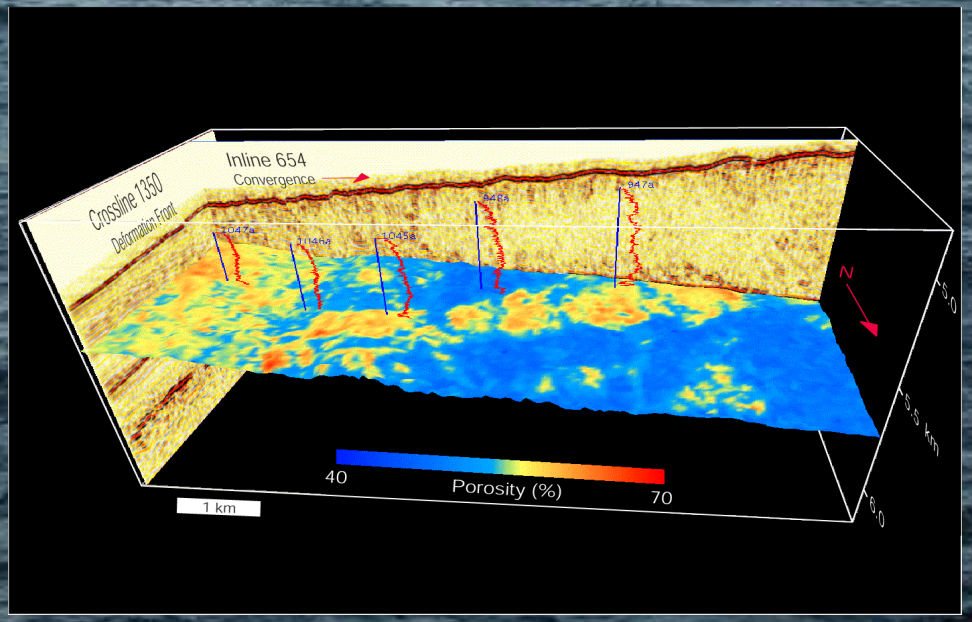
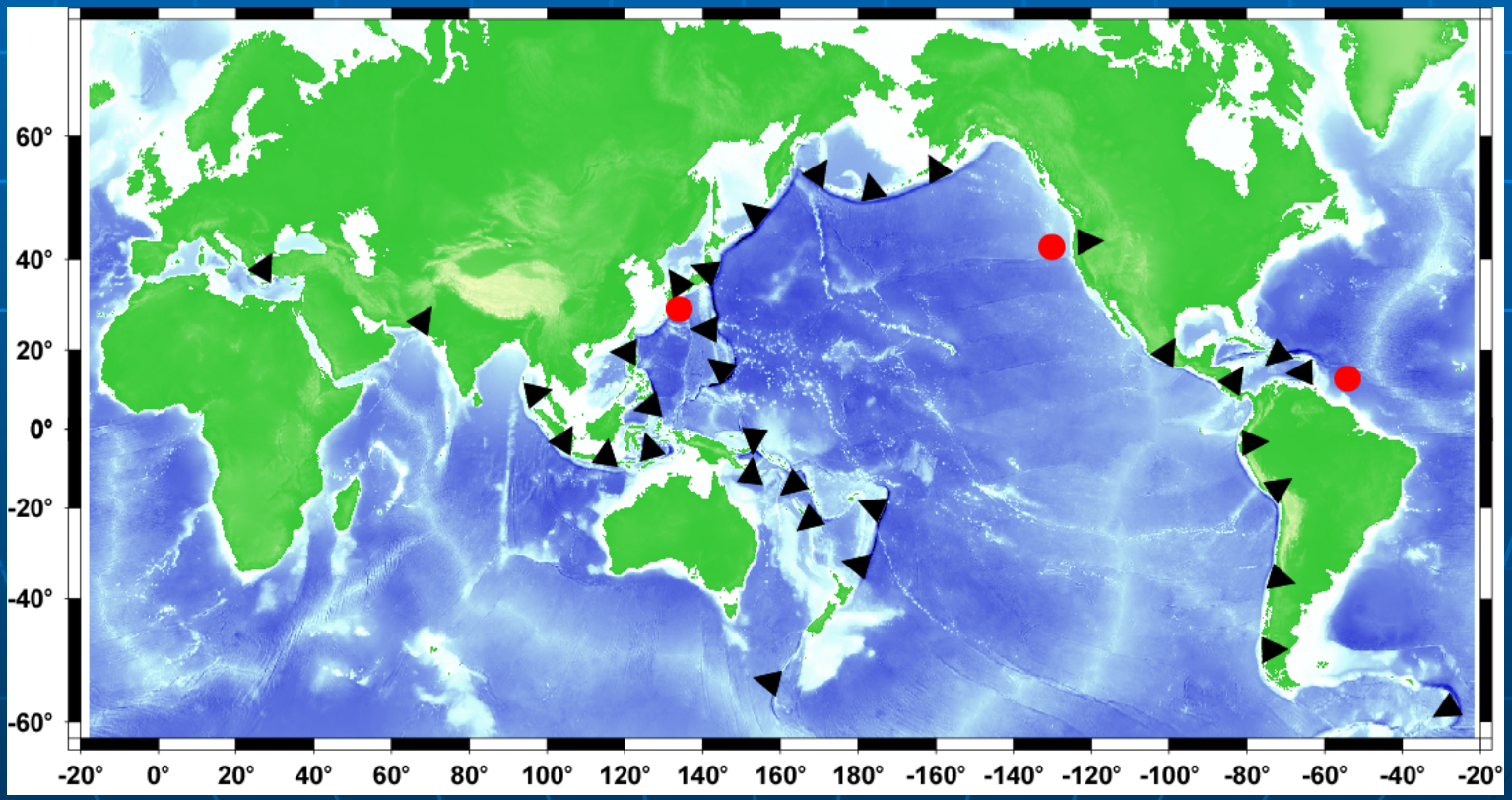
Achievements and lessons from 3-D seismic surveys of subduction zones



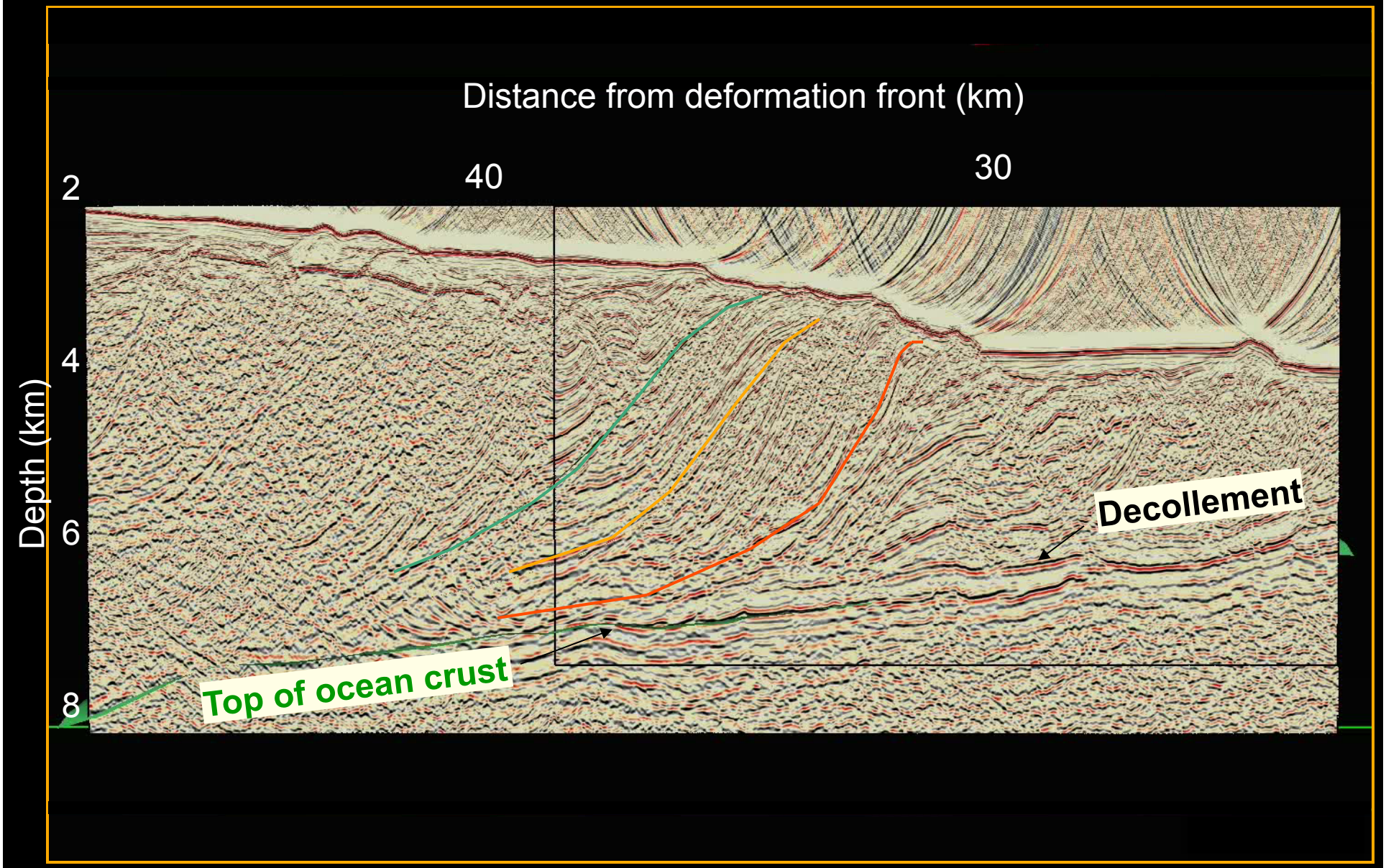
Nathan Bangs
University of Texas

Subduction zone 3-D seismic surveys

- Barbados Ridge (1992)
- Nankai Trough (1999)
- Hydrate Ridge (2000)



Nankai Trough large-thrust-slice zone



Barbados Ridge

1992

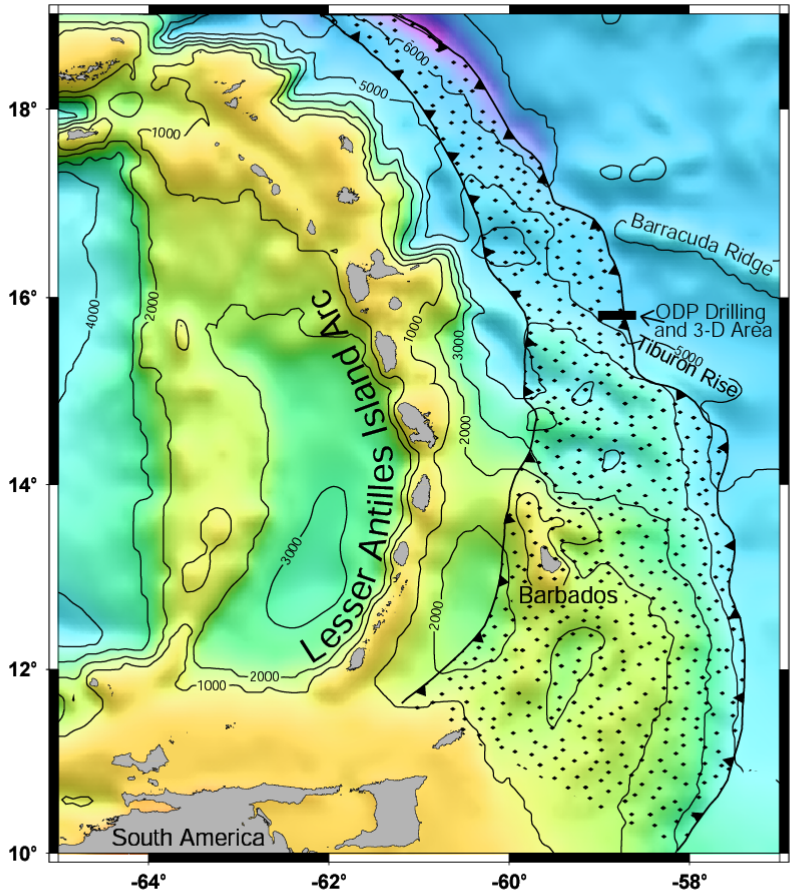
R/V Ewing

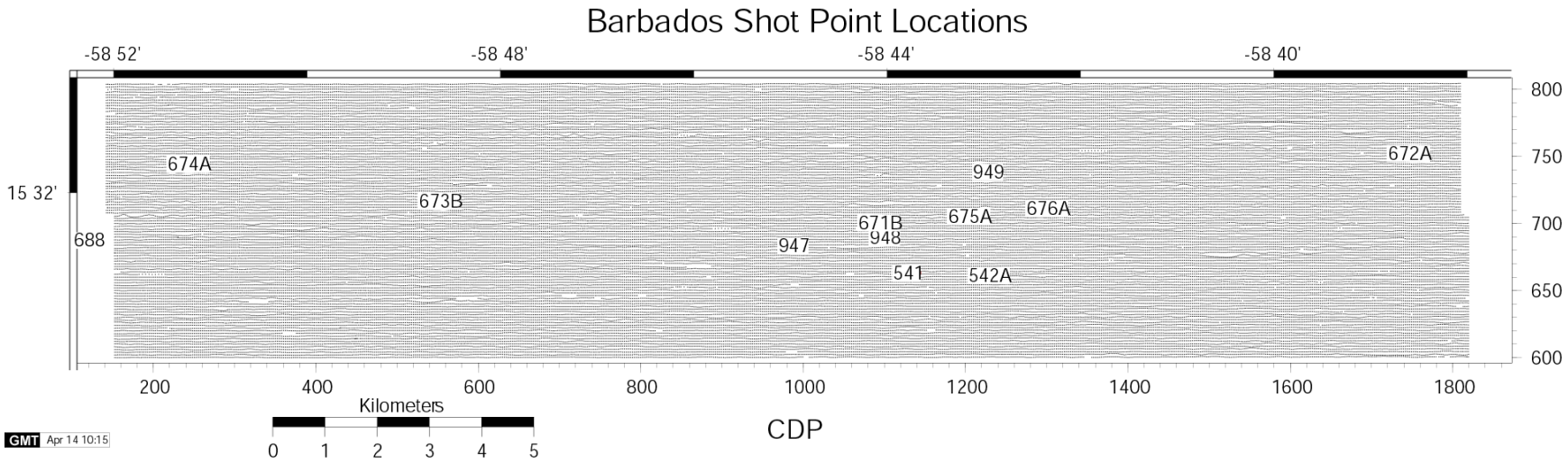
Short offset (<853 m) single streamer

52 channels

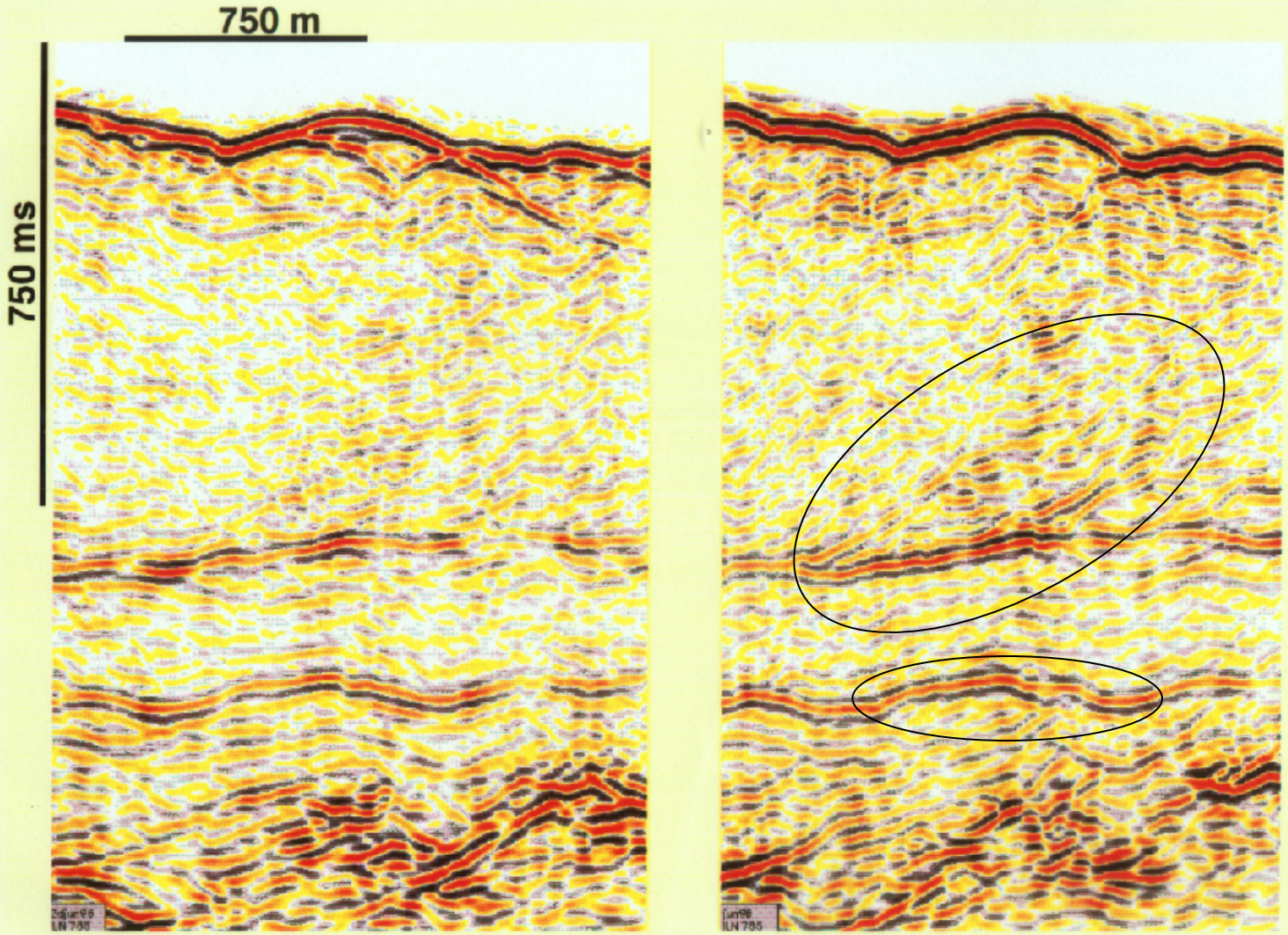
103, 25-km-long lines @ 50 m spacing
Total coverage 5 x 25 km

Data volume: prestack 45 Gbytes,
poststack 3.5 Gbytes

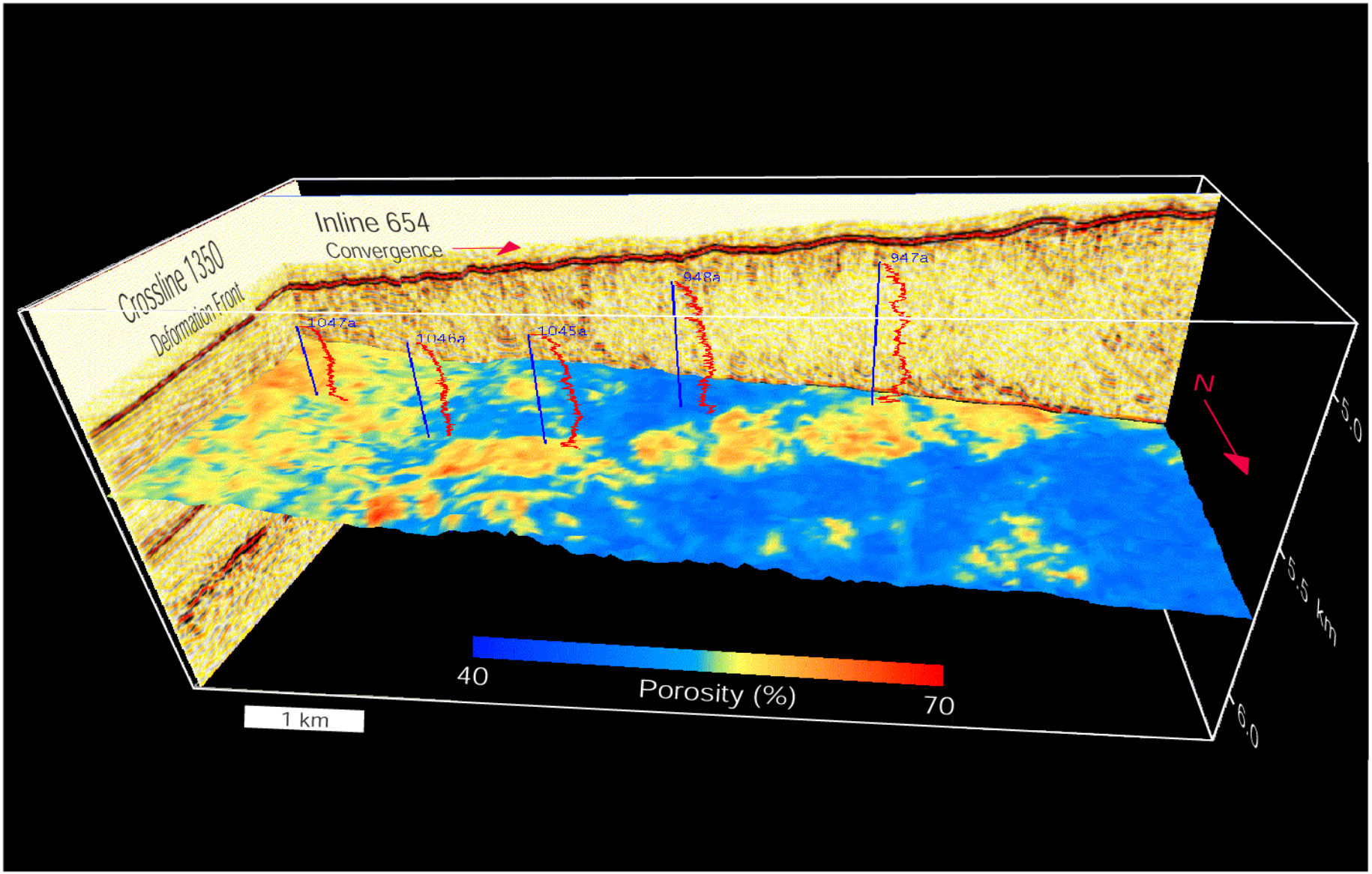



Barbados Shot Point Locations
-58 52'
-58 48'
-58 44'
-58 40'
15 32'
674A
673B
688
947
671B
948
541
675A
676A
542A
949
672A
800
750
700
650
600
200
400
600
800
1000
1200
1400
1600
1800
CDP
Kilometers
0 1 2 3 4 5
GMT Apr 14 10:15

Comparison of 2-D vs. 3-D Imaging

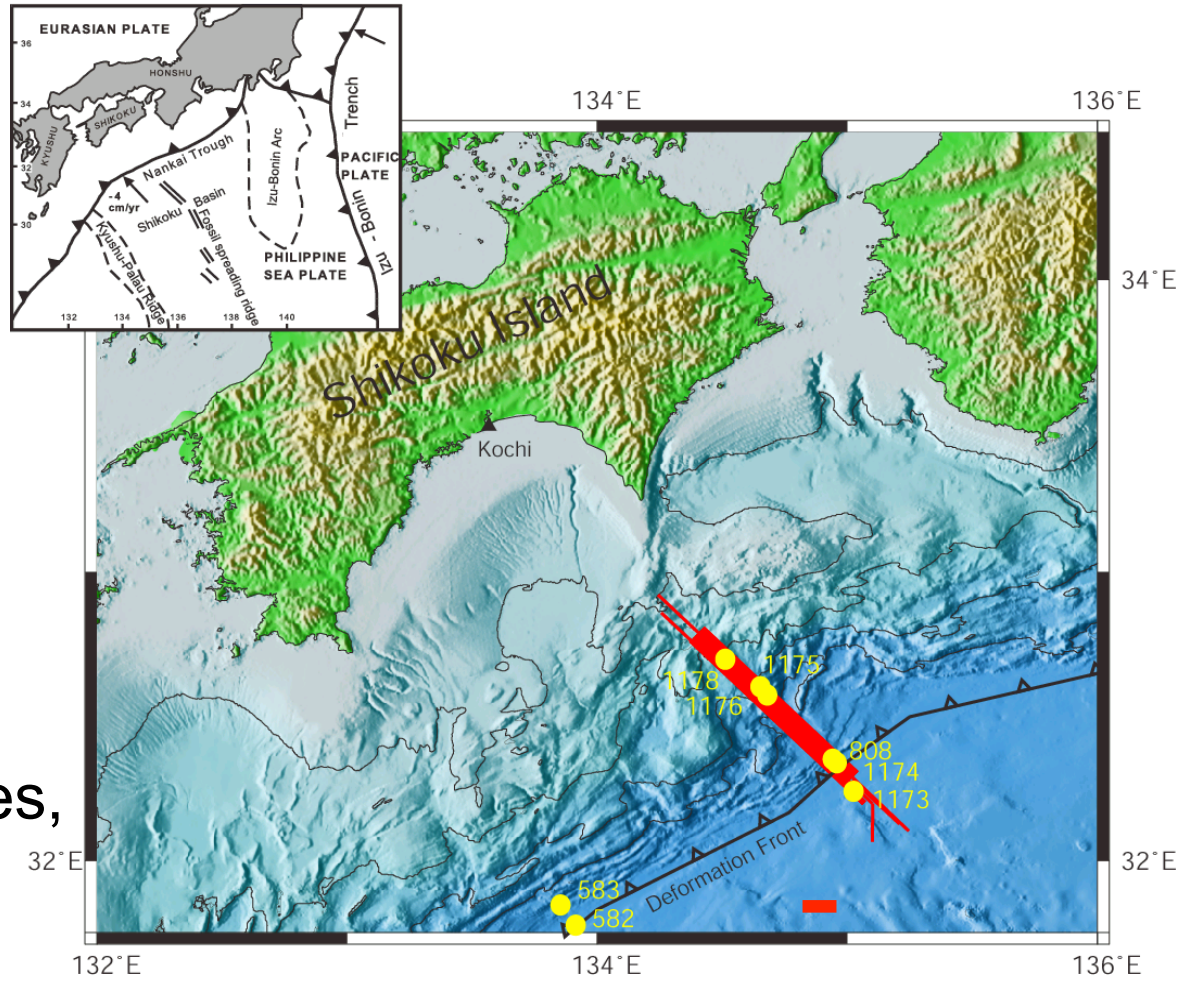


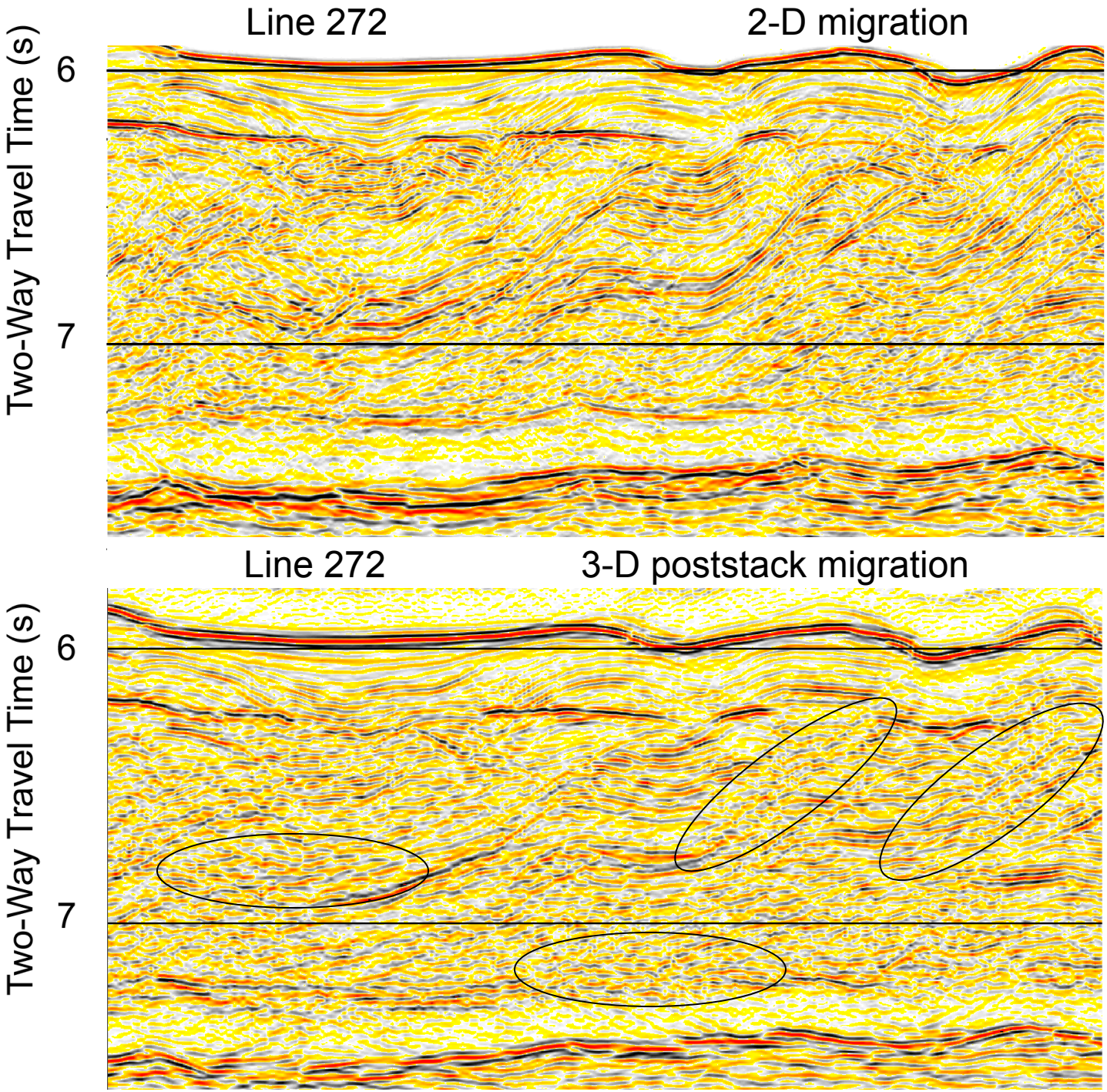
Barbados Ridge Decollement



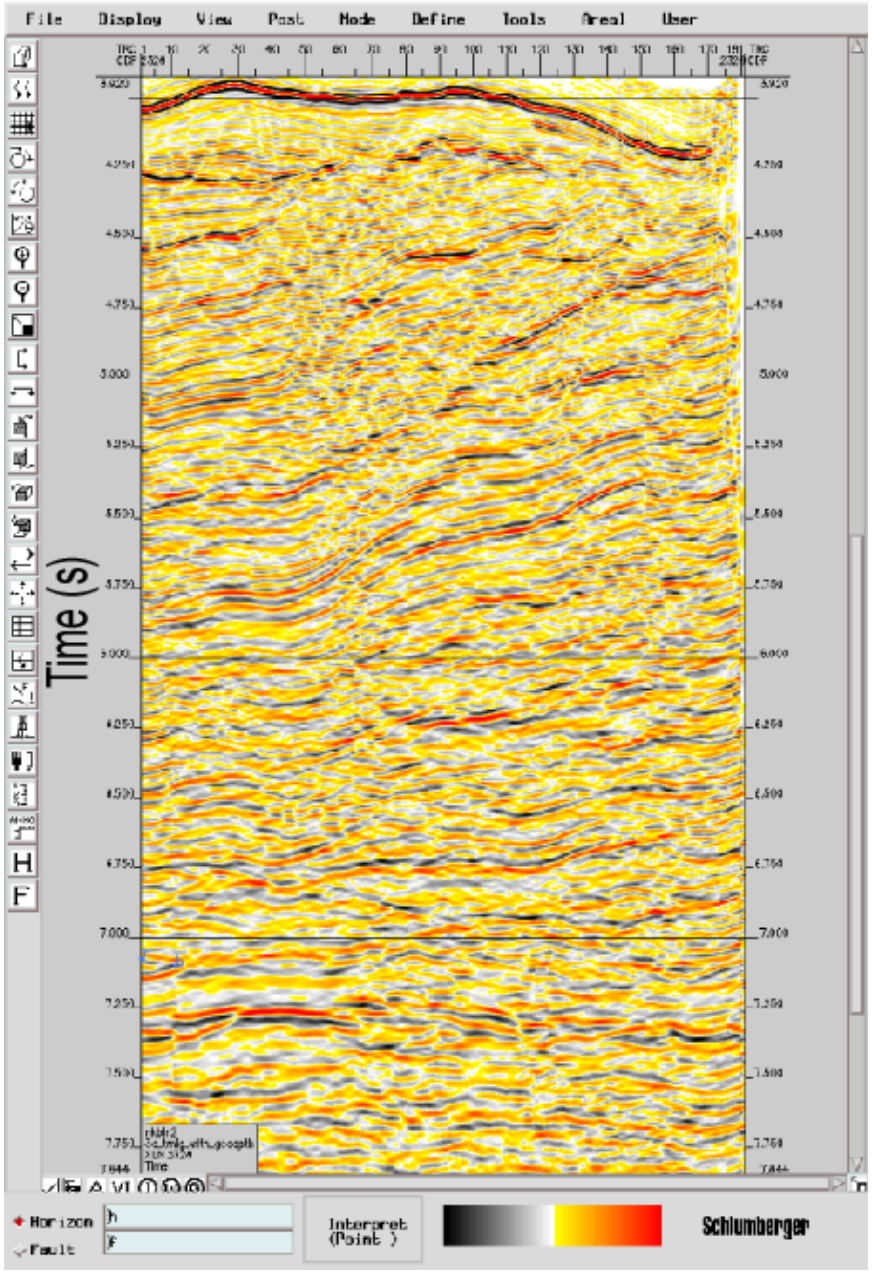
Nankai Trough

- 1999
- R/V Ewing
- Long offset (6000 m), single streamer
- 240 channels, 25 m groups
- 81, 80-km-long lines, 100 m spacing
- Coverage 8 x 80 km
- Prestack: ~500 Gbytes, Poststack 8 Gbytes




Line 272
2-D migration
Two-Way Travel Time (s)
6
7
Line 272
3-D poststack migration
Two-Way Travel Time (s)
6
7

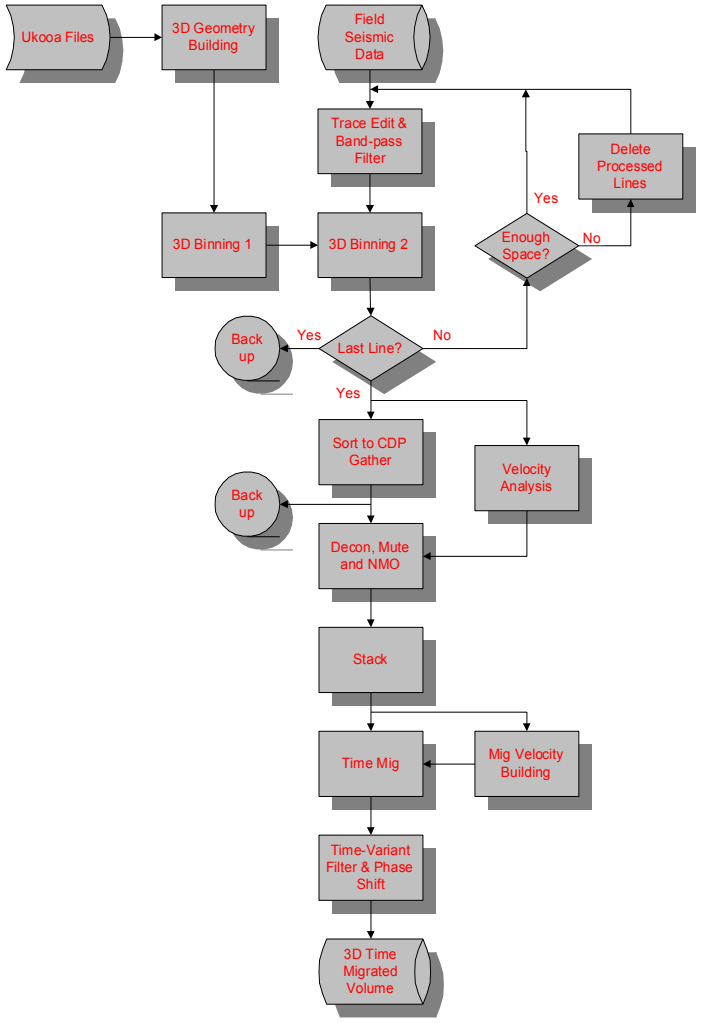
3-D Post-Stack Migration



Where did we go wrong?

R/V Ewing Acquisition

3D Seismic Processing Flow Chart



Potential problems?

- Navigation (raw data, streamer models, assignment)
- Bin size (25 x 50, 12.5 x 25: fold vs. spacing)
- Extended binning (filling vs. smearing)
- Sorting
- Velocities (smooth vs. detailed, stacking vs. migration)
- Acquisition parameters
  (weather, source/receiver depth, source configuration, infill, aperture, line spacing, etc.)

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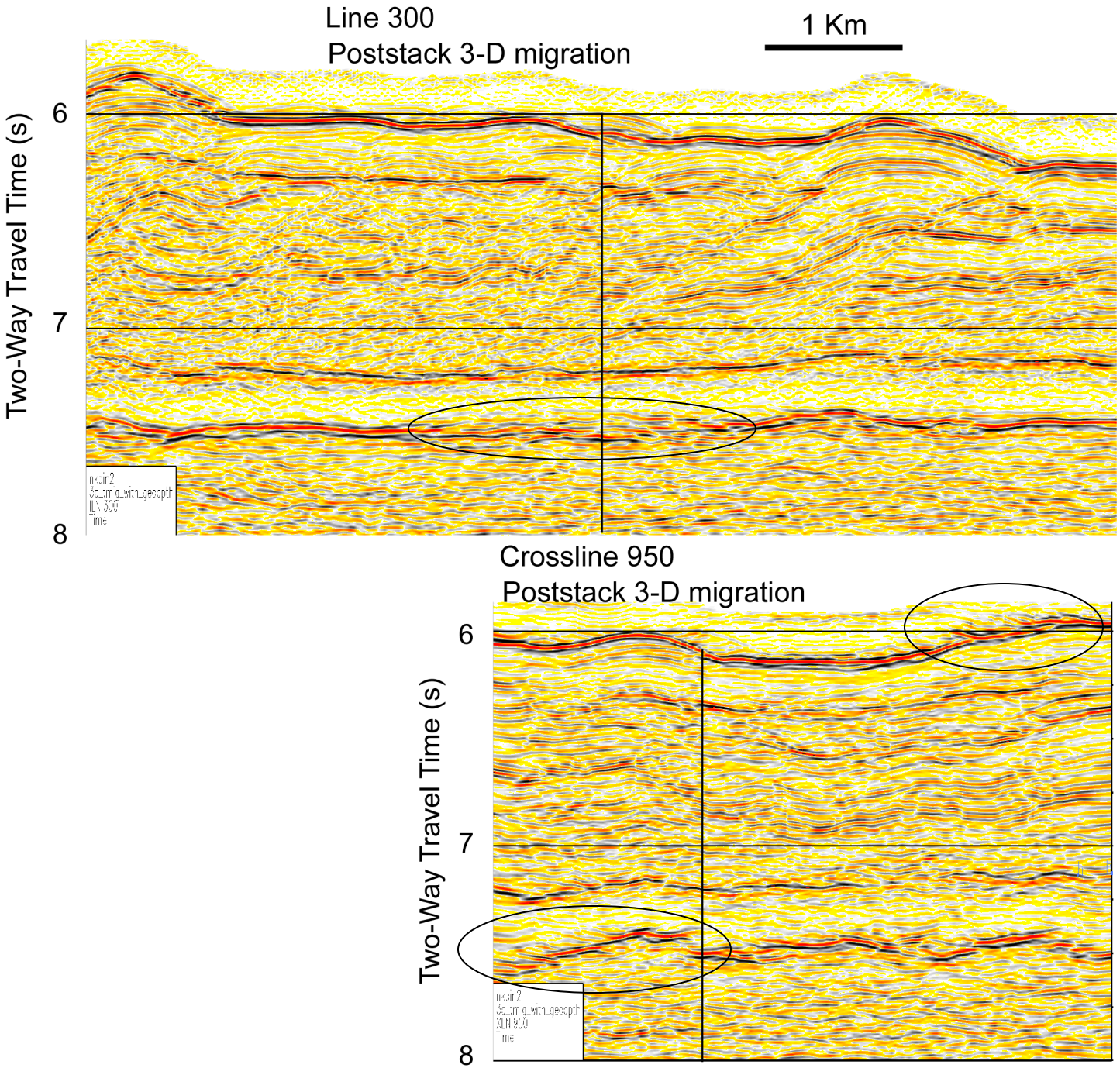

Line 300
Poststack 3-D migration
1 Km
Two-Way Travel Time (s)
6
7
8
Crossline 950
Poststack 3-D migration
Two-Way Travel Time (s)
6
7
8

Crossline 950

3-D Poststack Migration

Crossline 950

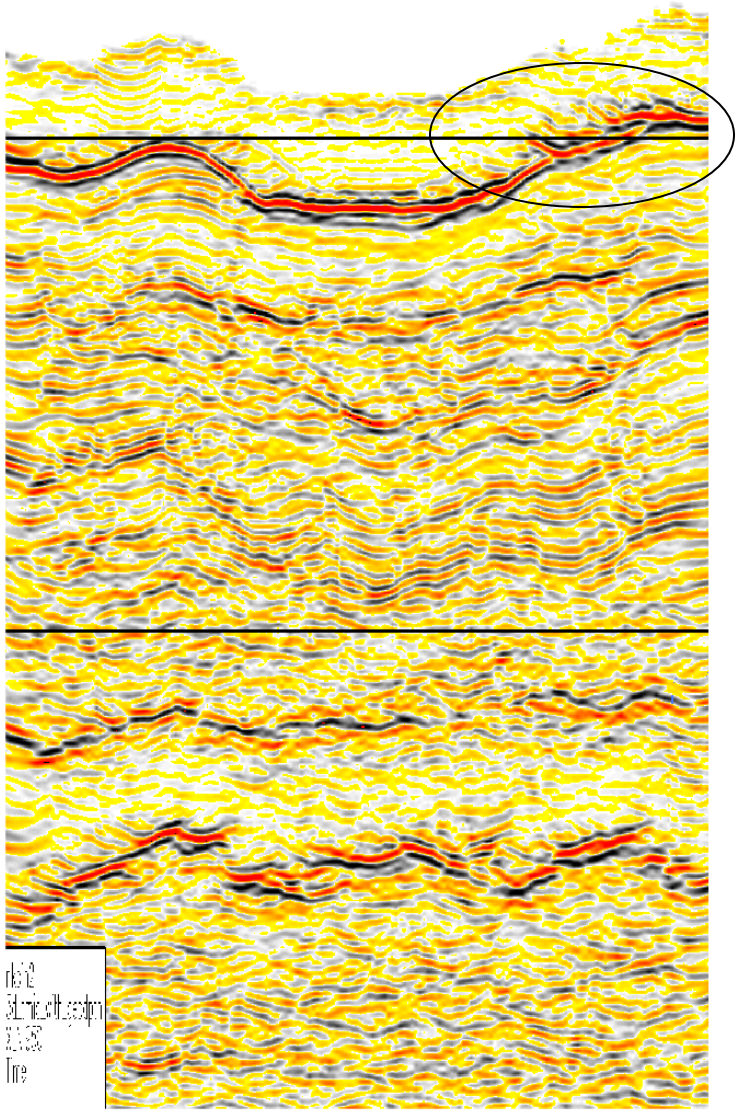
2-D Poststack Migration

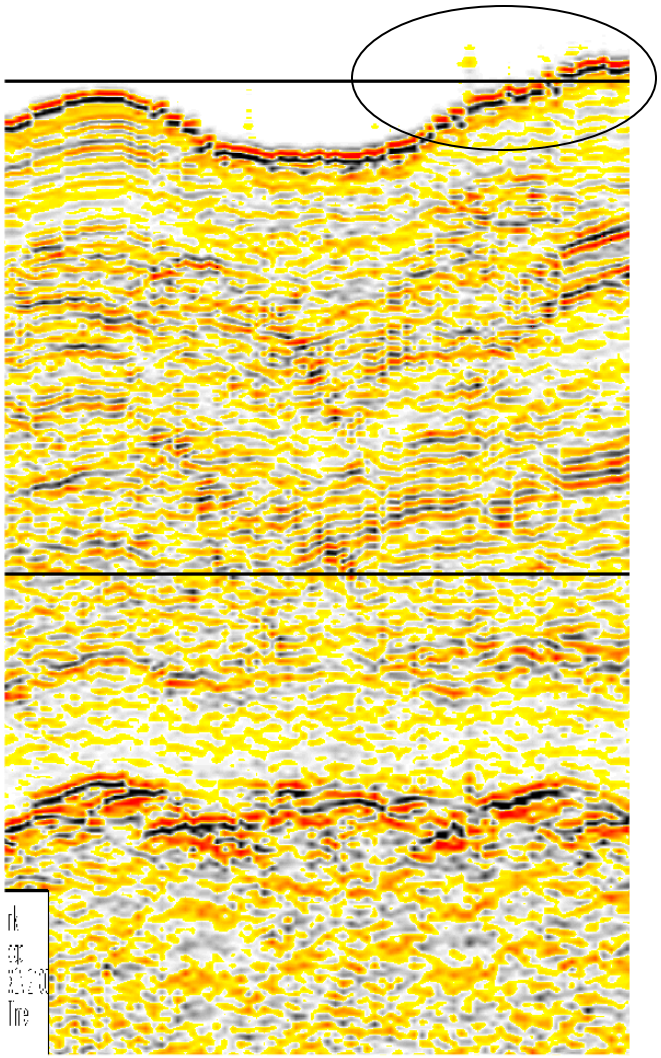
Two-Way Travel Time (s)

6

7

8





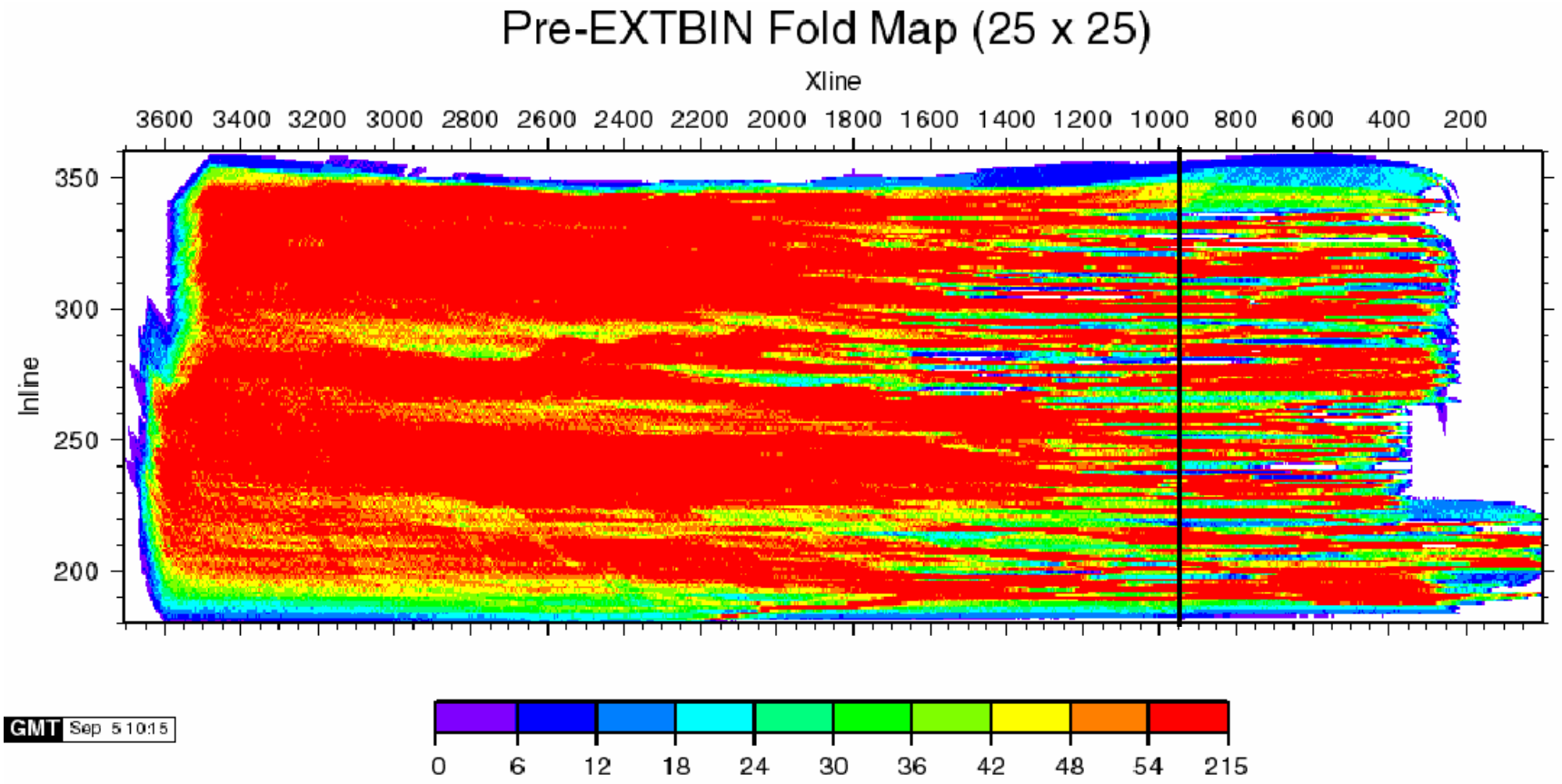


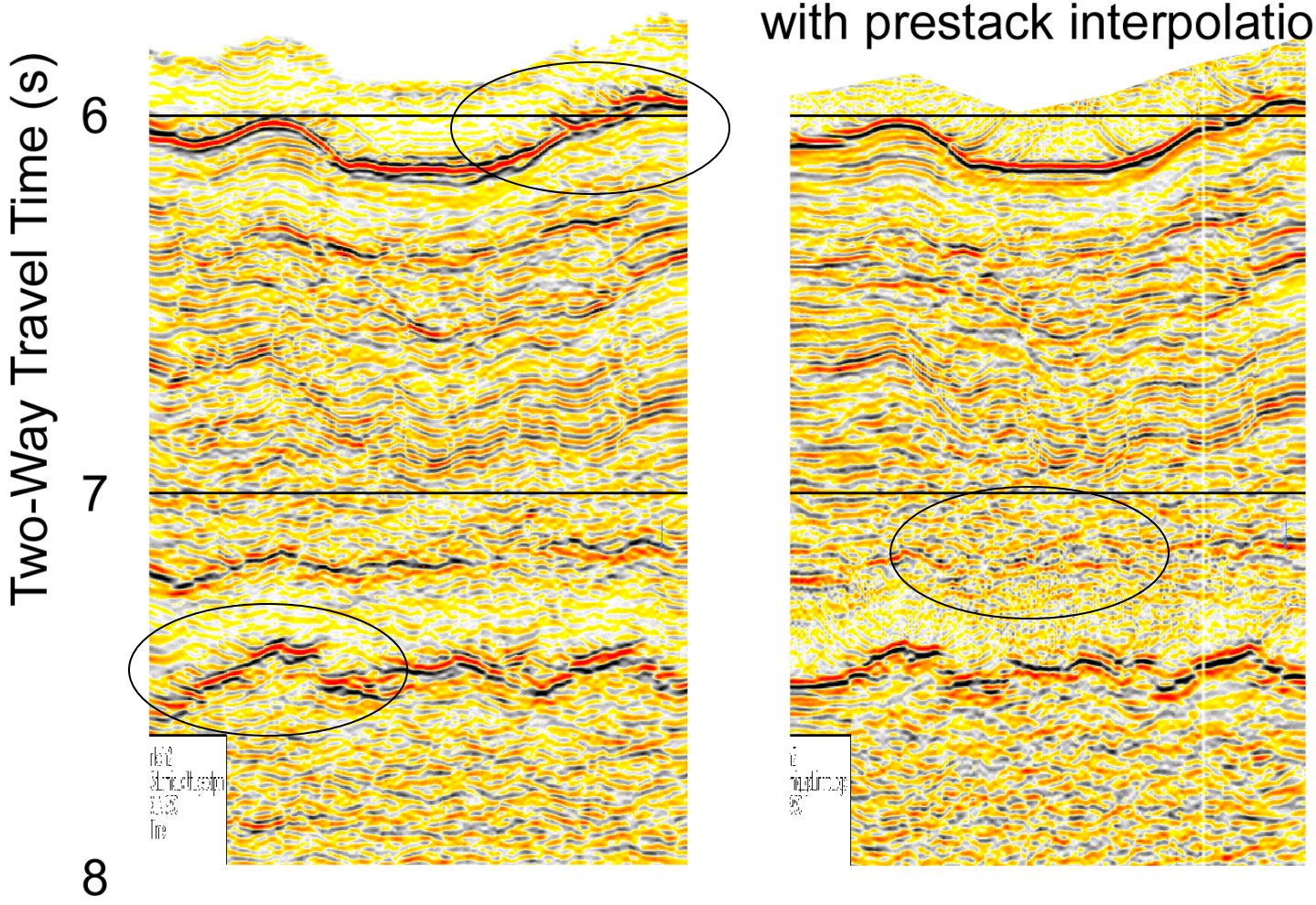
Figure 1. Fold map without bin extension. Bin size is 25 m by 50 m

Crossline 950

3-D Poststack Migration

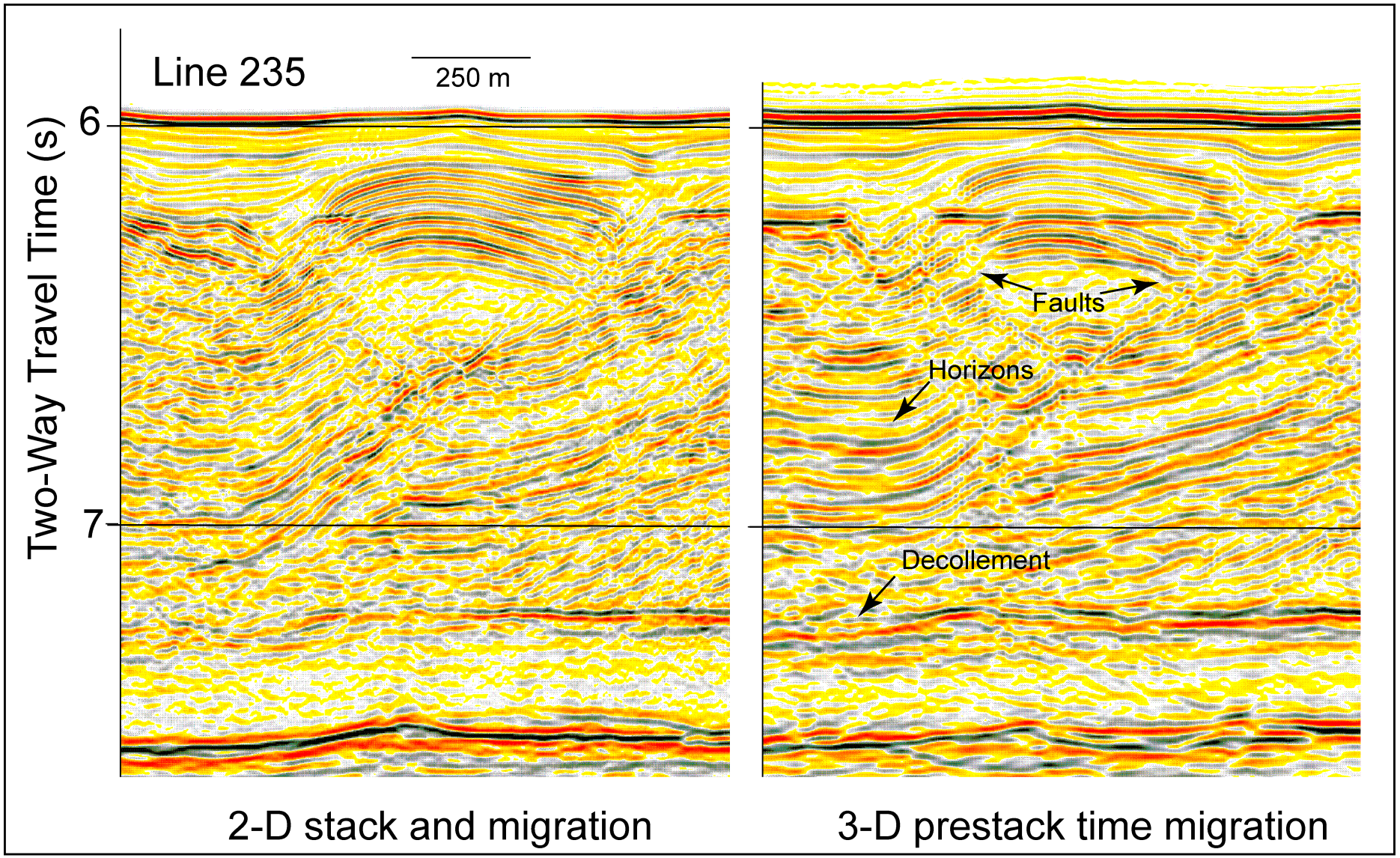
Crossline 950

3-D Poststack Migration
with prestack interpolation



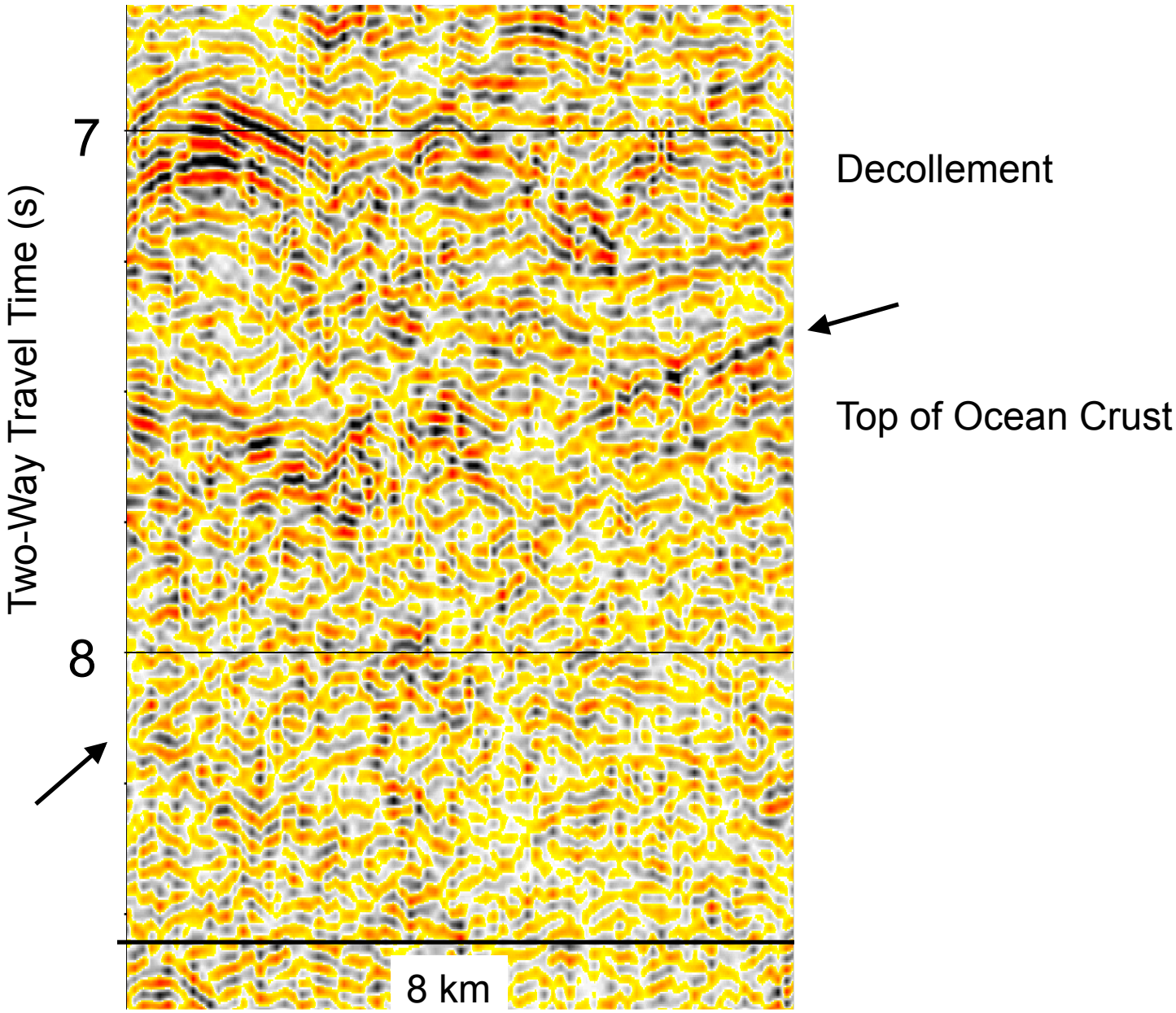
Lesson # 1

Infill

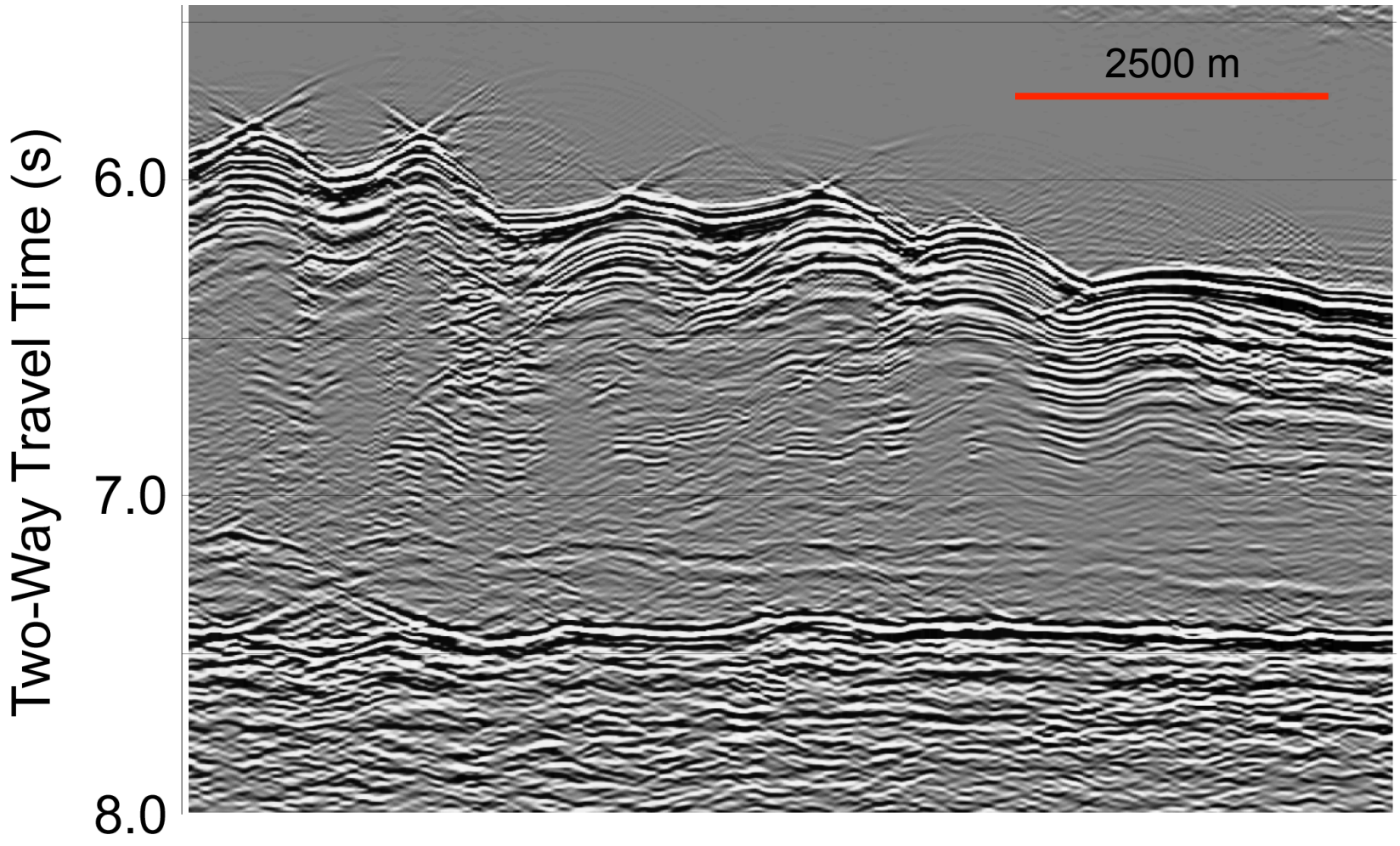

Line 235
250 m
Two-Way Travel Time (s)
6
7
Faults
Horizons
Decollement
2-D stack and migration
3-D prestack time migration

Crossline 4367

2D inline migration

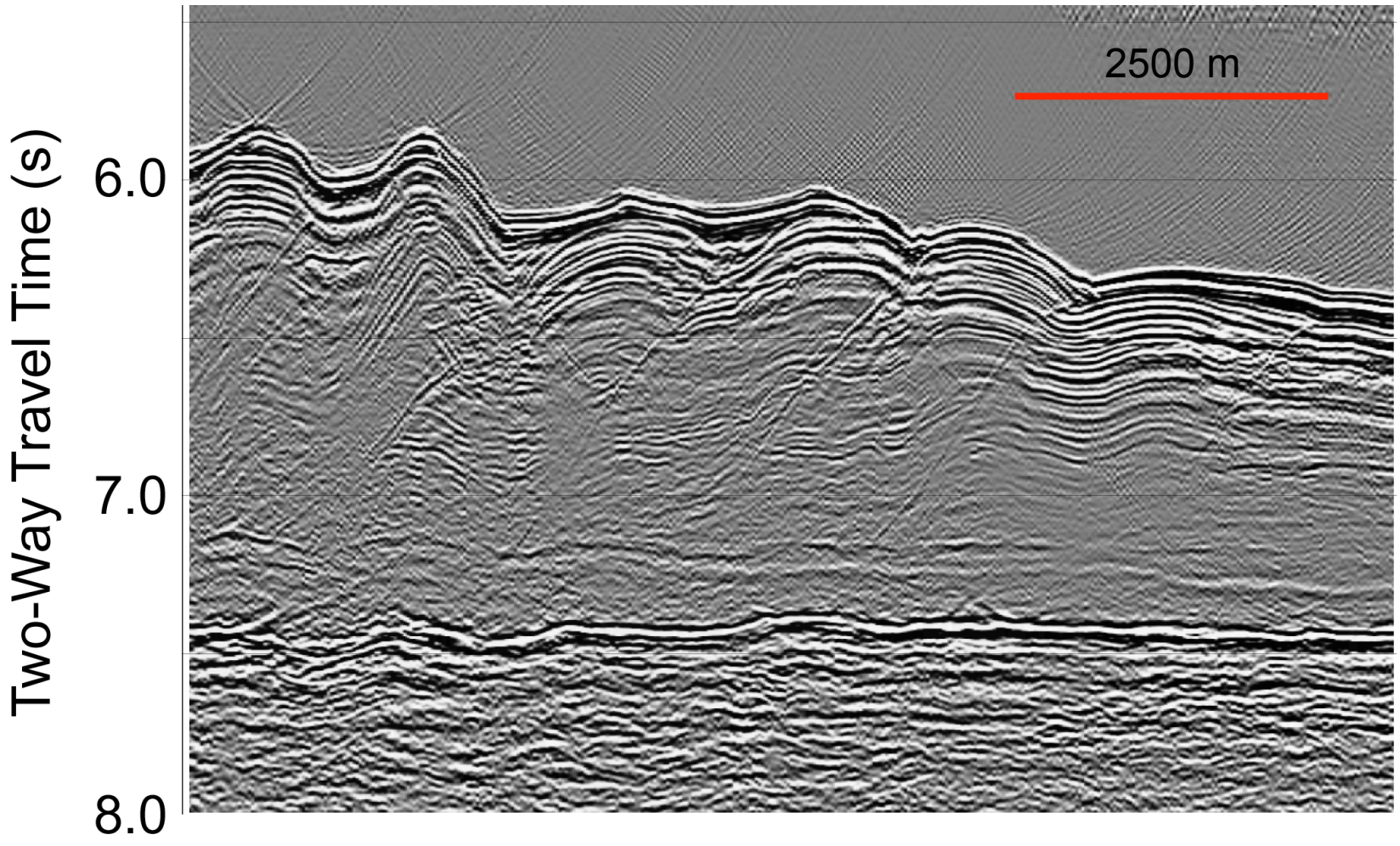


Line 270
Prestack Kirchhoff time migration
Very narrow aperture : 2,500 m inline, 500 m crossline

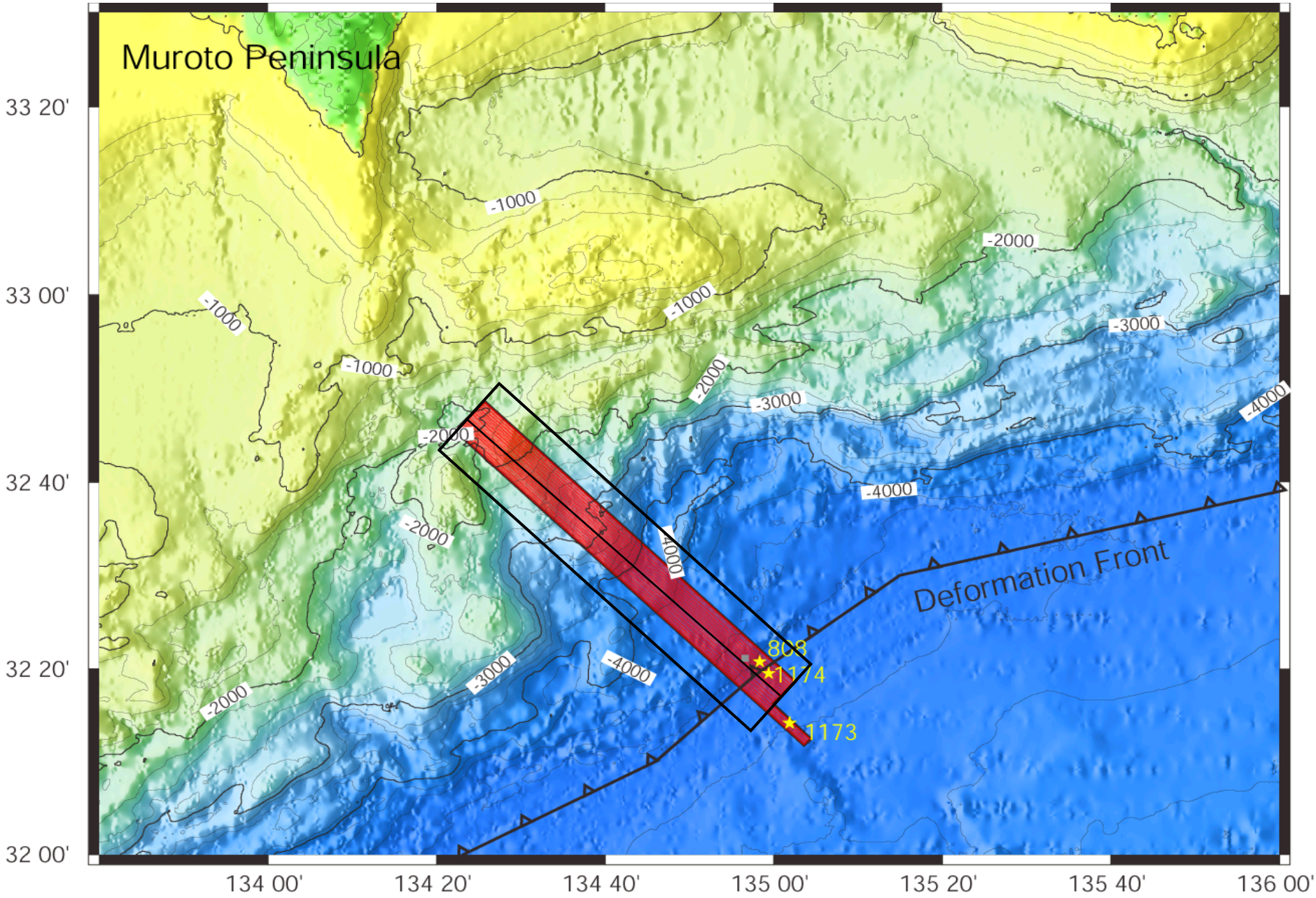


migtest 3.2

Line 270
Prestack Kirchhoff time migration
Narrow aperture : 12,500 m inline, 1,000 m crossline



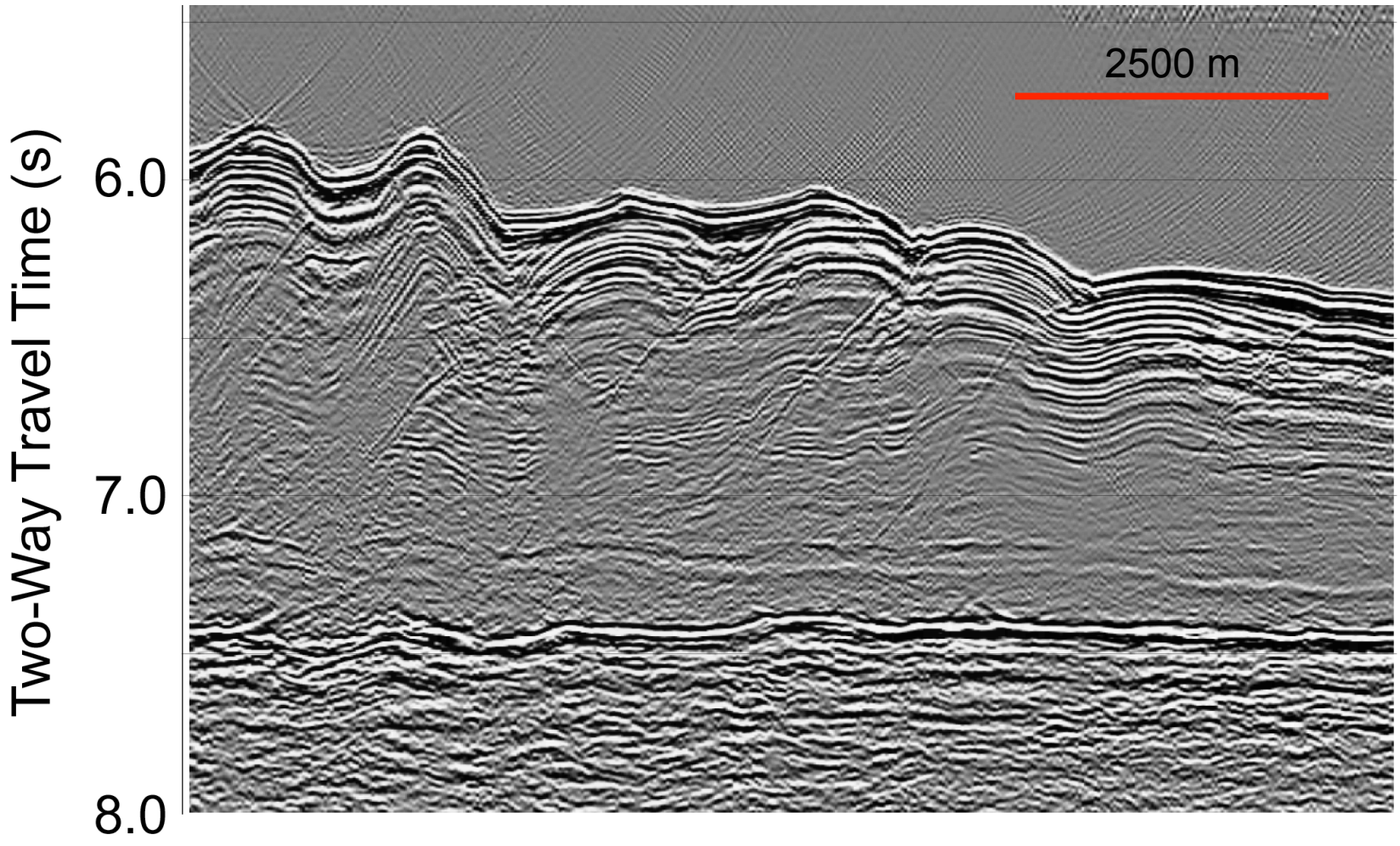
migtest 2.2


Muroto Peninsula
Deformation Front
808
1174
1173
33 20'
33 00'
32 40'
32 20'
32 00'
134 00'
134 20'
134 40'
135 00'
135 20'
135 40'
136 00'
-1000
-2000
-3000
-4000

Lesson # 2

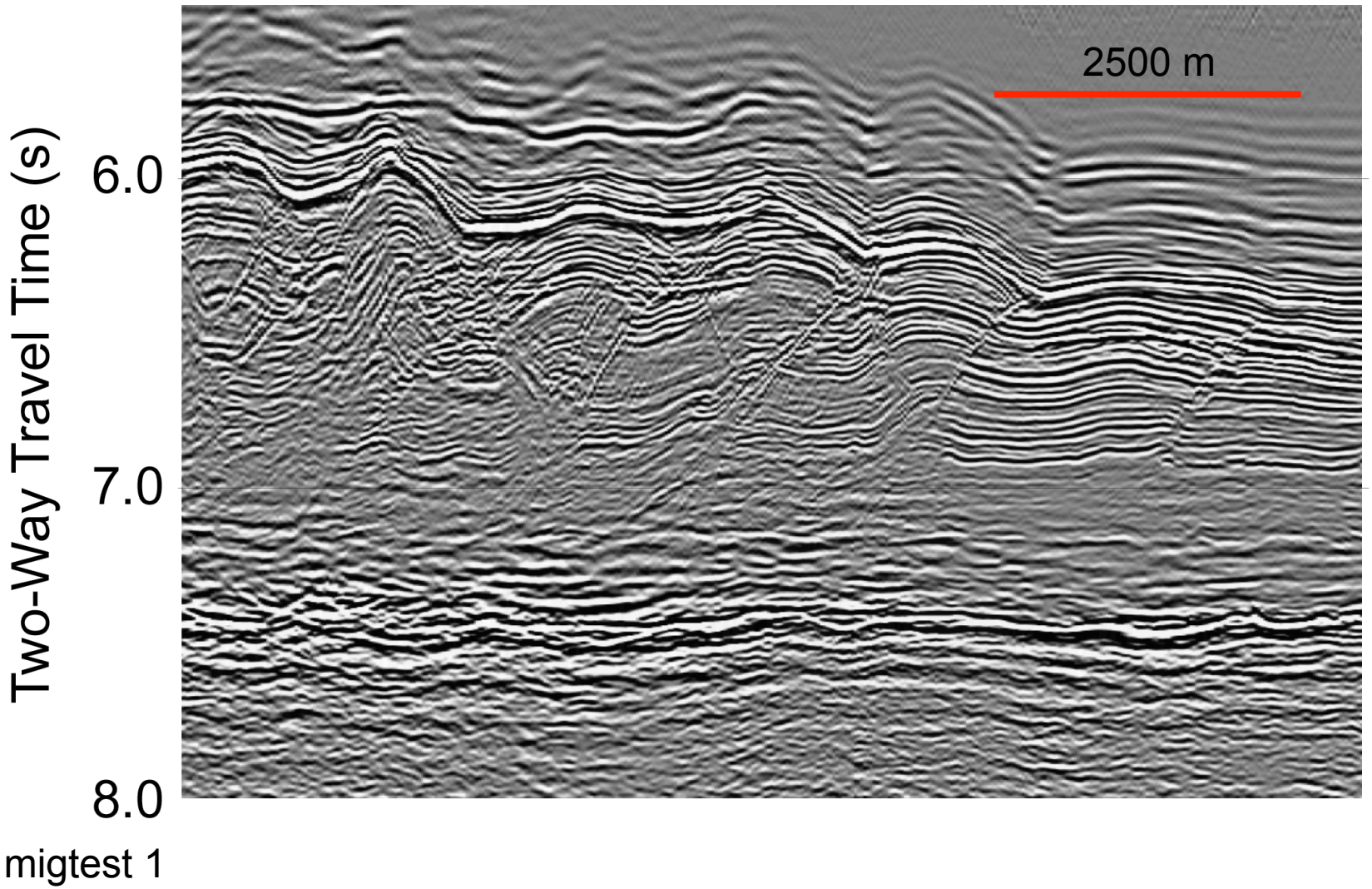
Aperture

Line 270
Prestack Kirchhoff time migration
Narrow aperture : 12,500 m inline, 1,000 m crossline

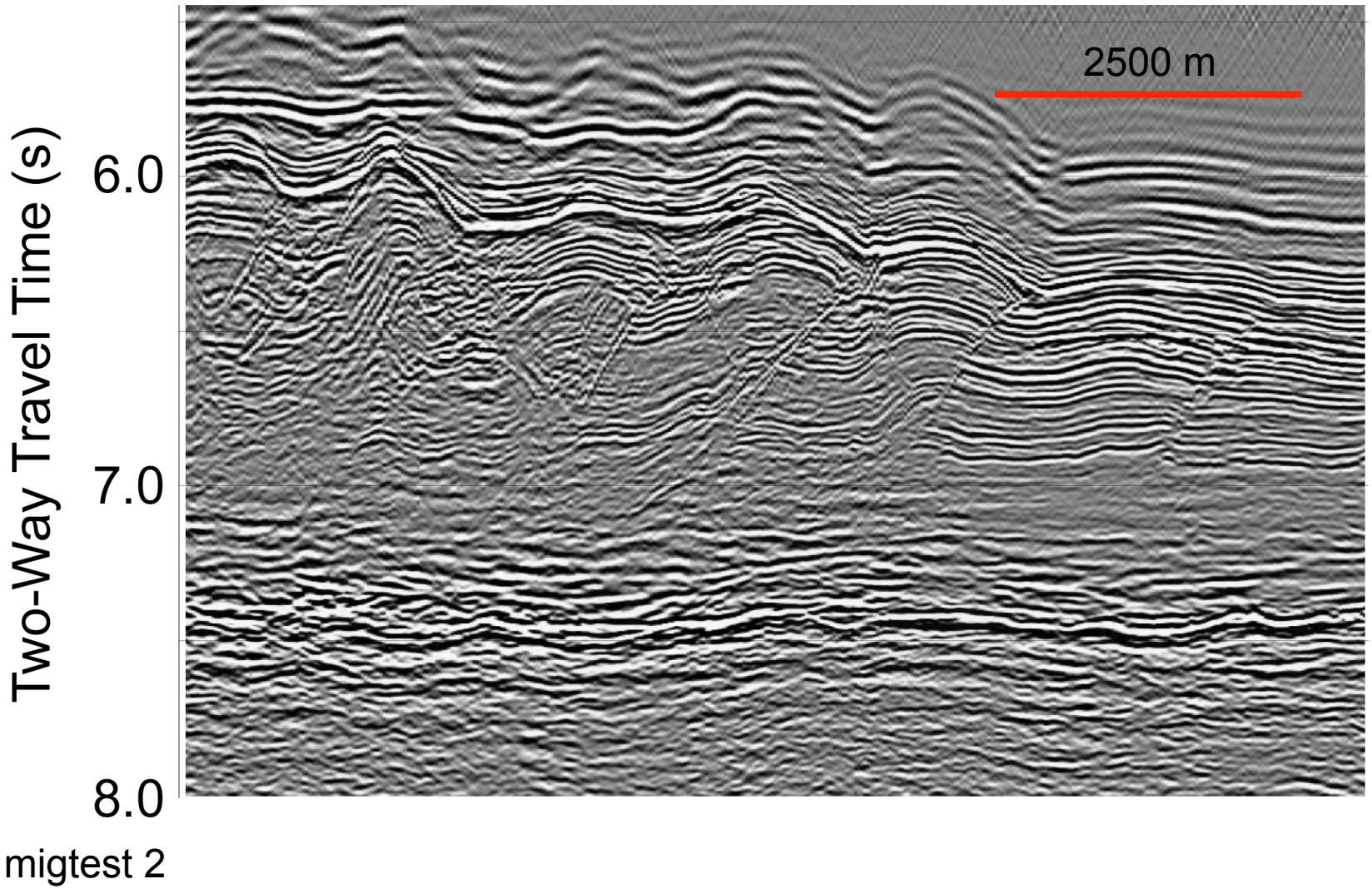


migtest 2.2

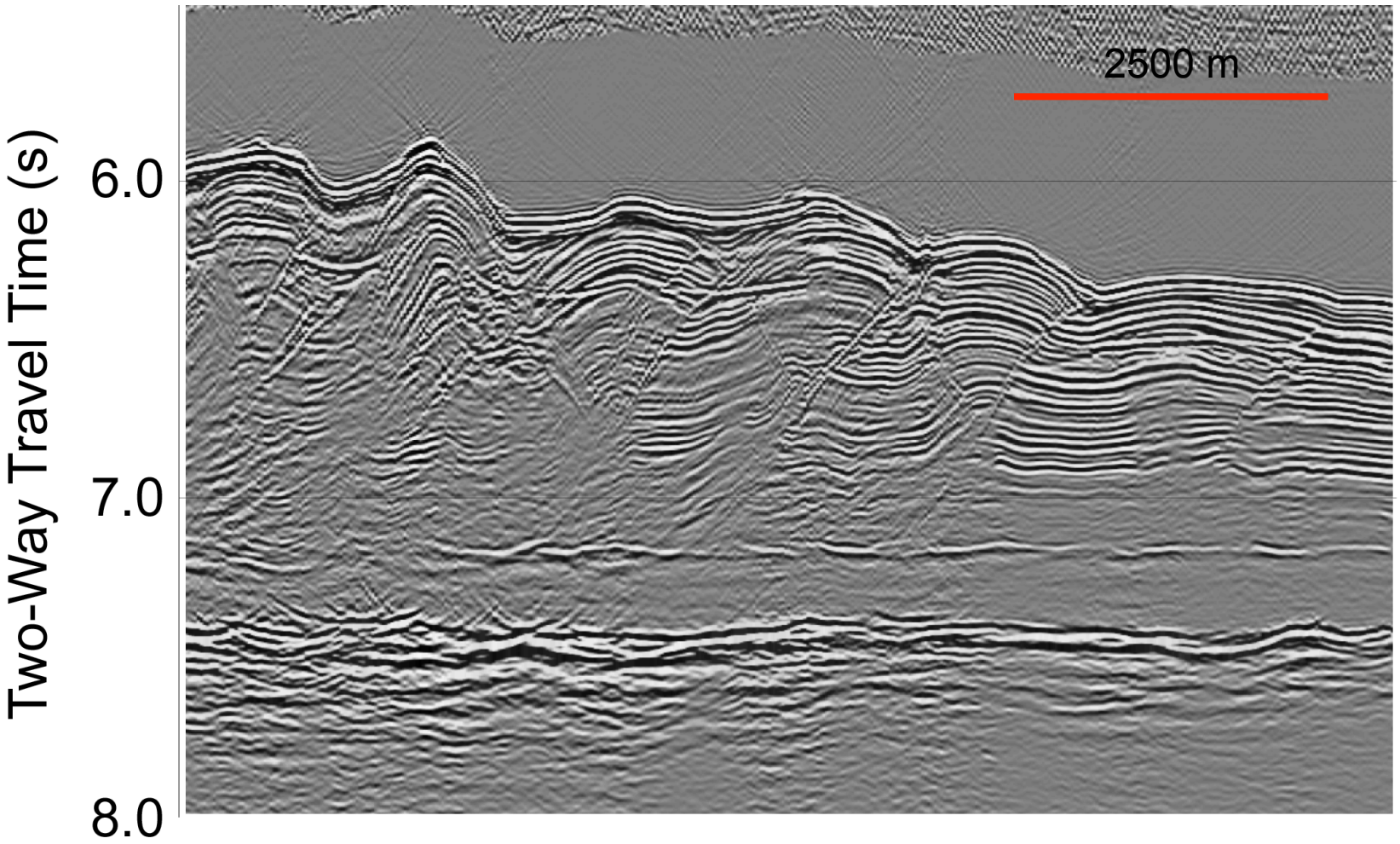
Line 270
Prestack Kirchhoff time migration
Moderate aperture : 12,500 m inline, 2,500 m crossline



Line 270
Prestack Kirchhoff time migration
Appropriate aperture : 12,500 m inline, 4500 m crossline



Line 270
Prestack Kirchhoff time migration
Narrow aperture : 6250 m inline, 500 m crossline

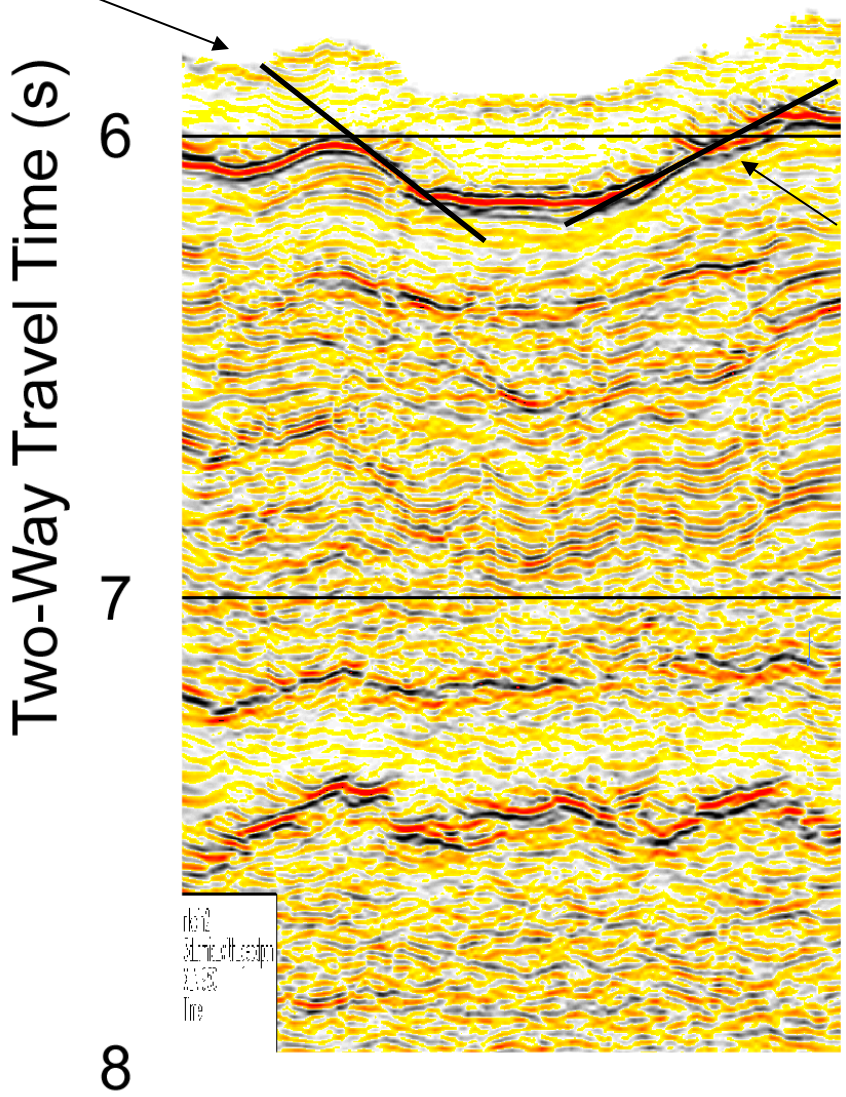


Dip = 7 degrees

Ailiasing
> 30 Hz @ 100m
> 15 Hz @ 200m

Crossline 950

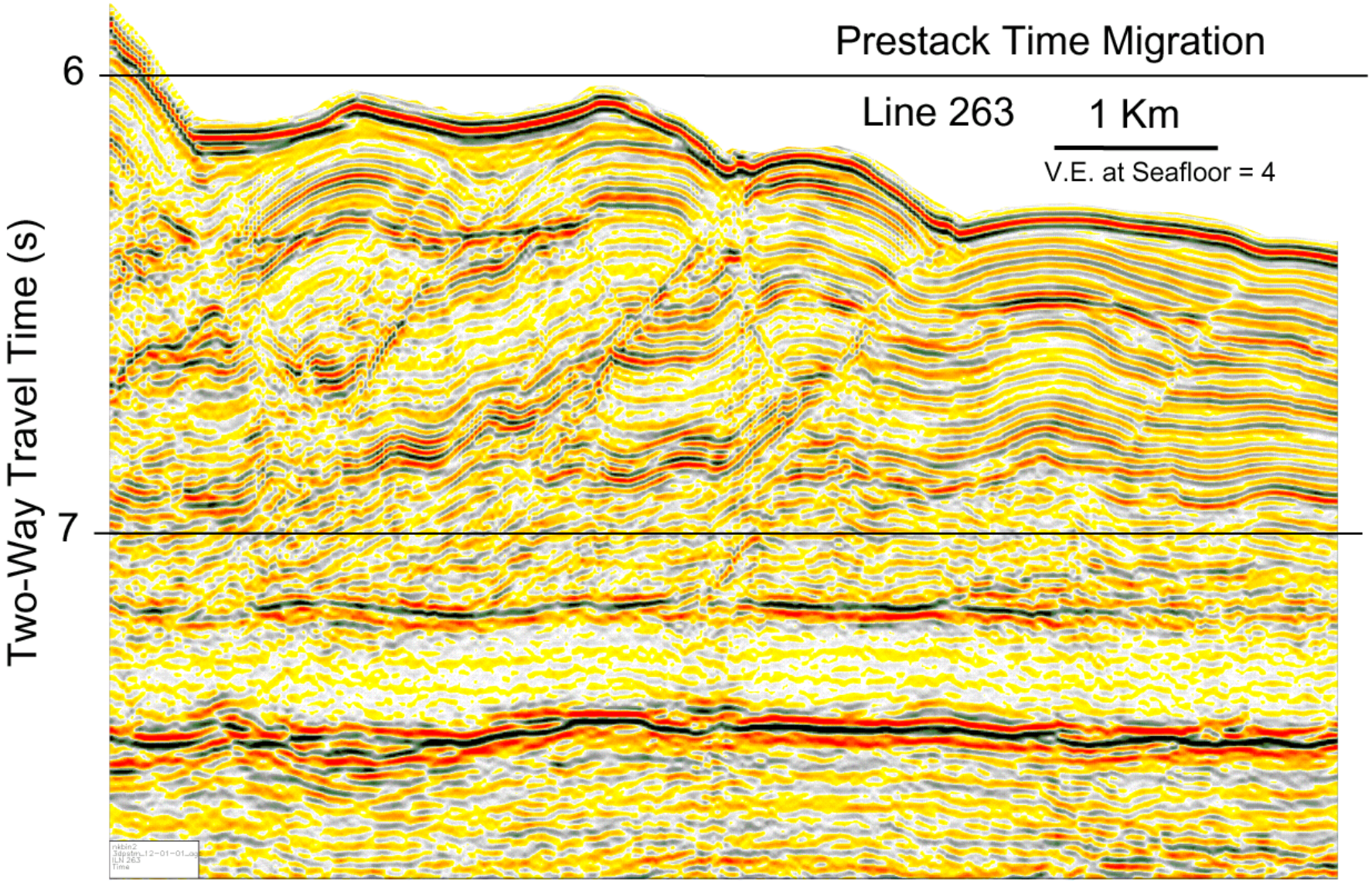
3-D Poststack Migration

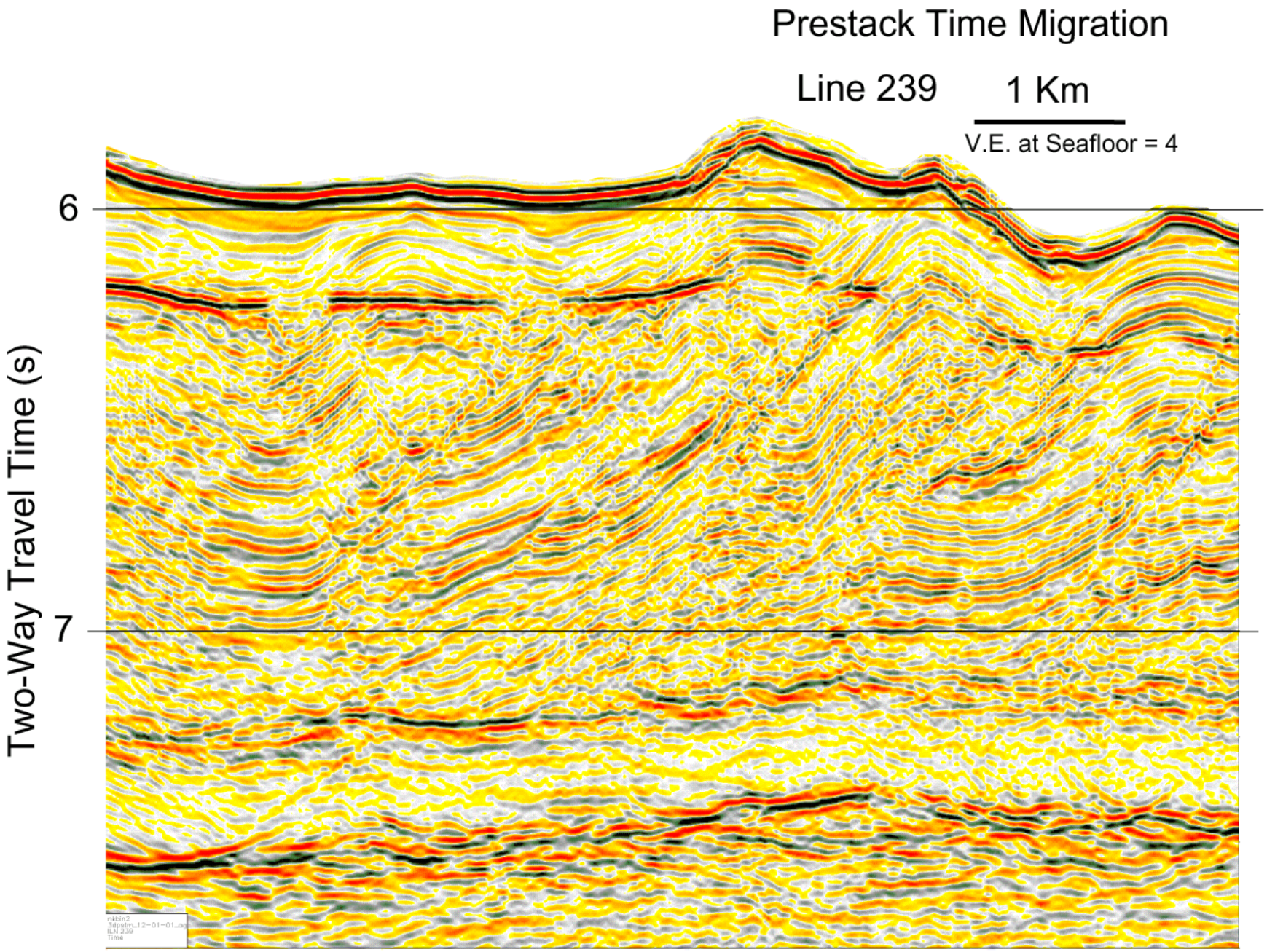


Dip = 4 degrees

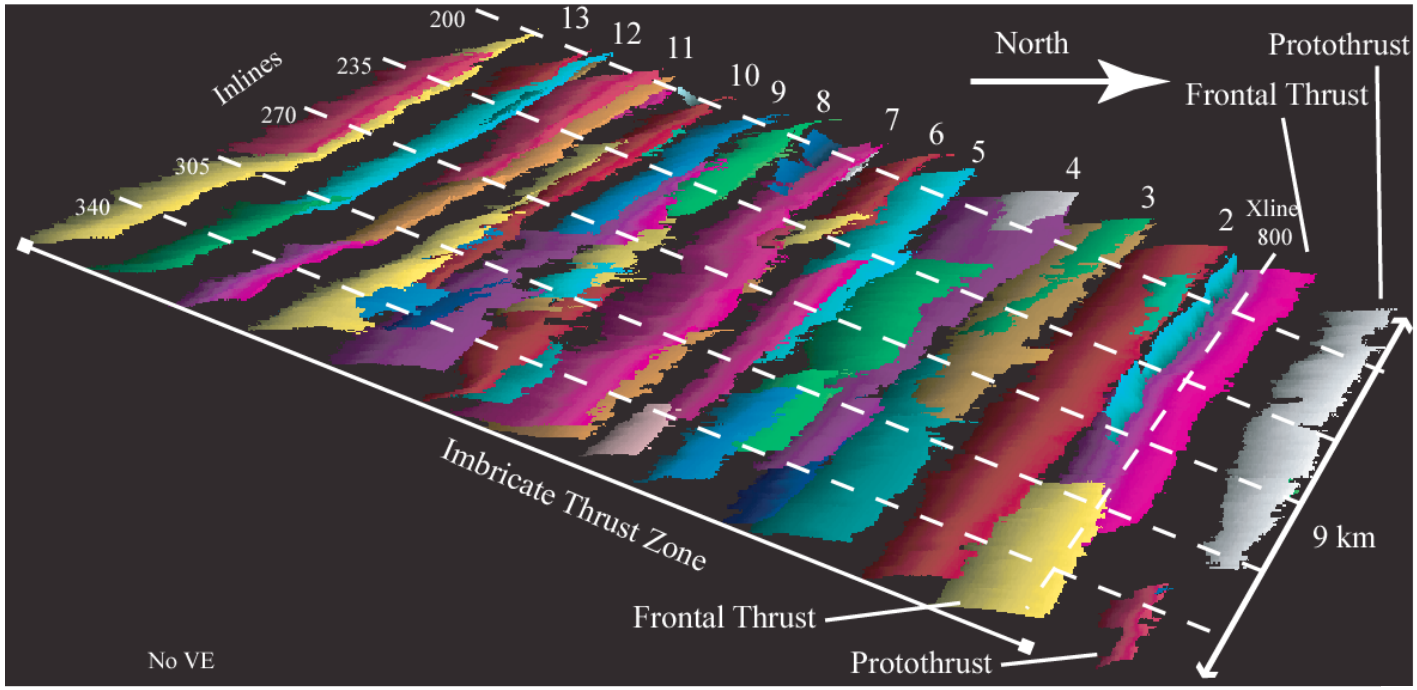
Ailiasing
> 54 Hz @ 100m
> 27 Hz @ 200m

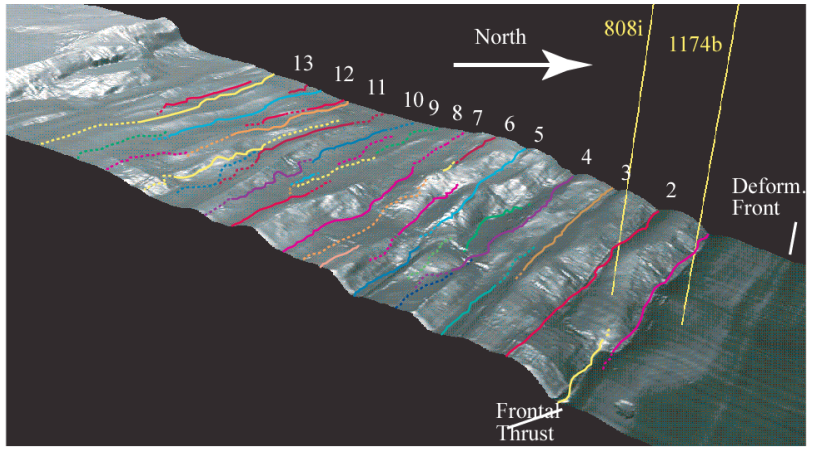
Lesson # 3


Prestack Time Migration
Line 263
1 Km
V.E. at Seafloor = 4
Two-Way Travel Time (s)
6
7


Prestack Time Migration
Line 239
1 Km
V.E. at Seafloor = 4
6
7
Two-Way Travel Time (s)

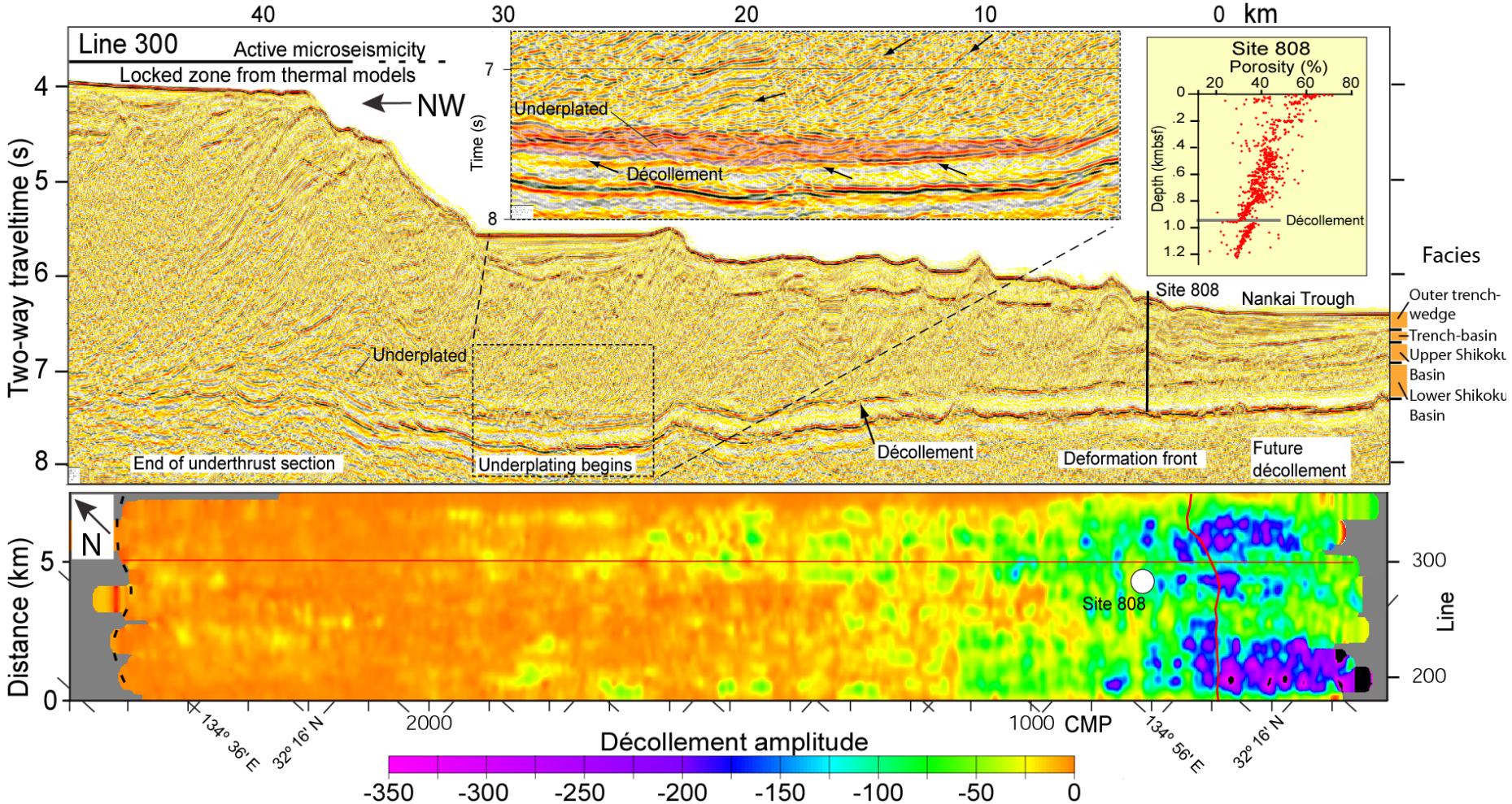
3-D Structure of the Imbricate Thrust Zone





Gulick et al. 2004

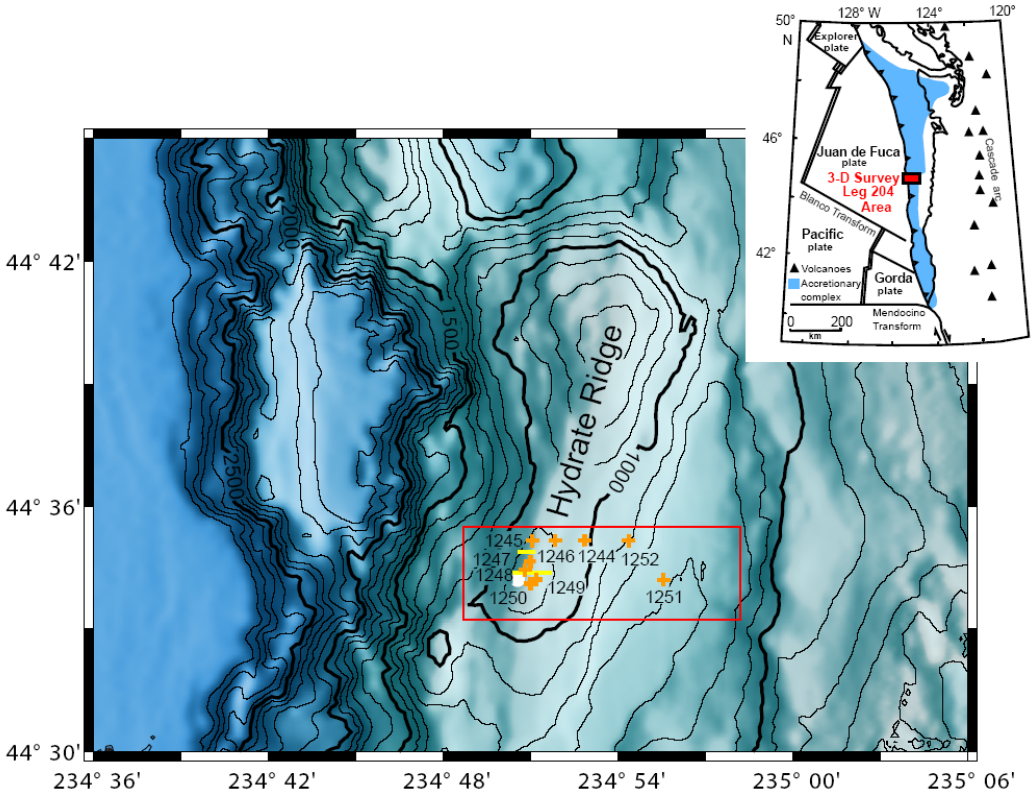
Cross section and map view of the Nankai Trough decollement



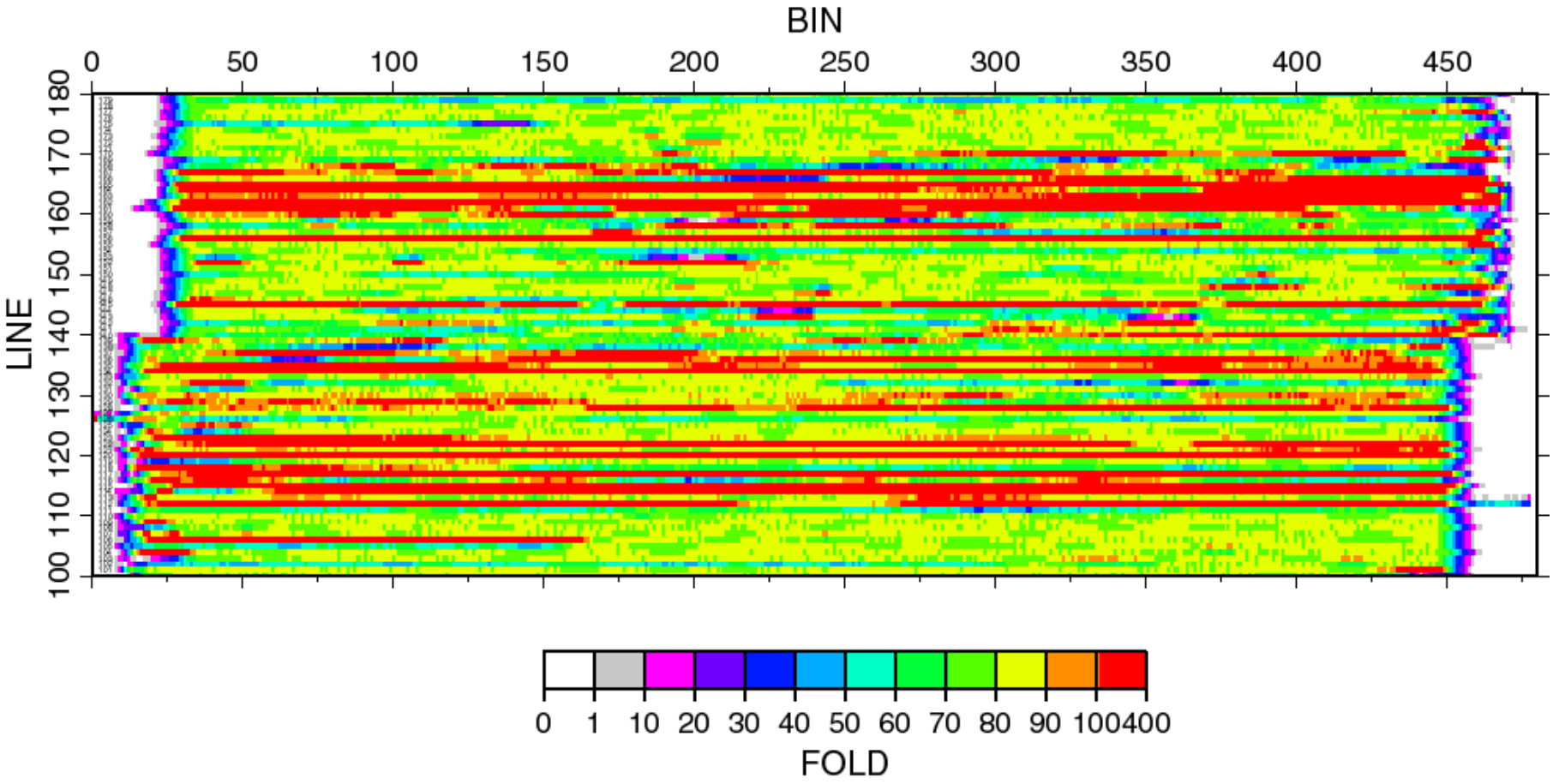
Bangs et al. 2004

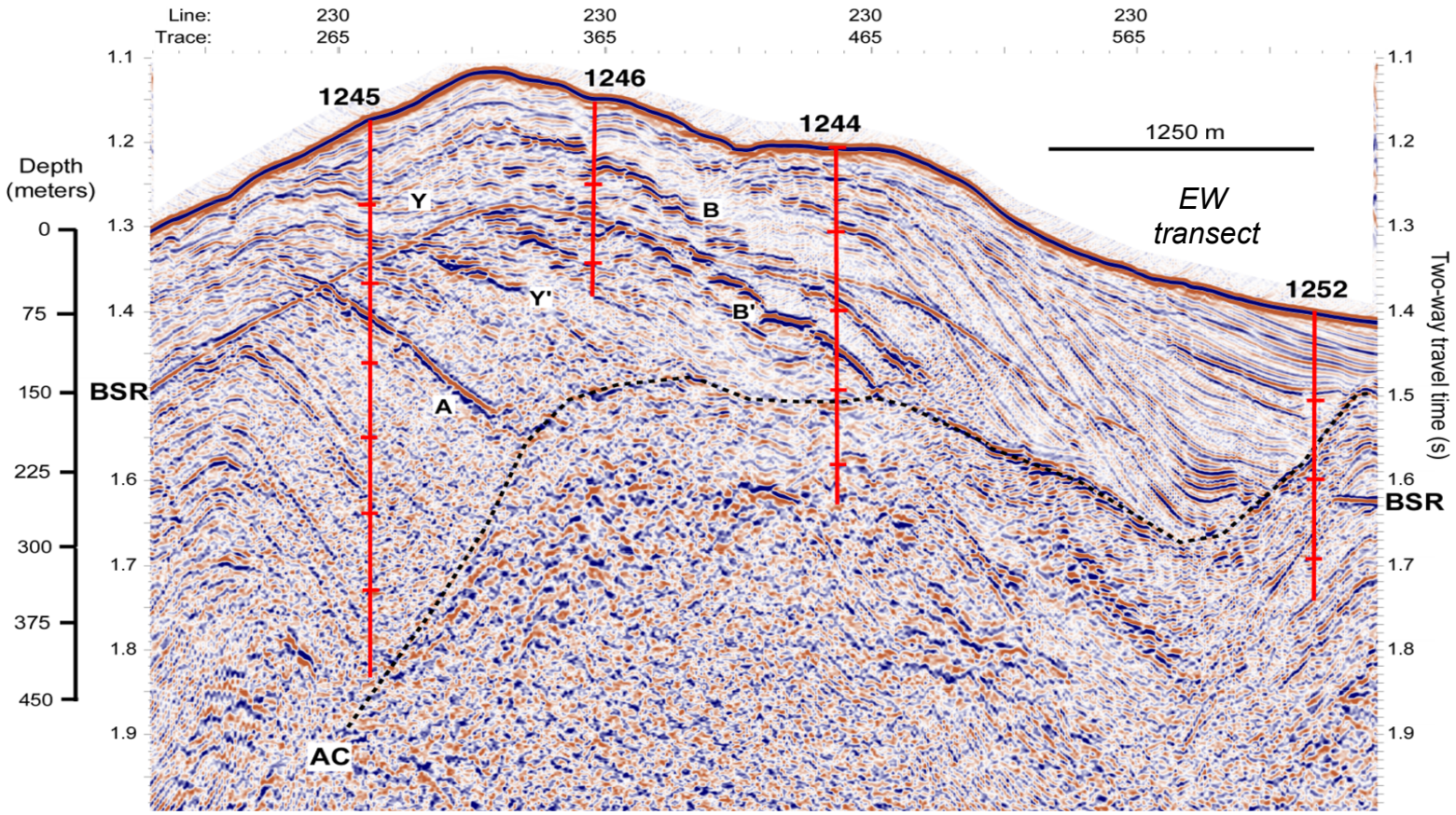
Hydrate Ridge (high-resolution)

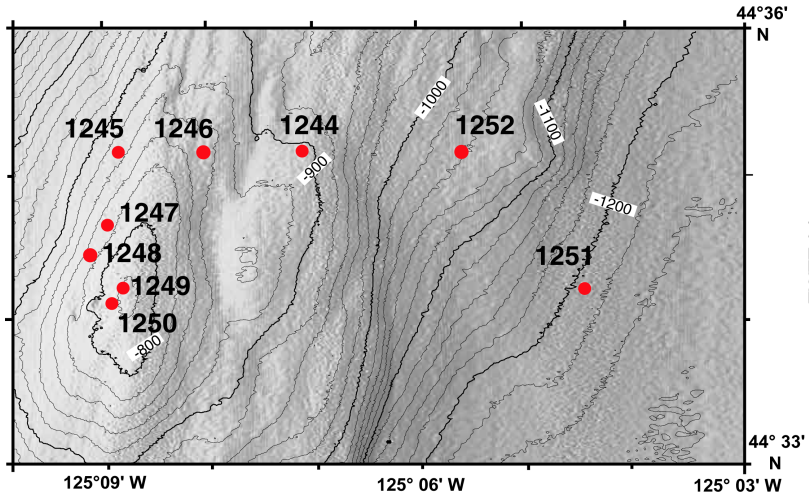
- 2000
- R/V Thompson (Lamont high-res system)
- Short offset (< 600 m), single streamer
- 2 – GI guns
- 81, 11-km-long lines @ 50 m spacing
- Coverage: 4 x 11 km
- Prestack: 61 Gbytes, Poststack 1.8 Gbytes

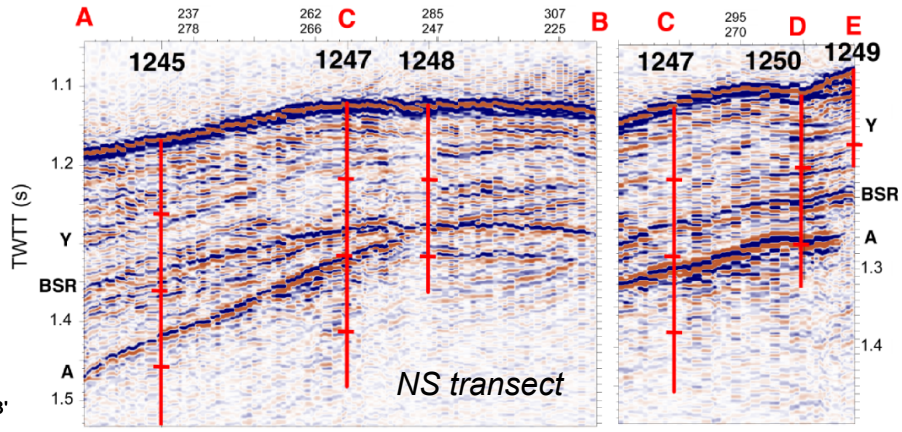


Hydrate Ridge 3-D Survey Bin Fold Map



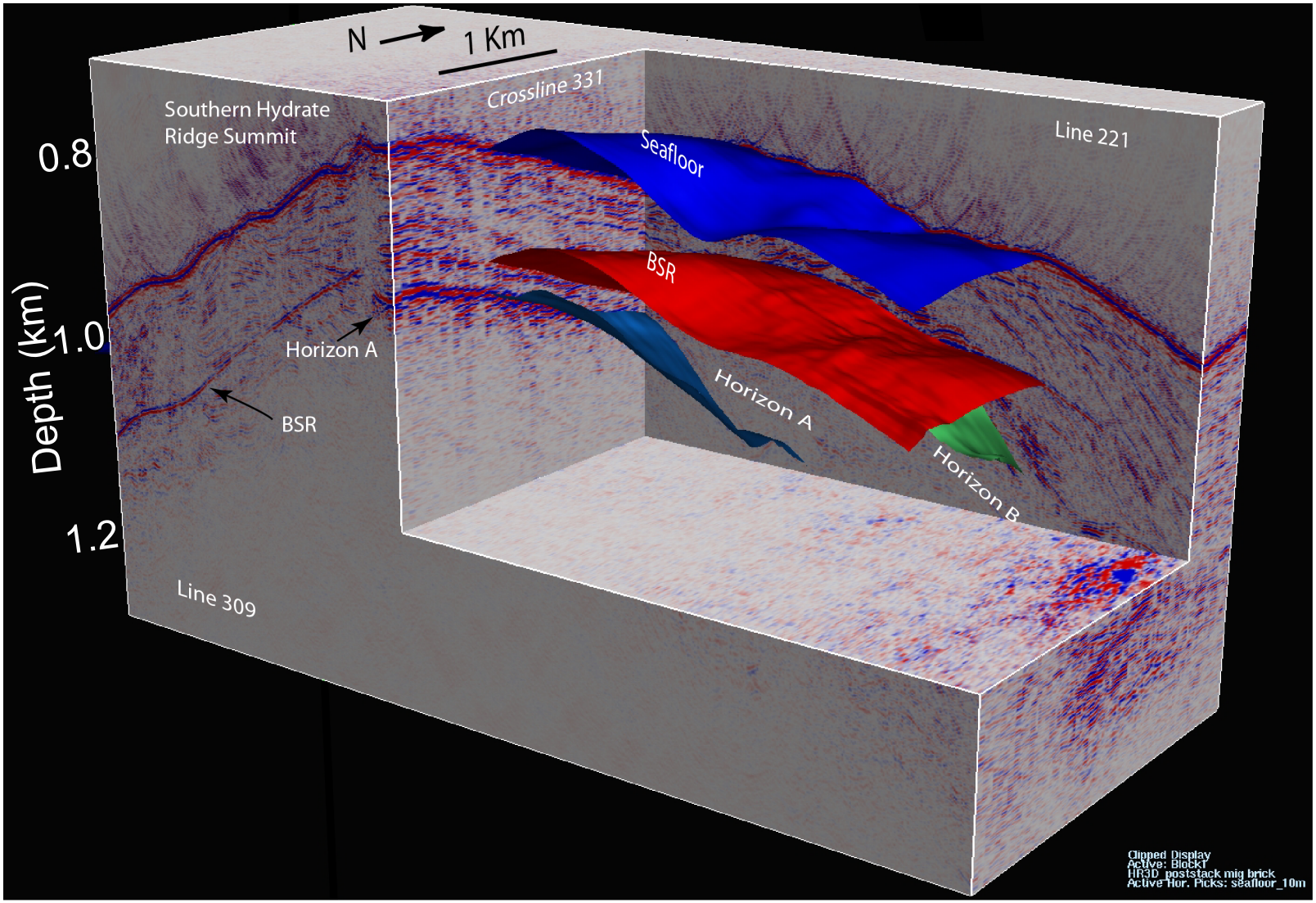

Line: 230 230 230 230
Trace: 265 365 465 565
1245
1246
1244
1252
1250 m
EW transect
Depth (meters)
0
75
150
225
300
375
450
BSR
Y
Y'
B
B'
A
AC
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
Two-way travel time (s)


44°36' N
1245
1246
1244
1252
1247
1248
1249
1250
1251
-1000
-1100
-900
-1200
-800
44° 33' N
125°09' W
125° 06' W
125° 03' W


A
C
B
C
D
E
1245
1247
1248
1247
1250
1249
TWTT (s)
Y
BSR
A
NS transect

Lesson # 4
(High Resolution)
Statics

3-D perspective view of South Hydrate Ridge



Summary

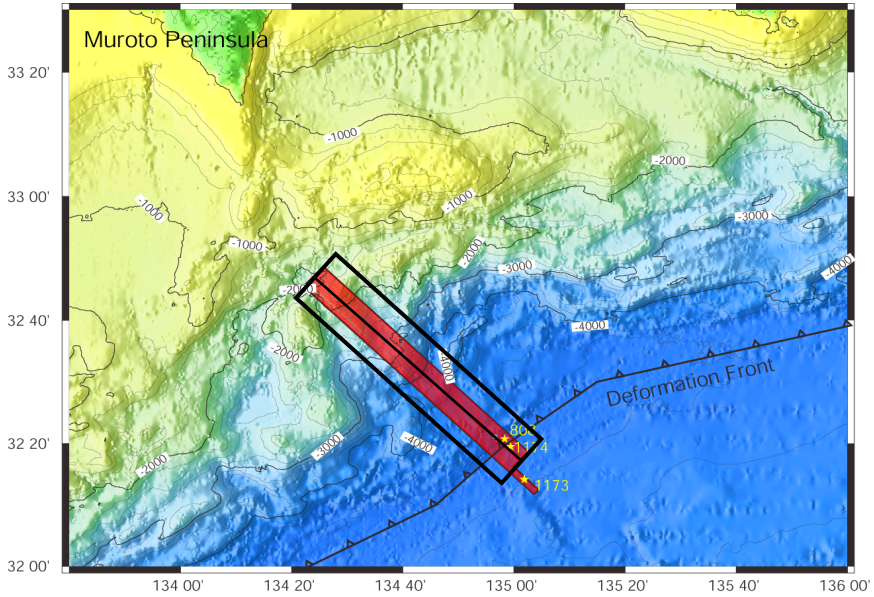
- Achievements
  - Improved images of complex structures
  - Maps of structures and rock properties

- Lessons
  - Infill
  - Aperture
  - Ailiasing
  - Statics

Proper 3-D imaging of a single line of the Muroto transect

Ewing (single streamer)

80 x 8 km @ 100 m	2 months
+ infill	2.5 months
+ aperture (80 x 16 km @ 100 m)	5 months
+ aliasing 80 x 16 km @ 50 m	10 months



Langseth (4 streamers)

/ 4(?) = 2.5 months