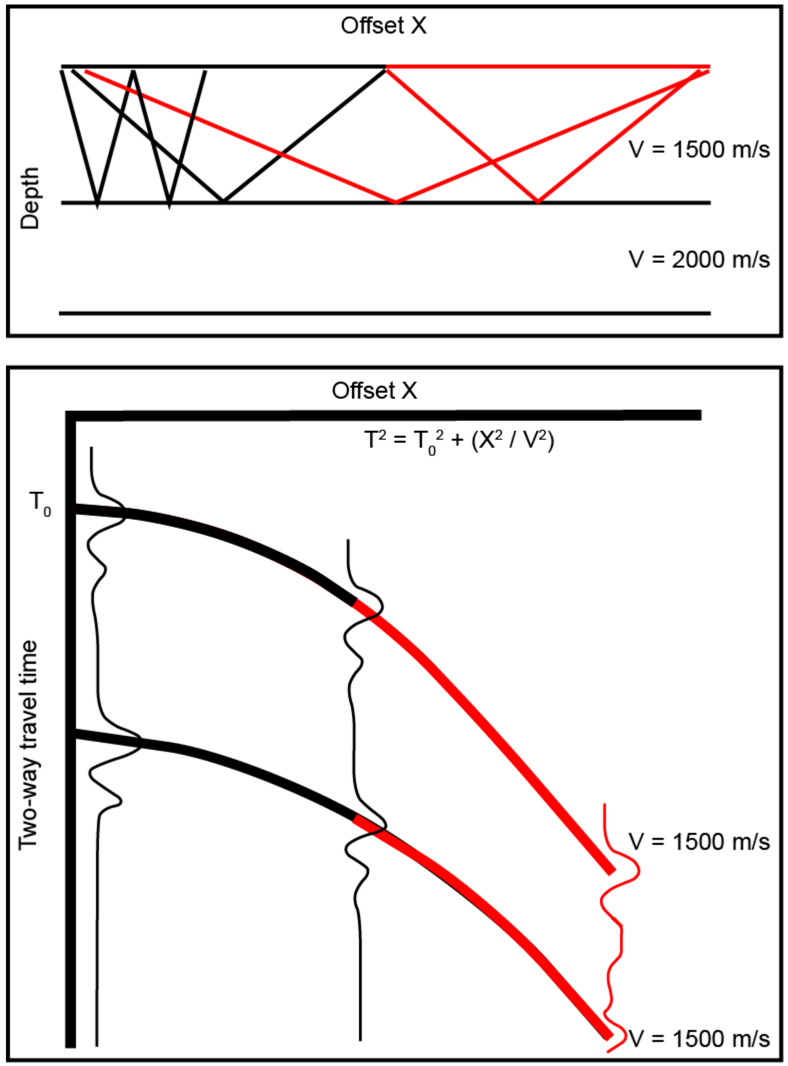
Velocity-Based Multiple Suppression



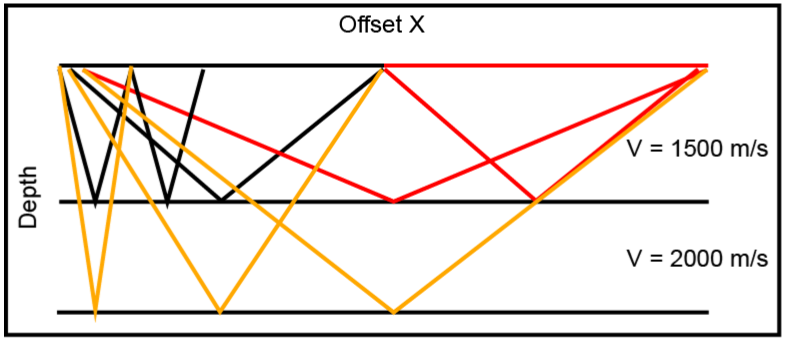
Velocity-Based Multiple Suppression

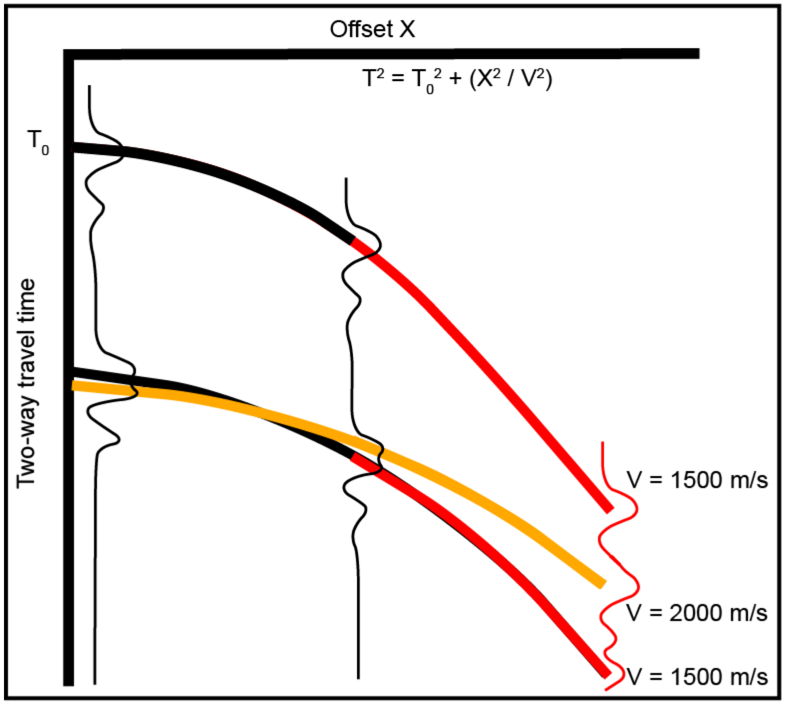




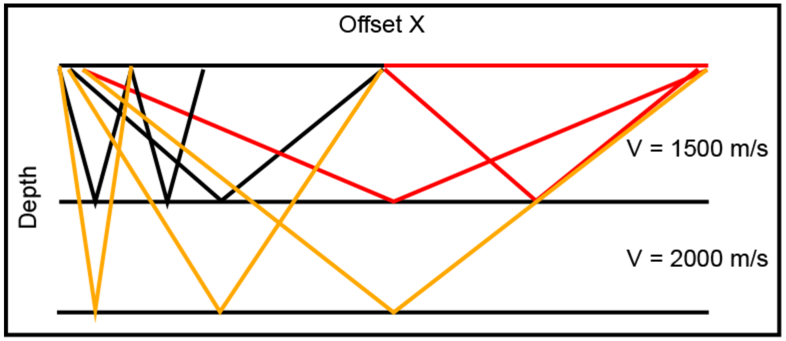


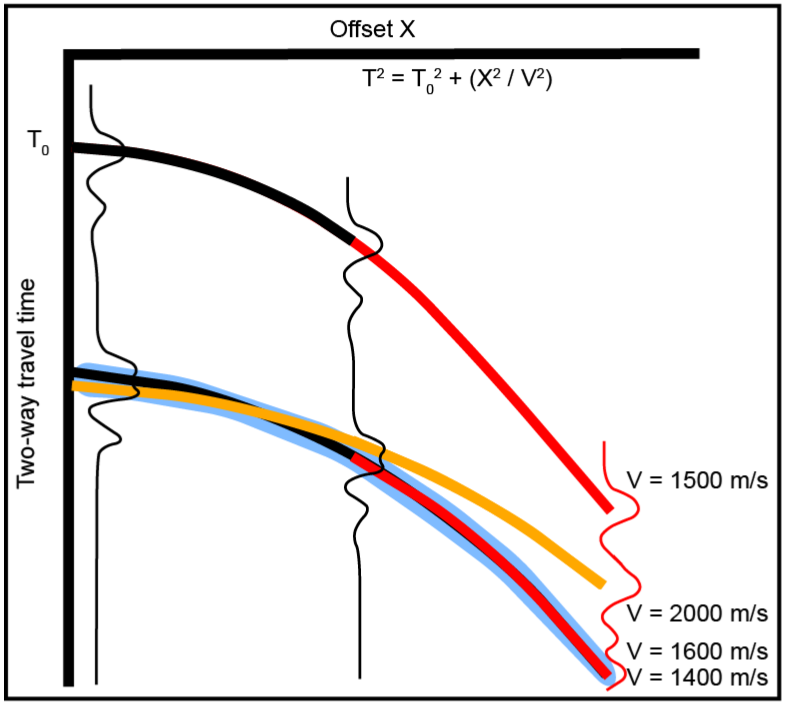
Multiples produce similar traveltime curves delayed relative to the primary.



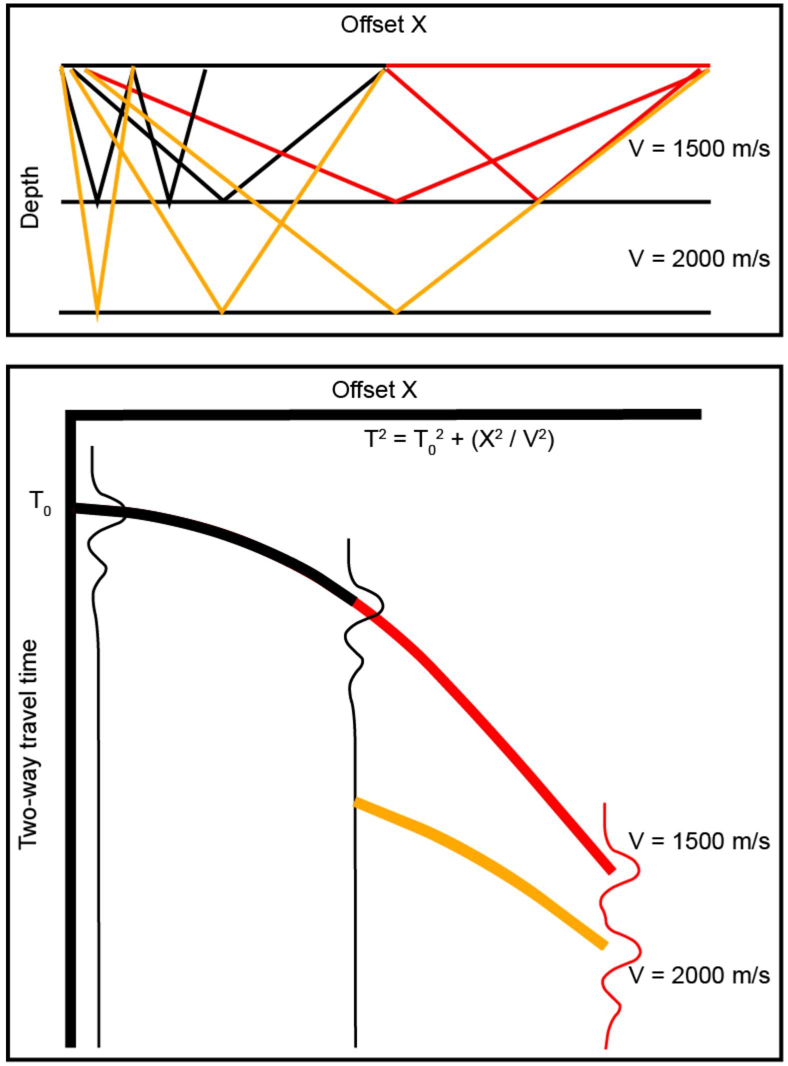


Multiples frequently interfere with primary arrivals.



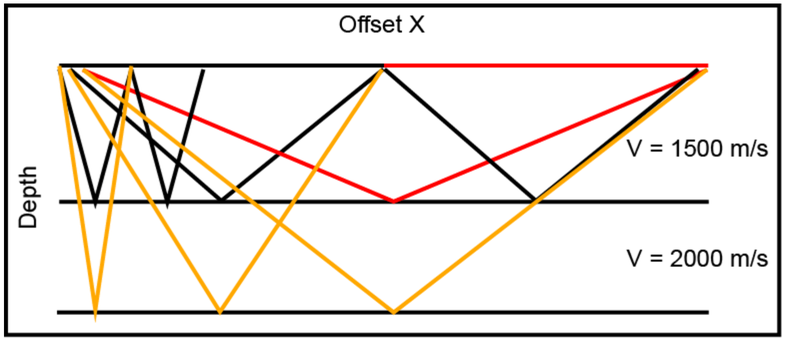


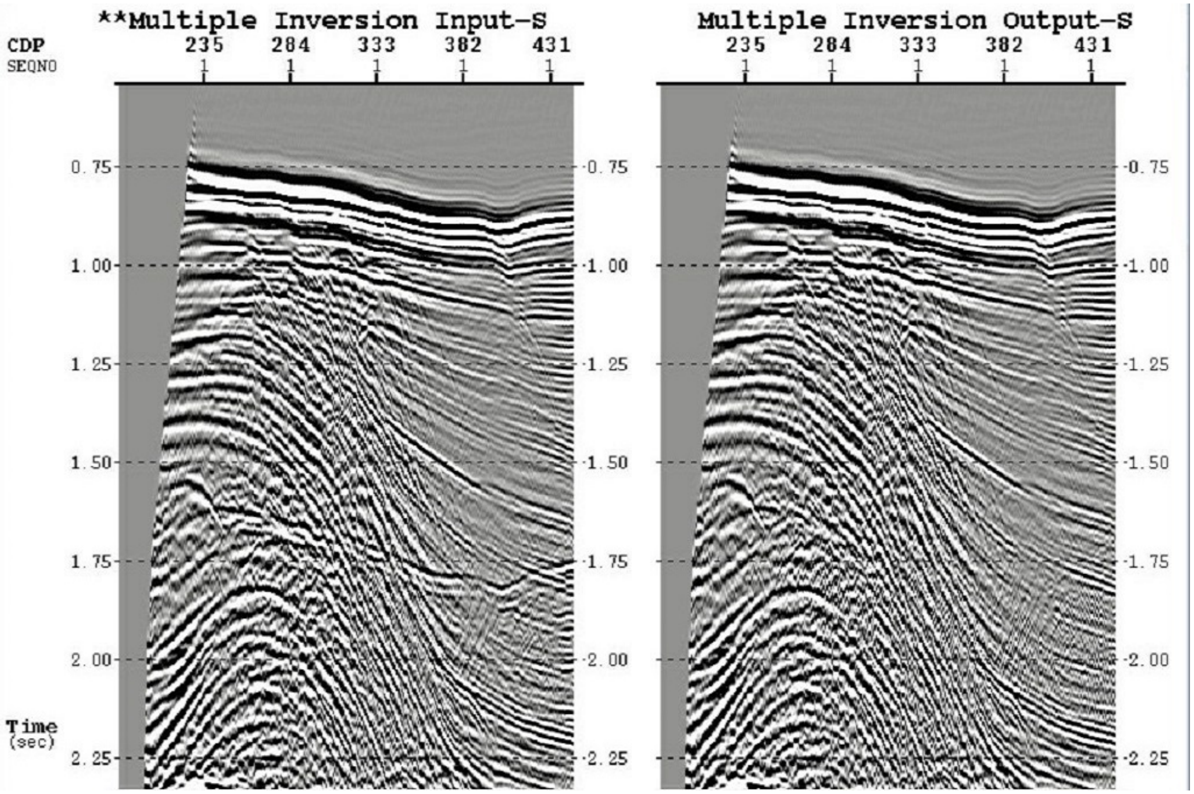
The arrival times of multiples that differ little at short offsets, separate at far offsets.



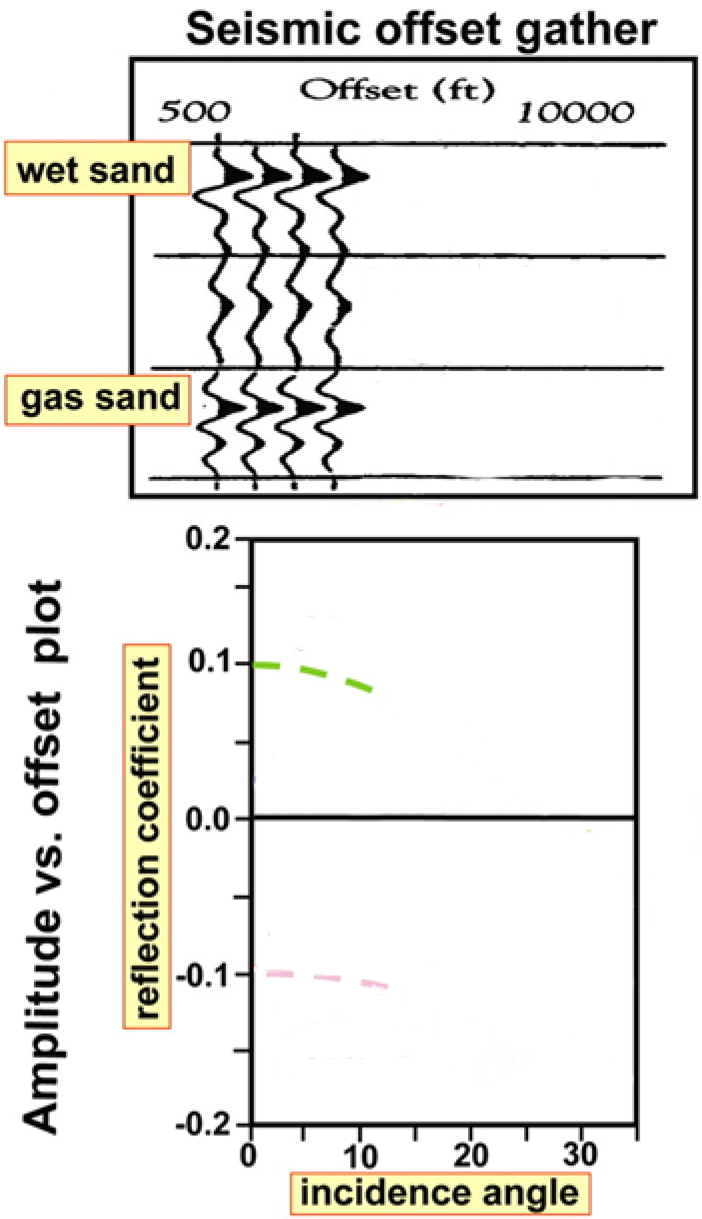
Multiples can be removed with partial loss of the primary.

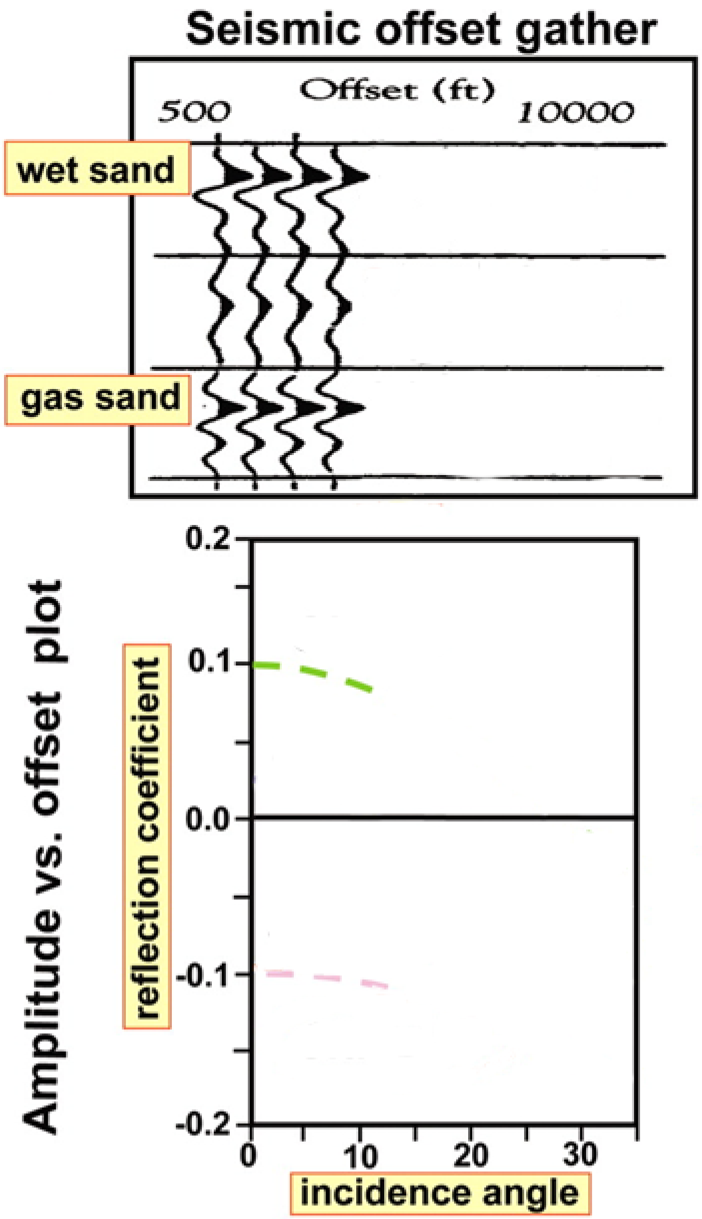
Velocity-Based Multiple Suppression

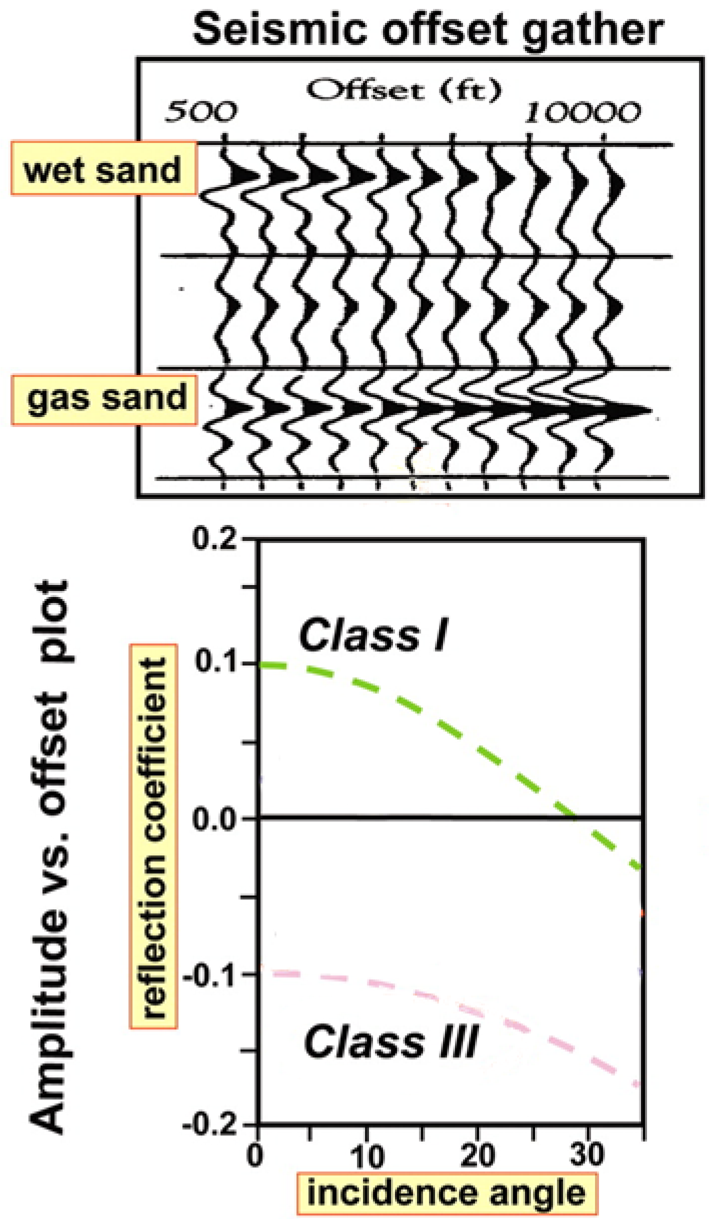




AVO and rock properties

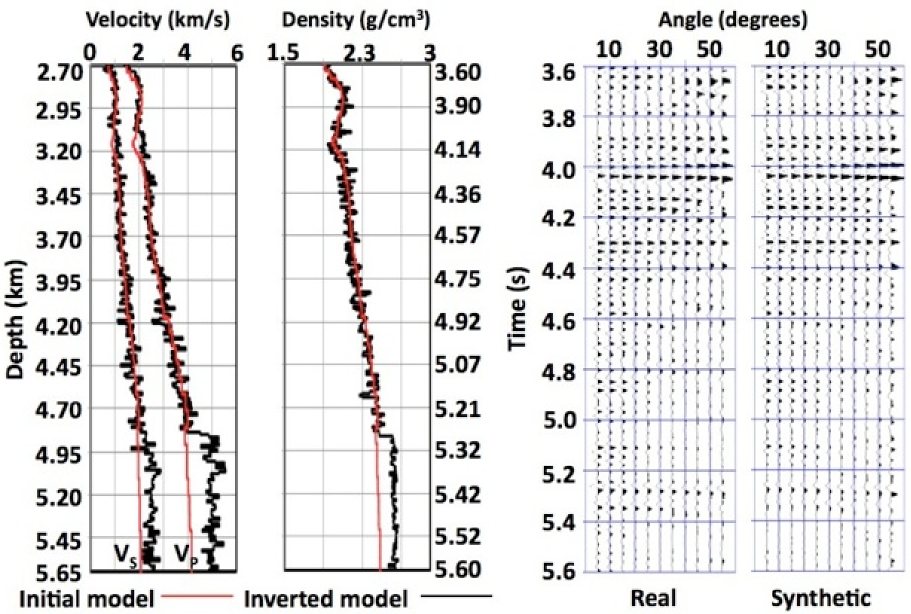



Seismic offset gather
Offset (ft)
500
10000
wet sand
gas sand
Amplitude vs. offset plot
reflection coefficient
0.2
0.1
0.0
-0.1
-0.2
0
10
20
30
incidence angle

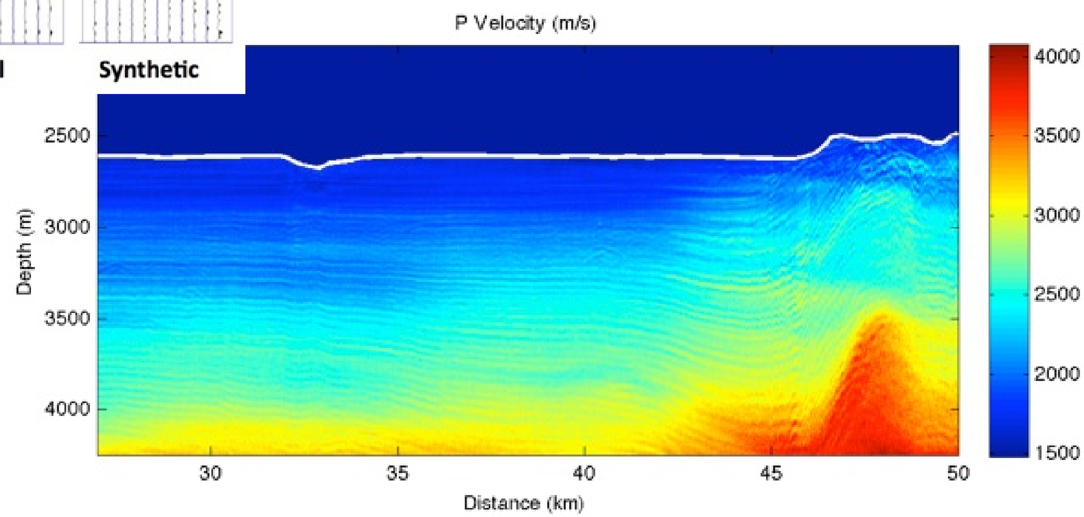

Seismic offset gather
Offset (ft)
500
10000
wet sand
gas sand
Amplitude vs. offset plot
reflection coefficient
Class I
Class III
0.2
0.1
0.0
-0.1
-0.2
0
10
20
30
incidence angle

Sediment properties from long offset streamers

Cascadia Subduction Zone
(COAST project)



Long offsets allow waveform inversion
- bulk property changes
- localized property anomalies



From Will Fortin, U. Wyoming

Physics requires long streamers for:

- Velocity control

    - imaging (normal moveout, stacking and migration, or prestack migration)

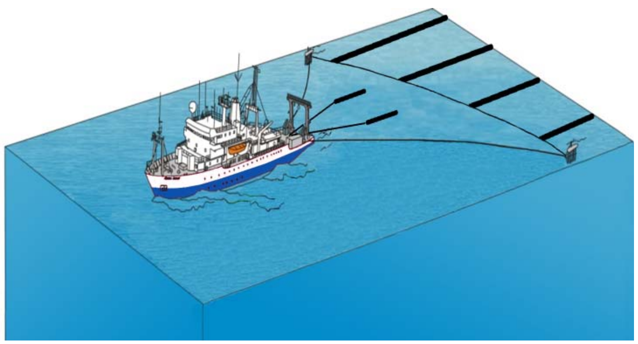
    - rock property information (V_p)

- Effective multiple suppression

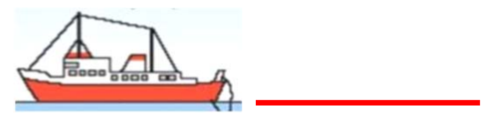
- Extracting rock property information by exploiting AVO (V_p, V_s, density)

3D vs. 2D

3D seismic acquisition

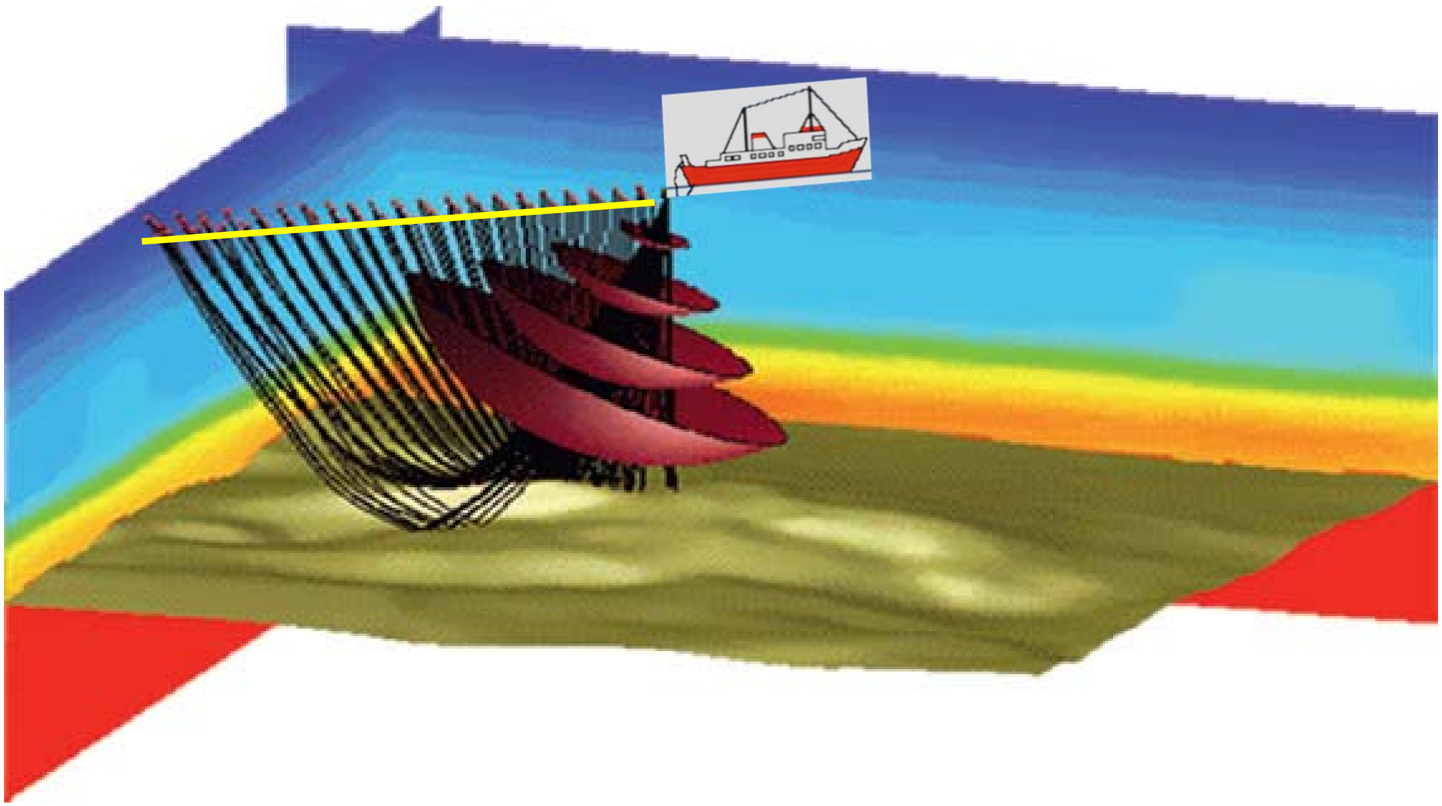


2D seismic acquisition



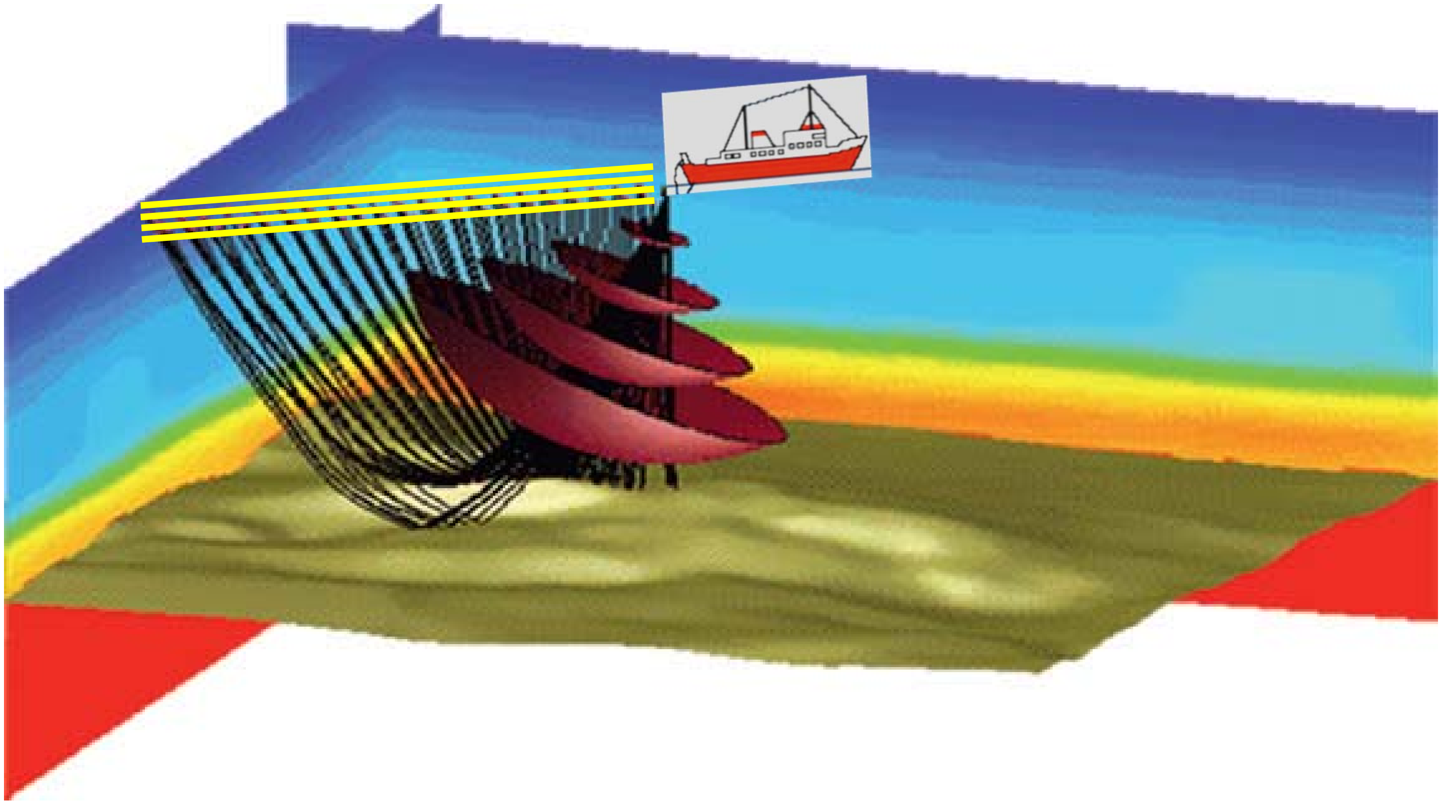
- Improves imaging (especially in structurally complex settings)
- Ability to map structures in their true 3D geometry

2D Imaging



On a single streamer, seismic signals reflected from an irregular surface will contain out-of-plane arrivals and miss other scattered energy.

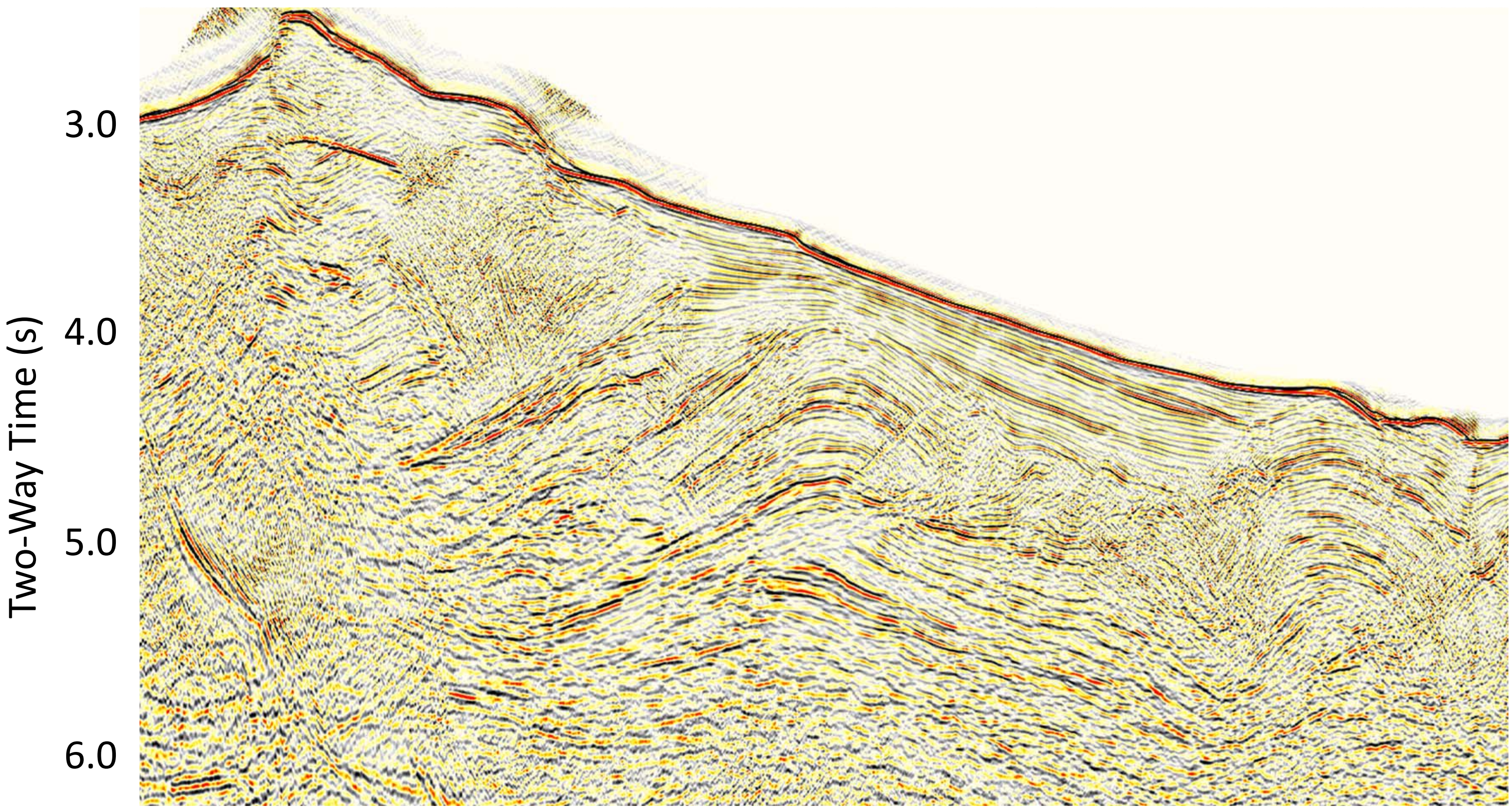
3D Improves Illumination which Improves Imaging



Multiple streamers receive seismic reflections the scattered energy that can be used to image the subsurface more completely.

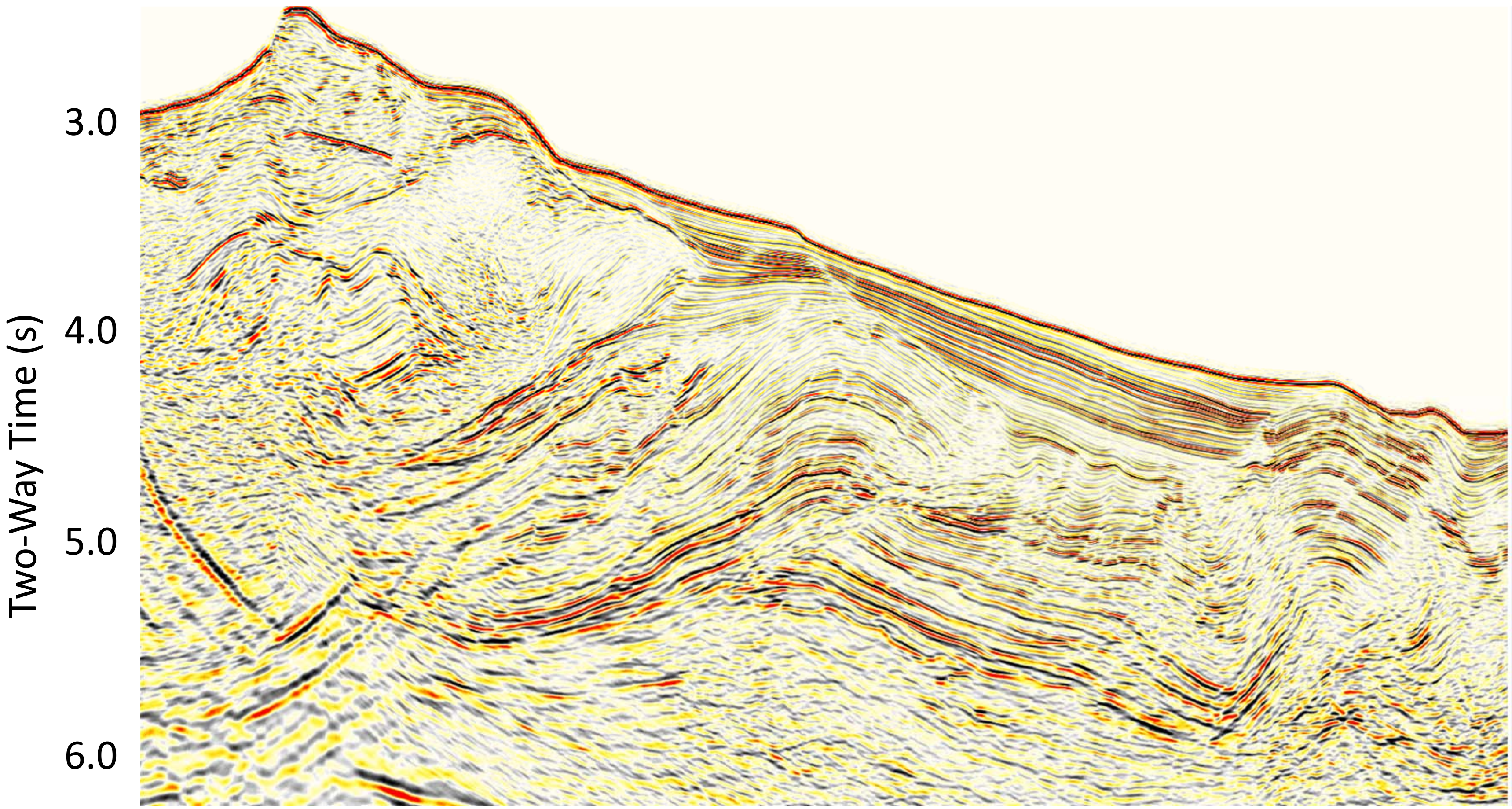
2D

Acquired by Fugro in ~2000
6000 m 480-channel streamer
4240 cu. in airgun array

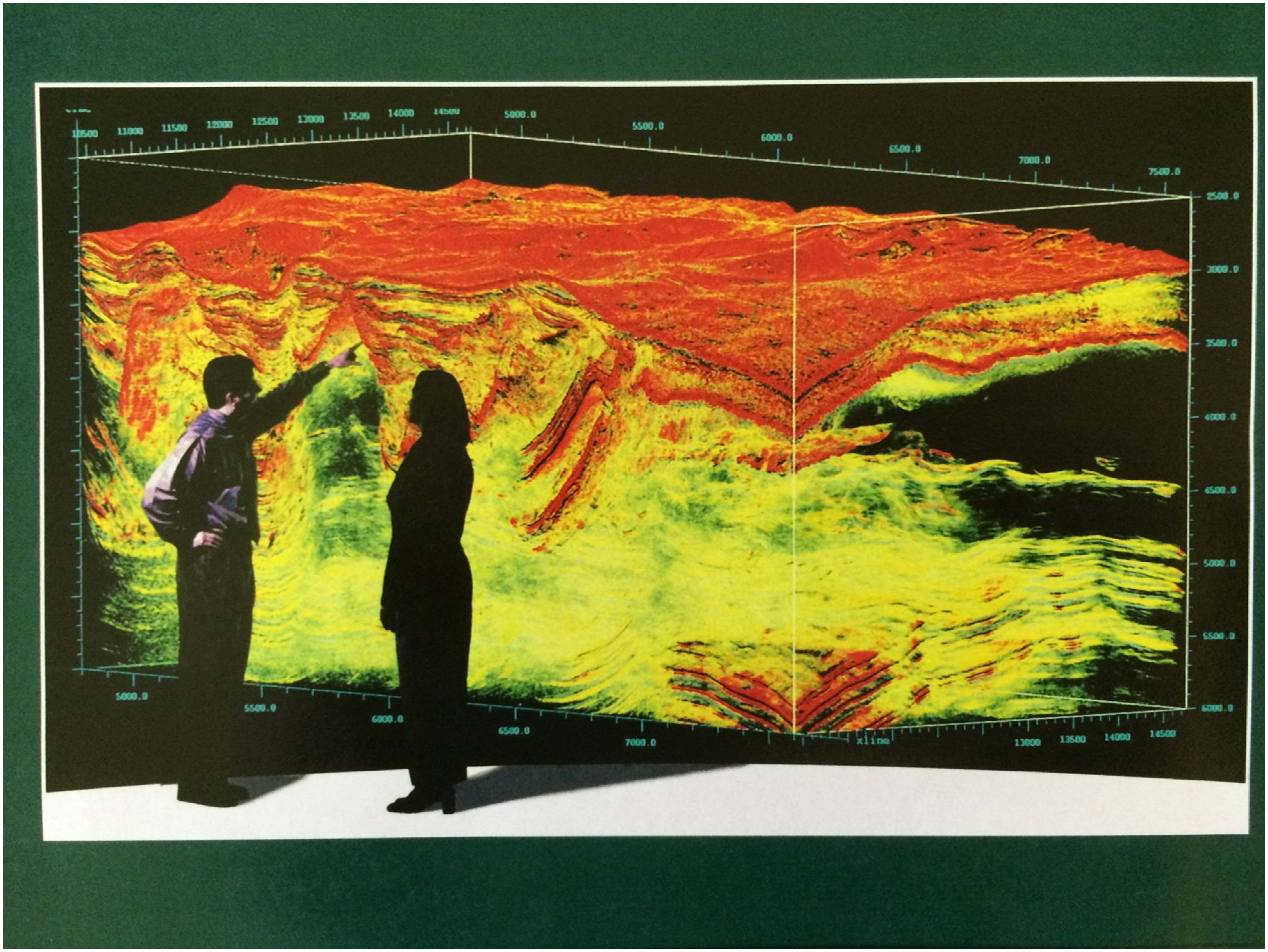


3D

Acquired by PGS in 2006
4500 m 360-channel streamer
3090 cu. in airgun array



3D Structural Interpretation



Can we maintain Langseth capabilities with a portable system?

Can we compromise on any of these capabilities and achieve our science goals?

Langseth Capabilities and Science Goals

- How did Langseth capabilities enable us to achieve science goals?

- How will Langseth capabilities enable us to achieve future science goals?

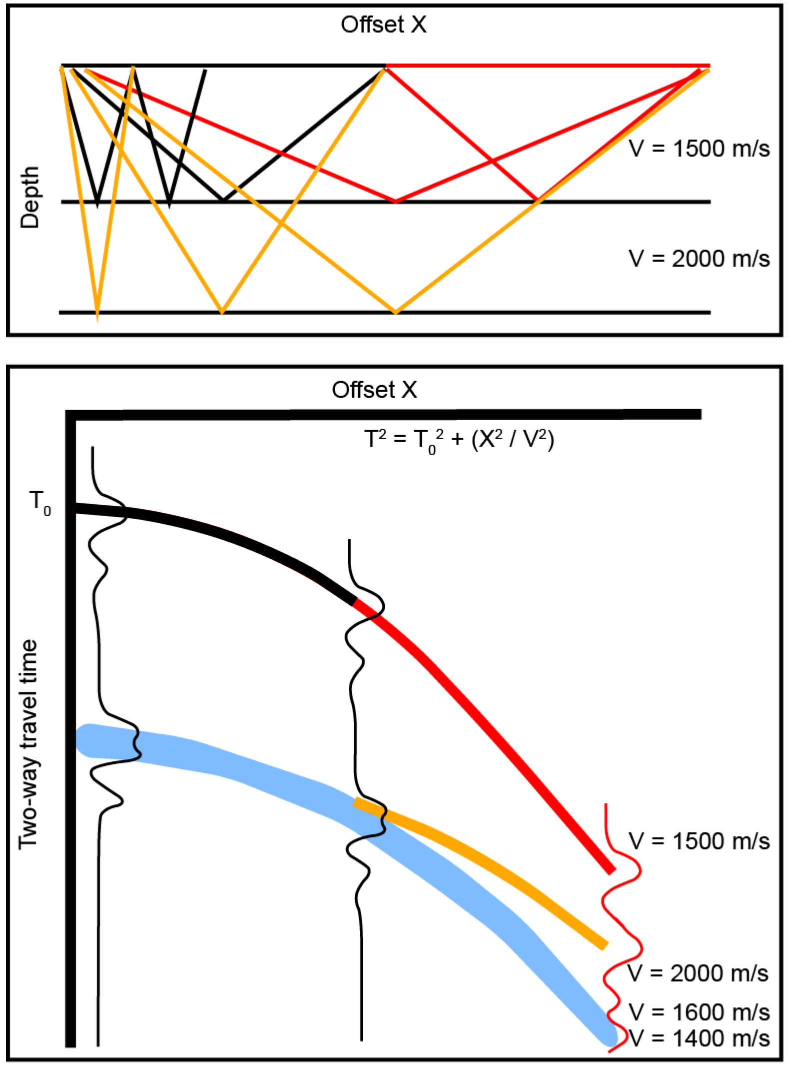
2D vs 3D

- Imaging of complex structures
- Interpreting true 3D geometry and mapping in 3 dimensions

Would losing the

- large, well-tuned source
- long streamer
- 3D imaging

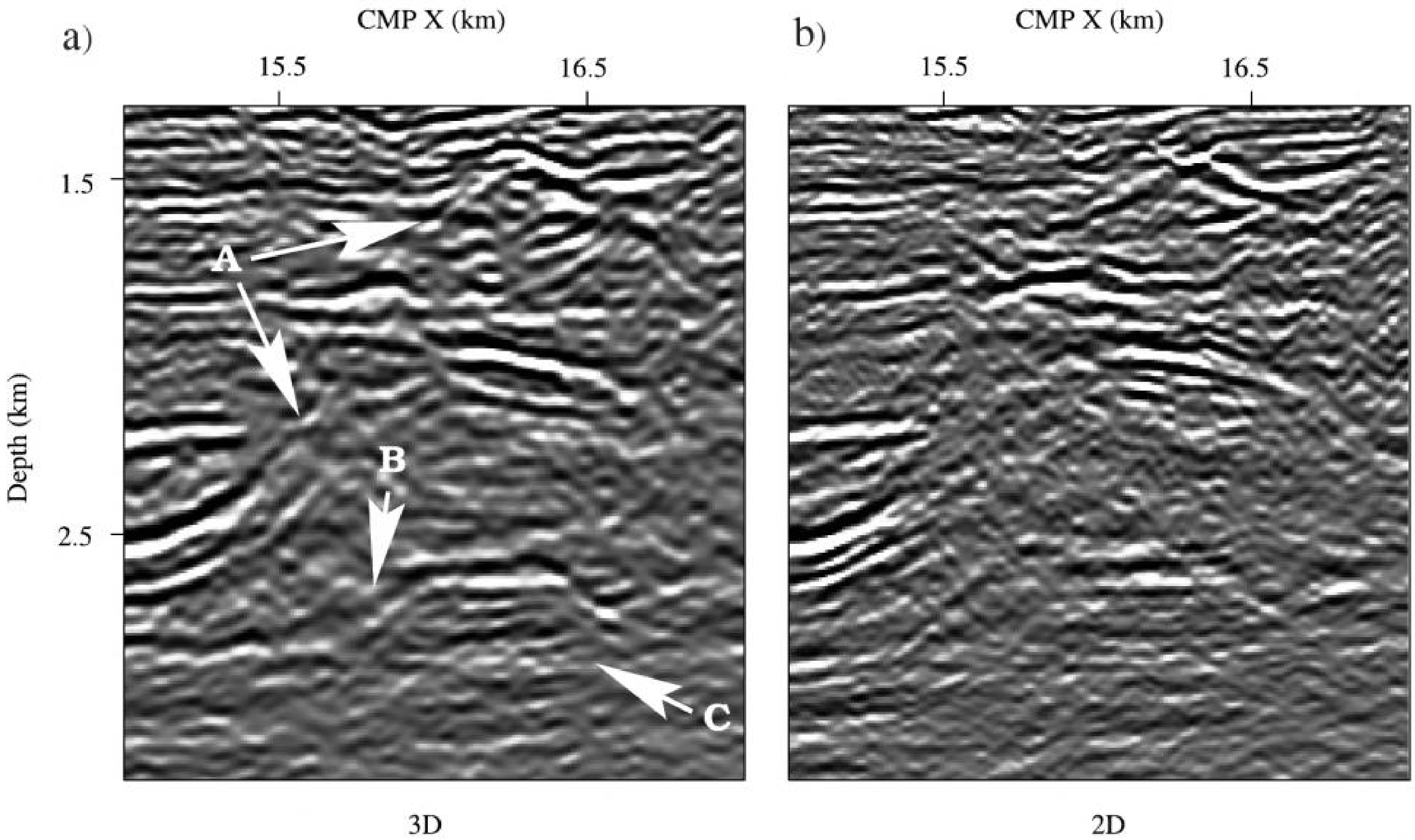
impact our ability to address important future science questions?



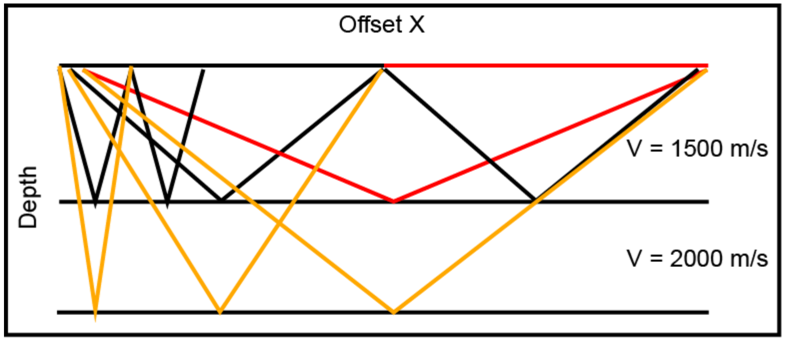
Multiples can be removed with partial loss of the primary.

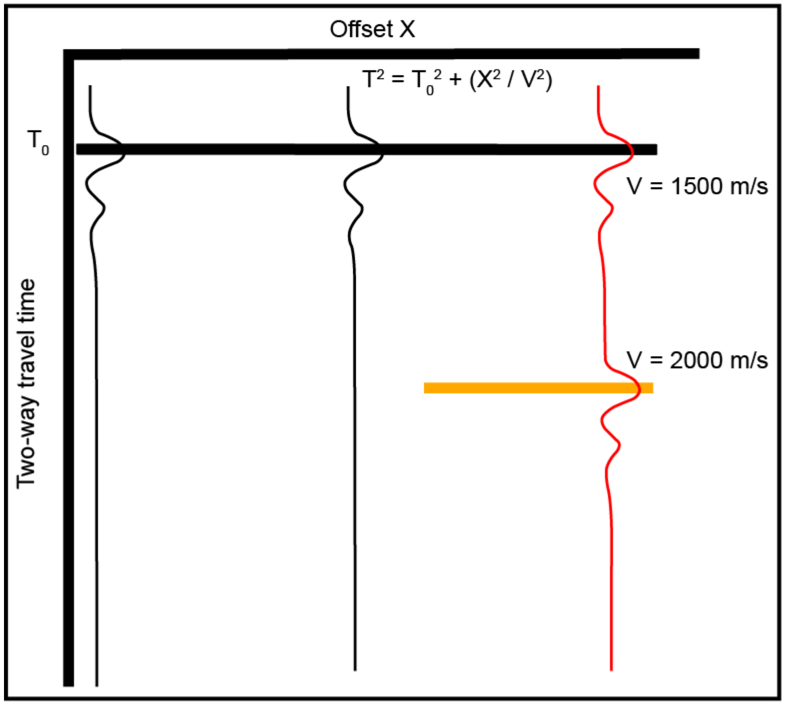
3D vs 2D Imaging

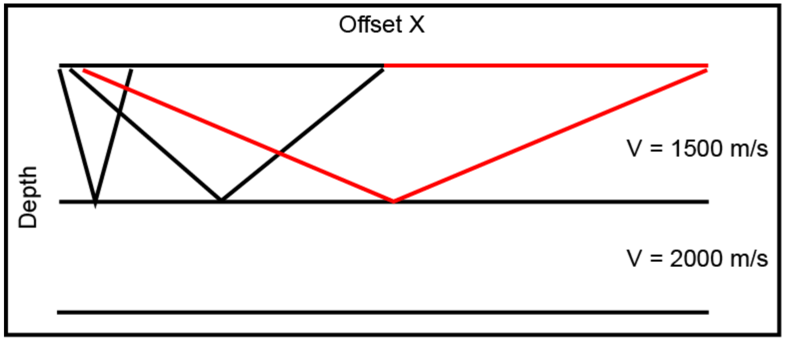
3D   2D

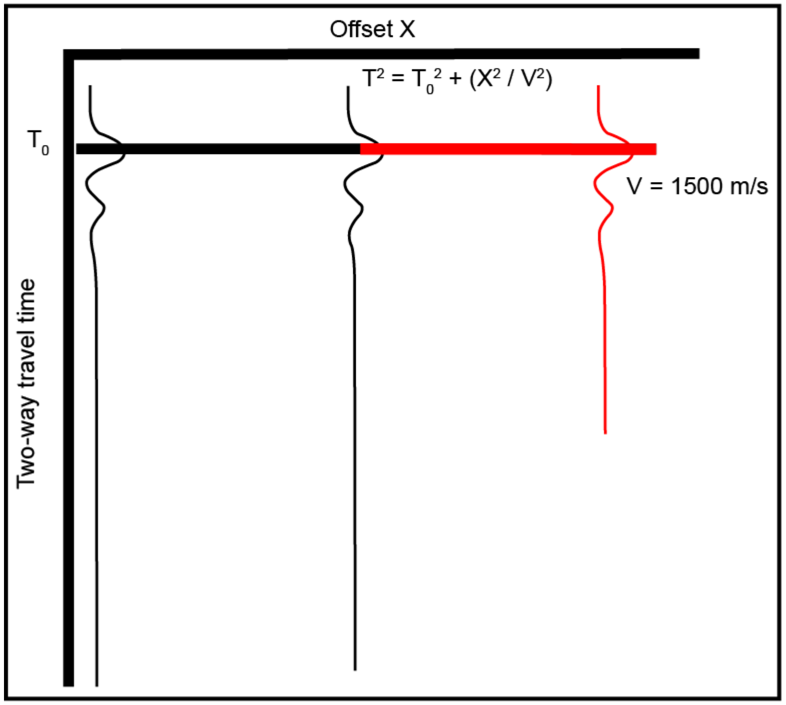


3D Seismic Imaging
By Biondo Biondi


Offset X
Depth
V = 1500 m/s
V = 2000 m/s


Offset X
$T^2 = T_0^2 + (X^2 / V^2)$
T_0
V = 1500 m/s
V = 2000 m/s
Two-way travel time


Offset X
V = 1500 m/s
Depth
V = 2000 m/s


Offset X
$T^2 = T_0^2 + (X^2 / V^2)$
T_0
V = 1500 m/s
Two-way travel time