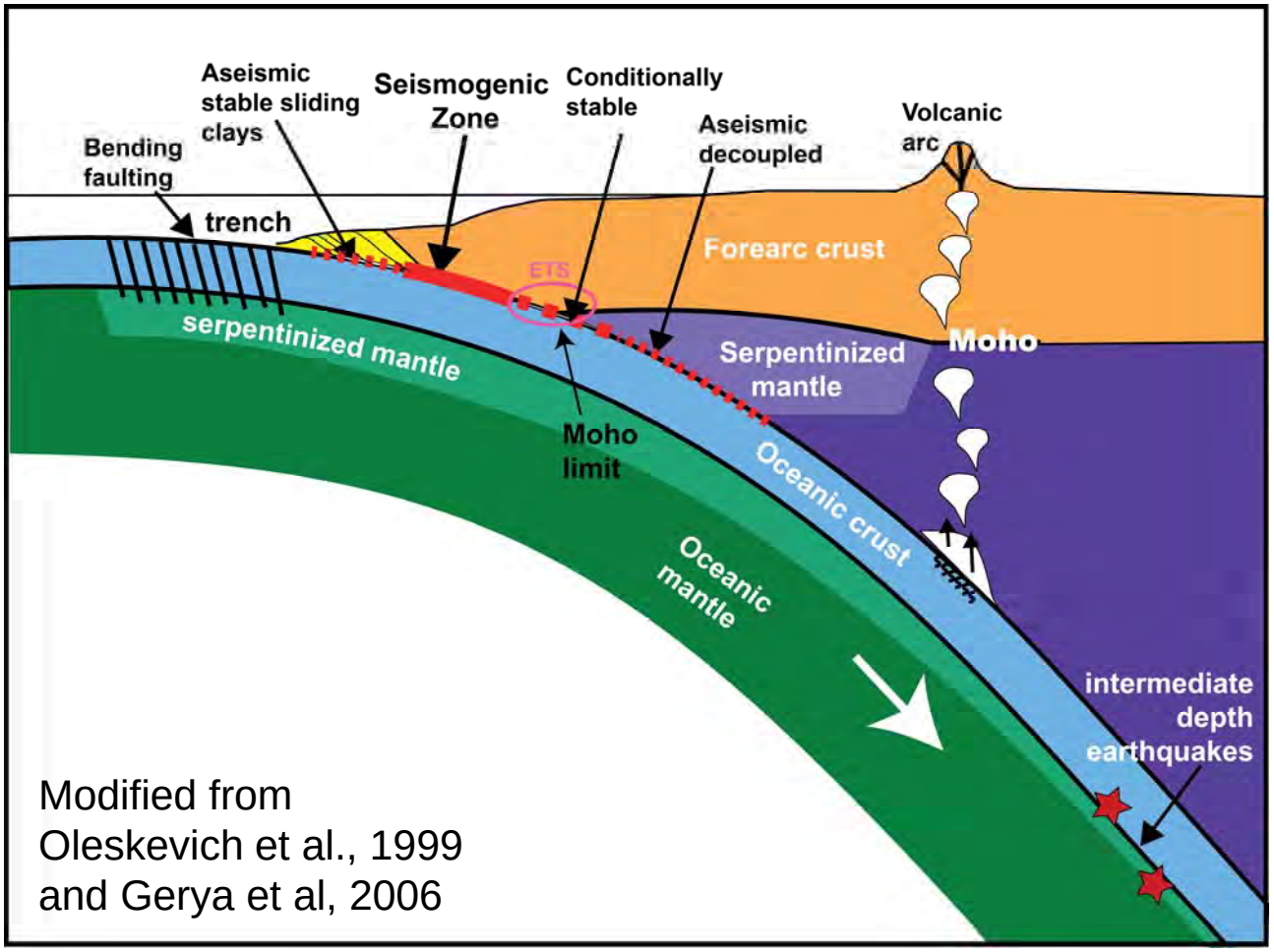
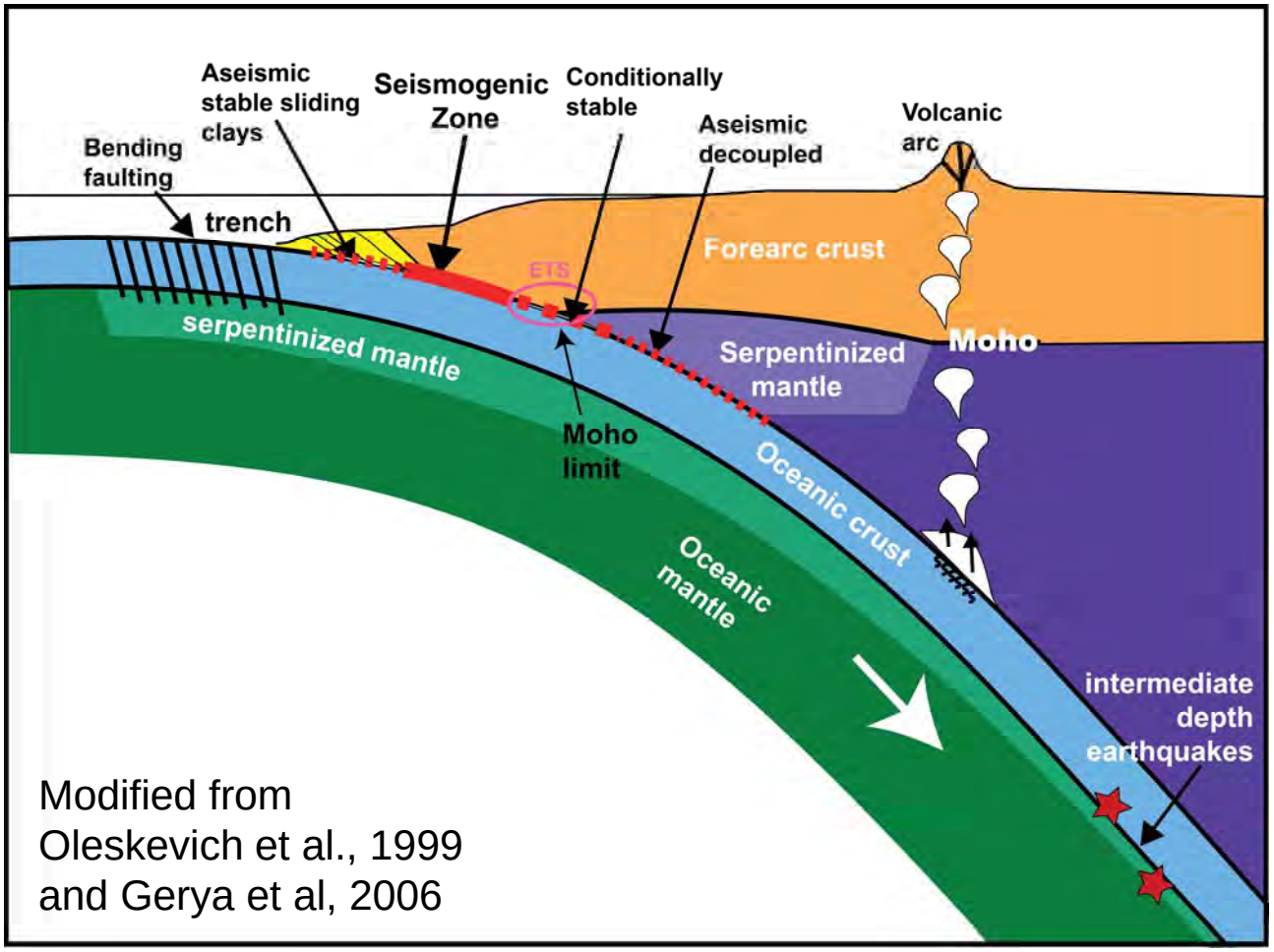
Outstanding questions at subduction zones



Modified from
Oleskevich et al., 1999
and Gerya et al, 2006

- Changes in megathrust properties and earthquake behavior downdip and along-strike
- Water and volatile cycling
- Pluming beneath volcanoes and creating of new crust

Imaging requirements



Modified from
Oleskevich et al., 1999
and Gerya et al, 2006

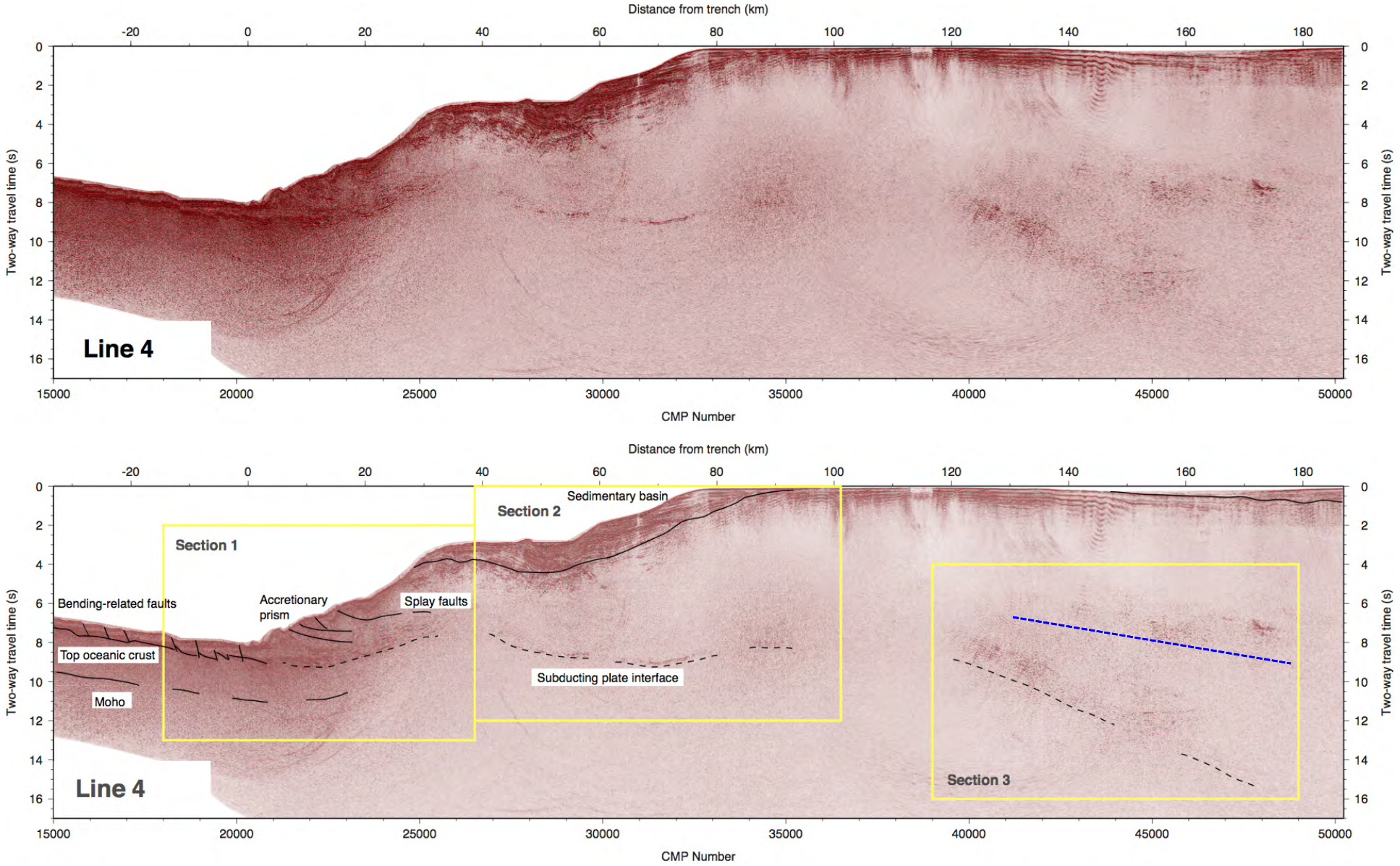
- Deep imaging of megathrust and other crustal structure with long streamers and large sources
- 3D imaging of complex structures
- Deep, long offset recordings of refractions and wide-angle reflections

Long streamers and large, well-tuned sources

Examples from:

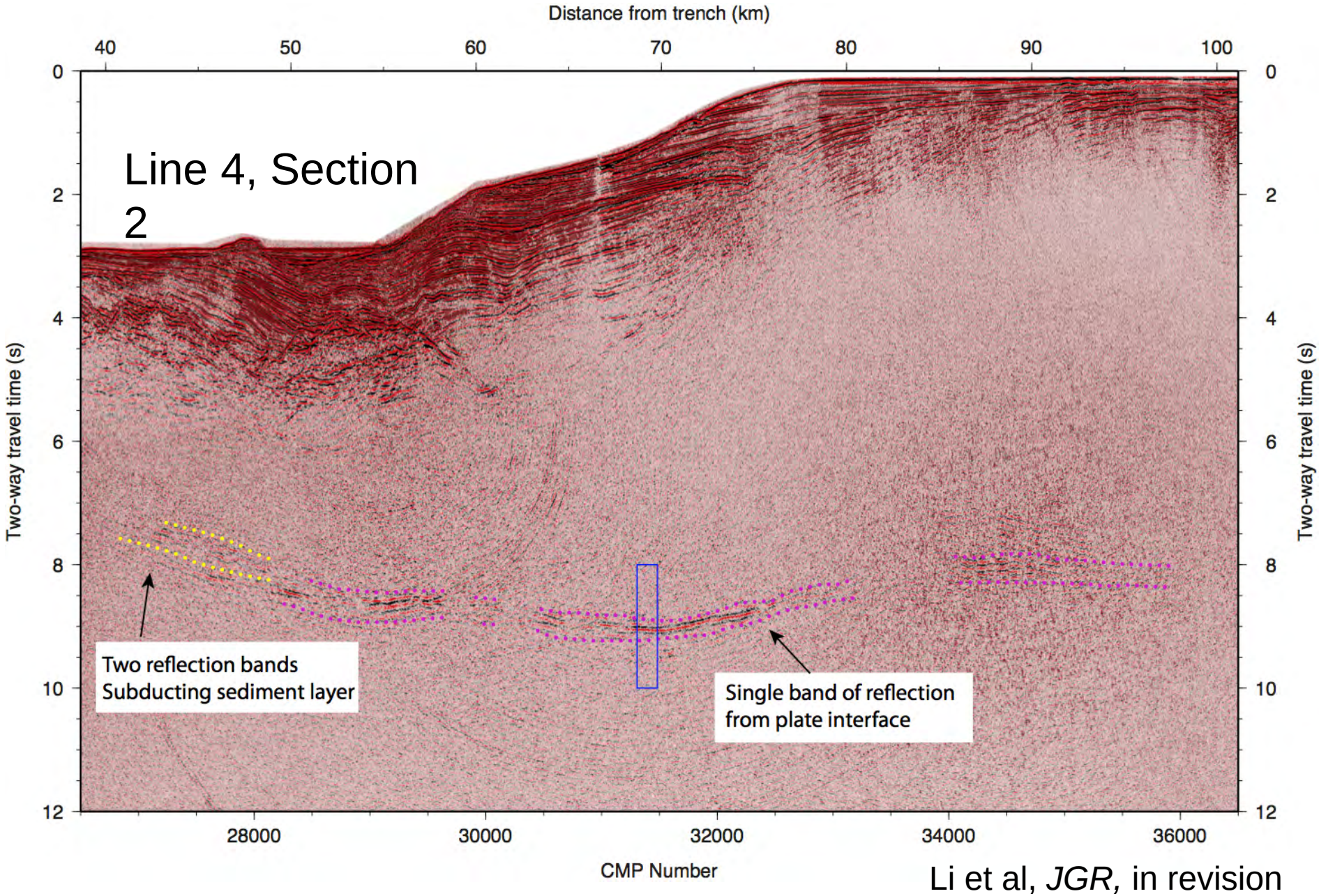
- Aleutians
- Sumatra

Deep imaging of Alaska subduction zone from MGL1110



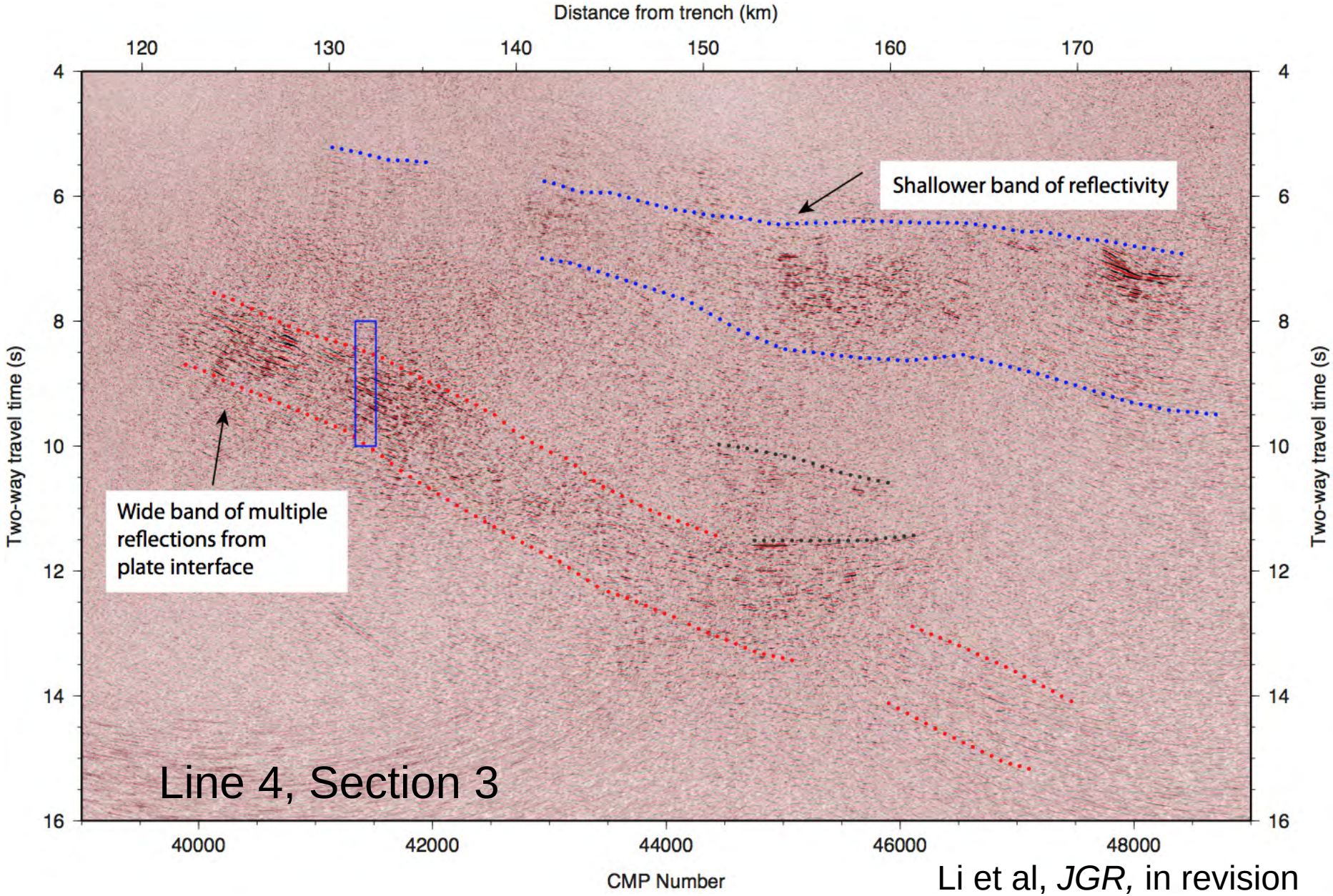
Li et al, *JGR*, in revision

Single reflection from the plate interface

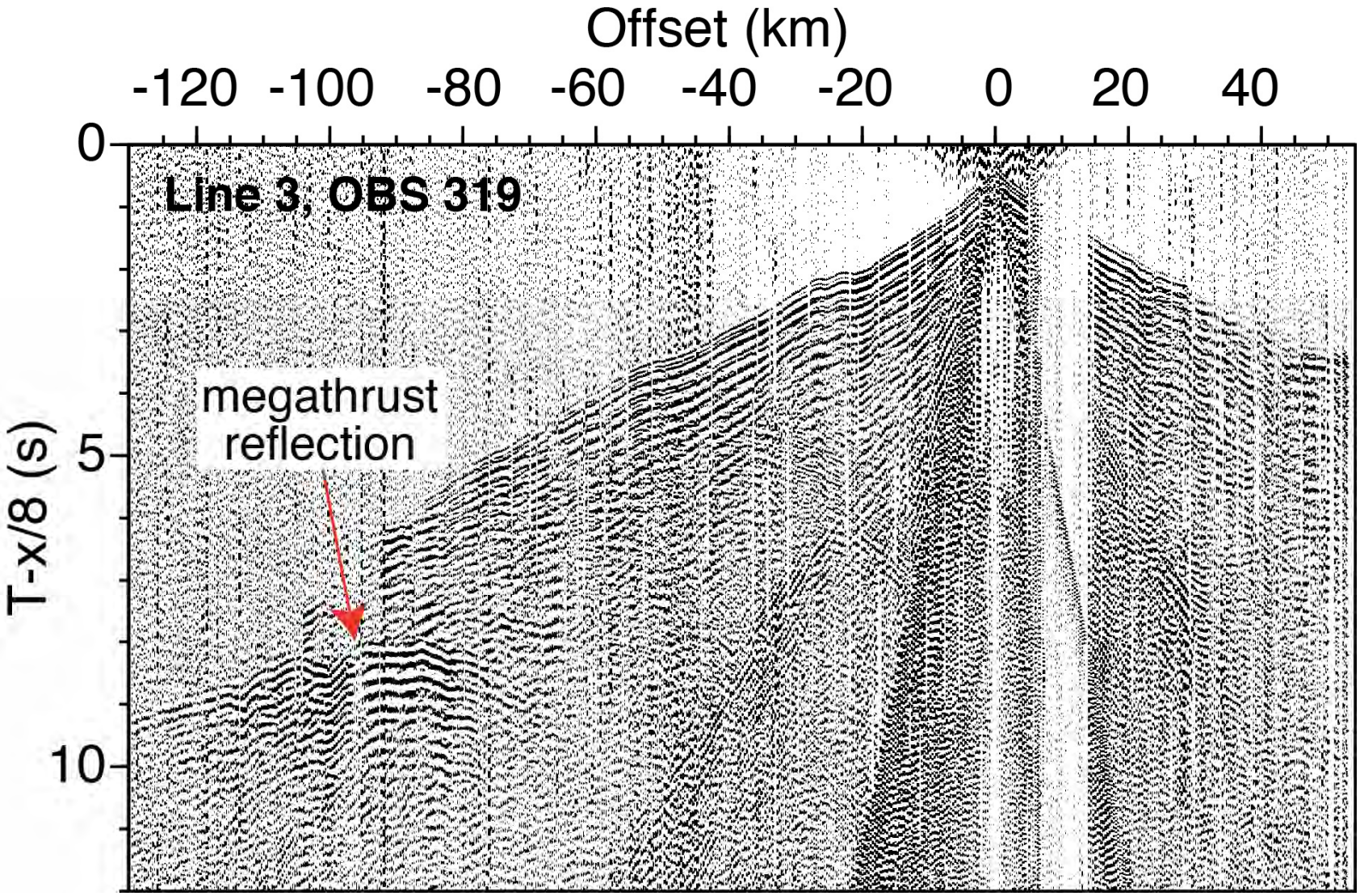


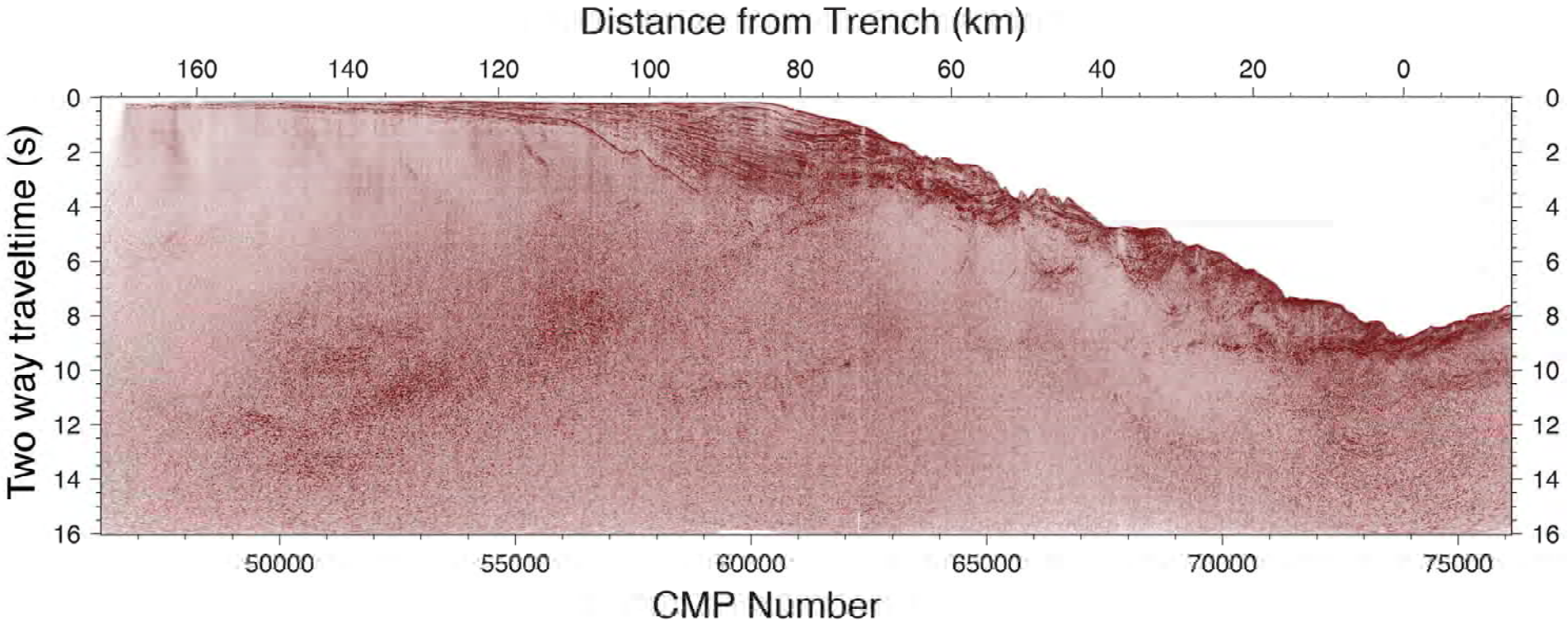
Li et al, *JGR,* in revision

Wide band of reflections from the plate interface

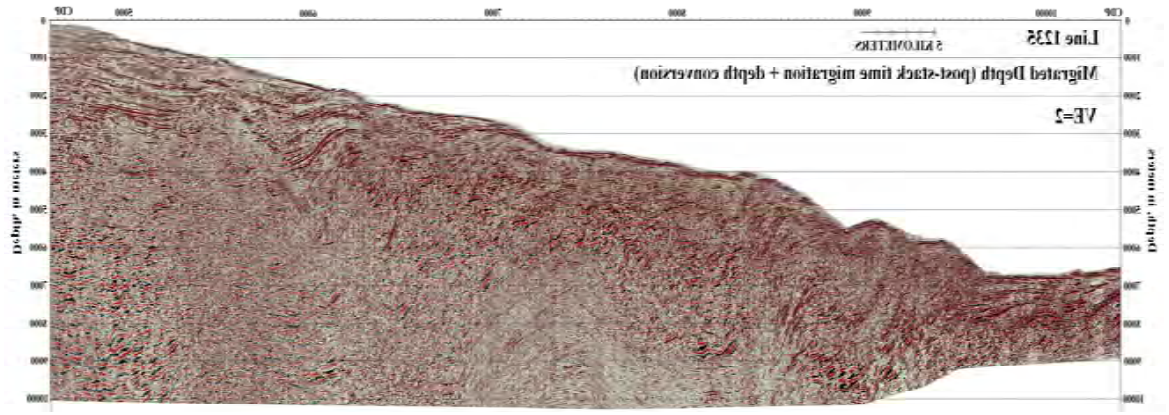


Li et al, *JGR,* in revision


Offset (km)
-120
-100
-80
-60
-40
-20
0
20
40
0
5
10
T-x/8 (s)
Line 3, OBS 319
megathrust
reflection

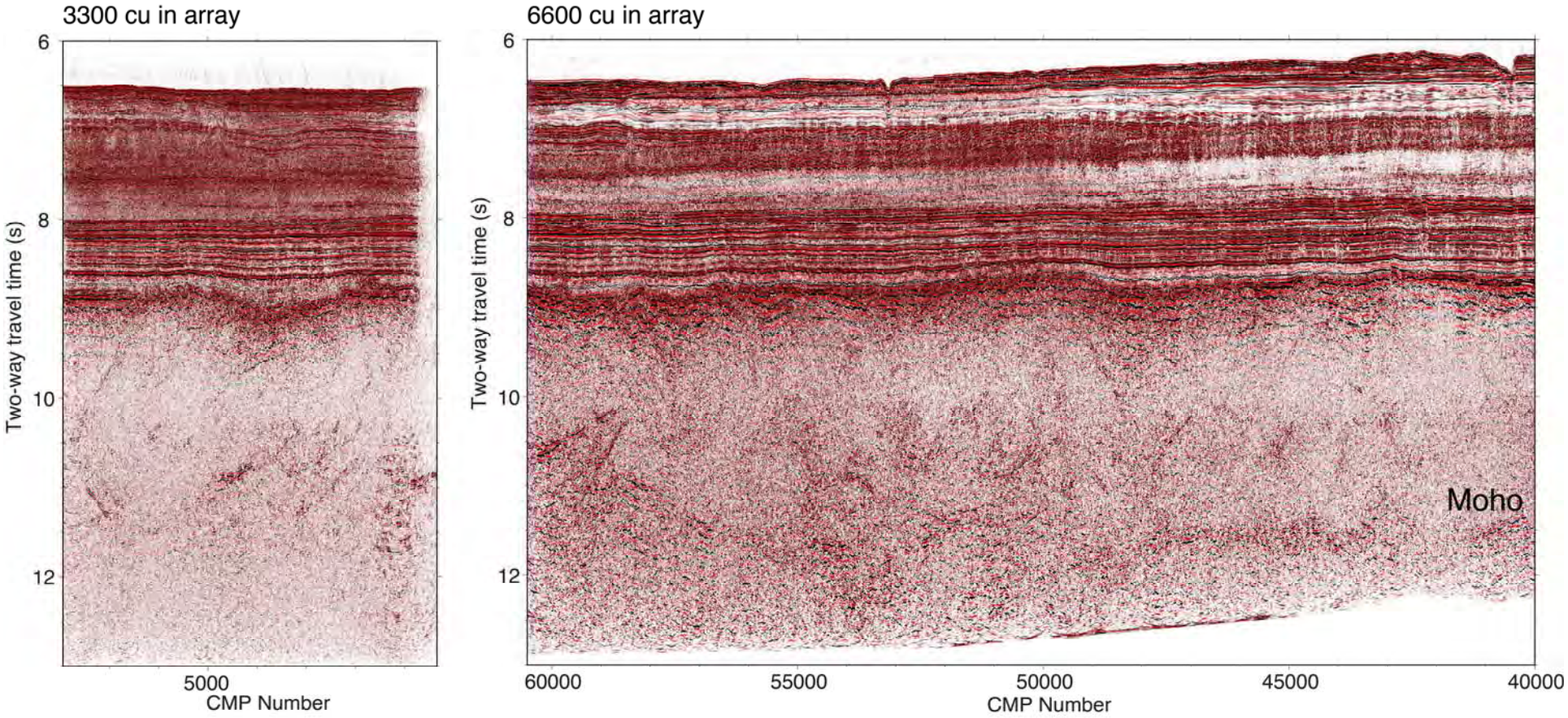


Comparison of 1994 Ewing data with 2011 Langsesth data

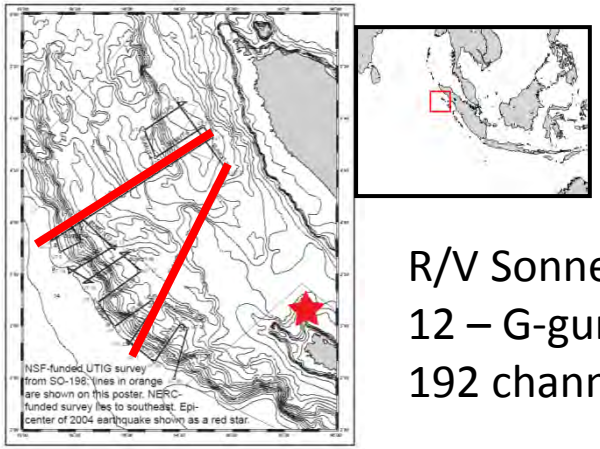


[Courtsey of John Miller, USGS]
http://pubs.usgs.gov/of/2014/1024/downloads/1235-uninterpreted.JPG

Comparison of 3300 and 6600 cu in source on Langseth from MGL14



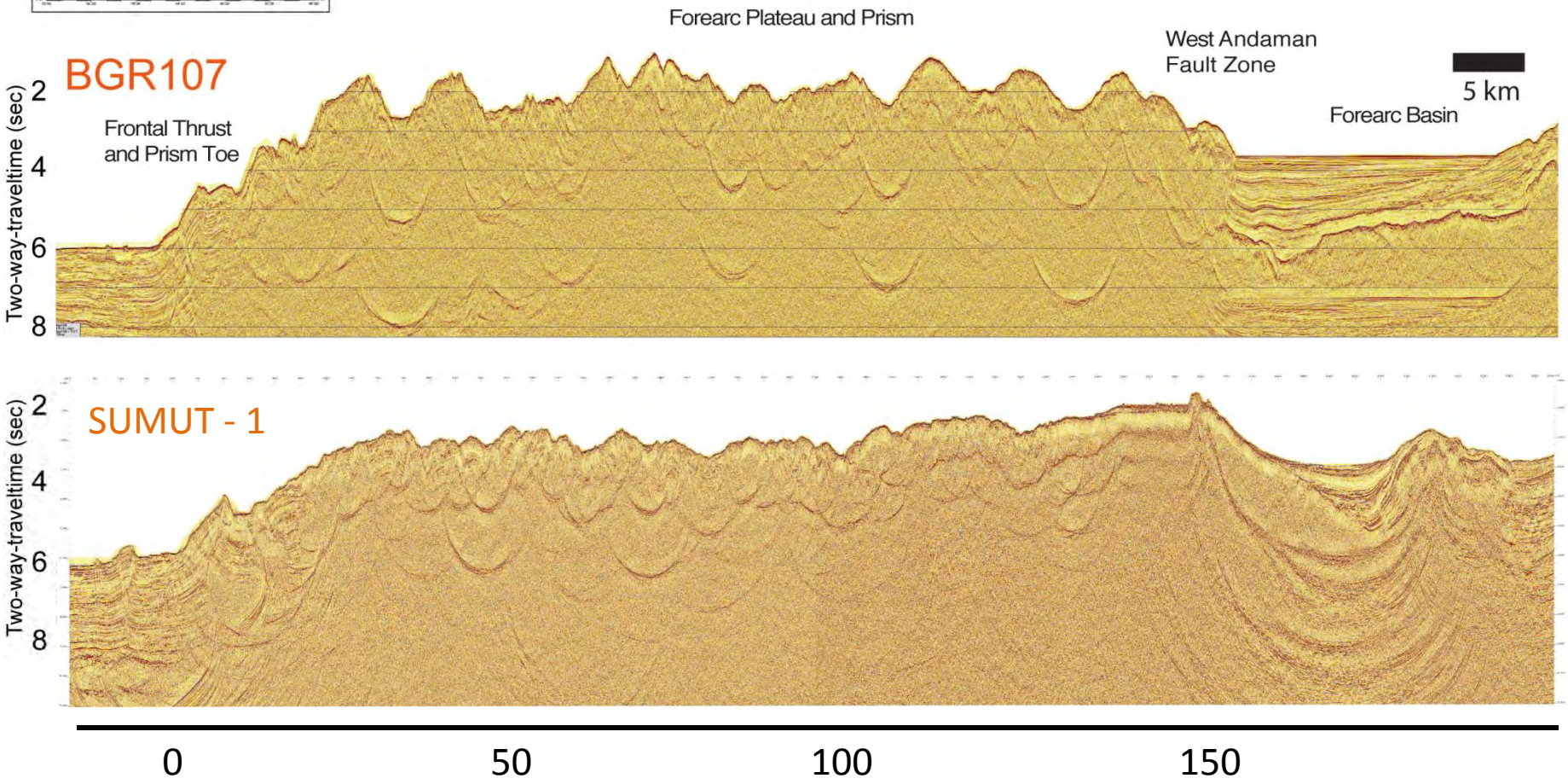
Sumatra



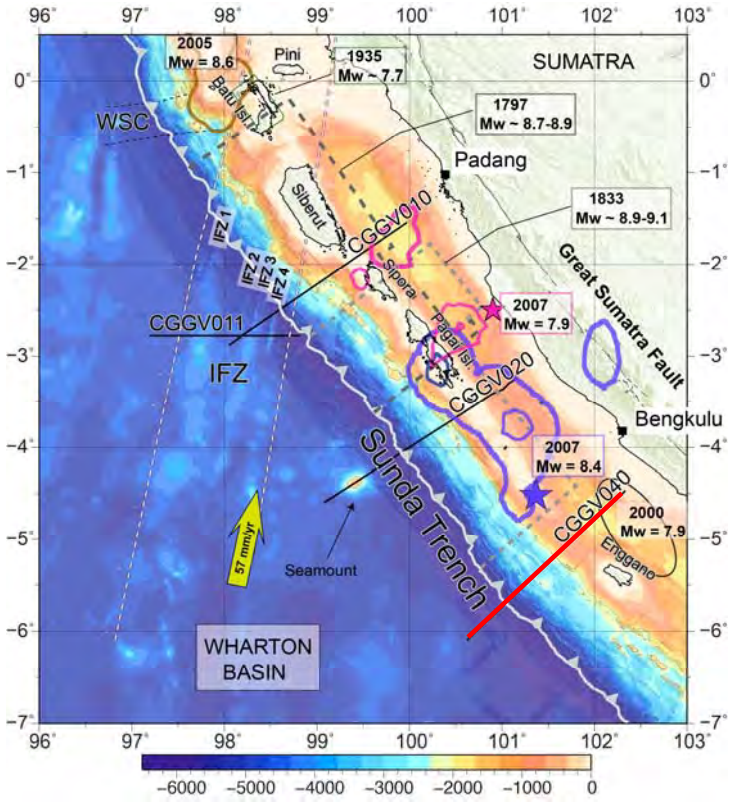
R/V Sonne 2008
12 – G-guns (5420 in^3)
192 channel, 2.4 km streamer

Short offset streamers:

- Poor deep imaging
- Poor velocity control
- Poor multiple suppression



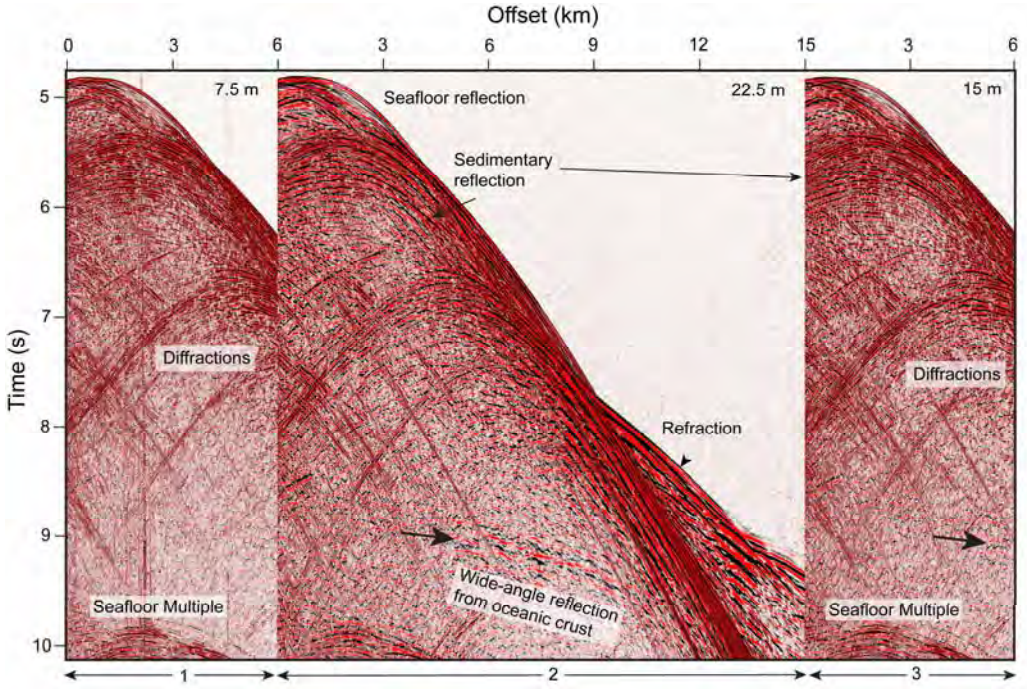
CGGVeritas survey



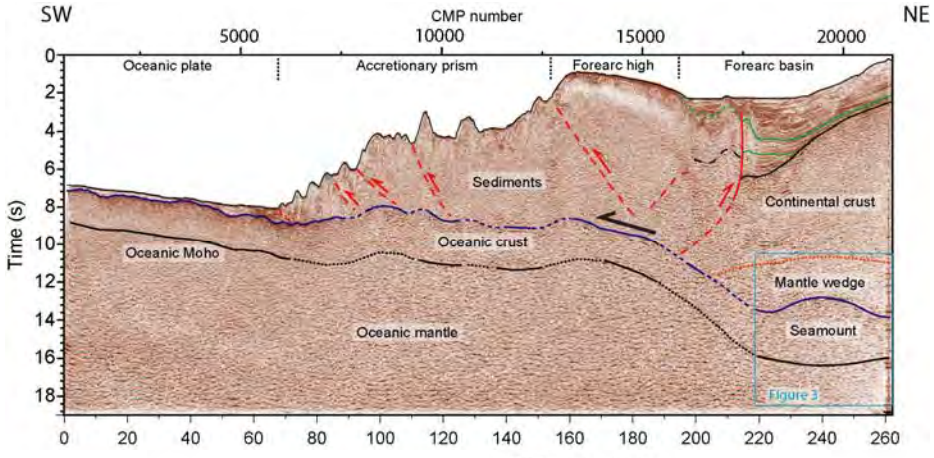
M/V Geowave Champion

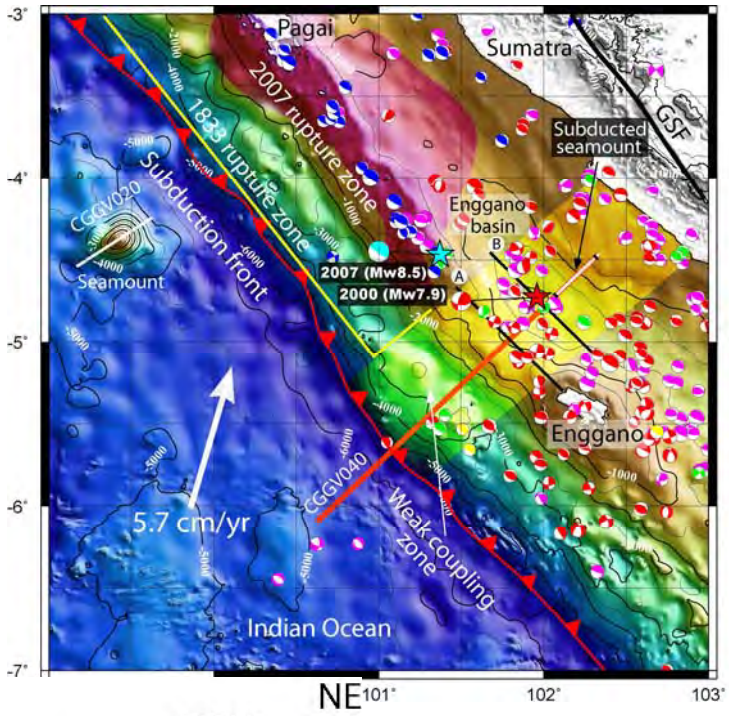
Long offset streamer (15 km)

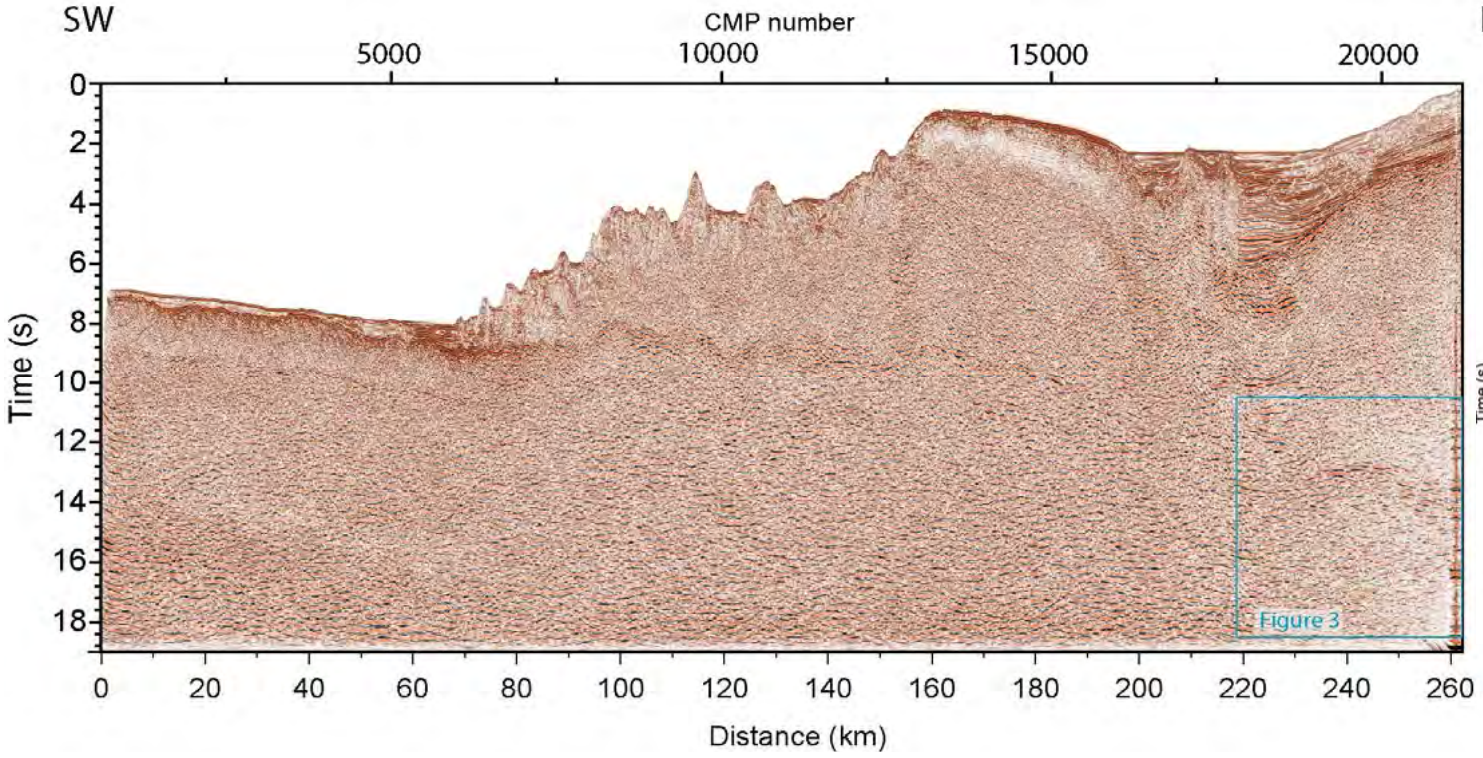
- improves velocity control
- improves imaging
- improves multiple suppression



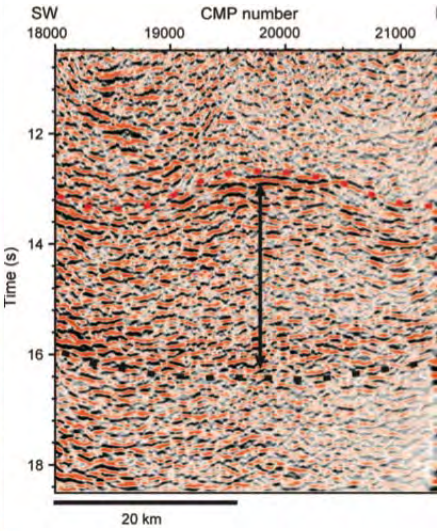
Subducted seamount beneath S. Sumatra forearc basin







Singh et al., 2011



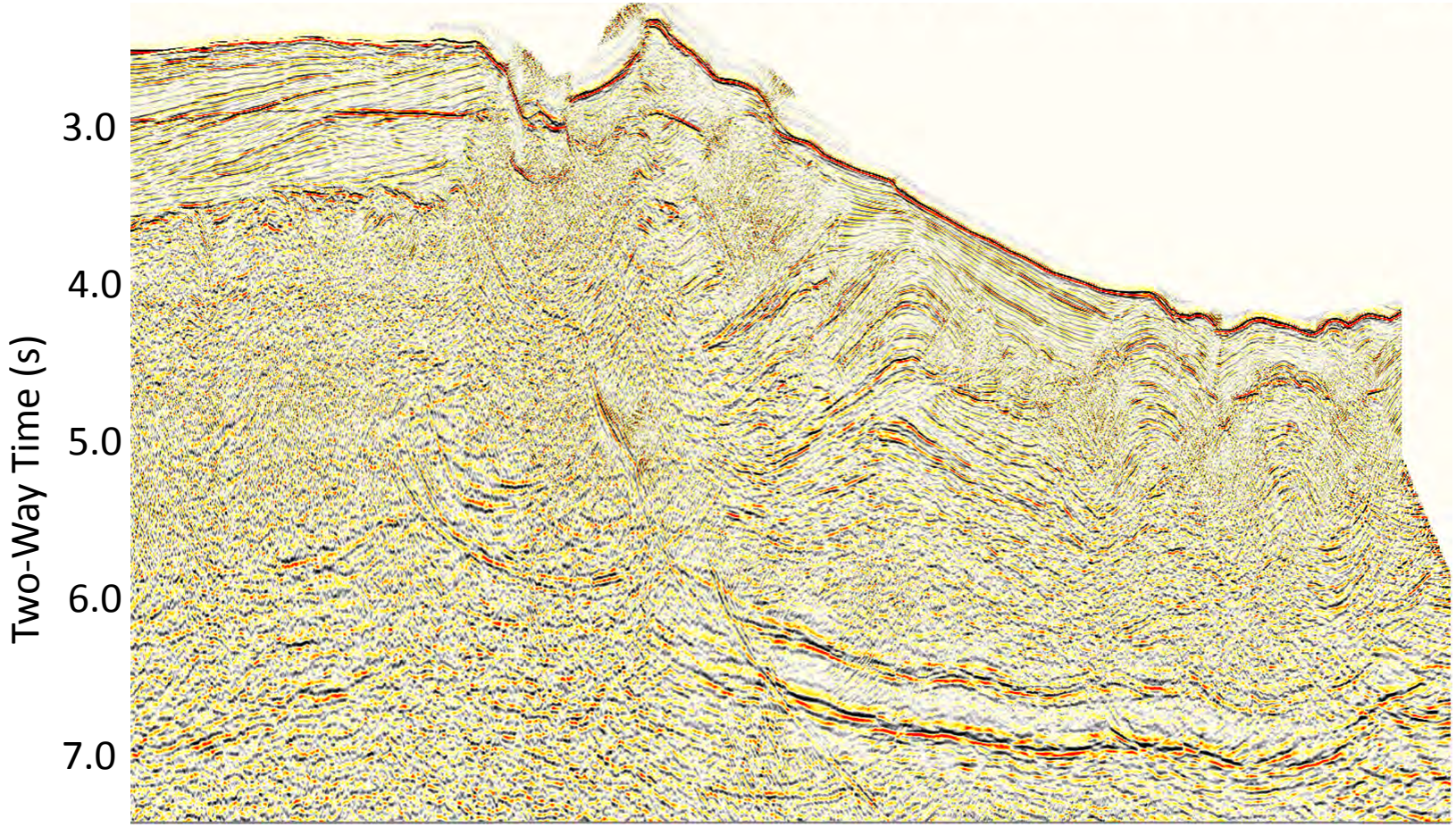
3D imaging of complex structures at subduction zones

Examples from:

- Nankai
- Costa Rica

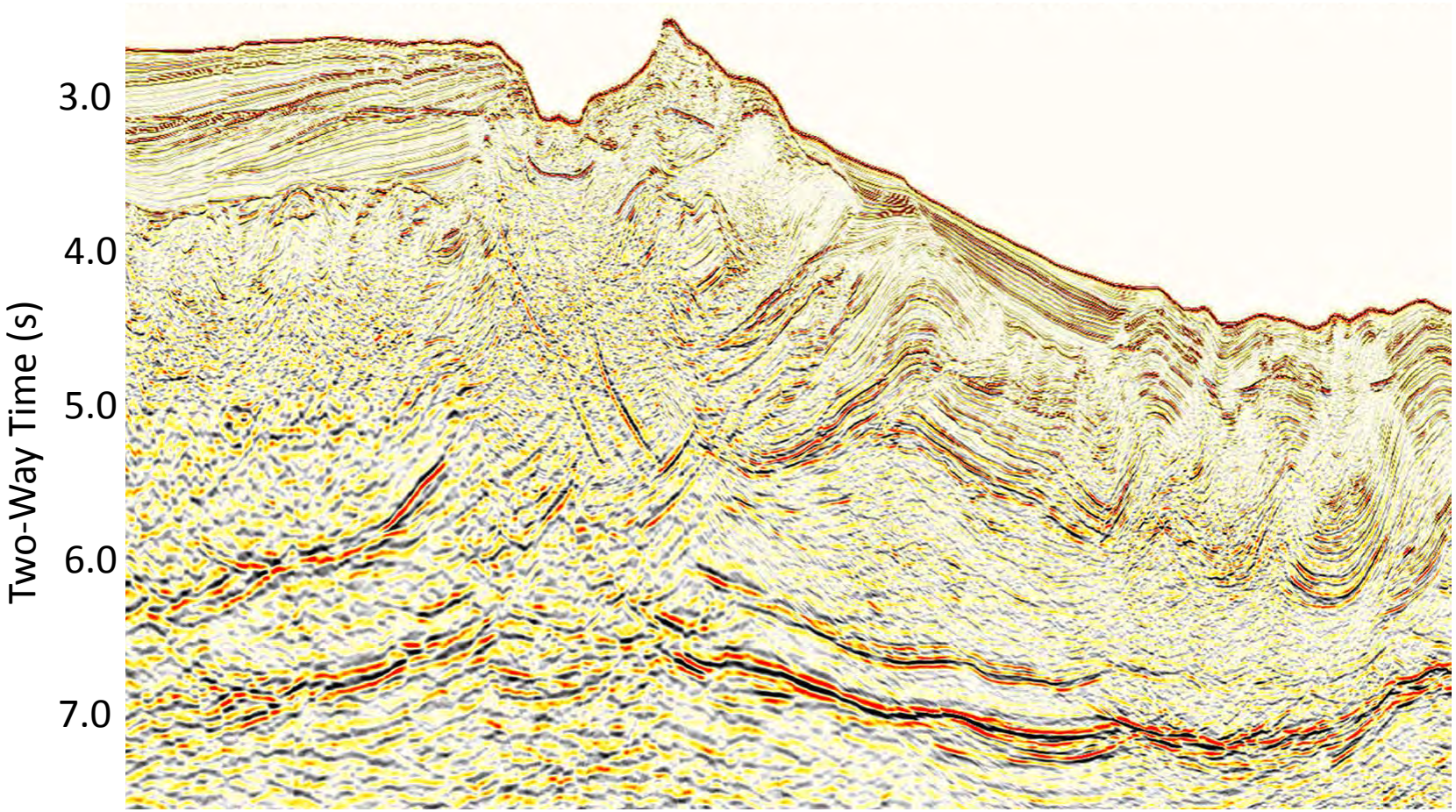
2D Seismic Image of Splay System

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



Overlapping 3D Seismic Image of Splay System

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



Overlapping 3D Seismic Image of Splay System

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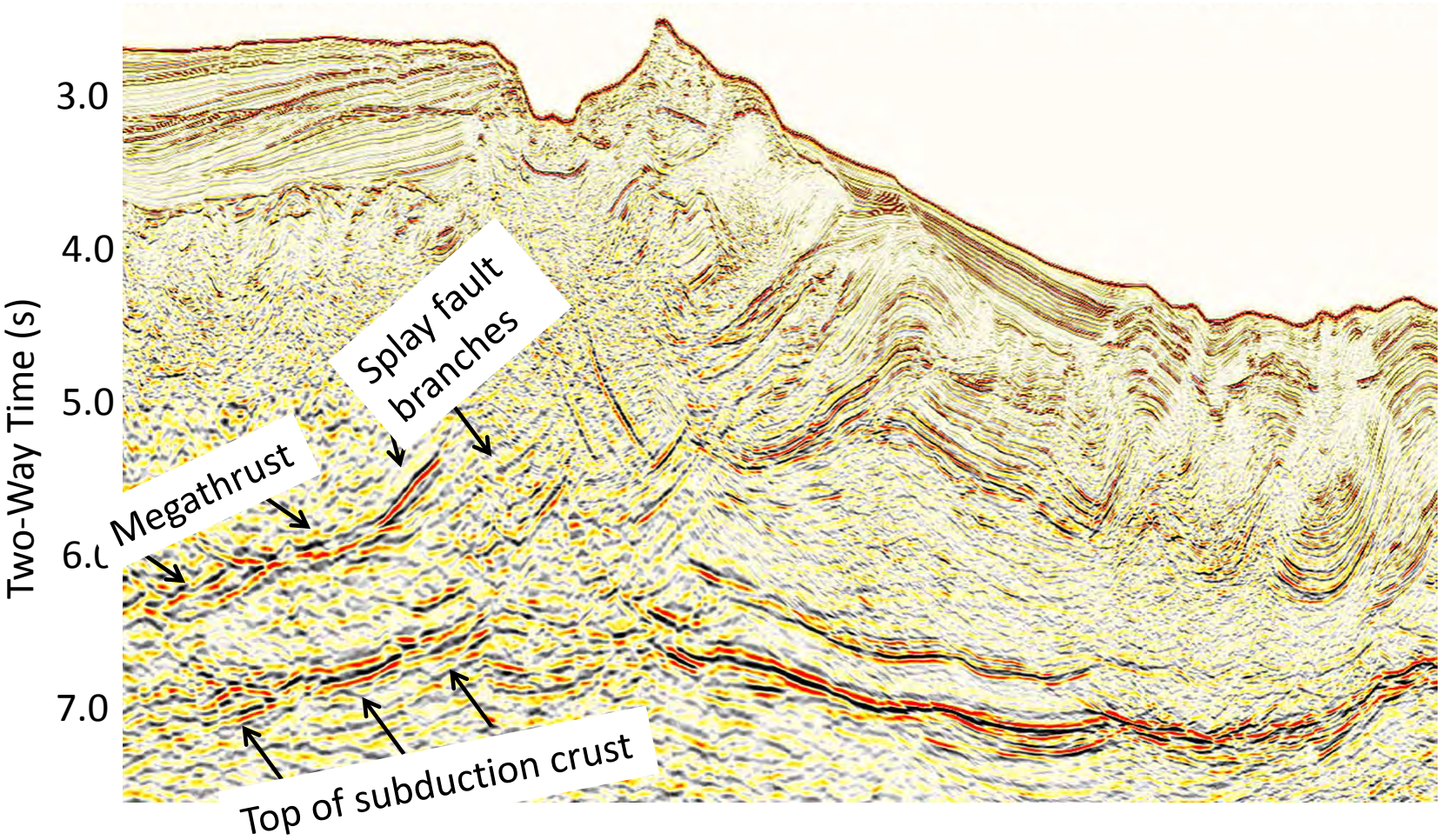
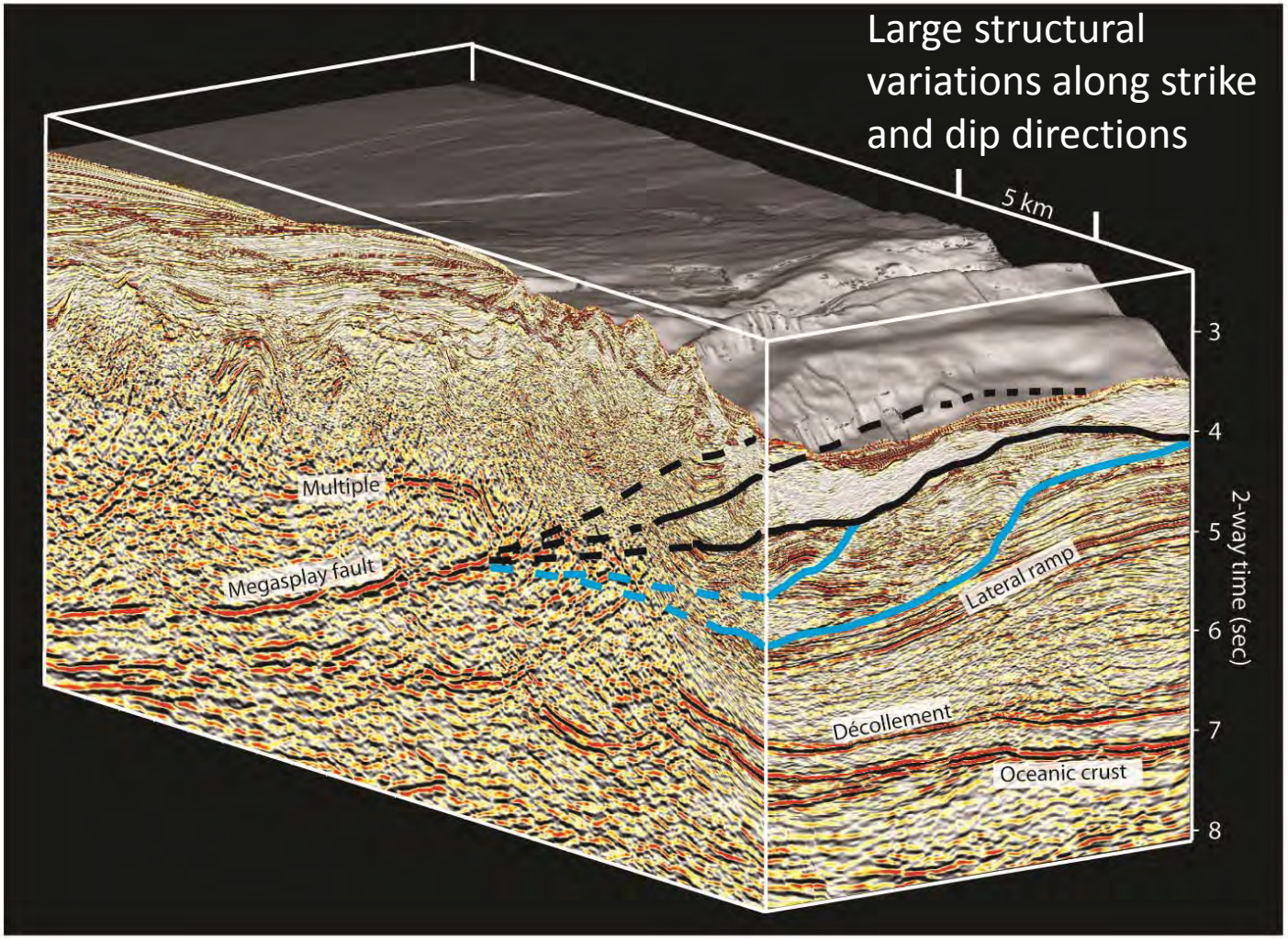
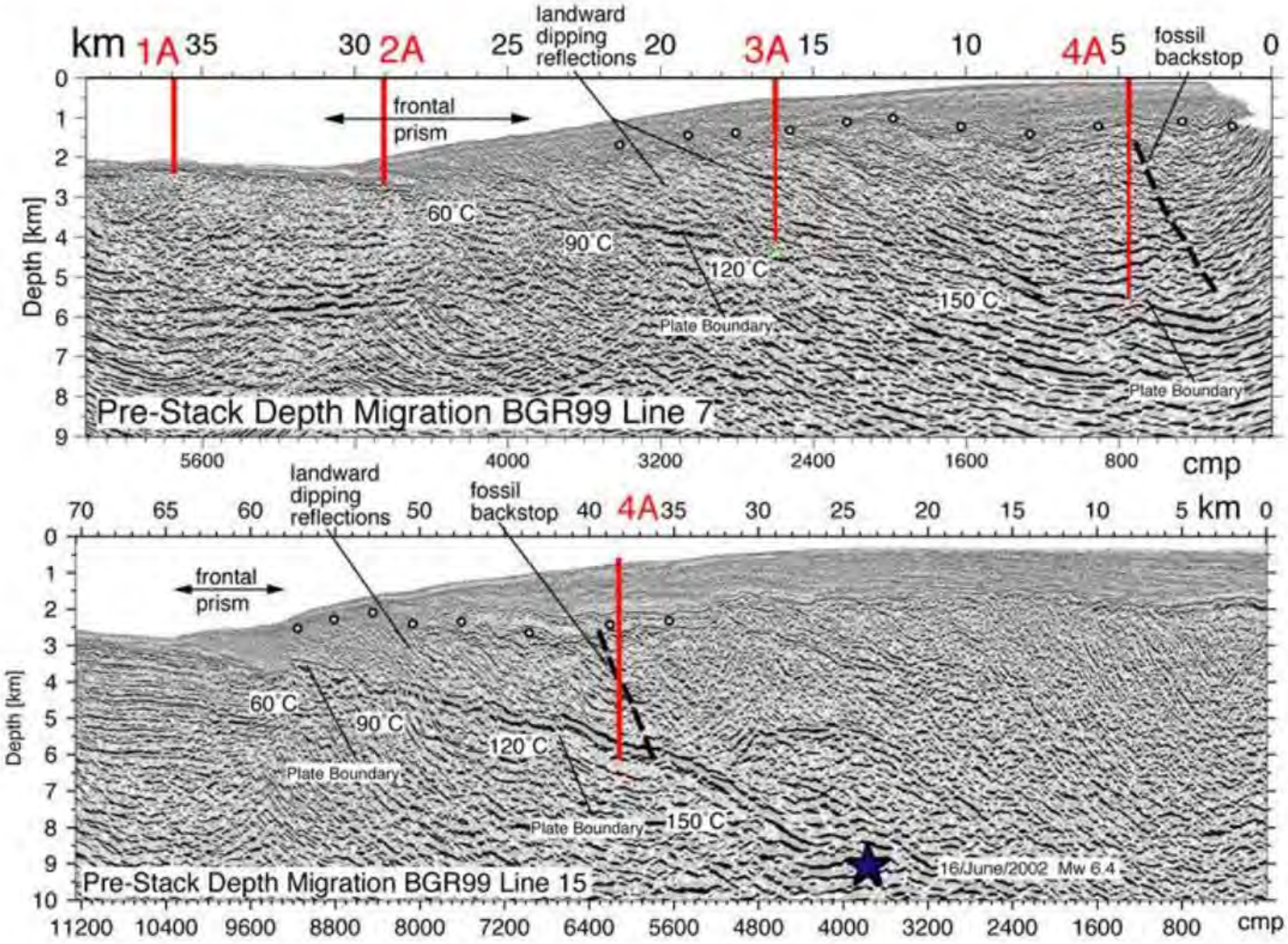
3090 cu. in airgun array

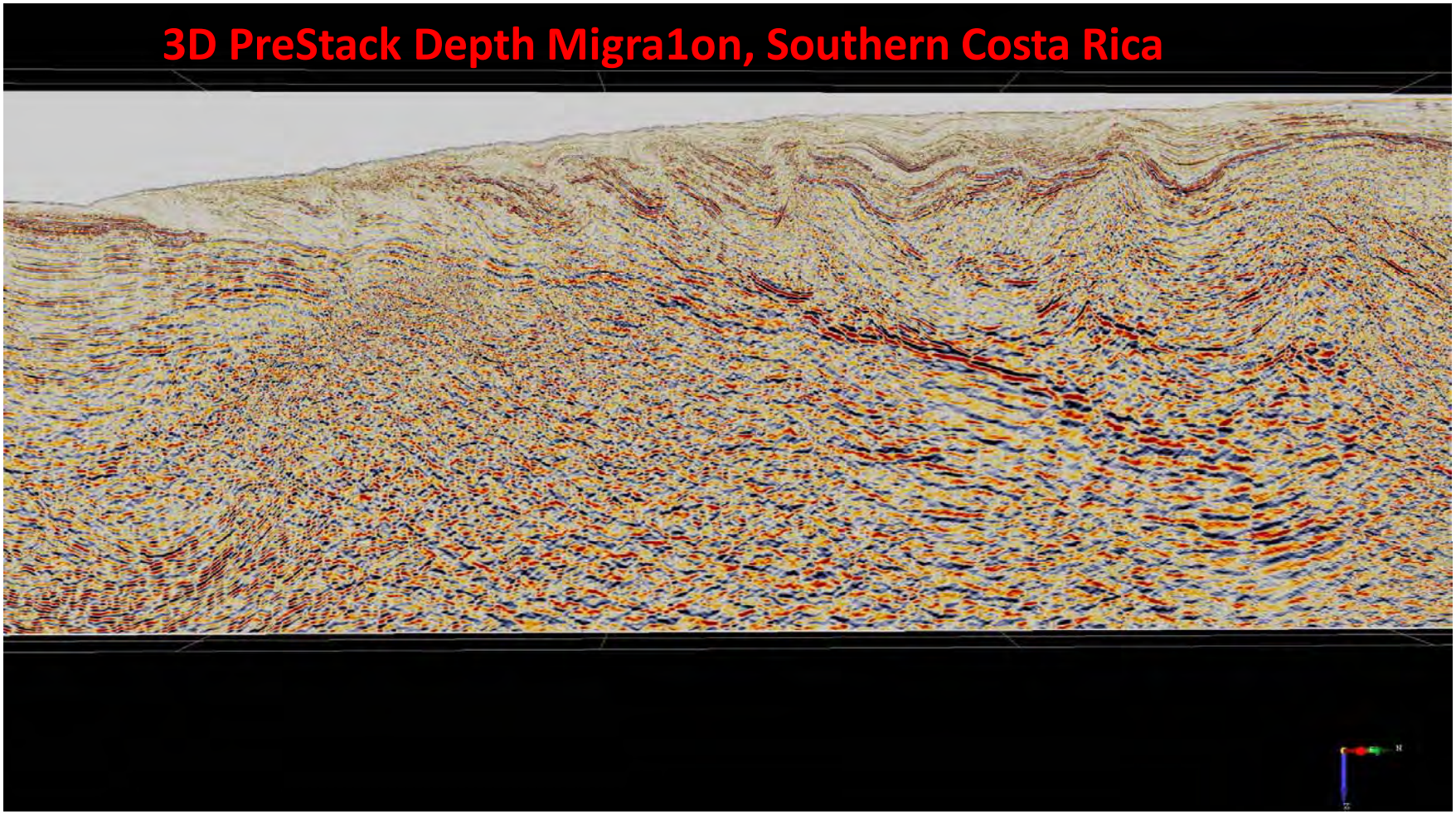


NantroSEIZE 3D Volume




km
1A
2A
3A
4A
landward dipping reflections
fossil backstop
frontal prism
60˚C
90˚C
120˚C
150˚C
Plate Boundary
Depth [km]
Pre-Stack Depth Migration BGR99 Line 7
cmp
Pre-Stack Depth Migration BGR99 Line 15
16/June/2002 Mw 6.4

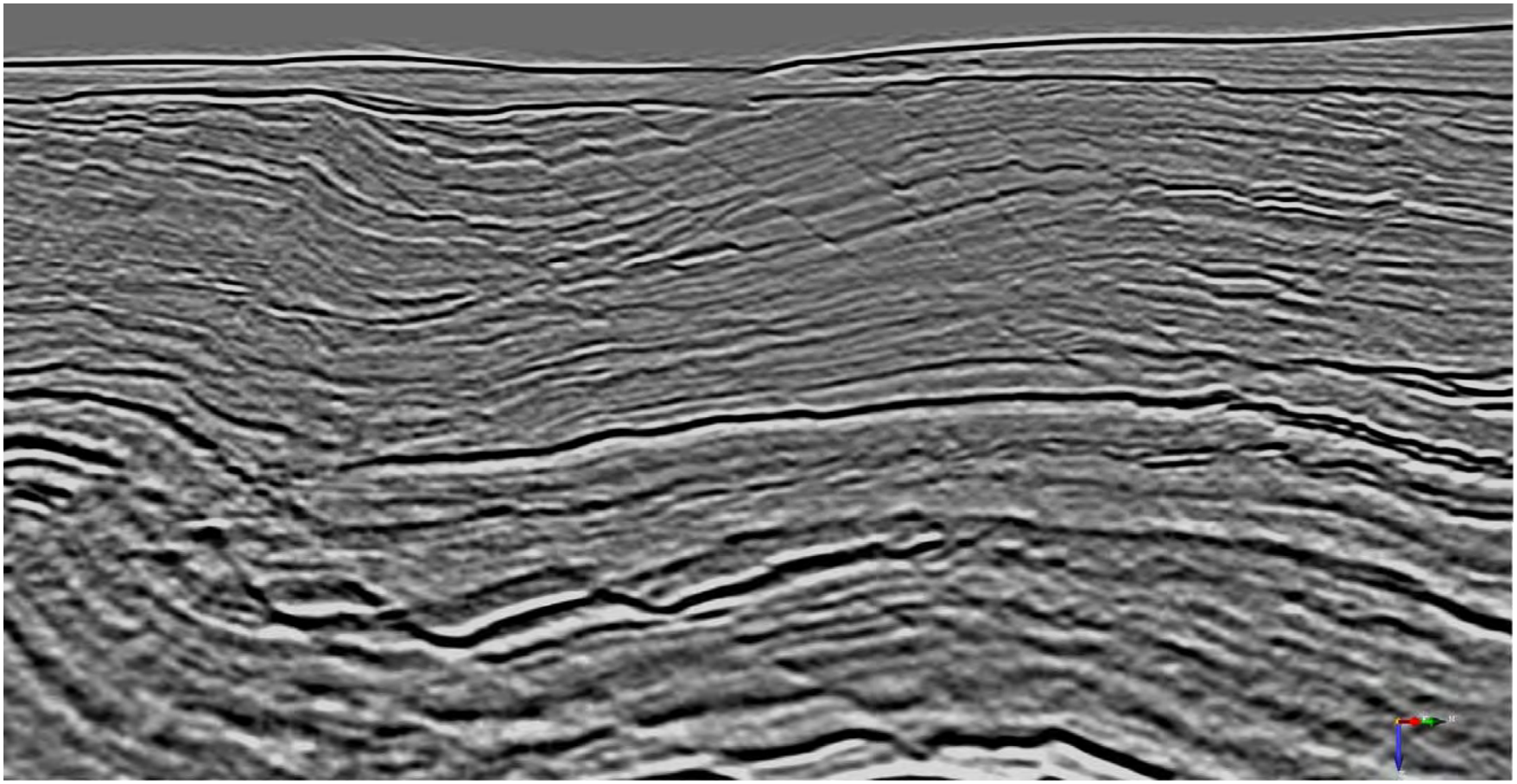
3D PreStack Depth Migra1on, Southern Costa Rica



10 Km

4 Km

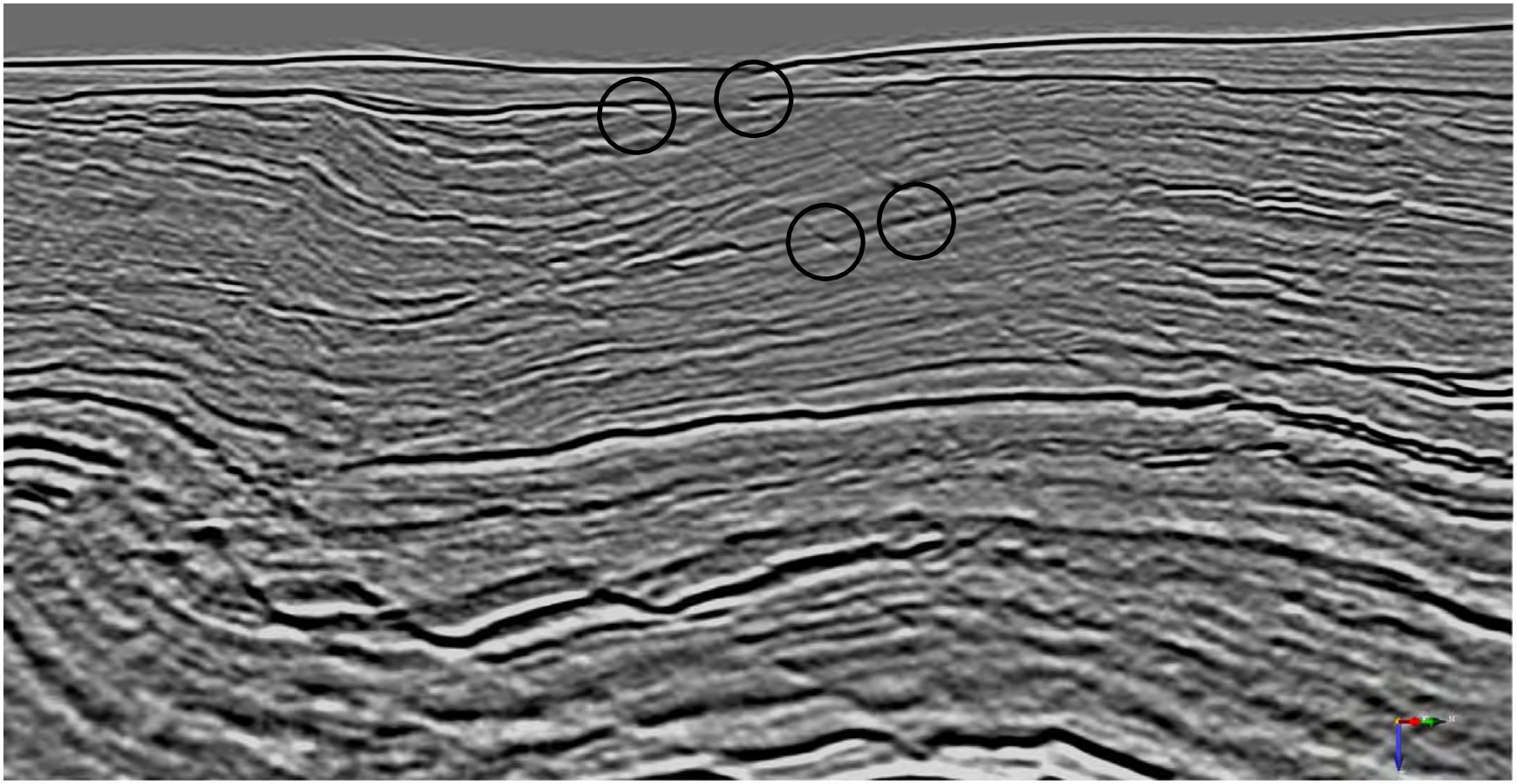
InLine 2560



InLine 2400

500 m

500 m

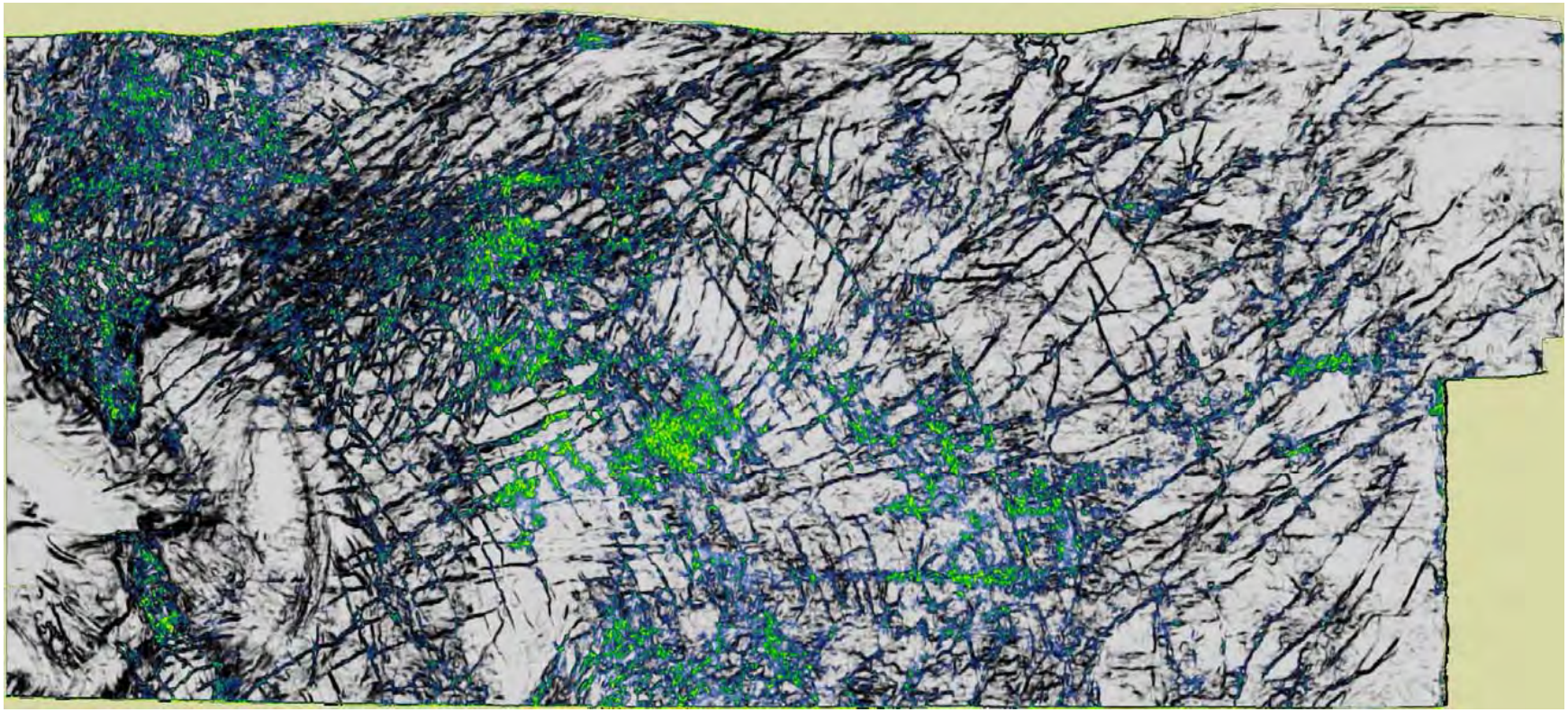


InLine 2400

500 m

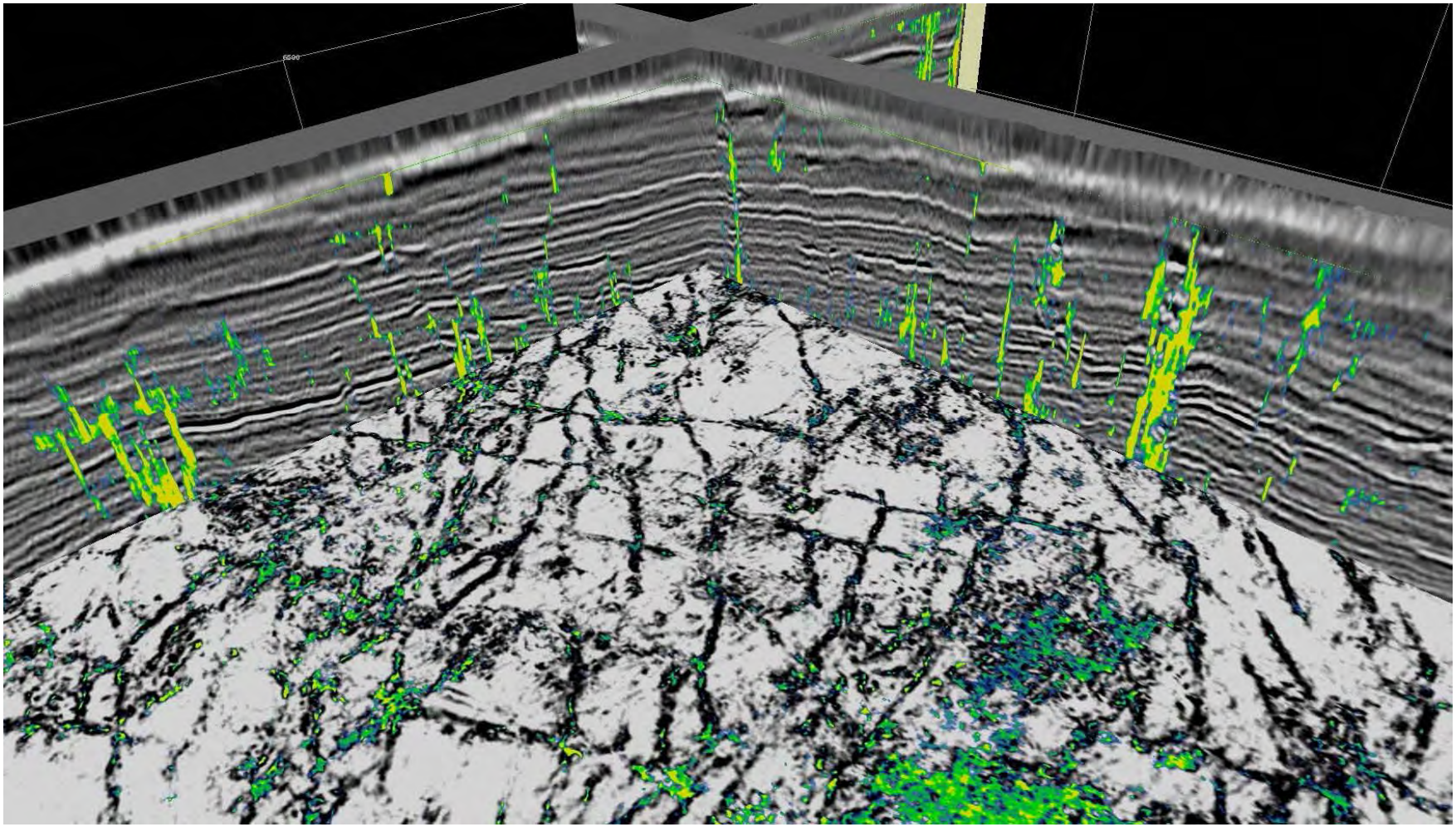
500 m

Normal offset at depth, thrust
Offset shallow

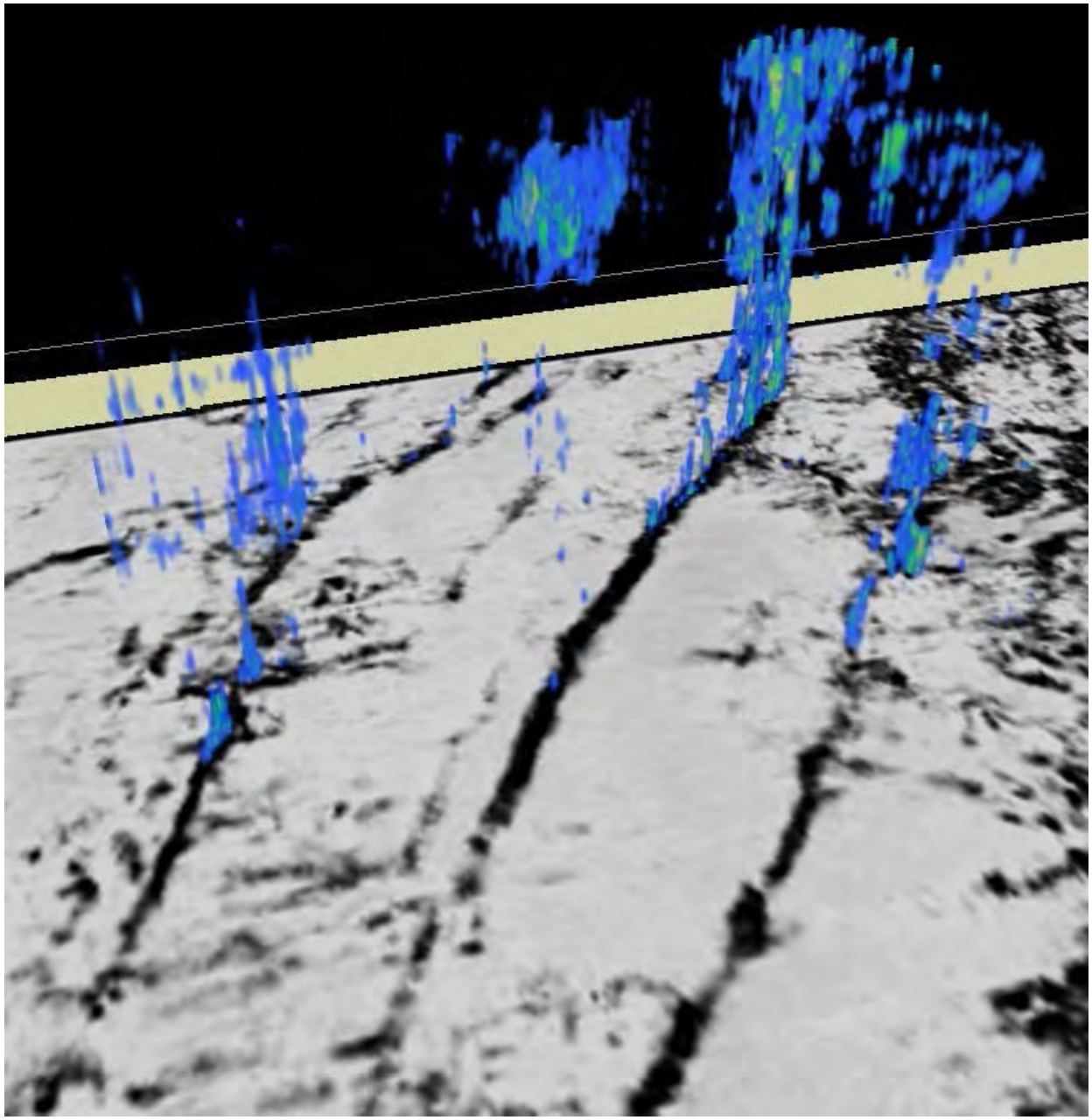


Neural Network, dip steering, filtered

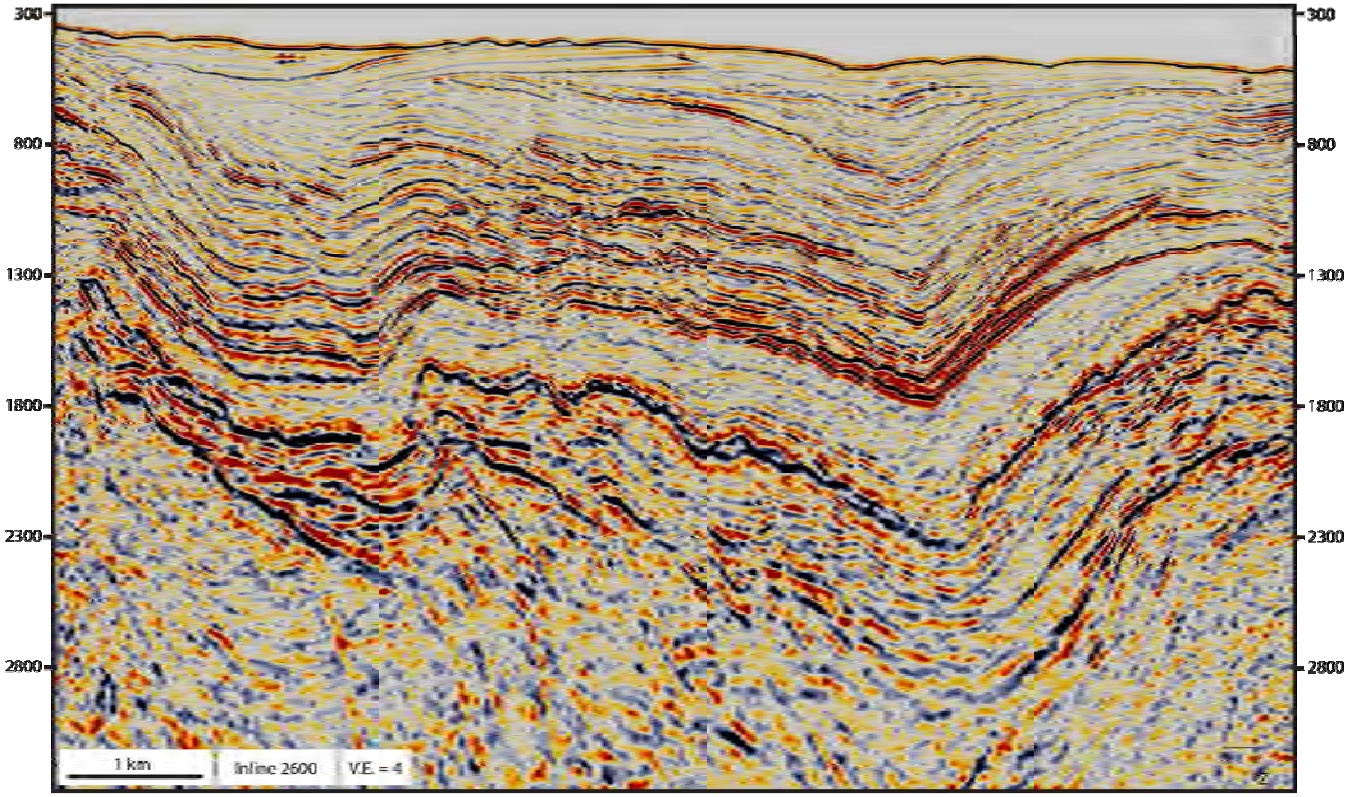
525 m (620 ms)



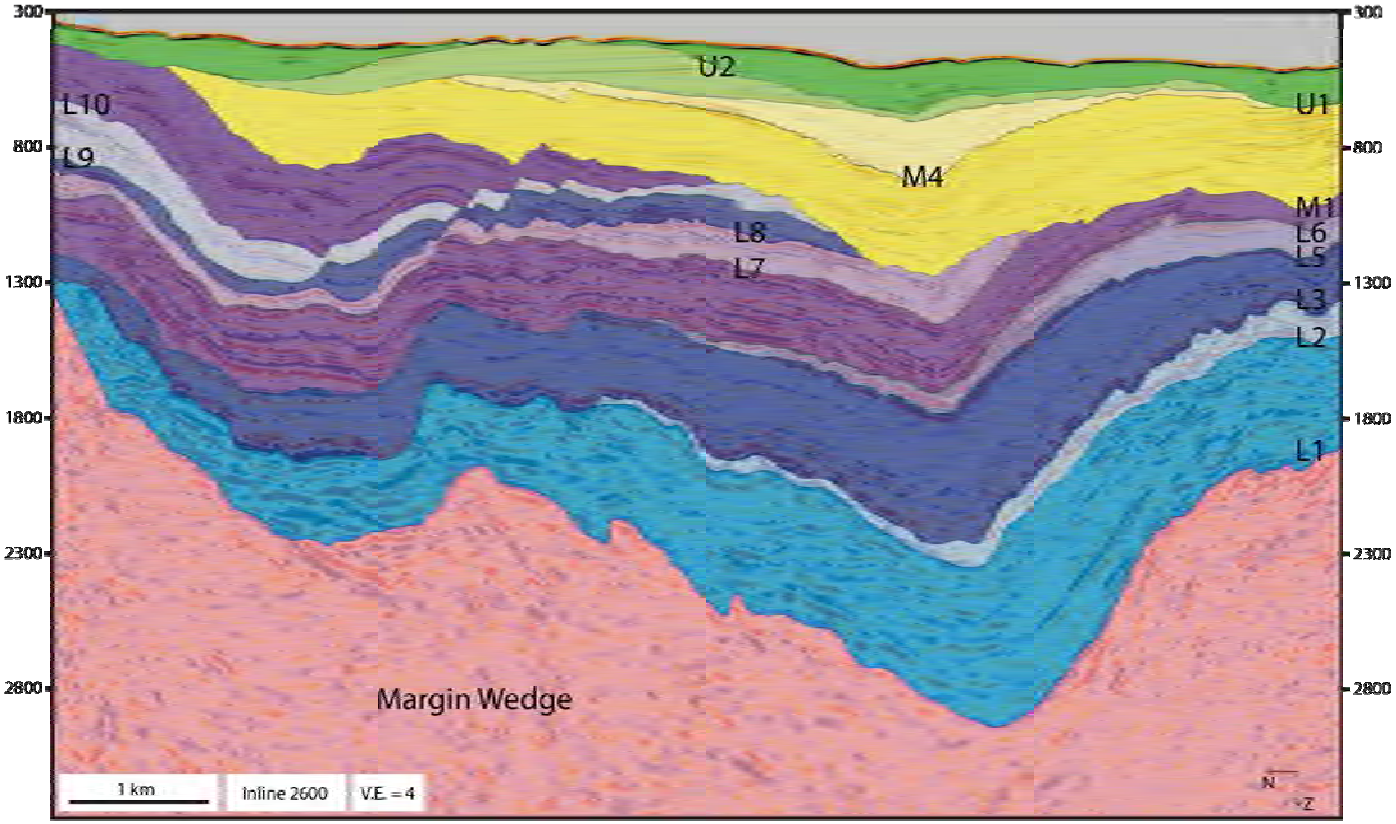
Fluid Percentage Probability on Neural Network Fault cube



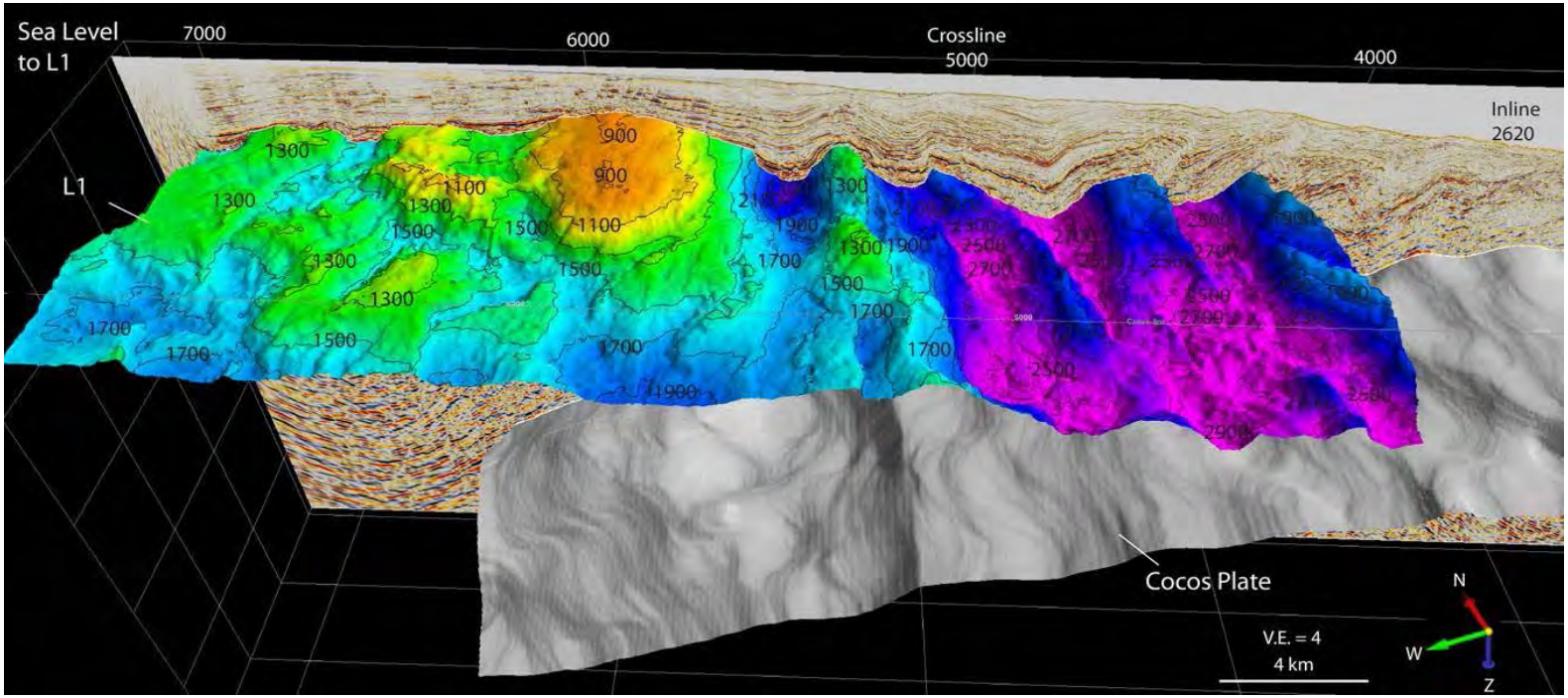
Inline 2600



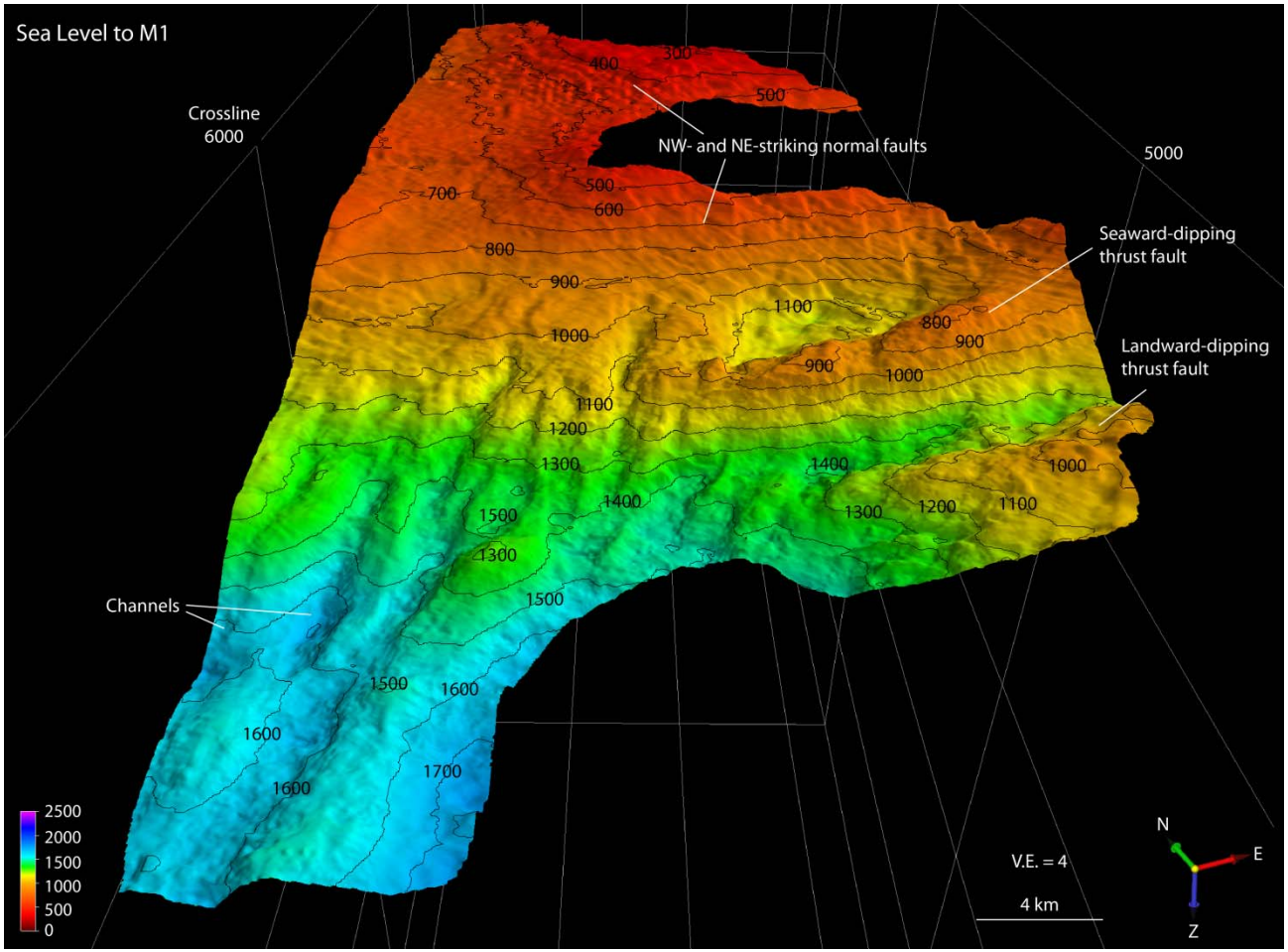
Inline 2600

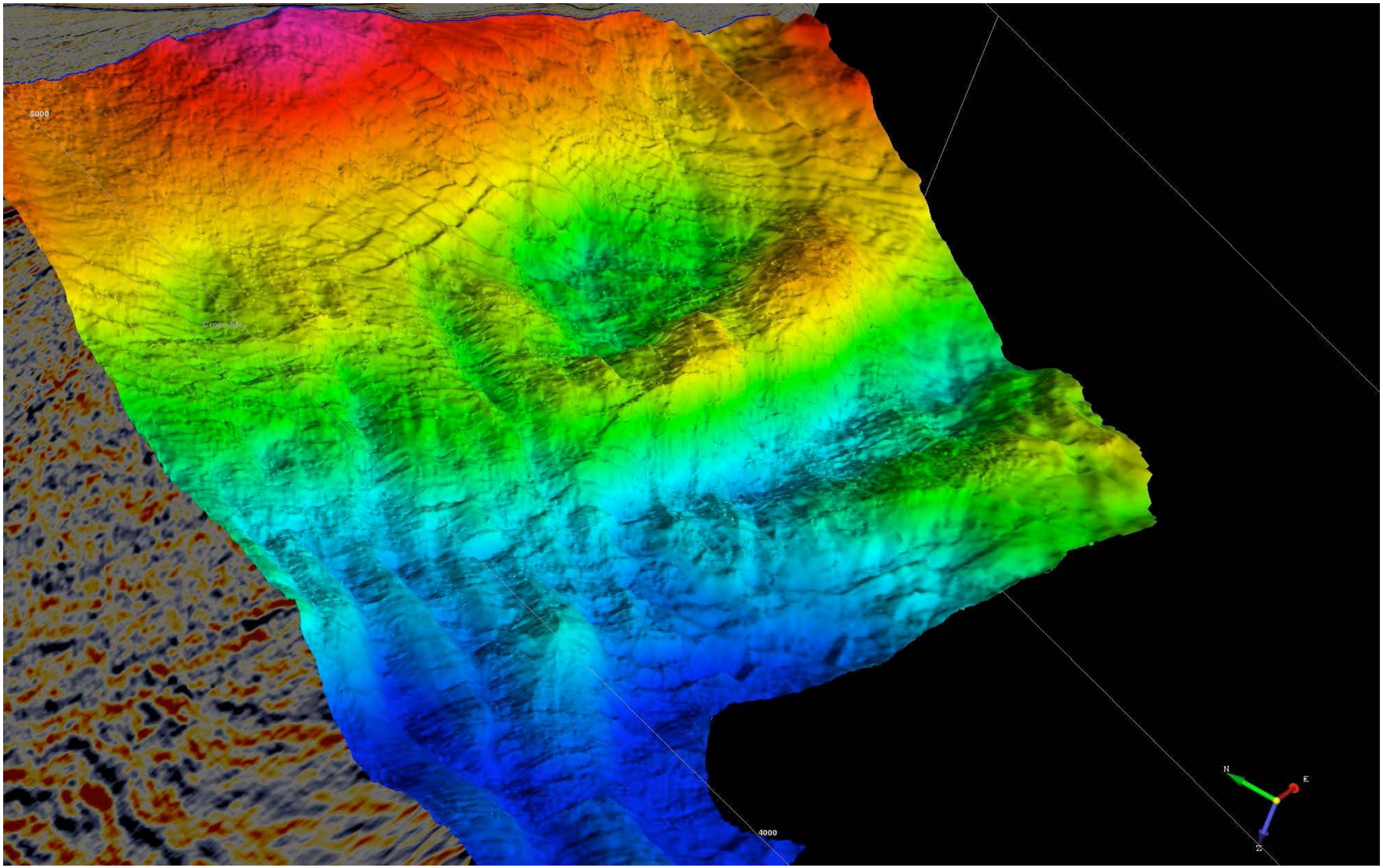

300
800
1300
1800
2300
2800
U2
U1
L10
L9
M4
M1
L8
L6
L7
L5
L3
L2
L1
Margin Wedge
1 km
Inline 2600
V.E. = 4
N

L1 Z Values


Sea Level
to L1
7000
6000
Crossline
5000
4000
Inline
2620
L1
900
1300
1100
1500
1700
1900
2500
2700
Cocos Plate
V.E. = 4
4 km
N
W
Z

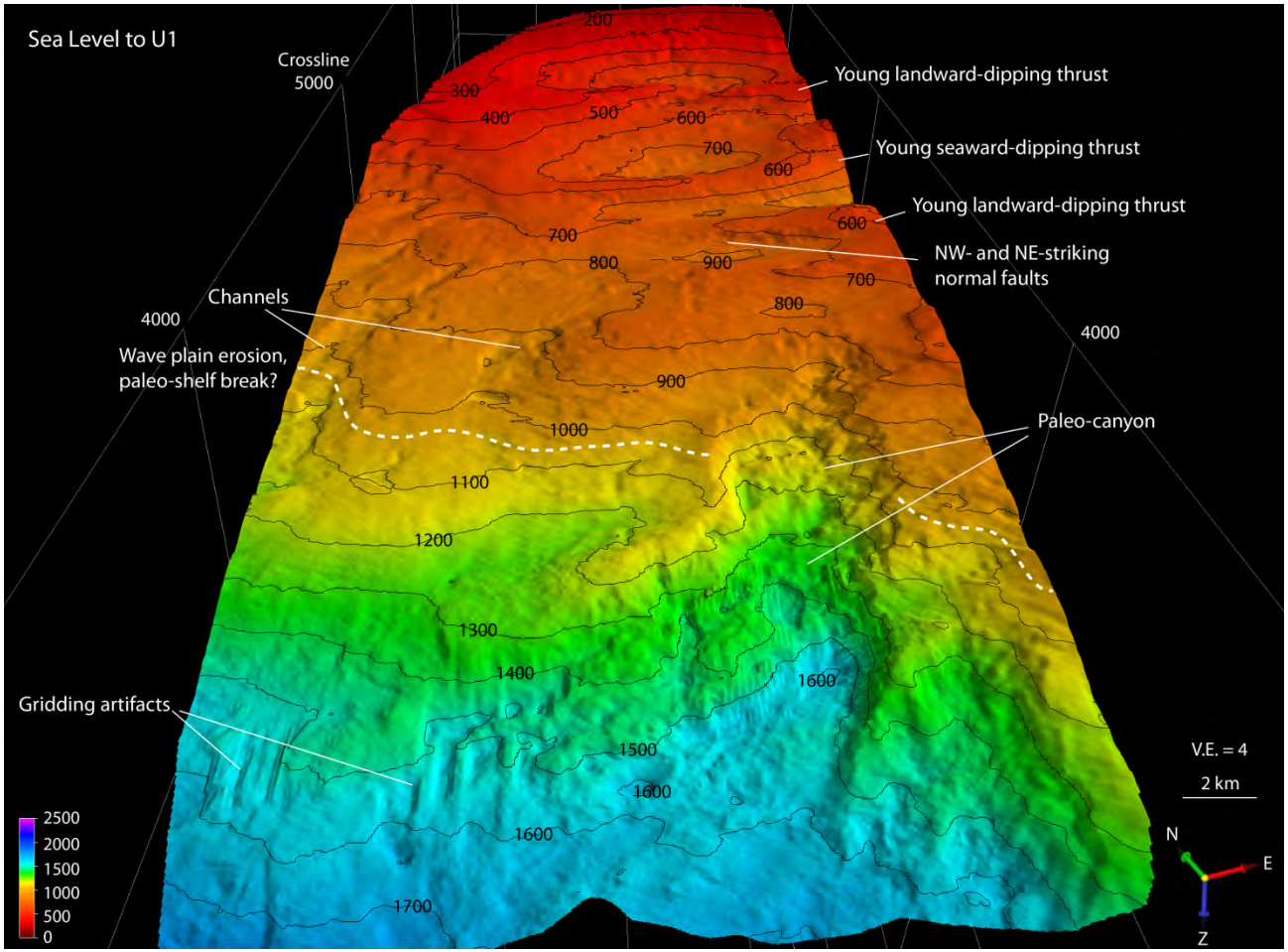
Upslope M1


Sea Level to M1
Crossline
6000
5000
NW- and NE-striking normal faults
Seaward-dipping
thrust fault
Landward-dipping
thrust fault
Channels
400
300
500
700
500
600
800
900
1100
1000
800
900
900
1000
1100
1200
1300
1400
1000
1500
1400
1300
1200
1100
1300
1500
1500
1600
1600
1700
1600
2500
2000
1500
1000
500
0
V.E. = 4
4 km
N
E
Z

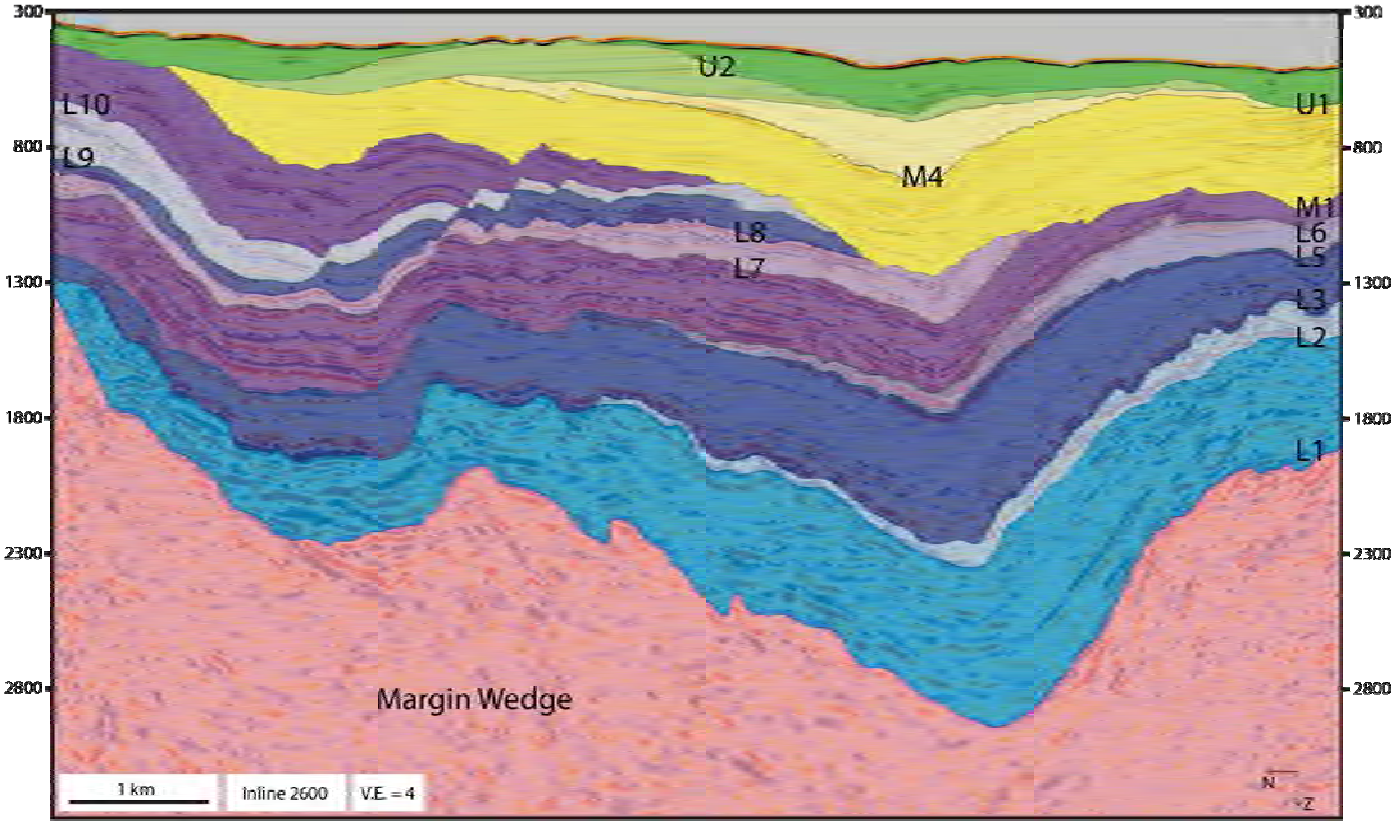


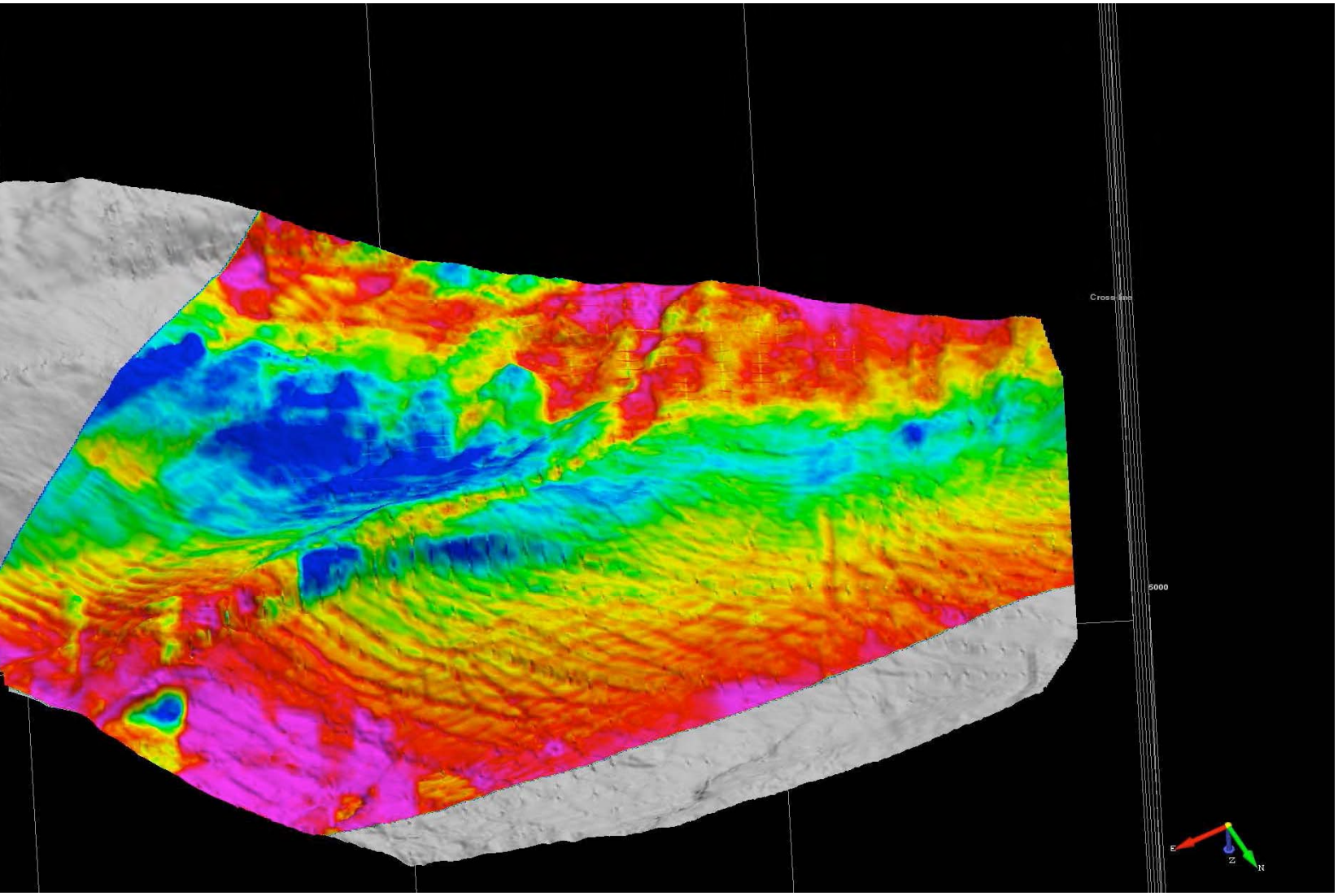
Mid 1 unconformity (approximately 2 Ma)

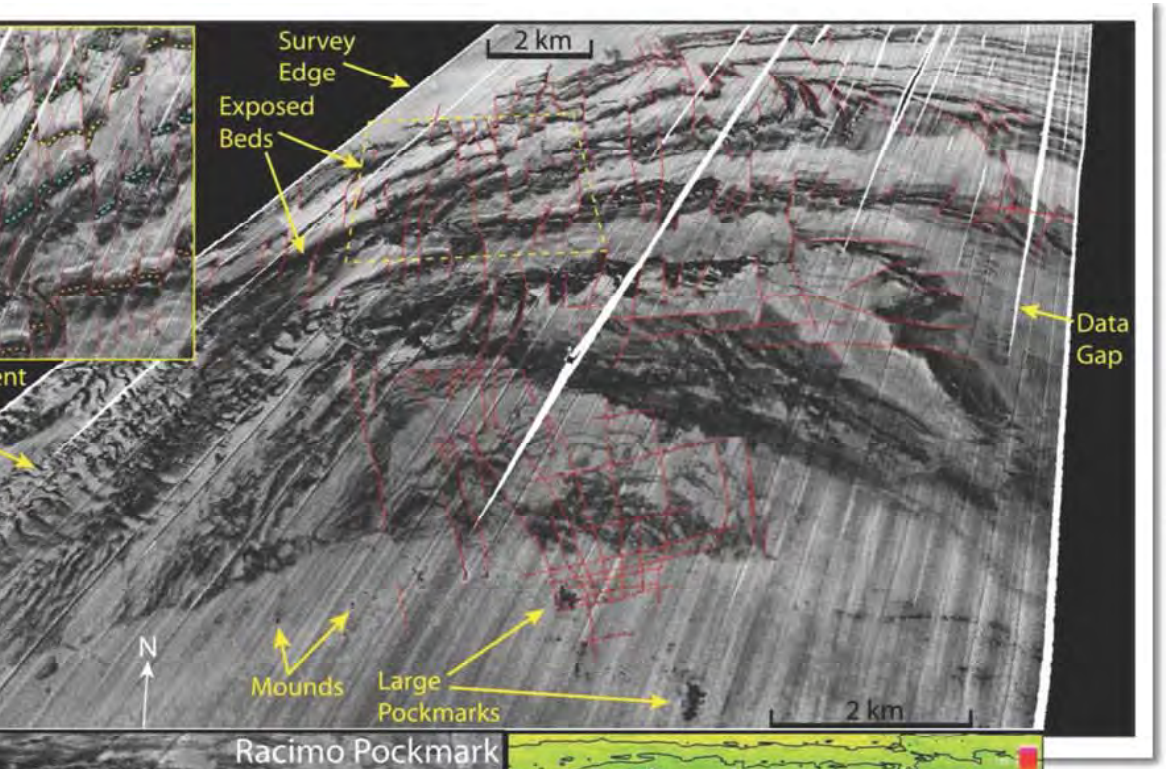
Upslope U1

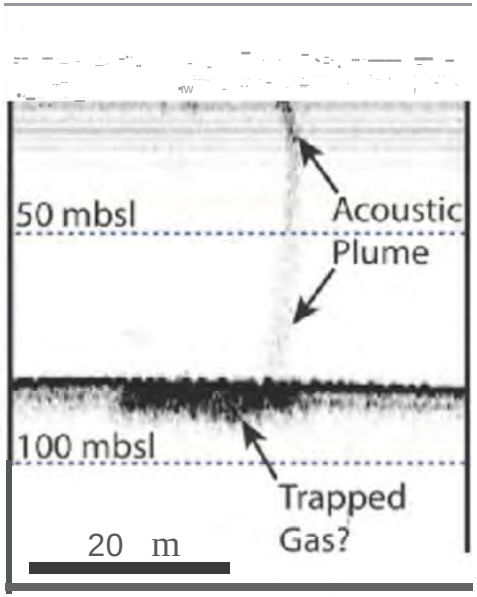

Sea Level to U1
Crossline
5000
Young landward-dipping thrust
Young seaward-dipping thrust
Young landward-dipping thrust
NW- and NE-striking
normal faults
Channels
Wave plain erosion,
paleo-shelf break?
Paleo-canyon
Gridding artifacts
4000
4000
200
300
400
500
600
700
600
600
700
800
900
700
800
900
1000
1100
1200
1300
1400
1600
1500
1600
1600
1700
2500
2000
1500
1000
500
0
V.E. = 4
2 km
N
E
Z

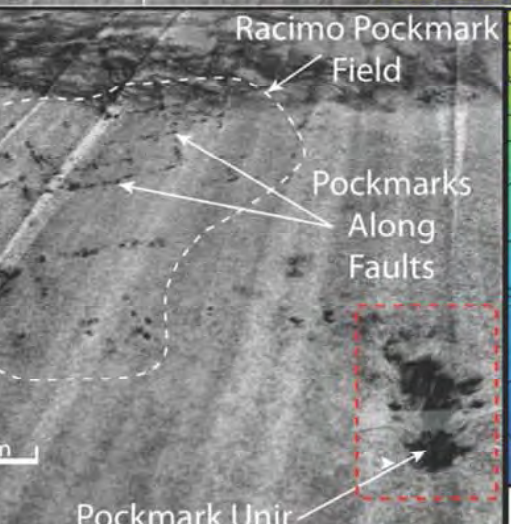
Inline 2600

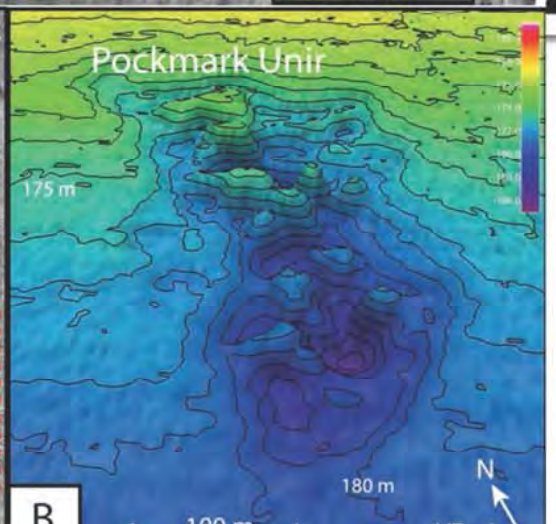

300
800
1300
1800
2300
2800
U2
U1
L10
L9
M4
M1
L8
L6
L7
L5
L3
L2
L1
Margin Wedge
1 km
Inline 2600
V.E. = 4
N


5000
E
Z
N


Survey
Edge
2 km
Exposed
Beds
Data
Gap
N
Mounds
Large
Pockmarks
2 km


50 mbsl
Acoustic
Plume
100 mbsl
Trapped
Gas?
20 m


Racimo Pockmark
Field
Pockmarks
Along
Faults
Pockmark Unir


Pockmark Unir
175 m
180 m
N
B

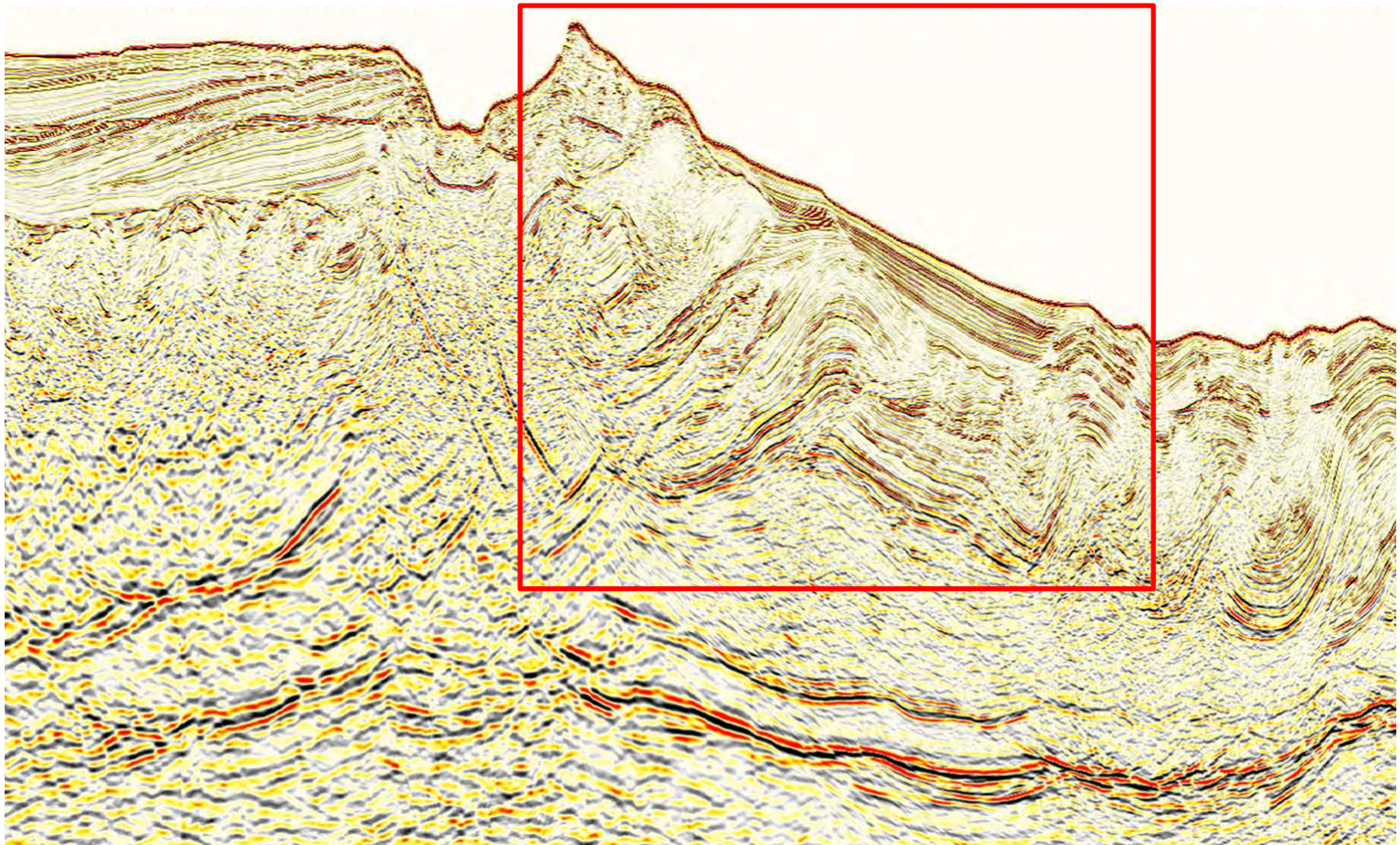
Future needs for 3D imaging

Example from:

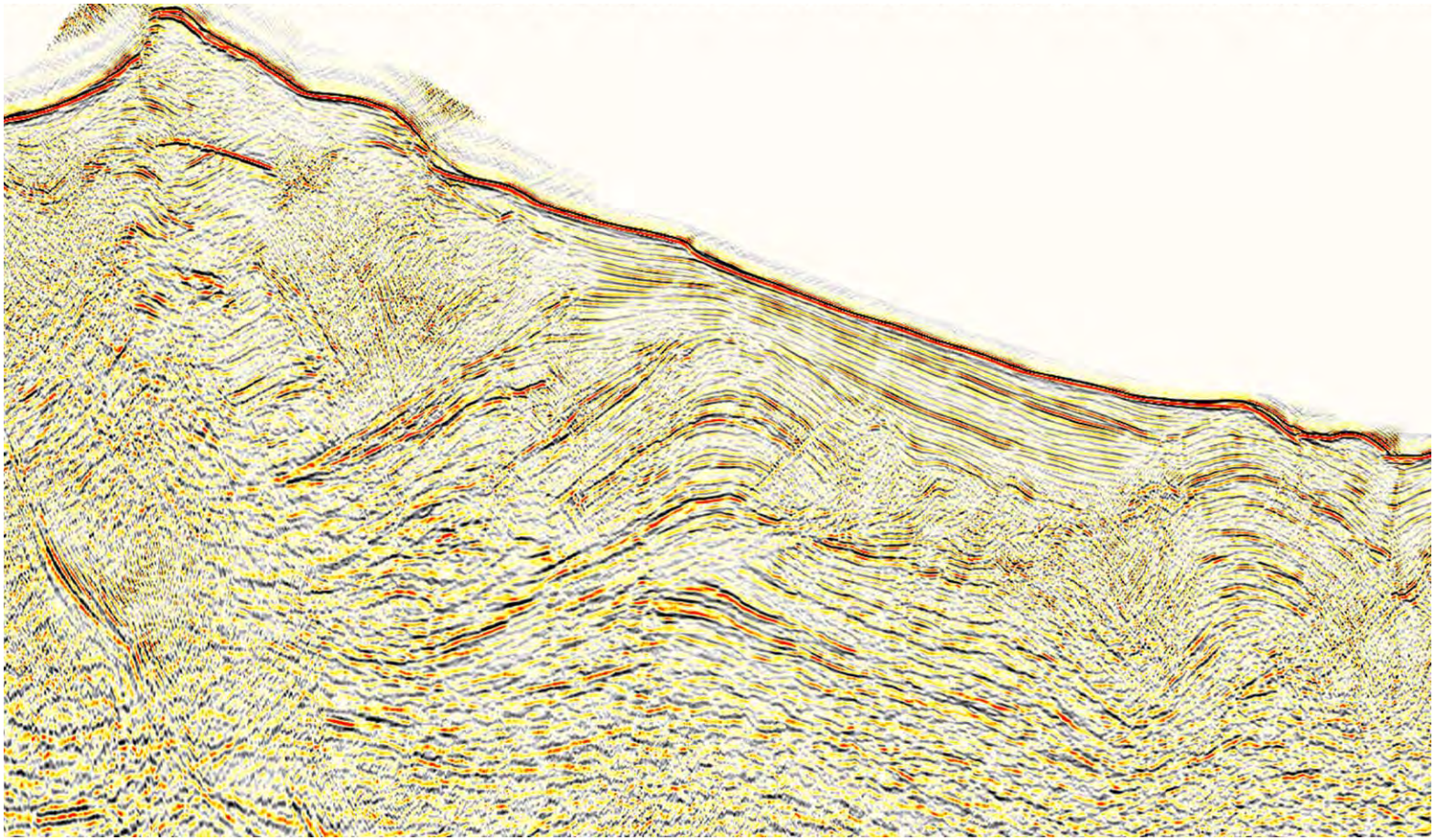
- Hikurangi margin, New Zealand

3D Seismic Image of Splay System

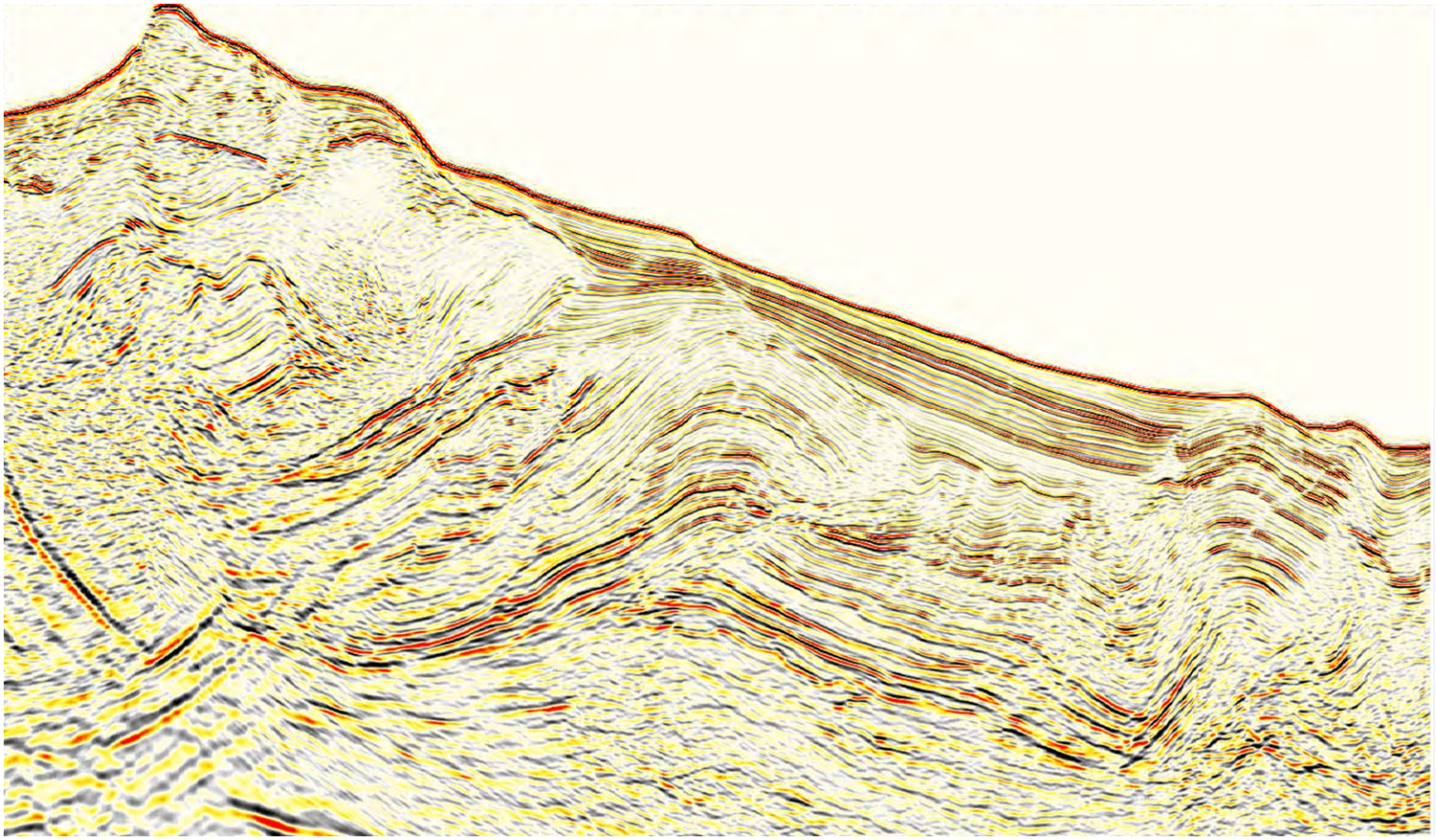
red by PGS in 2006
m 360-channel streamer
cu. in airgun array



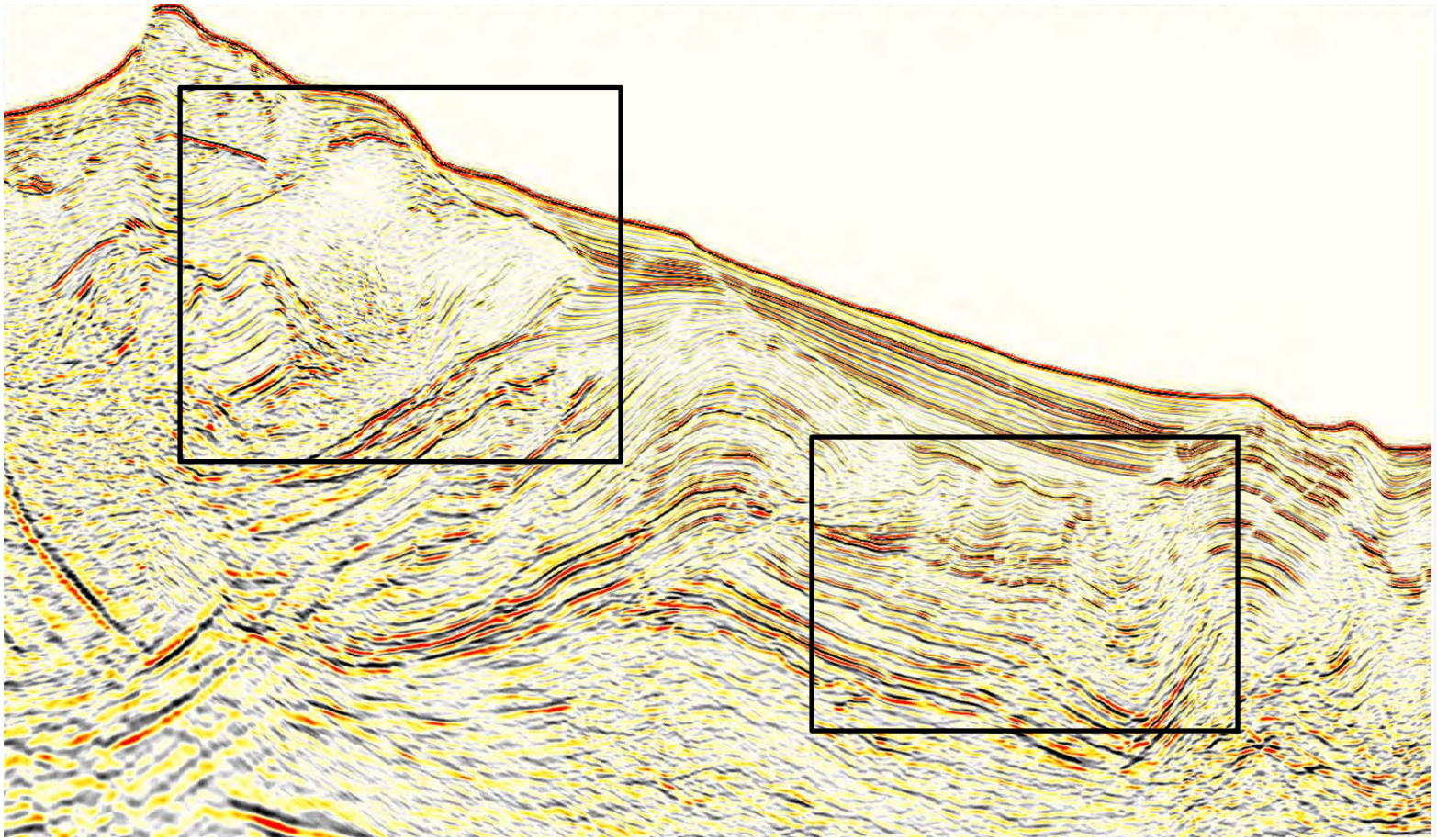
2D



3D

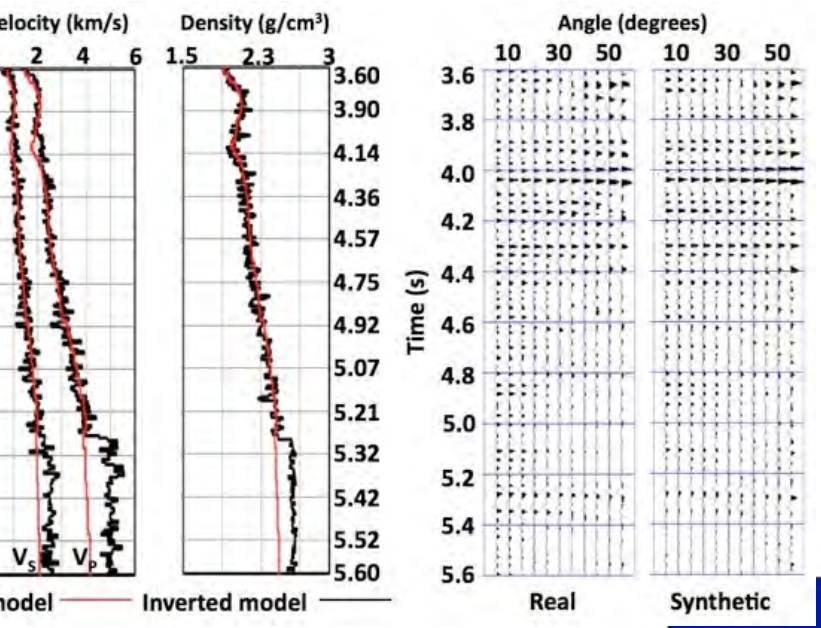


3D



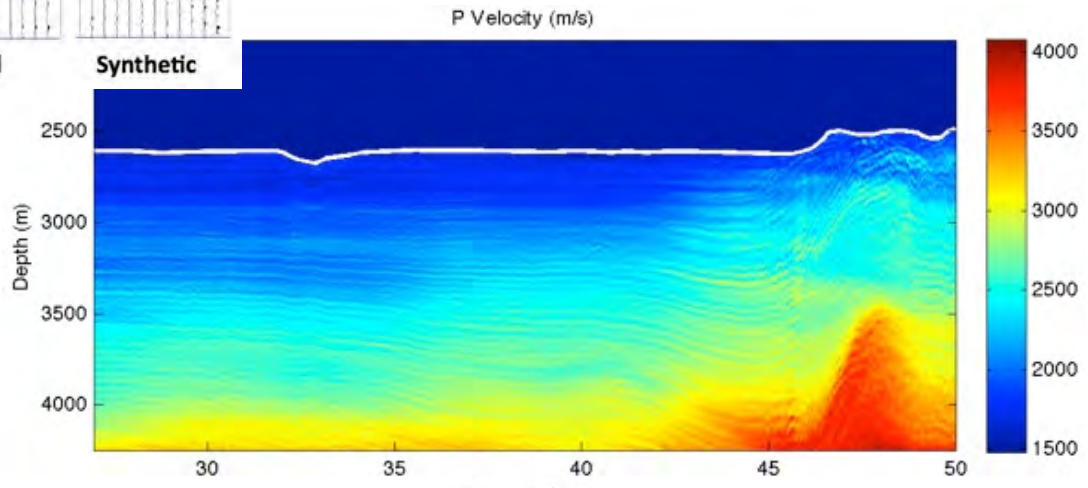
Sediment properties from long offset streamers

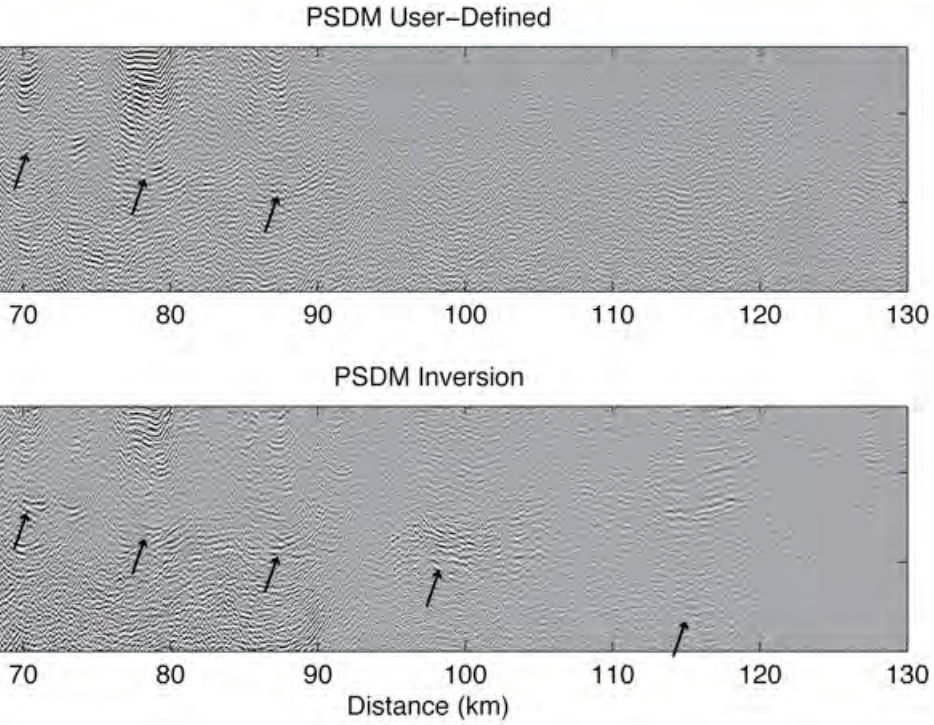
Cascadia Subduction Zone
(COAST project)



Long offsets allow waveform inversion

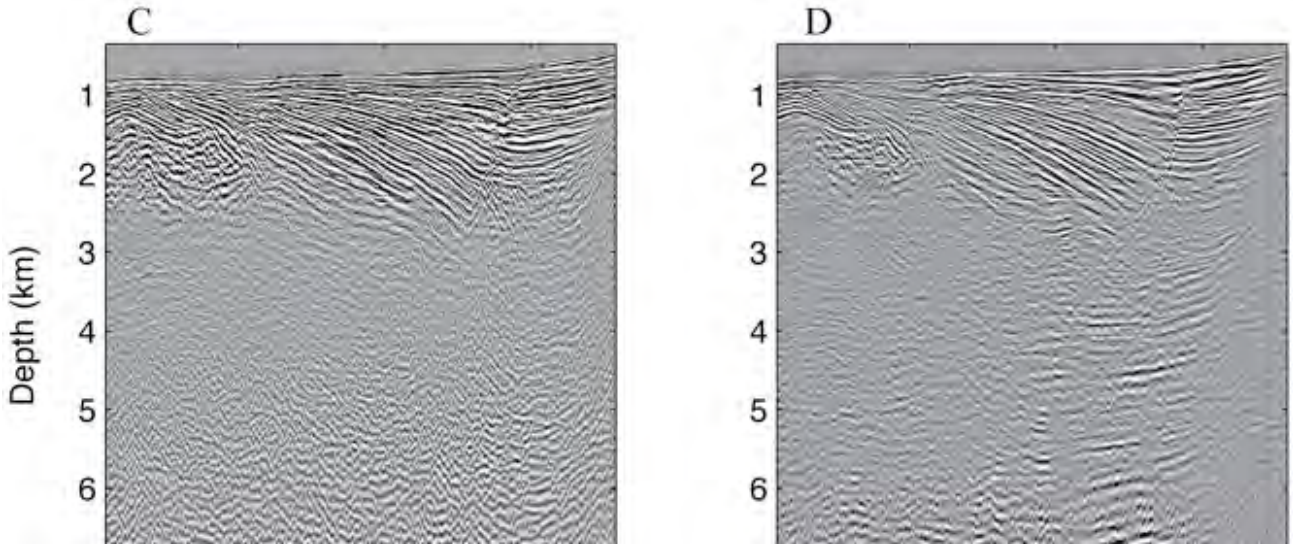
- bulk property changes
- localized property anomalies

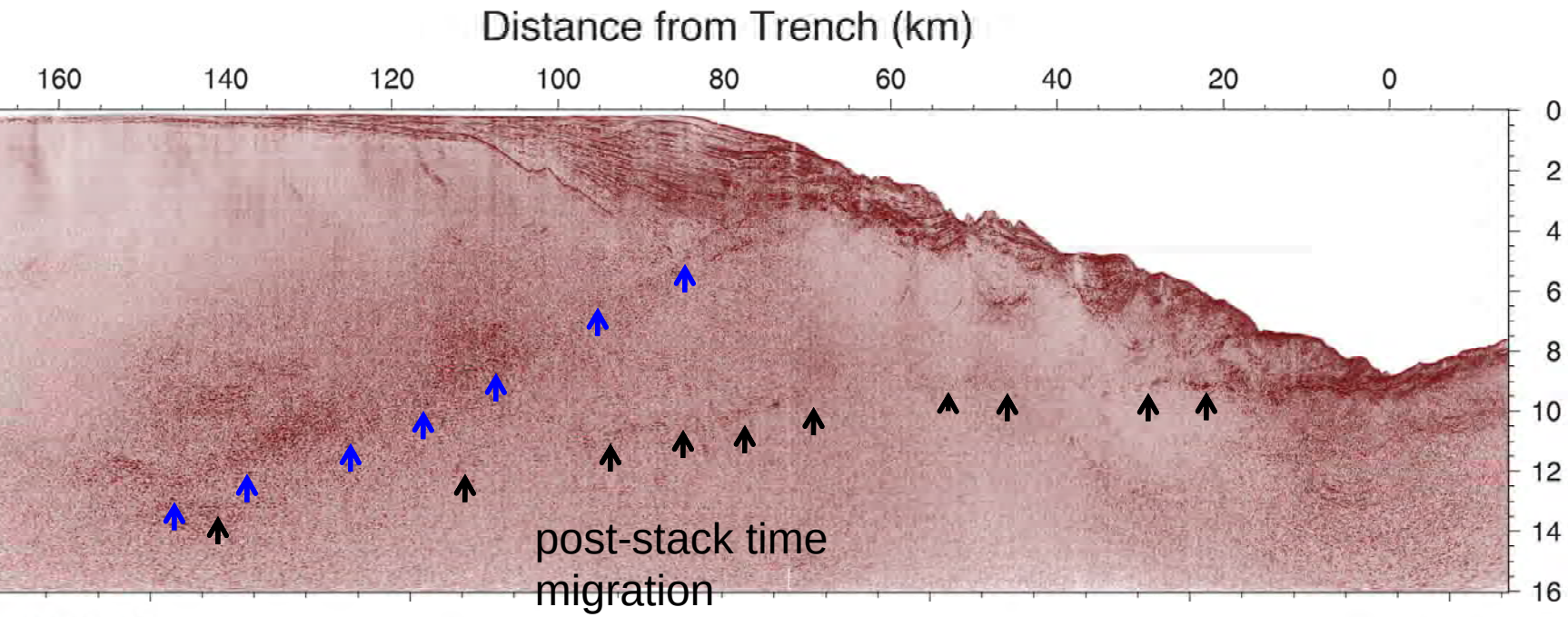


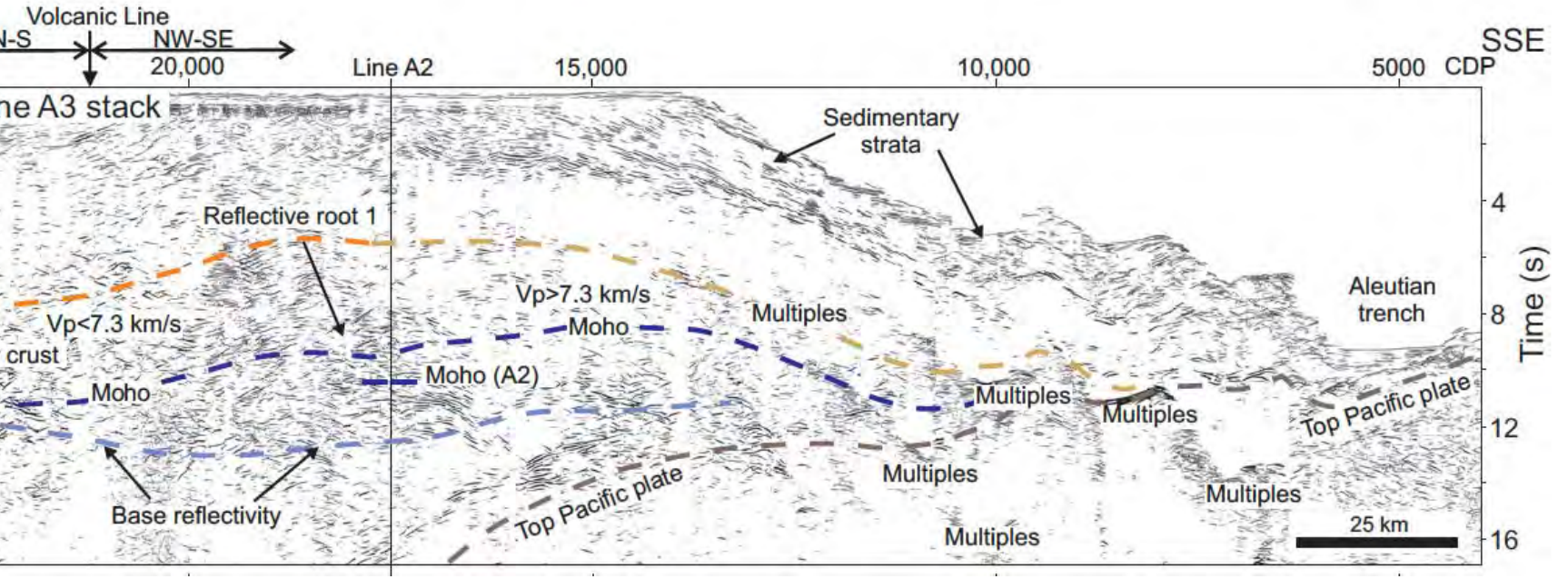


Cascadia Subduction Zone (COAST project)

Better velocities
- improved images
- multiple suppression




Distance from Trench (km)
160
140
120
100
80
60
40
20
0
0
2
4
6
8
10
12
14
16
post-stack time migration


Volcanic Line
N-S
NW-SE
SSE
20,000
Line A2
15,000
10,000
5000
CDP
ne A3 stack
Sedimentary strata
Reflective root 1
Vp<7.3 km/s
crust
Vp>7.3 km/s
Moho
Multiples
Aleutian trench
Moho
Moho (A2)
Multiples
Multiples
Top Pacific plate
Multiples
Top Pacific plate
Multiples
Base reflectivity
Multiples
25 km
4
8
12
16
Time (s)