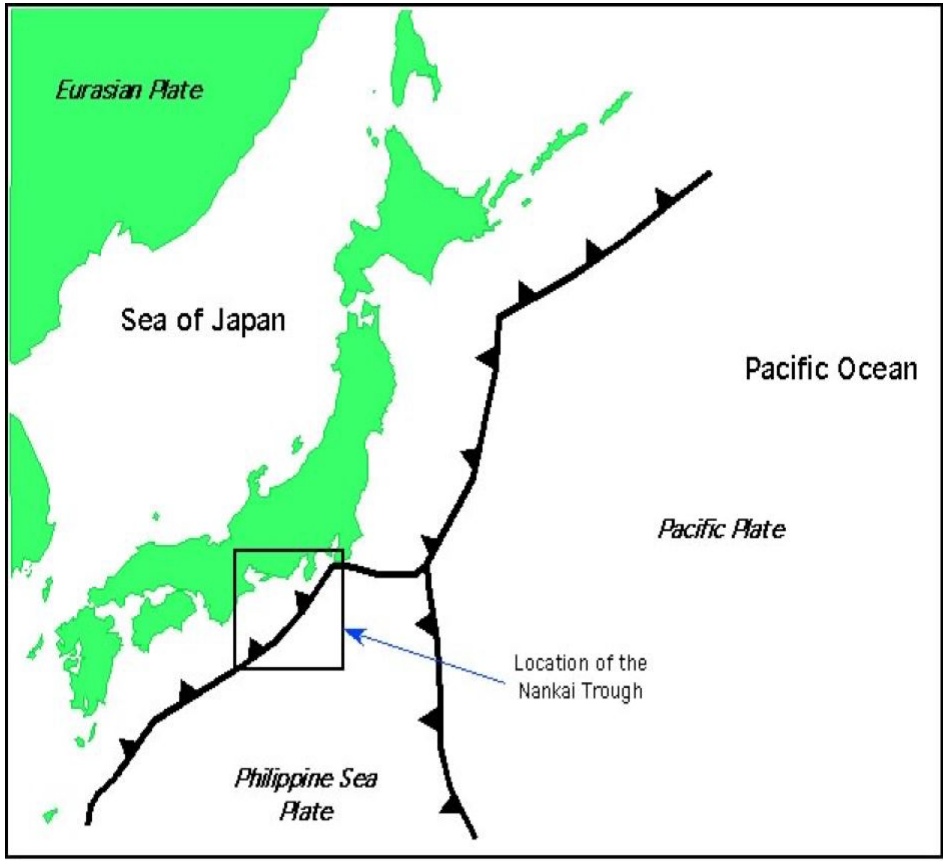
Nankai Trough 2D seismic line processing

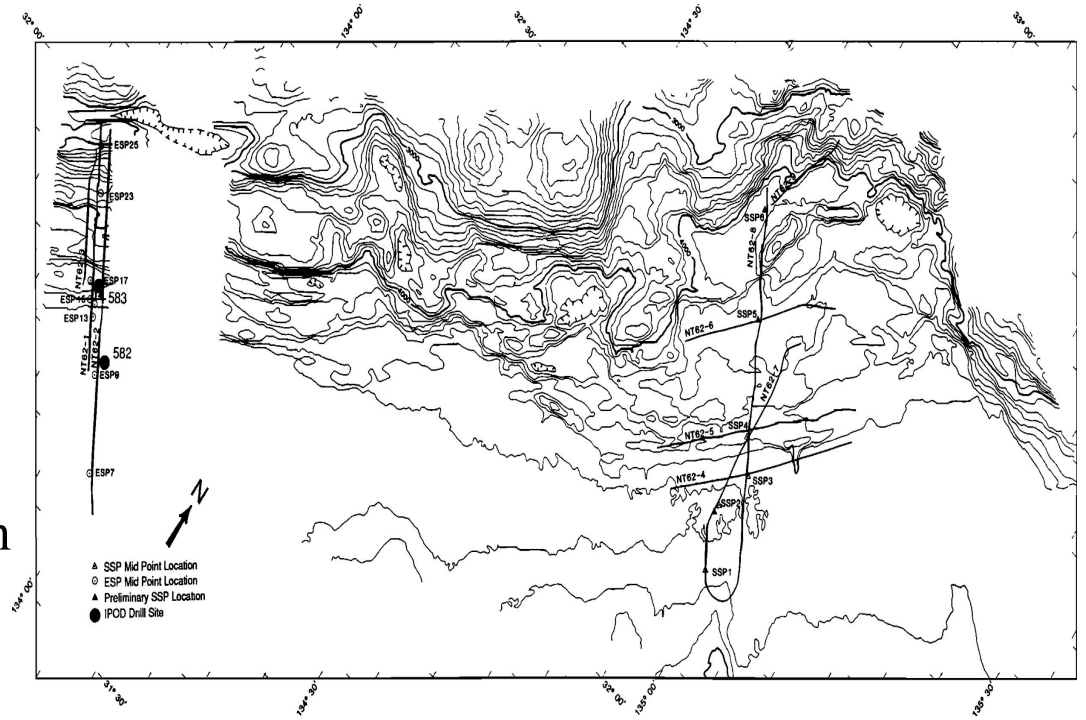
Location

- Nankai Trough
  -900 km S Japan
- The Shikoku Basin
- Relatively shallow trench.

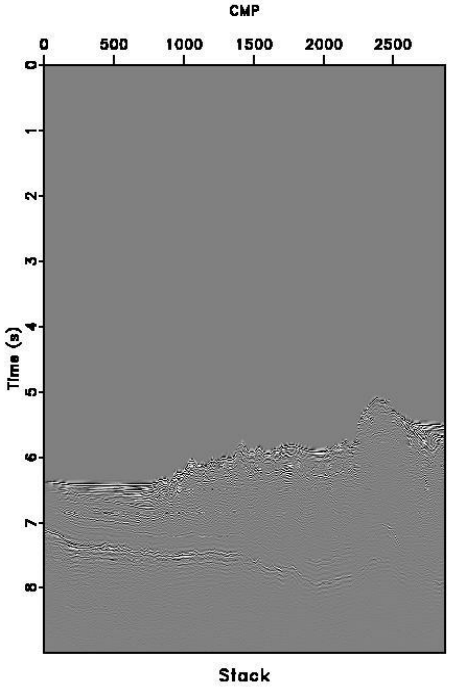


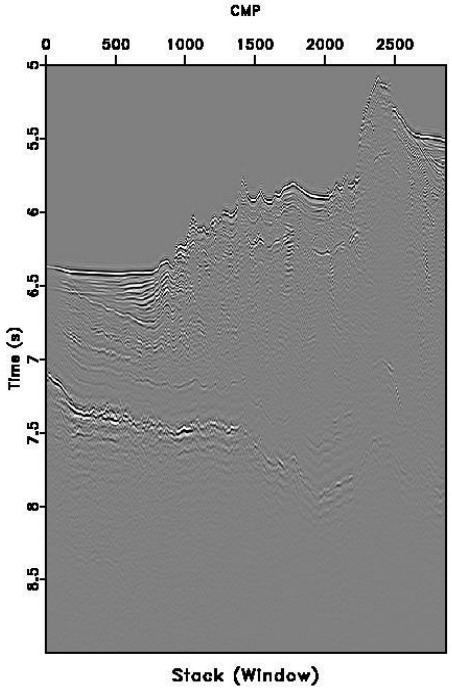
Seismic acquisition

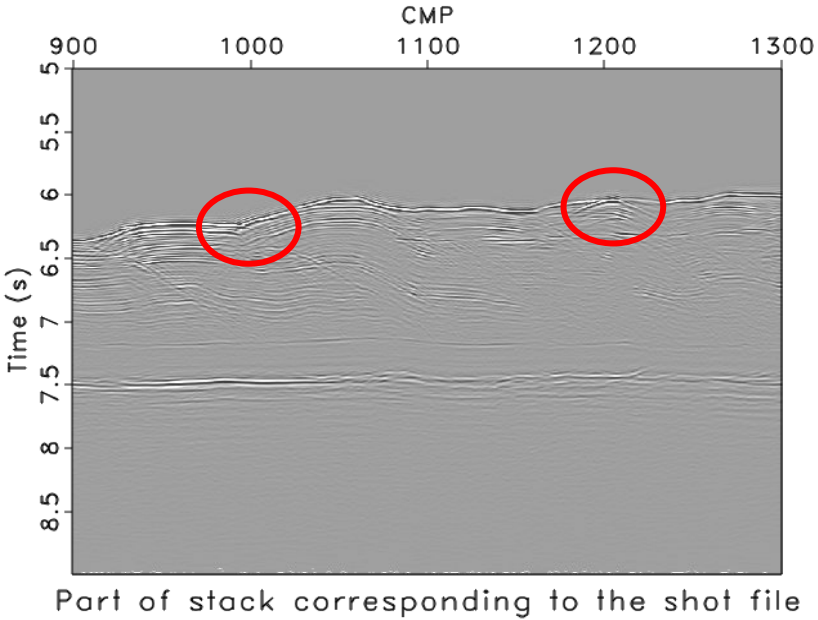
- The data were collected by the University of Texas and the University of Tokyo.
- High-resolution multichannel seismic.
- Sources: Tuned array of 6 air guns.
- Receivers: Analog hydrophone streamer.
- Field data were sorted into 16.66-m bins.



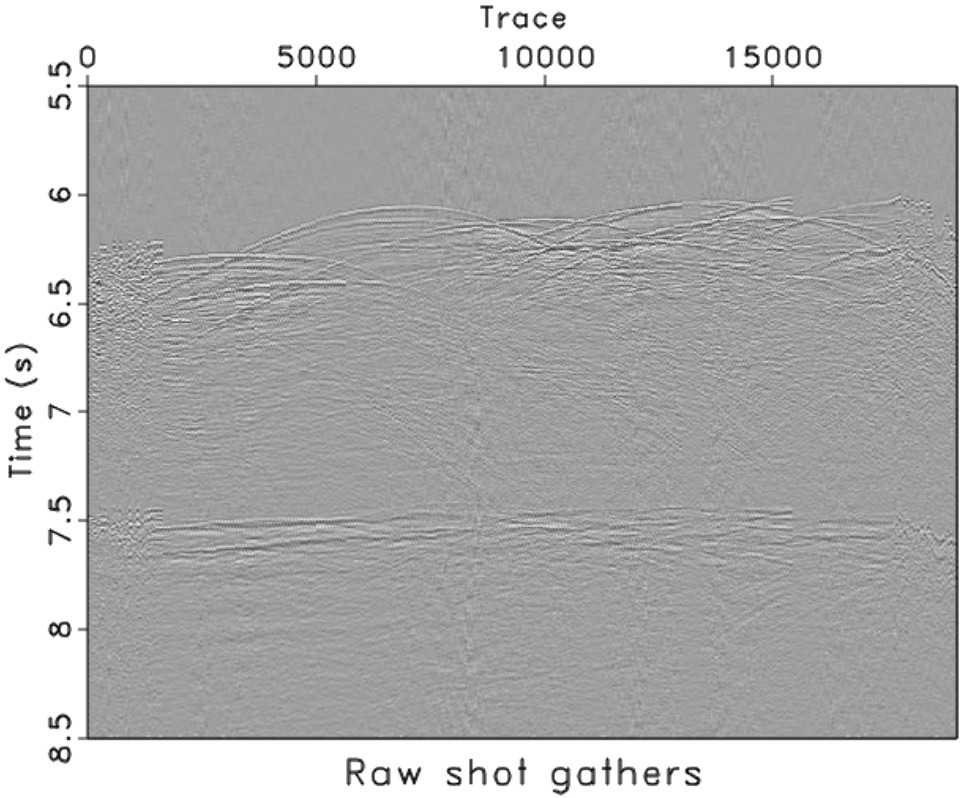
Published migrated stack





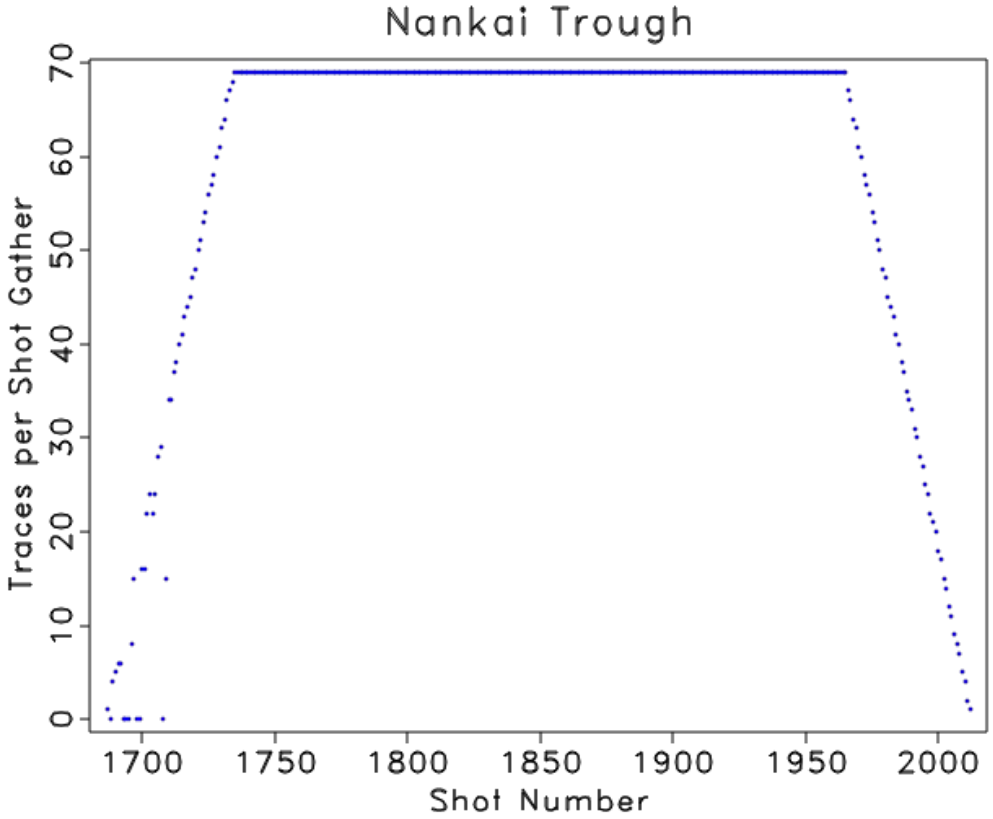


Shot gathers first look

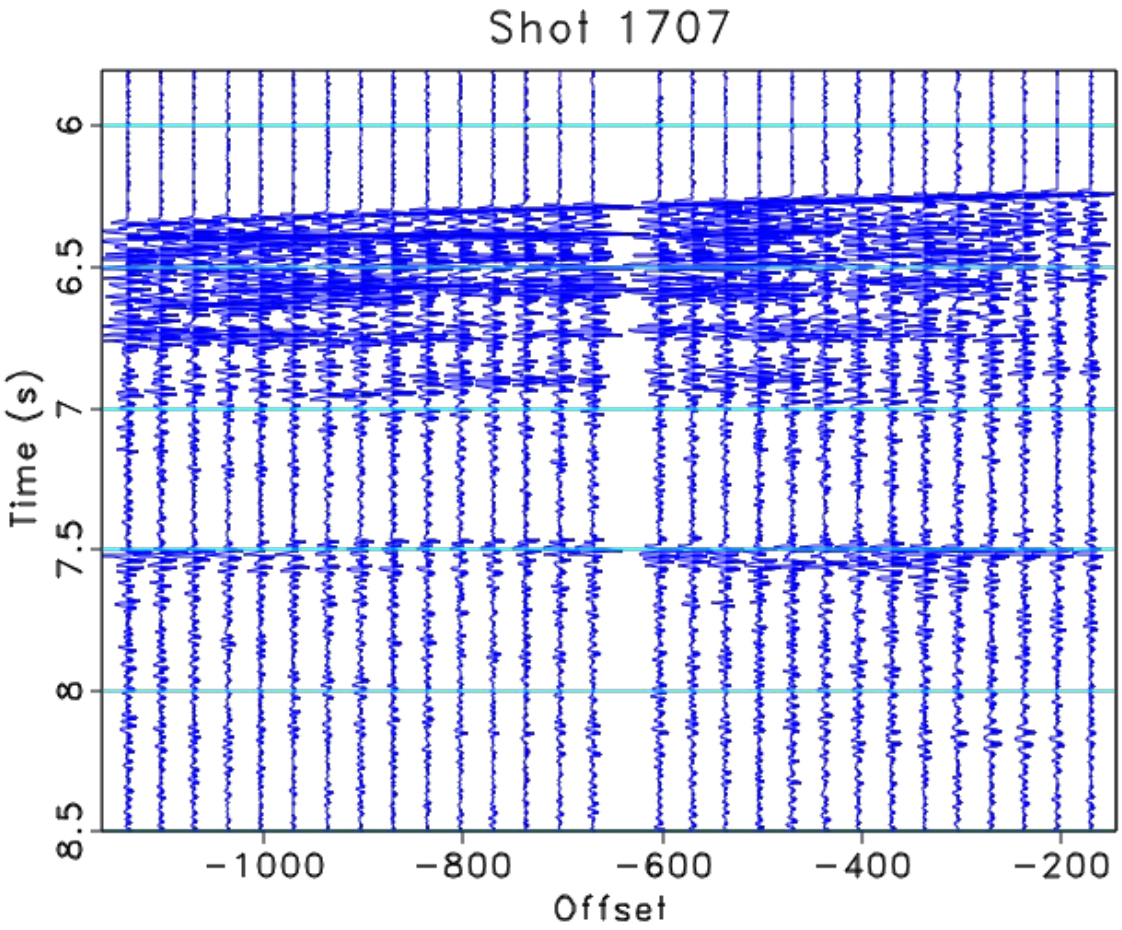


- 326 shot gathers with 19057 traces. Total time sample is 11 seconds with interval 0.002 seconds.
- The published stacked data has 2250 traces with total time length of 9 seconds and 0.004 seconds sample interval.
- The shot-gather data has 401 CMPs while the stacked data has 2869 CMPs.

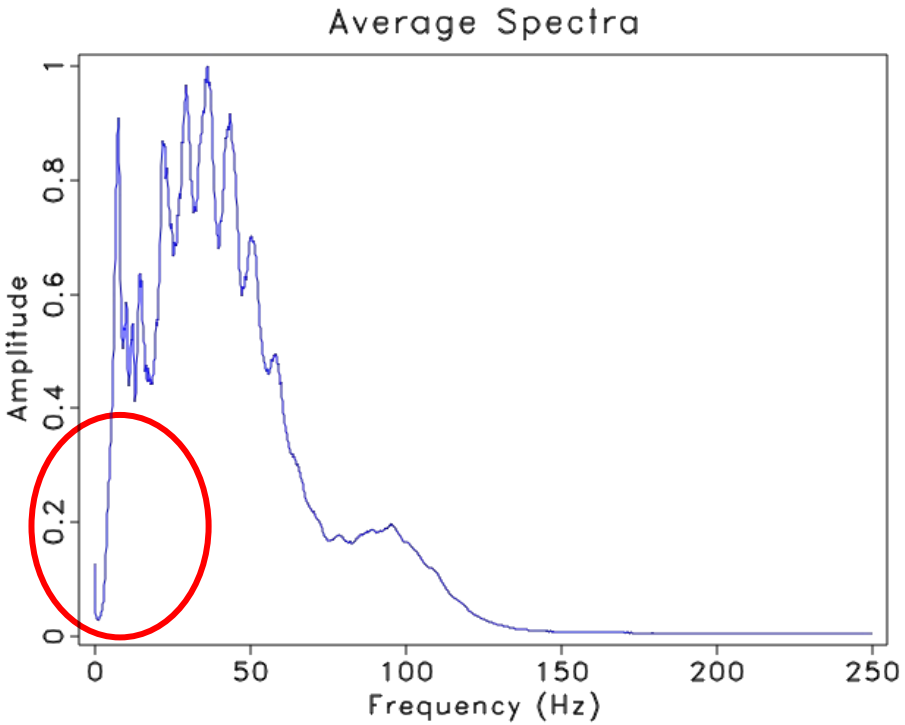
Shot gathers first look



- The first shot gather has one trace. The number of traces per gather increases to a maximum of 69 at gather 1735.
- The number of traces per gather keeps constant through gather 1965 and decreases to 1 at the last gather 2012.
- There are missing traces at some shot gathers.

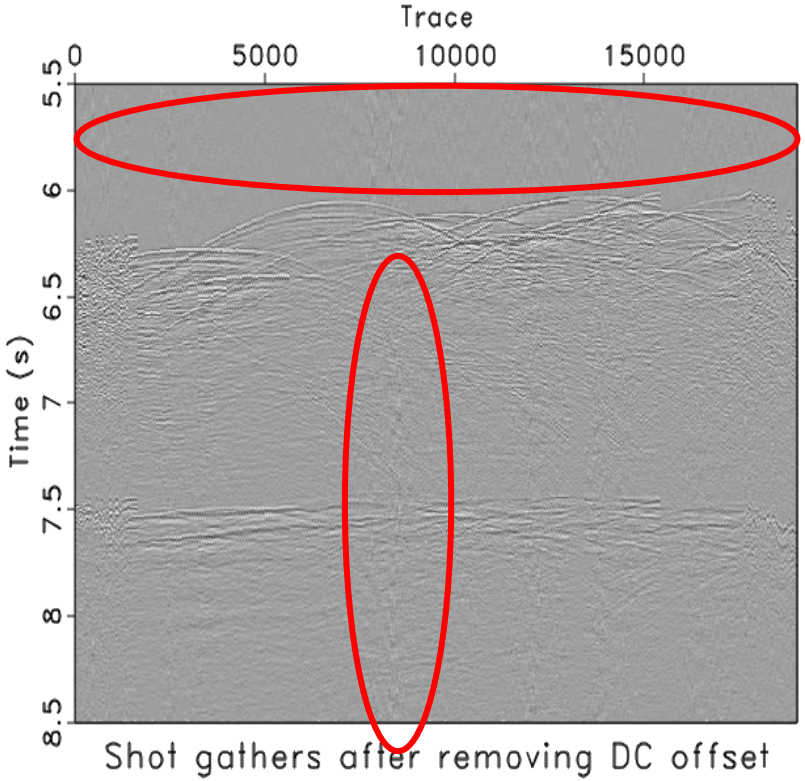

Shot 1707
Time (s)
6
6.5
7
7.5
8
8.5
−1000
−800
−600
−400
−200
Offset

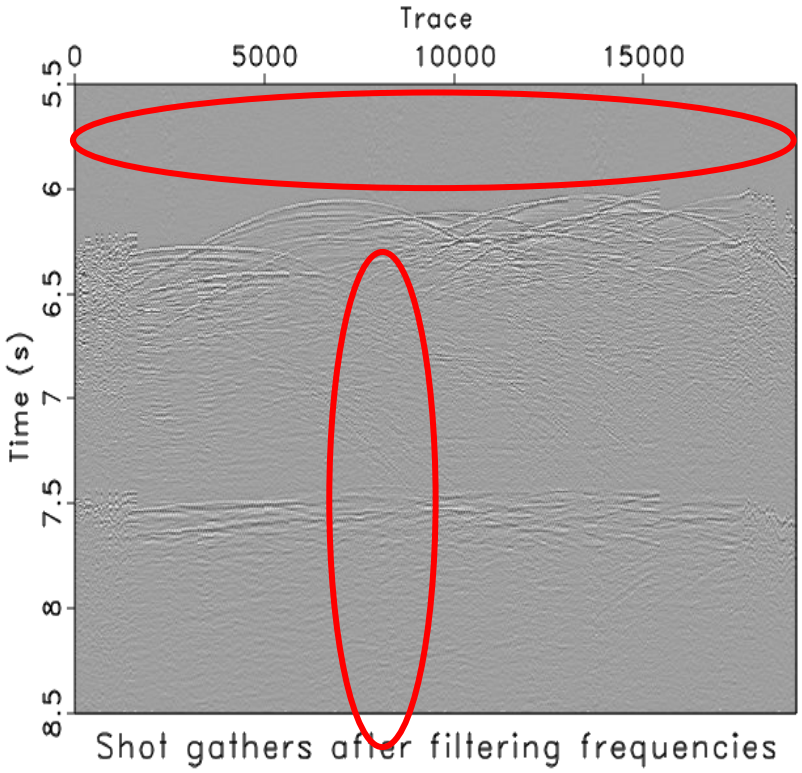
Shot gathers first look

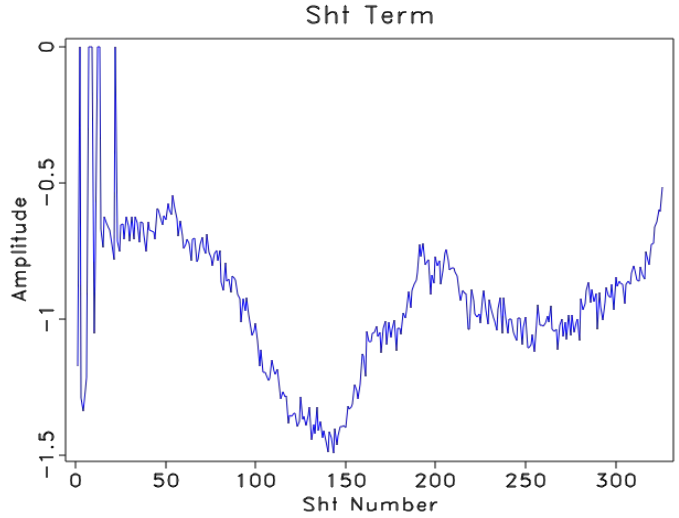


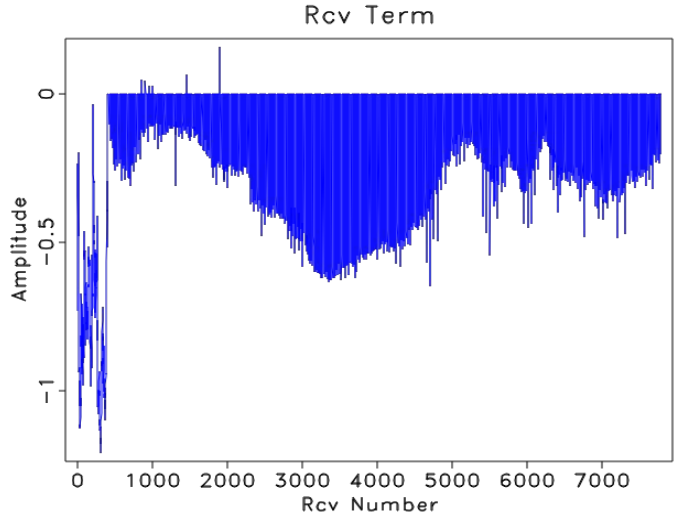
- Low frequencies smaller than 10 Hz need to be filtered.
- The data was resampled to 4 ms sample interval later so high frequencies above 125 Hz need to be filtered to prevent aliasing and remove noise.

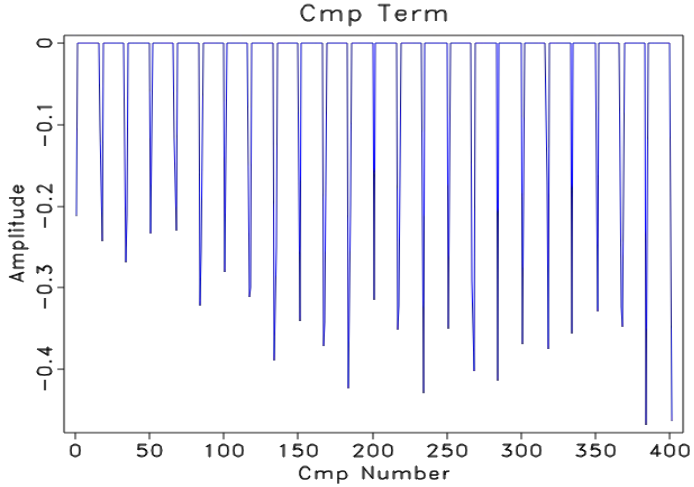
Surface-consistent amplitude balancing

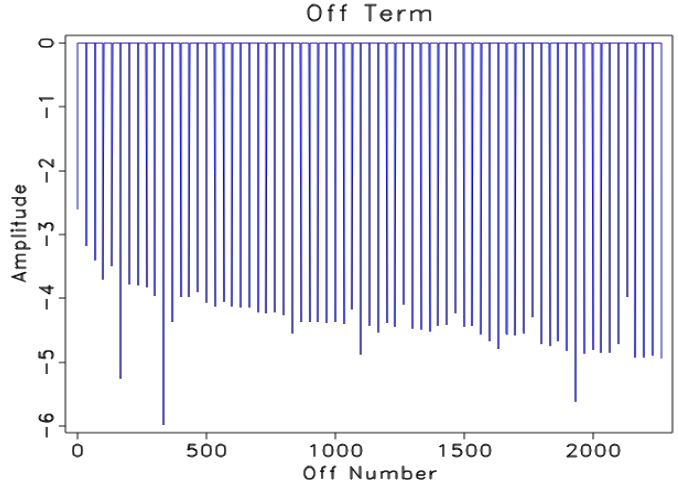




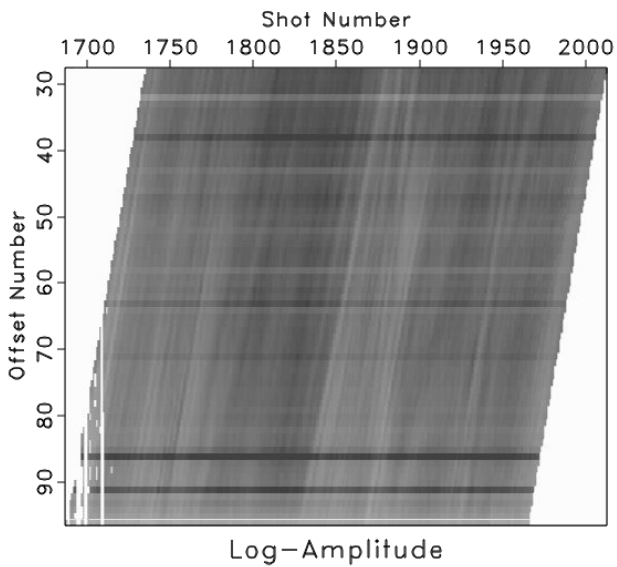

Sht Term
Amplitude
0
−0.5
−1
−1.5
0
50
100
150
200
250
300
Sht Number

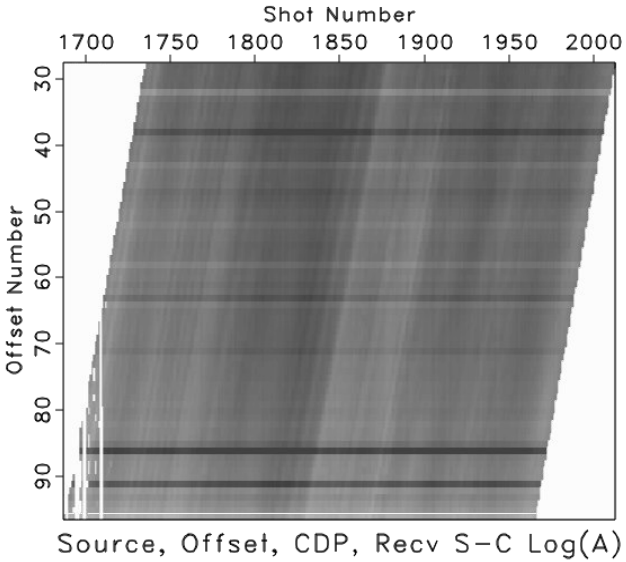

Rcv Term
Amplitude
0
−0.5
−1
0
1000
2000
3000
4000
5000
6000
7000
Rcv Number

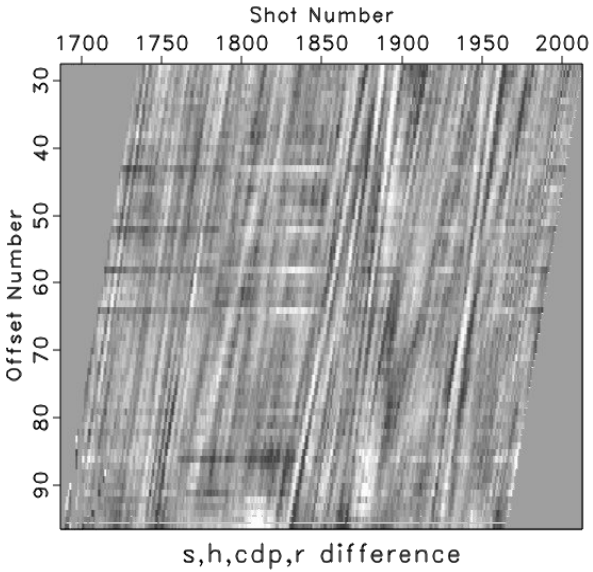

Cmp Term
Amplitude
0
−0.1
−0.2
−0.3
−0.4
0
50
100
150
200
250
300
350
400
Cmp Number


Off Term
Amplitude
0
−1
−2
−3
−4
−5
−6
0
500
1000
1500
2000
Off Number

Surface-consistent amplitude balancing

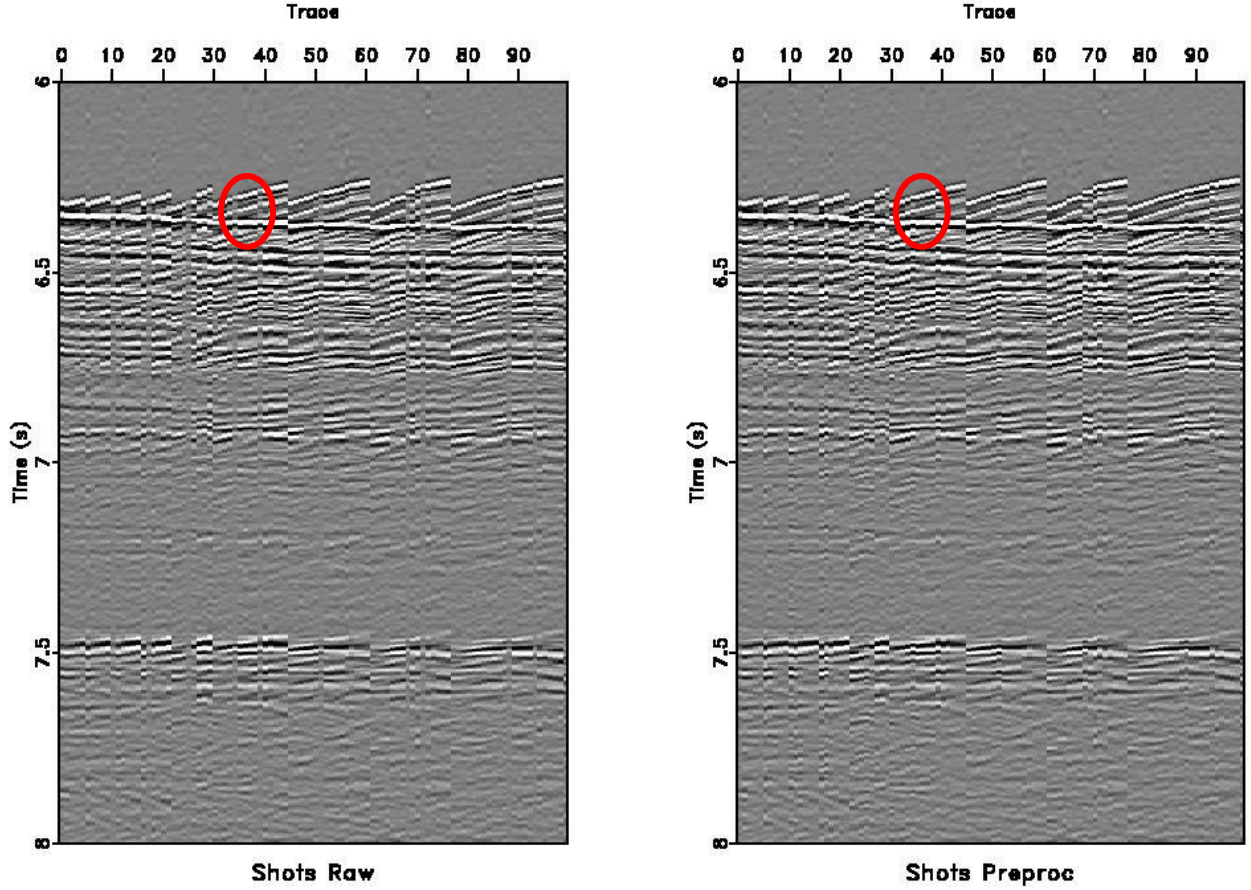




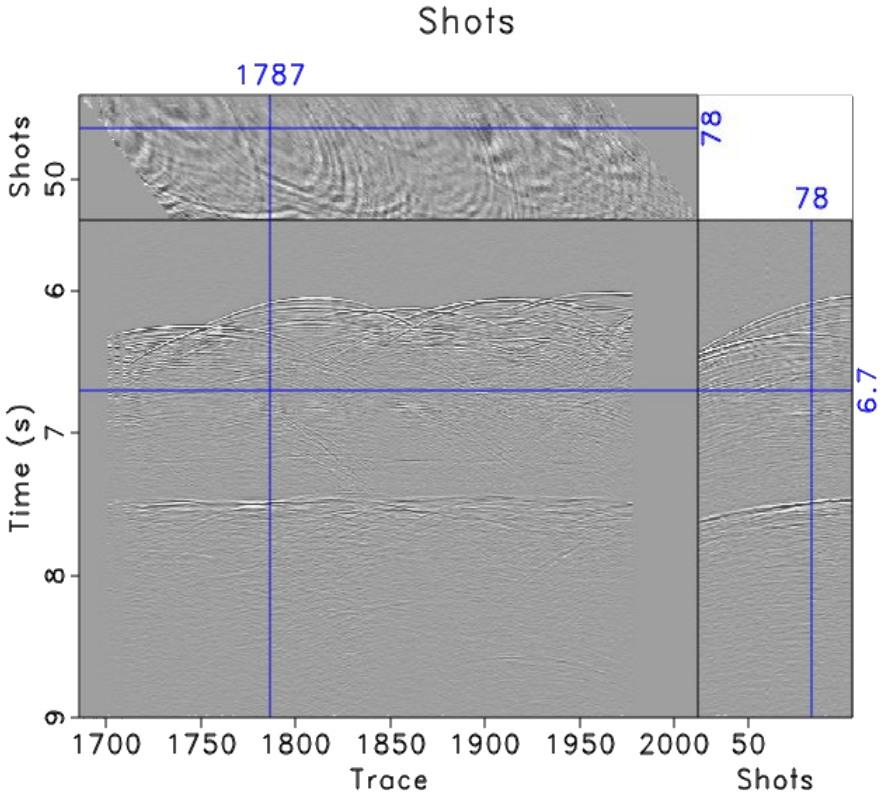


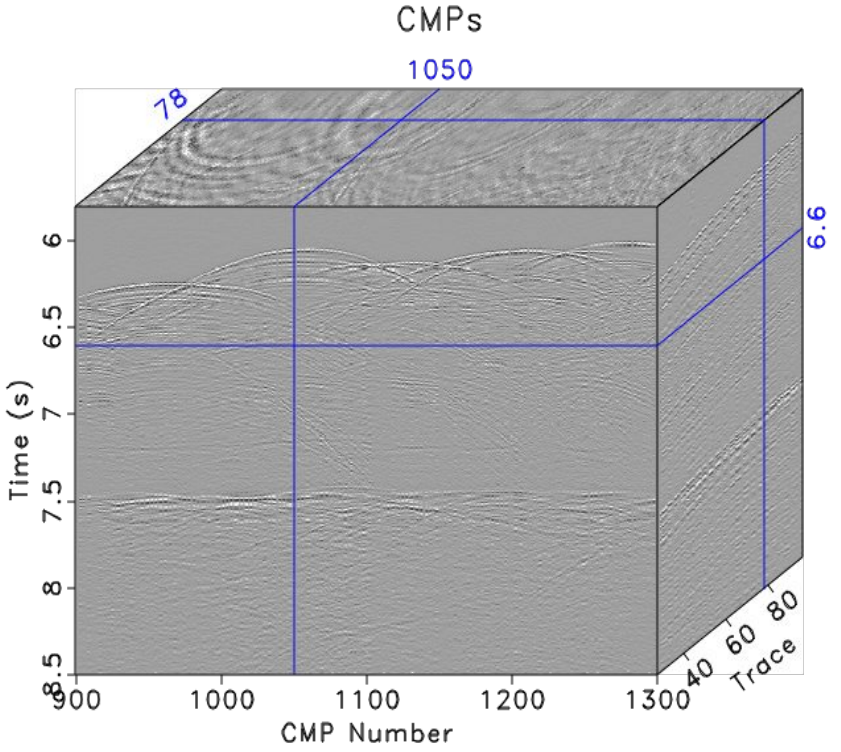
- Zero traces were removed. The surface-consistent model tries to explain the trace amplitude using a product of source, receiver, offset, and midpoint factors.
- The horizontal stripes come from the offset term. The vertical stripes come from the shot term. The diagonal stripes come from the CMP and receiver terms.

Surface-consistent amplitude balancing

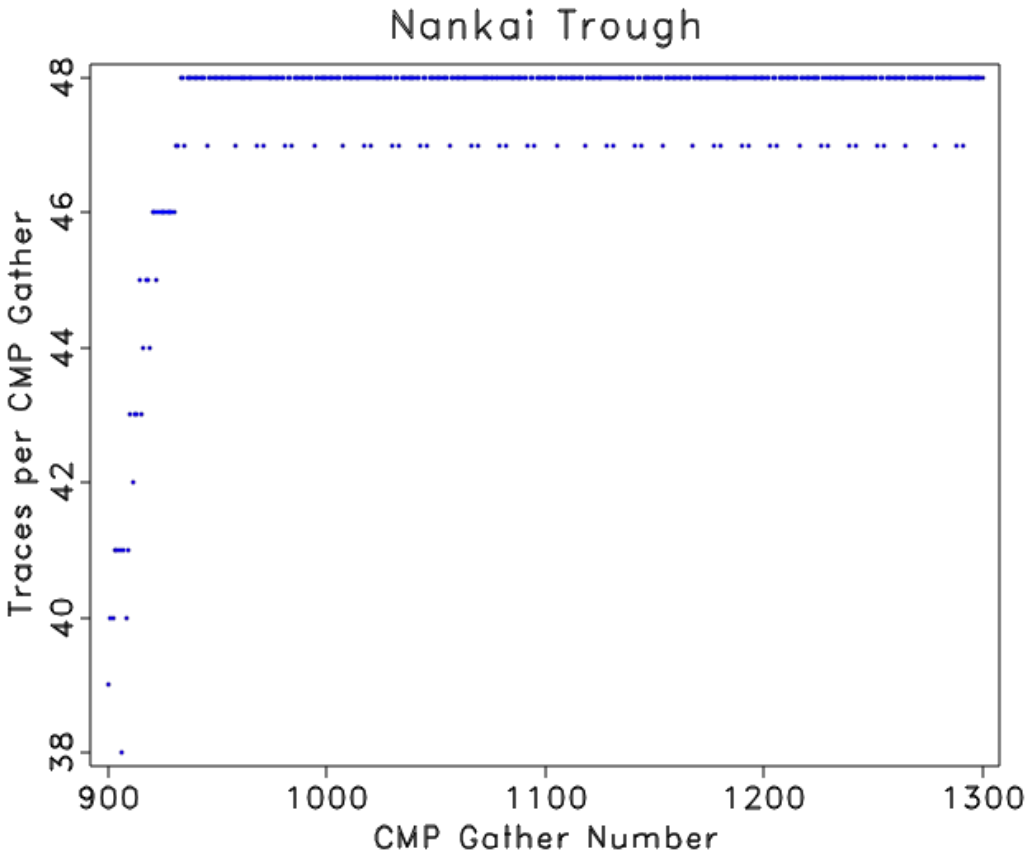


CMP sorting


Shots
1787
78
78
6.7
Shots
50
6
7
8
9
Time (s)
1700
1750
1800
1850
1900
1950
2000
50
Trace
Shots

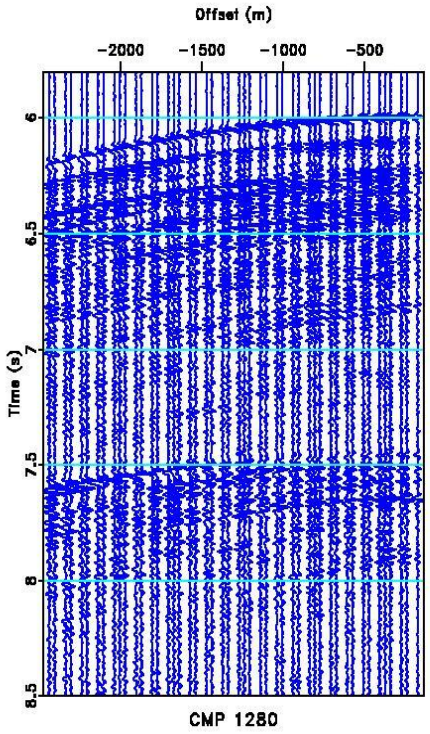

CMPs
1050
78
6.6
6
6.5
7
7.5
8
8.5
Time (s)
900
1000
1100
1200
1300
CMP Number
40
60
80
Trace

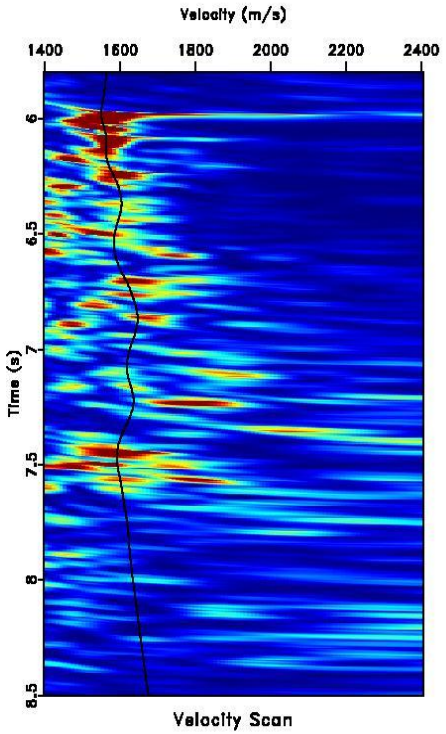
Fold distribution

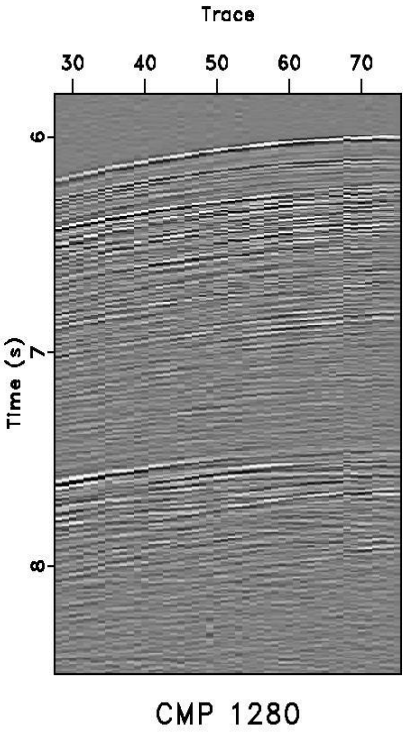


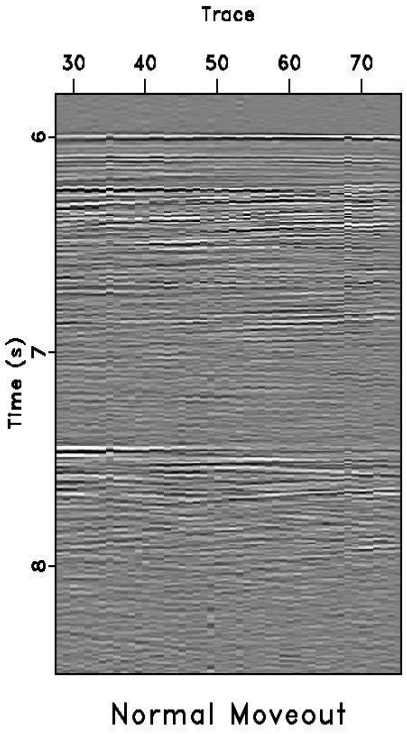
- First CMPs are not full fold.
- The first full-fold CMP gather is CMP 933 with 48 traces.

Velocity analysis and NMO

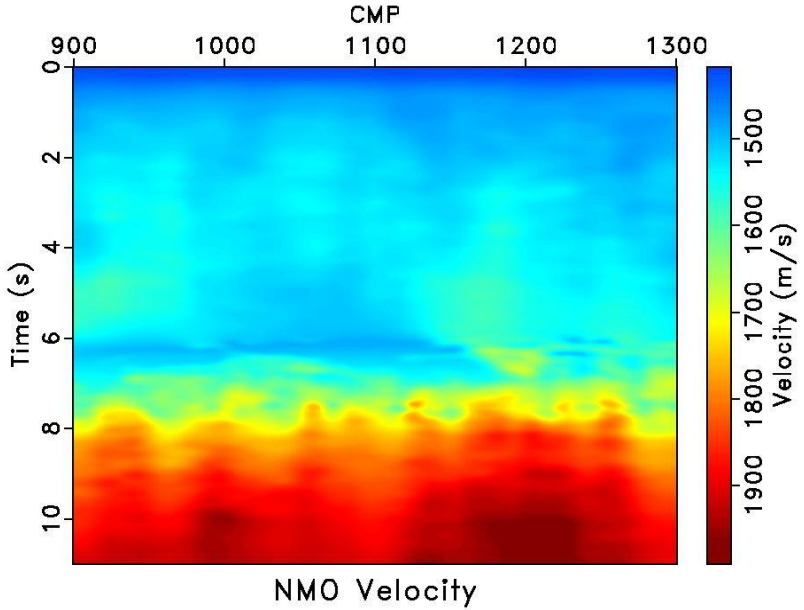


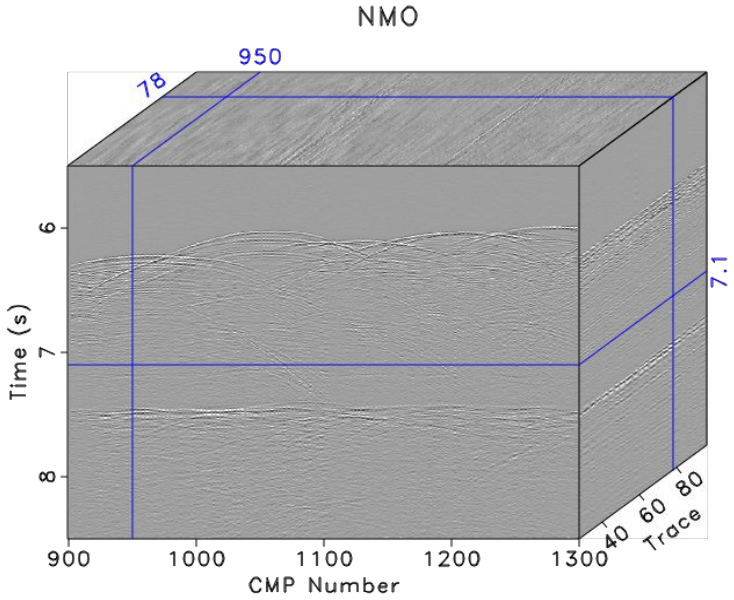




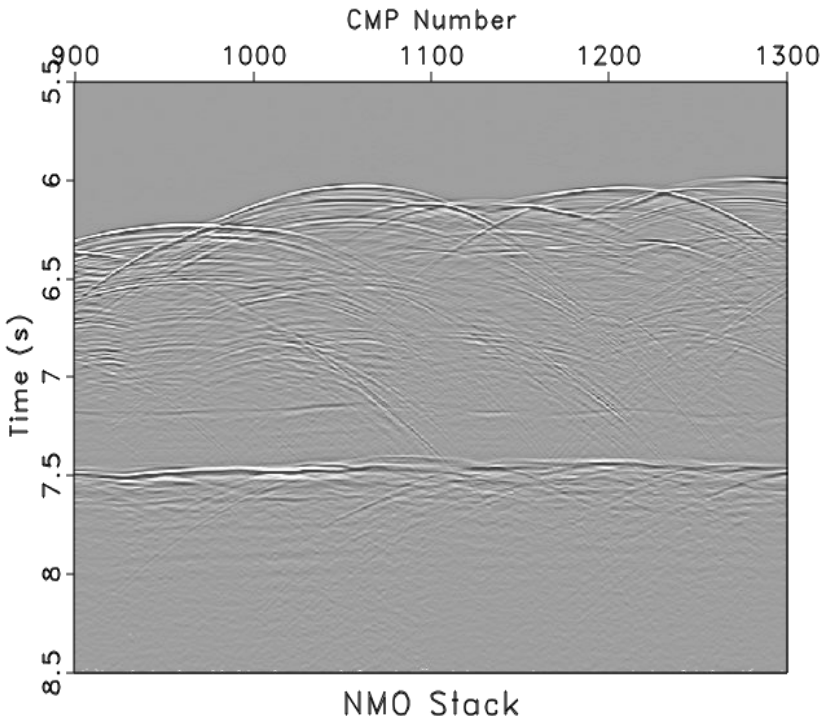


Velocity analysis and NMO

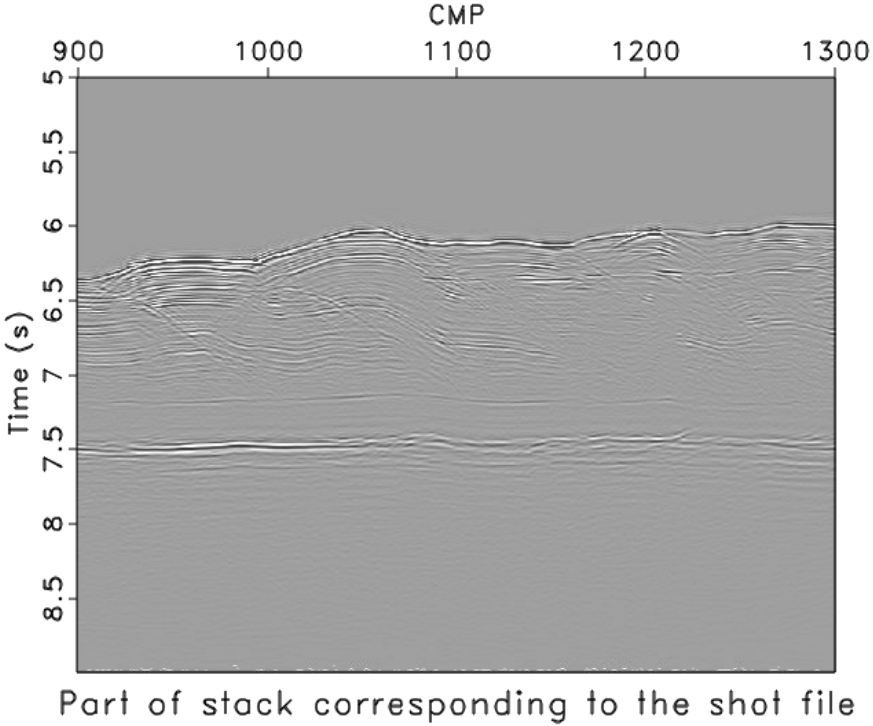




Stack

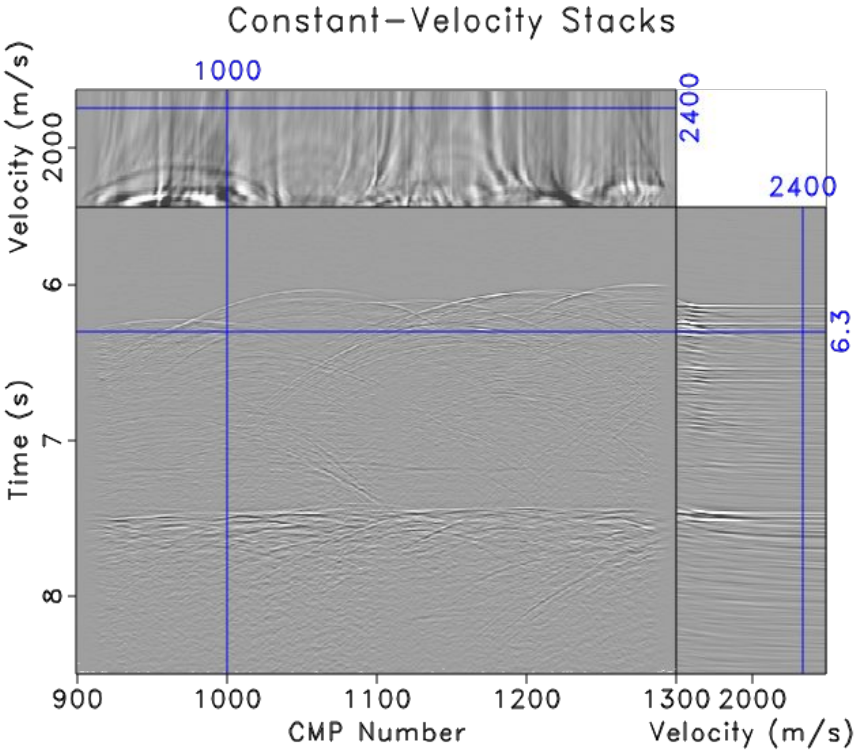


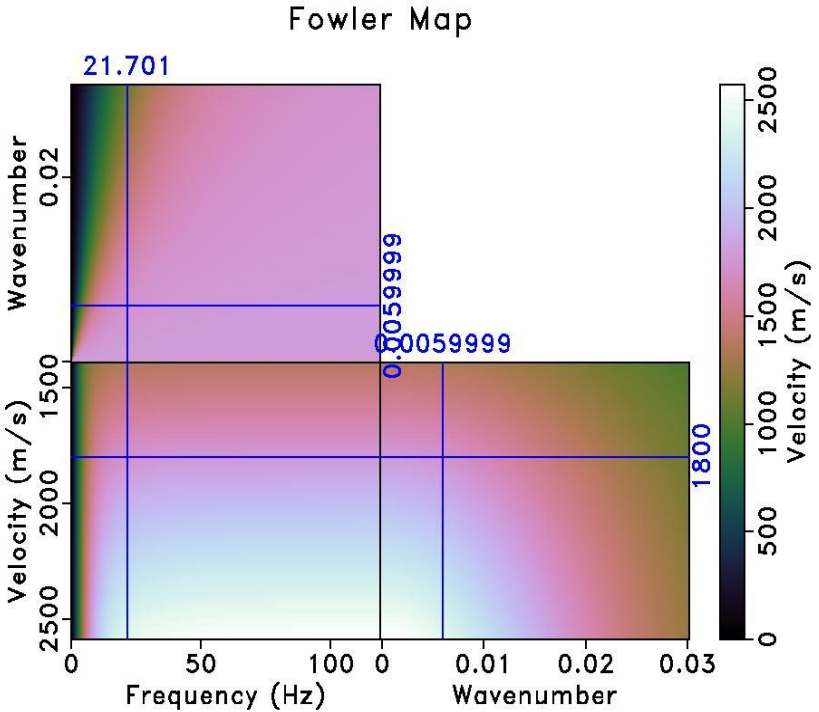
NMO Stack



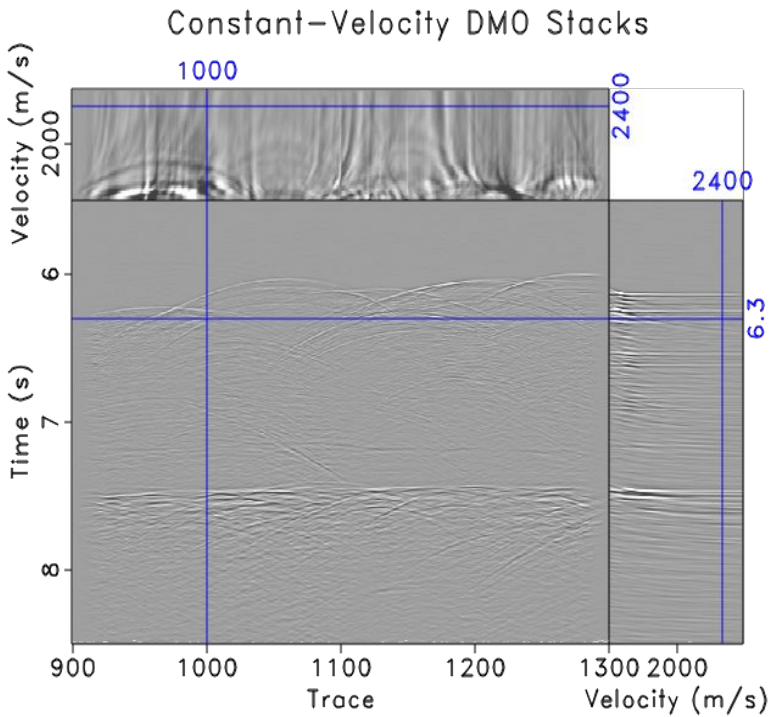
Part of stack corresponding to the shot file

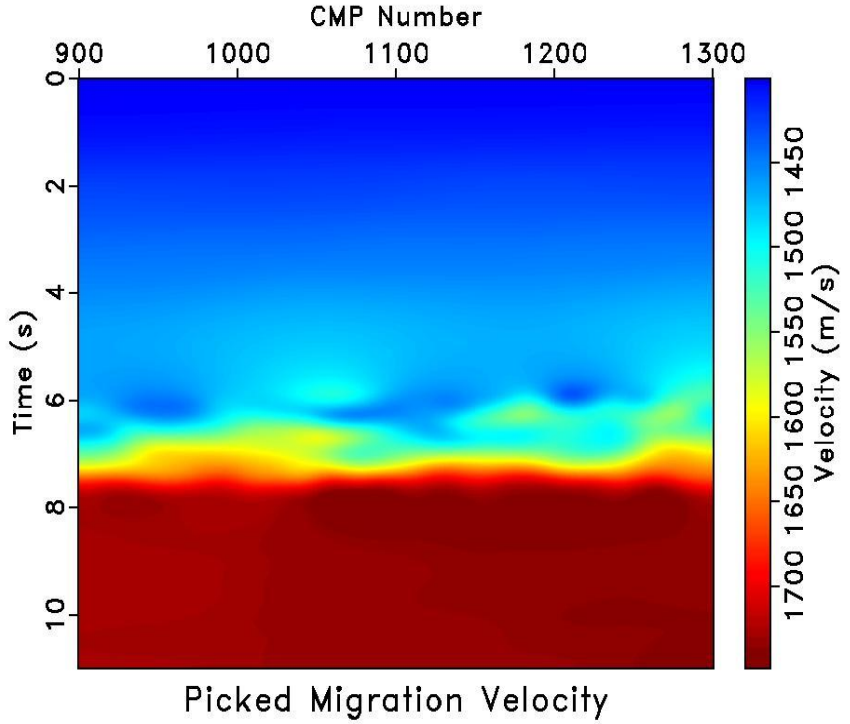
DMO


Constant−Velocity Stacks
1000
2400
2400
6.3
Velocity (m/s)
2000
6
Time (s)
7
8
900
1000
1100
1200
1300
2000
CMP Number
Velocity (m/s)

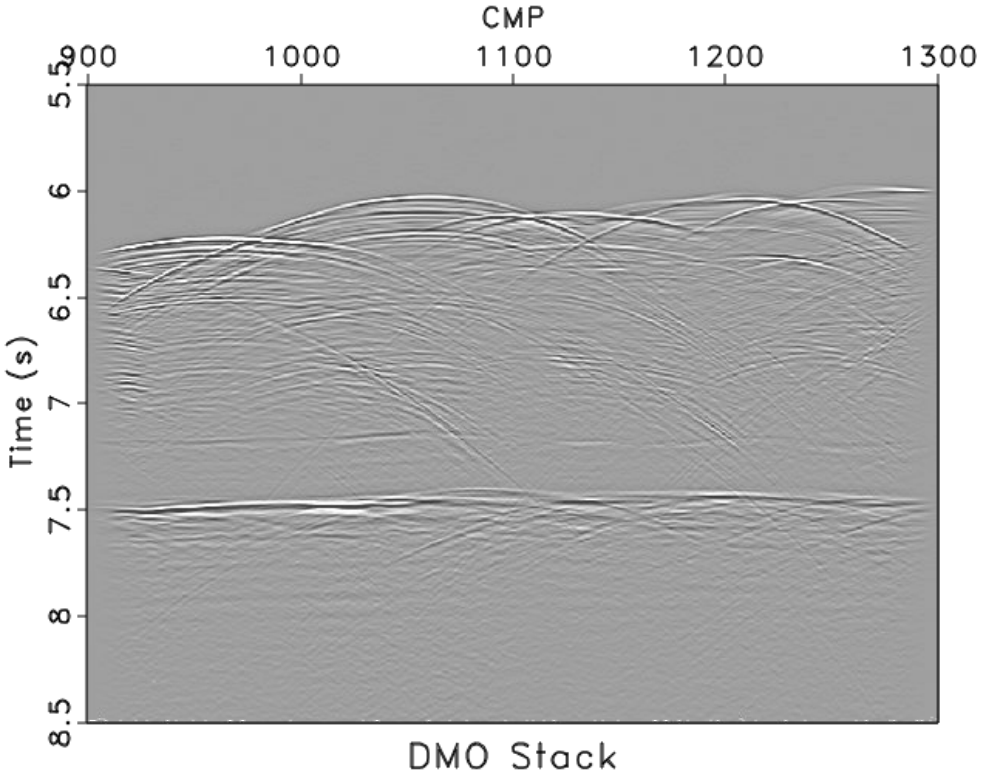

Fowler Map
21.701
0.0059999
0.0059999
1800
Wavenumber
0.02
Velocity (m/s)
1500
2000
2500
0
50
100
Frequency (Hz)
0
0.01
0.02
0.03
Wavenumber
Velocity (m/s)
2500
2000
1500
1000
500
0

DMO


Constant–Velocity DMO Stacks
1000
2400
2400
6.3
Velocity (m/s)
2000
6
Time (s)
7
8
900
1000
1100
1200
1300
2000
Trace
Velocity (m/s)

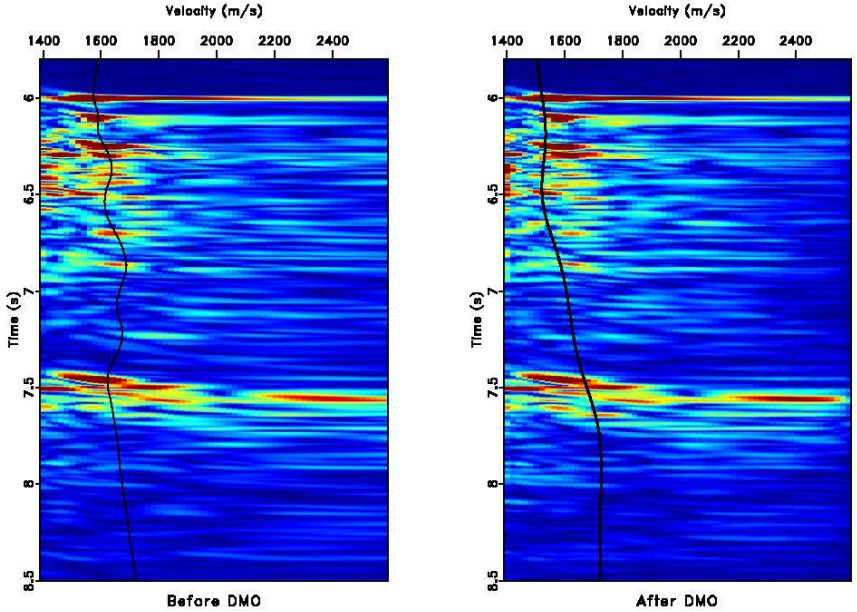

CMP Number
900
1000
1100
1200
1300
0
2
4
Time (s)
6
8
10
1700 1650 1600 1550 1500 1450
Velocity (m/s)
Picked Migration Velocity

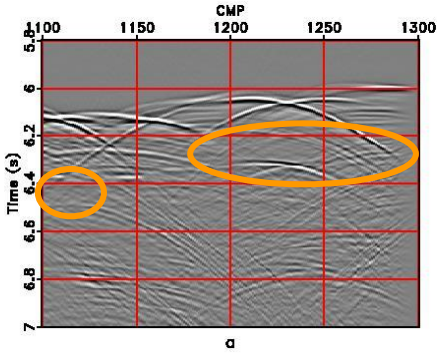
DMO



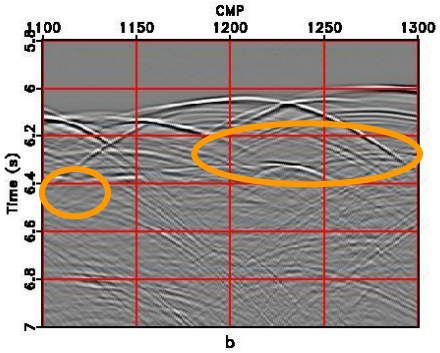
- DMO stack corrects for dips.
- Generated from an ensemble stack of different velocities.
- DMO velocities were picked automatically from the envelope.

DMO





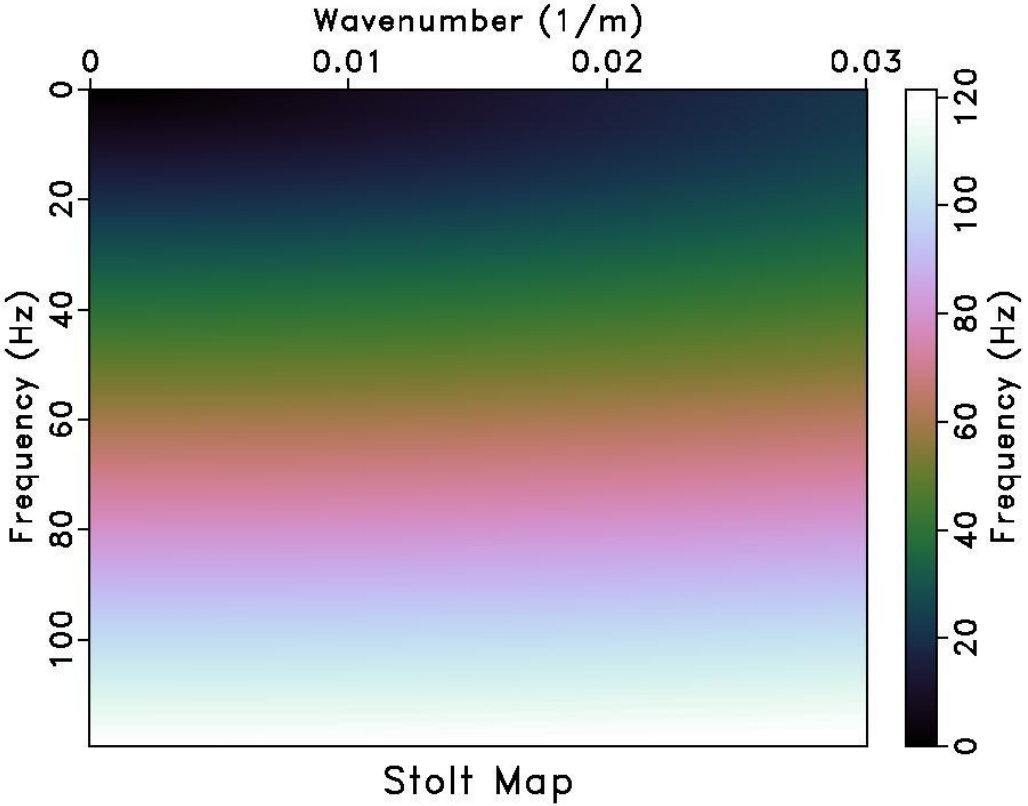
DMO

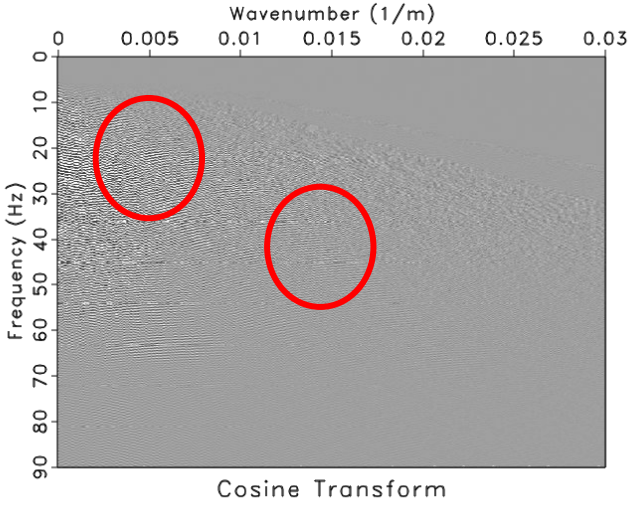


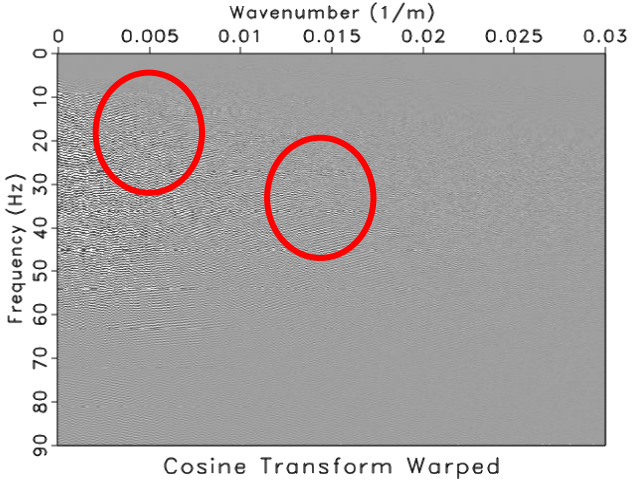
NMO

- Velocities are corrected for dips.
- Picked velocities are smoother and increase with depth.
- Events are clearer in DMO stack.

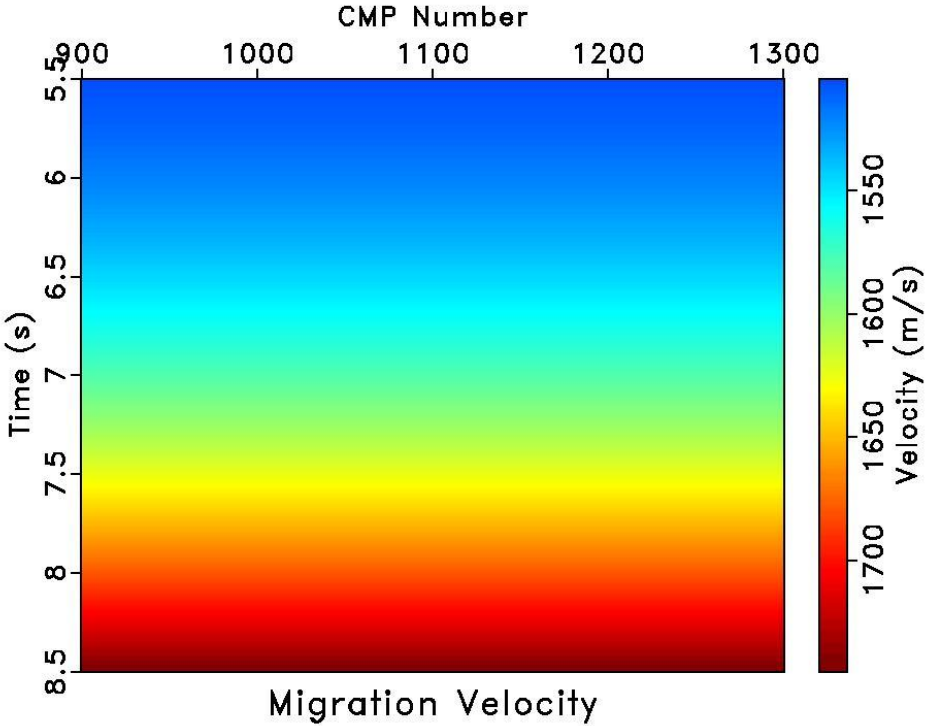
Stolt migration constant velocity

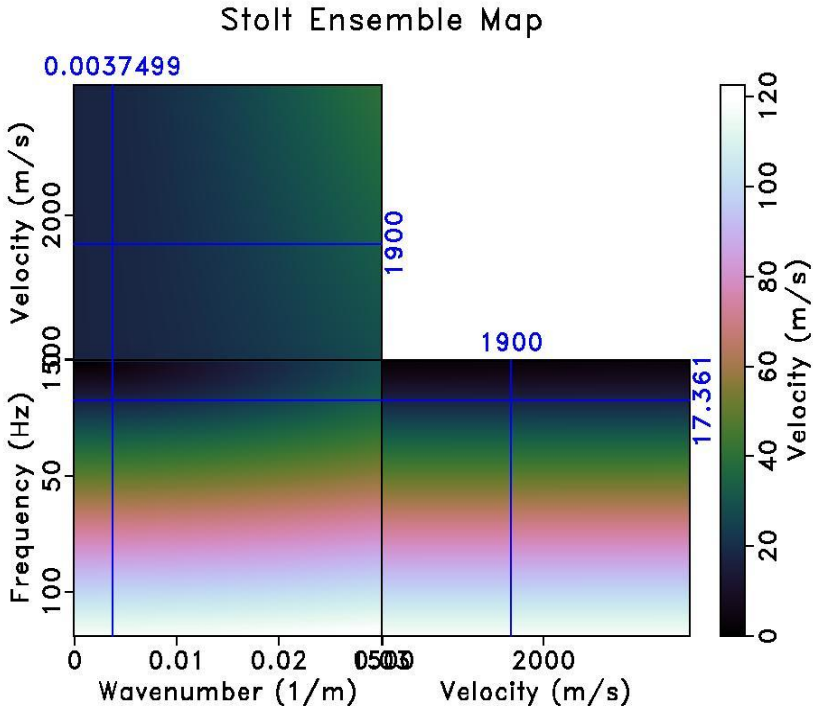






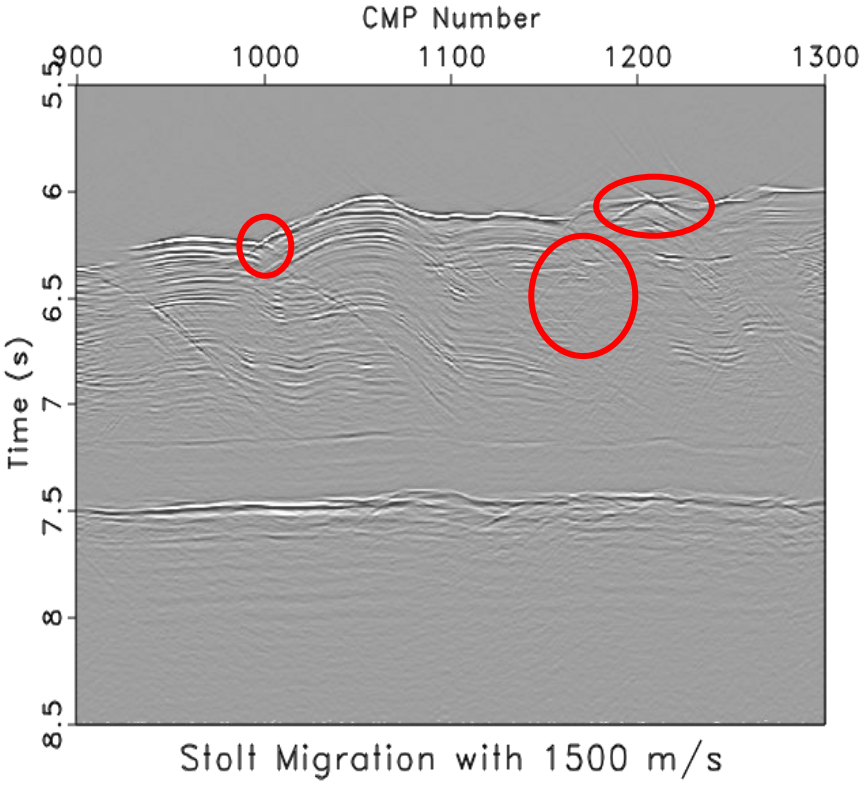
Stolt migration variable velocity

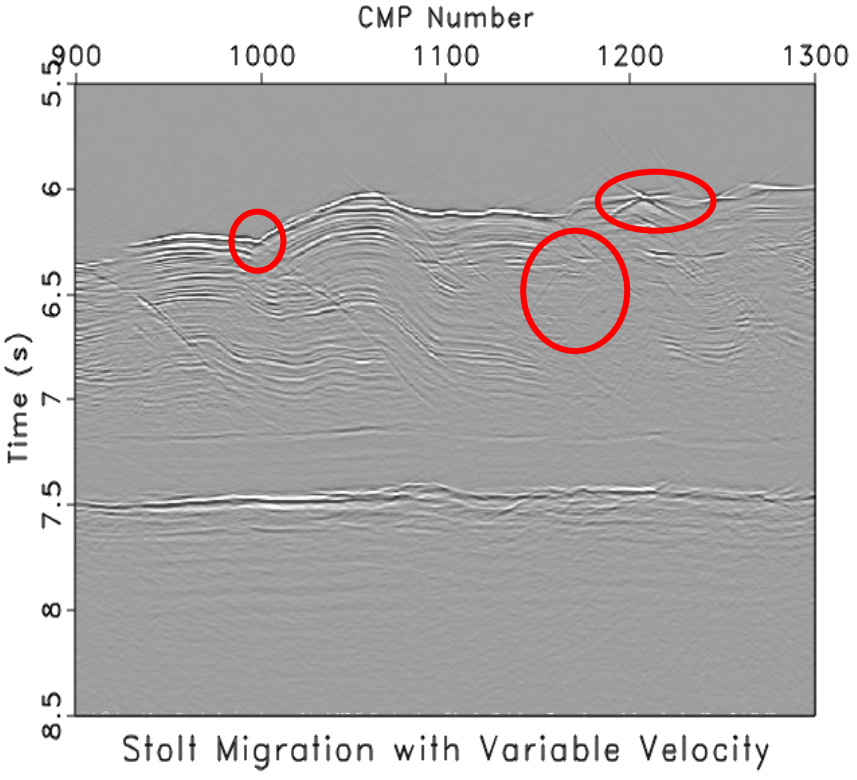




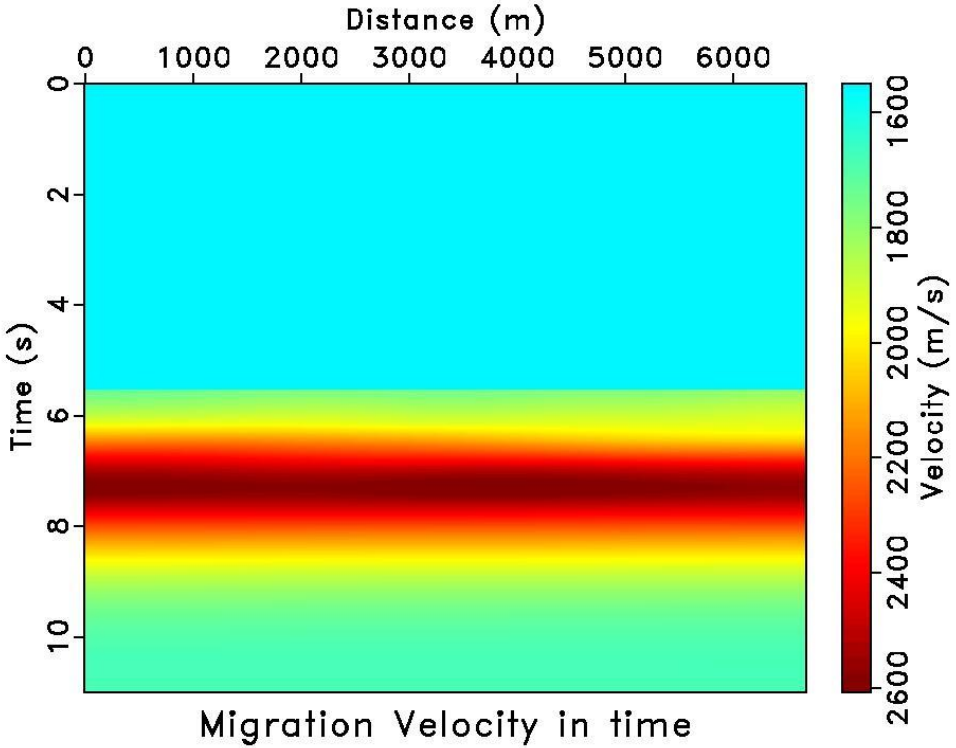
- More realistic velocity distribution.

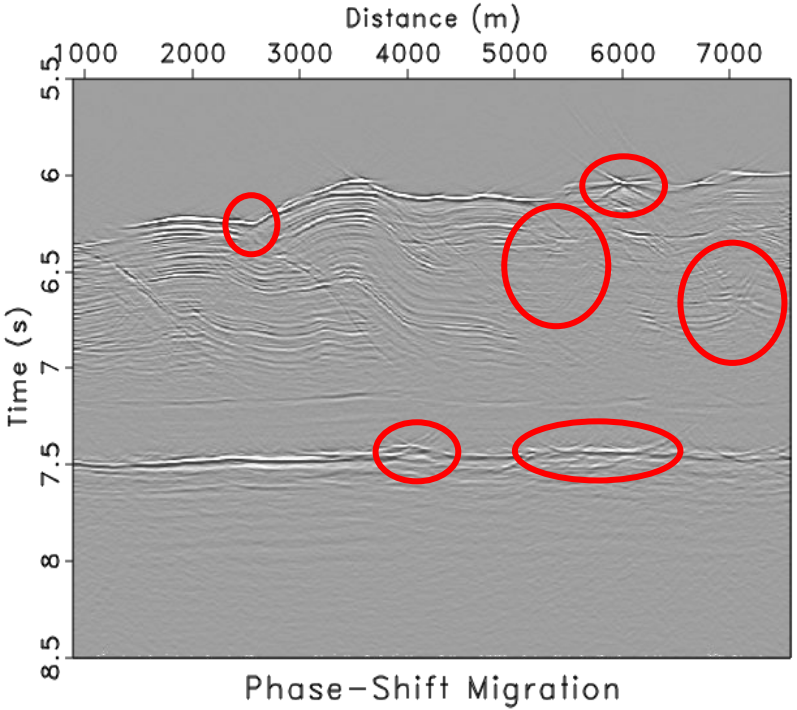
Stolt migration



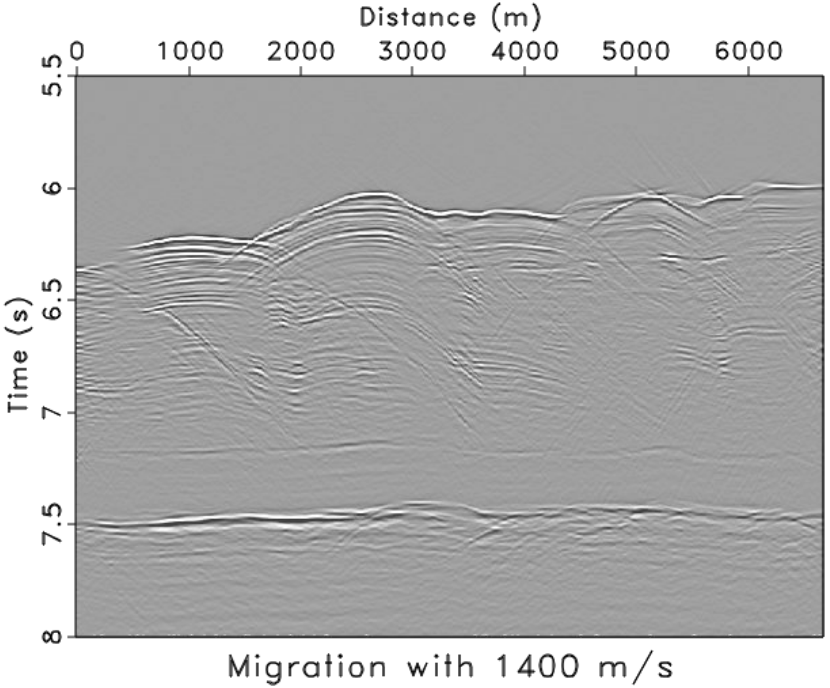


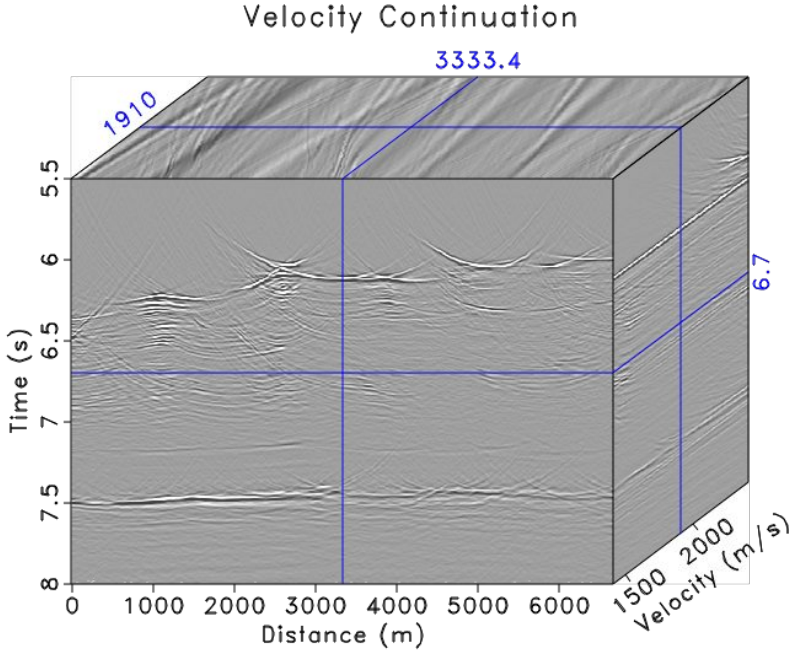
Gazdag migration



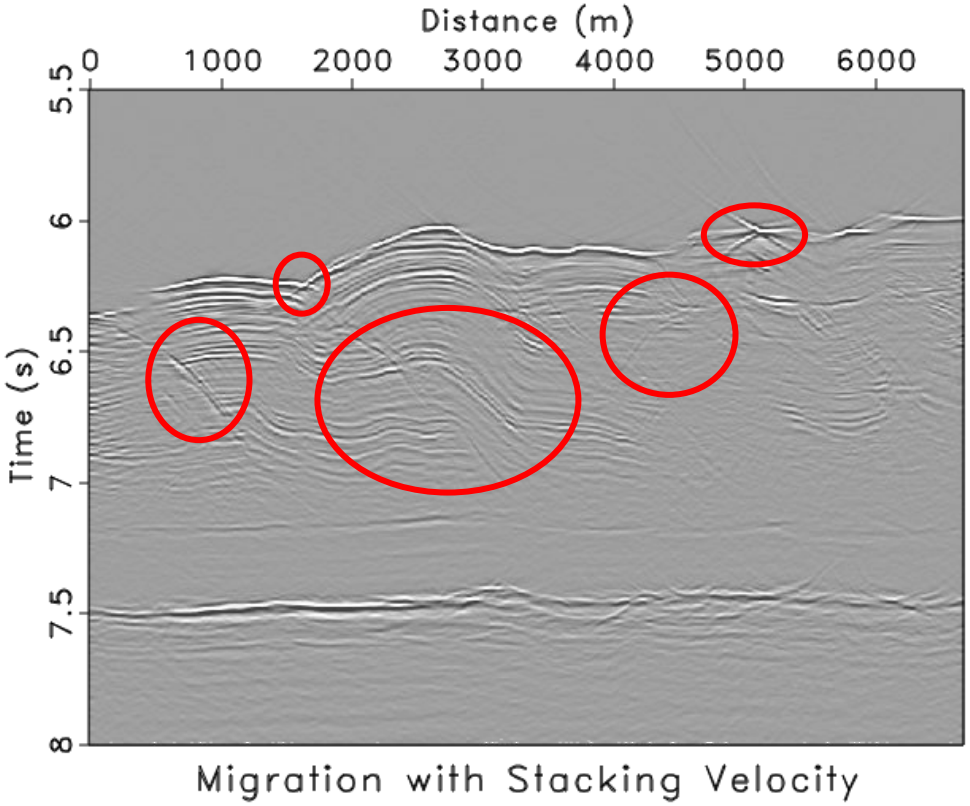


Velocity continuation

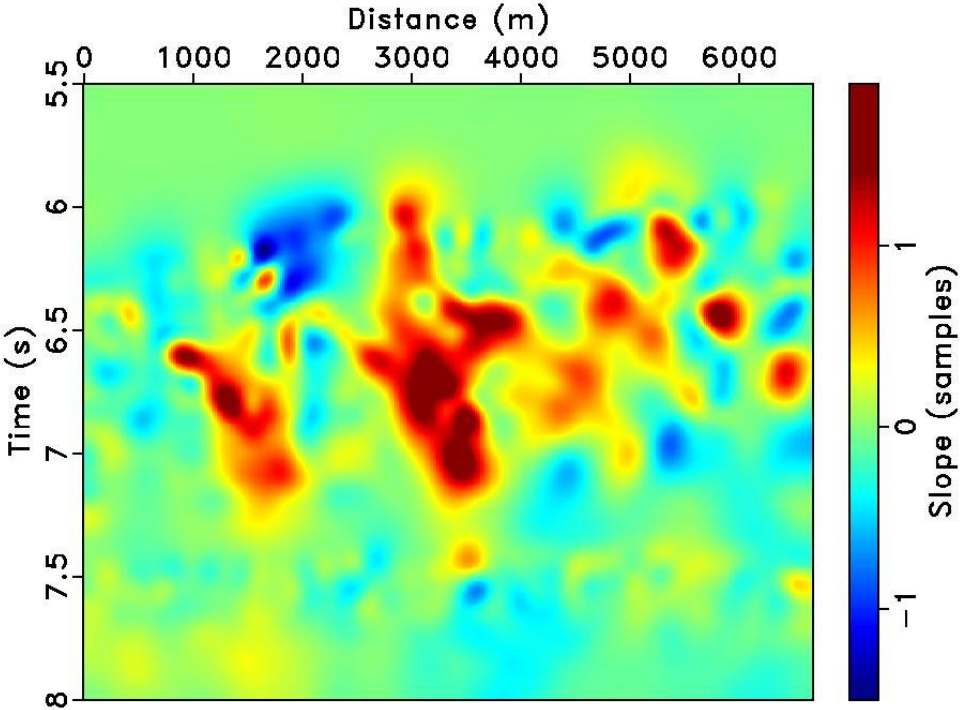


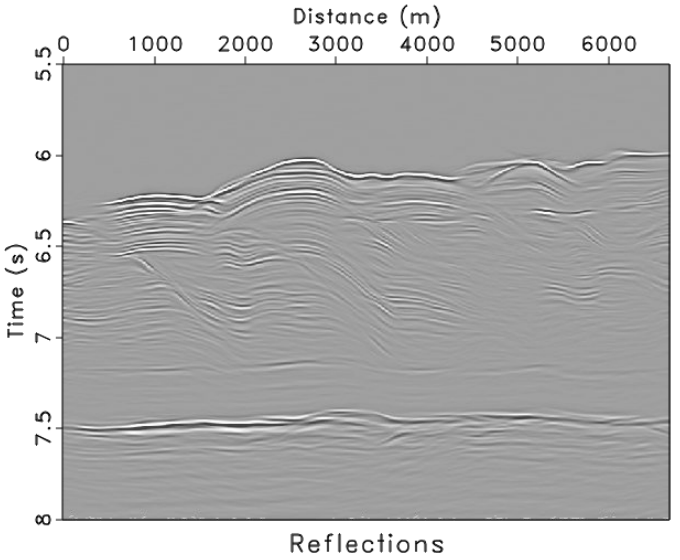


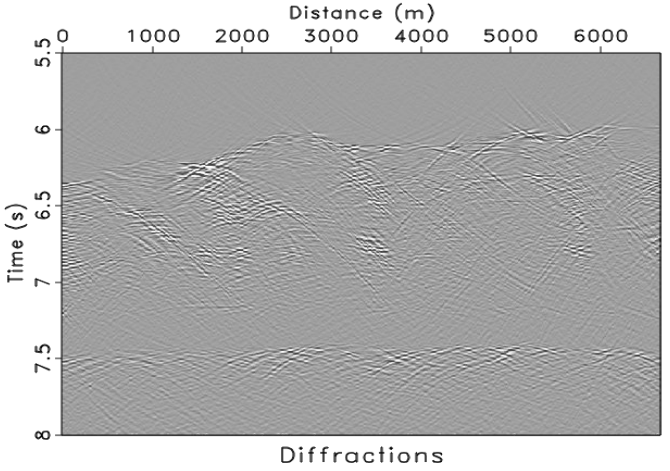
Velocity continuation



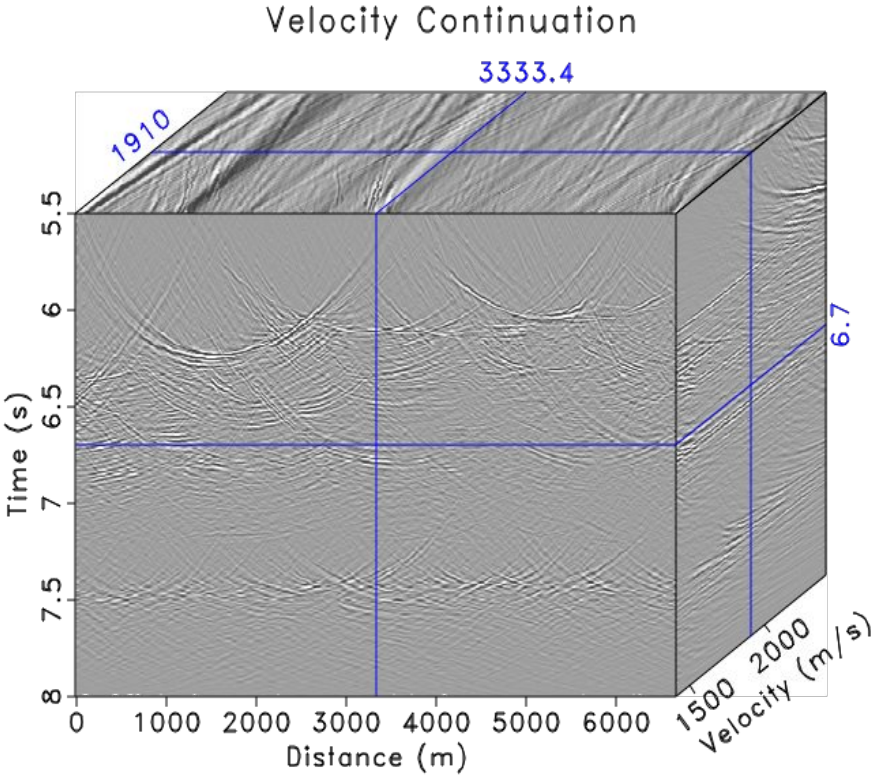
Velocity continuation

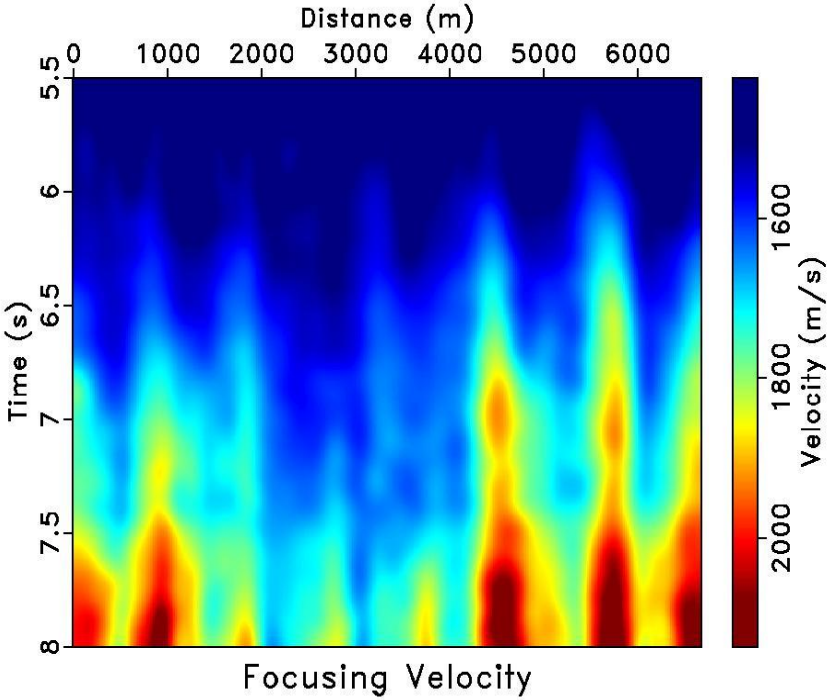




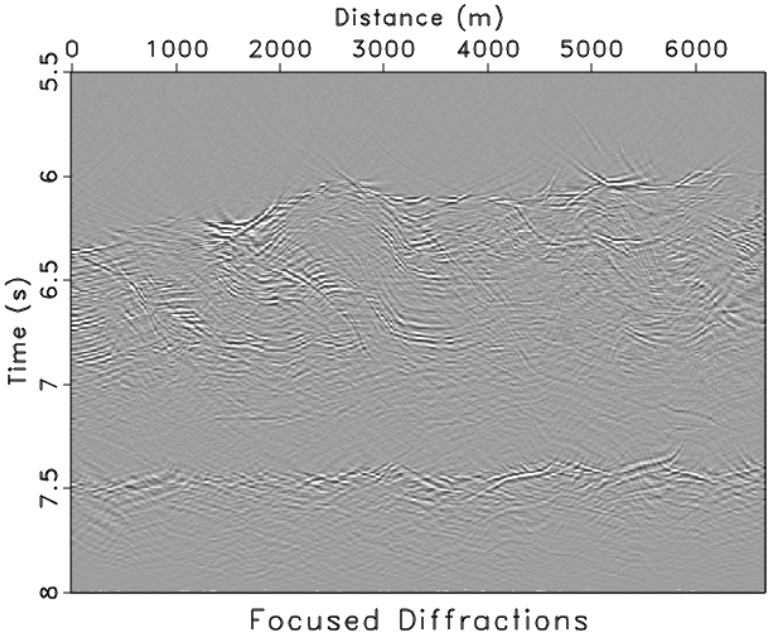


Velocity continuation

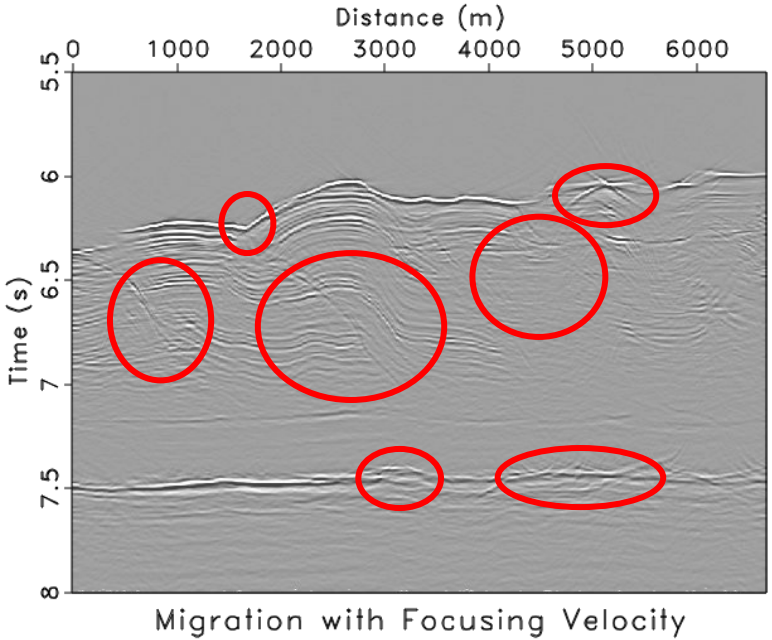




Velocity continuation

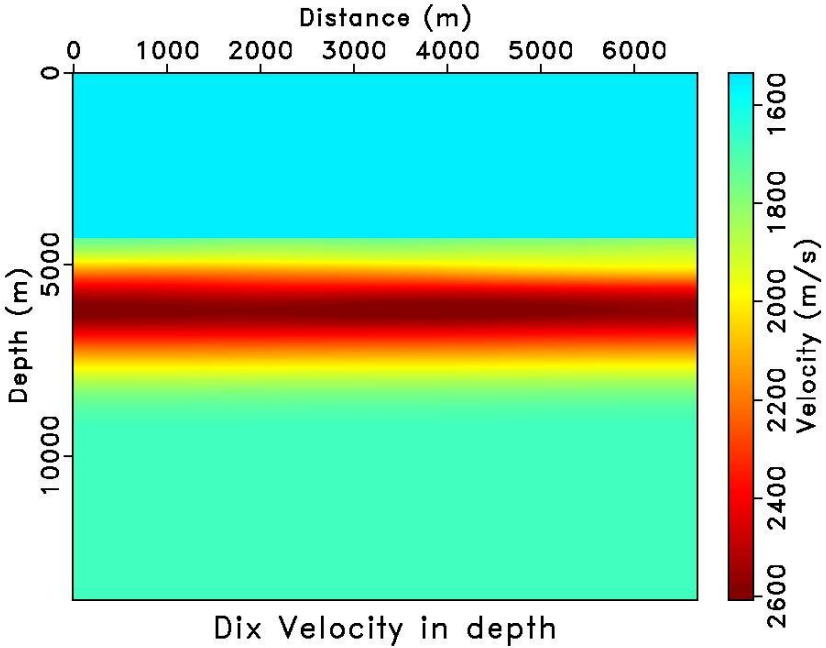


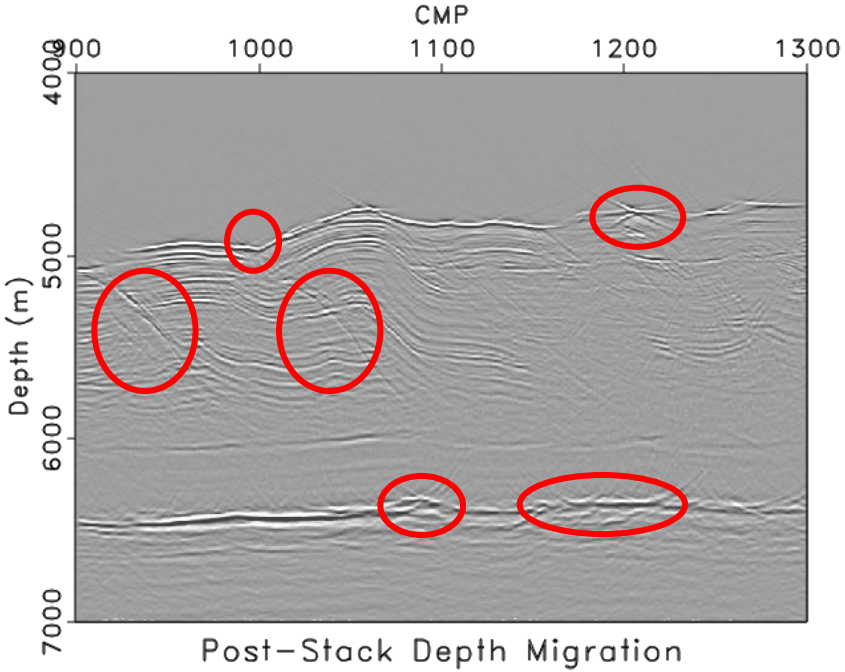
Focused Diffractions



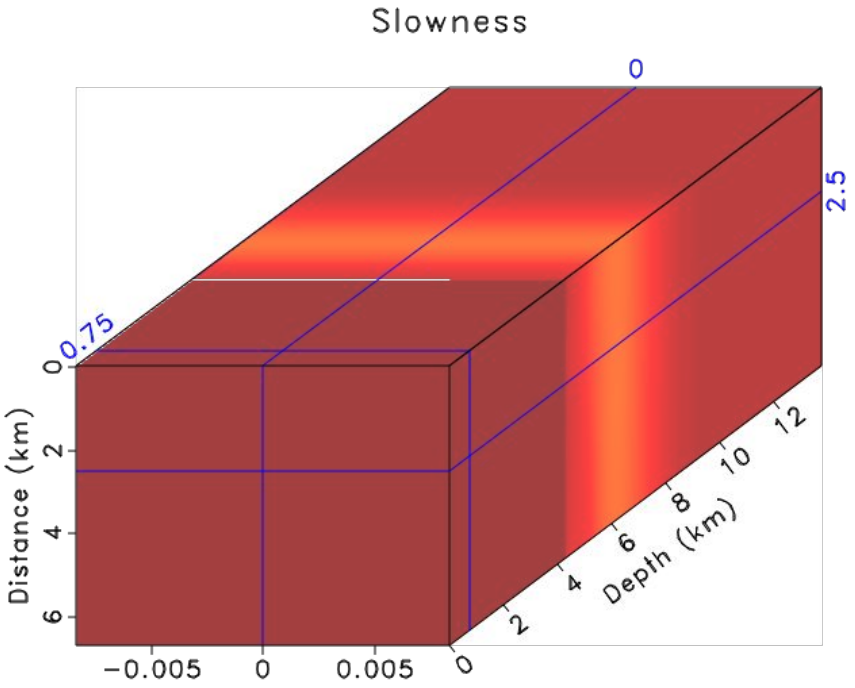
Migration with Focusing Velocity

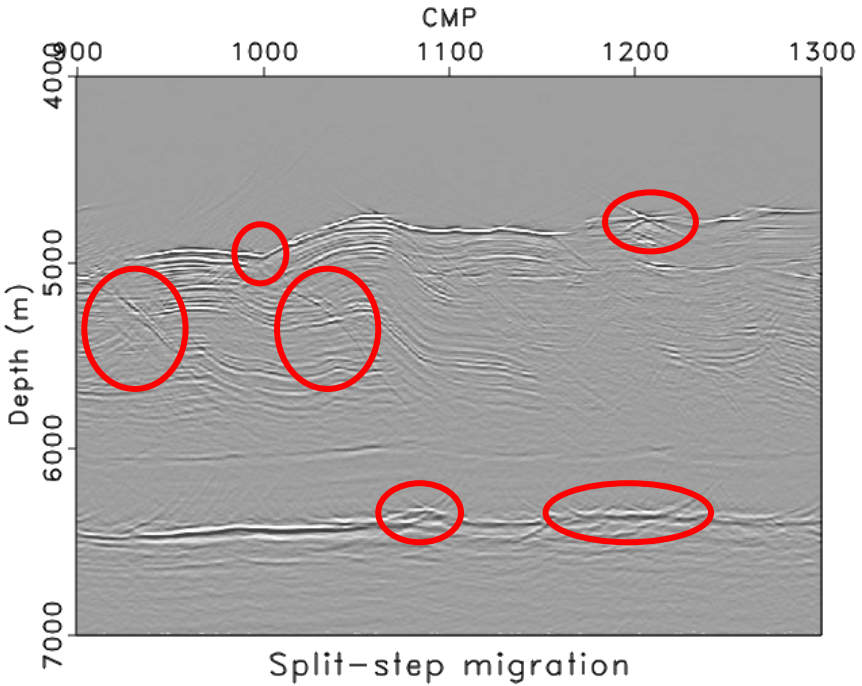
Reverse-time migration



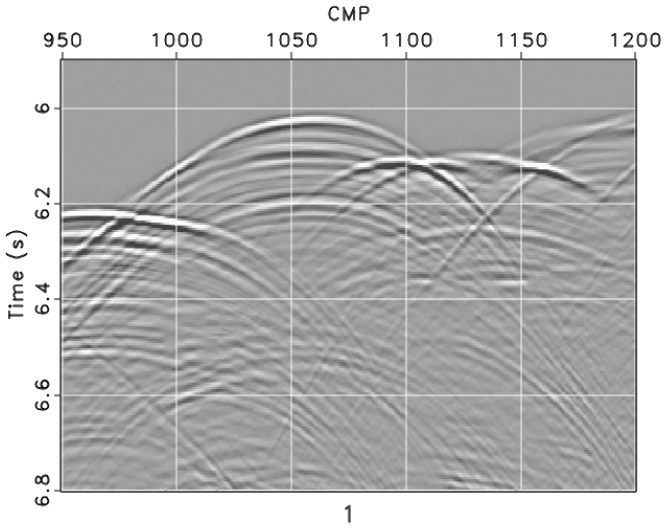


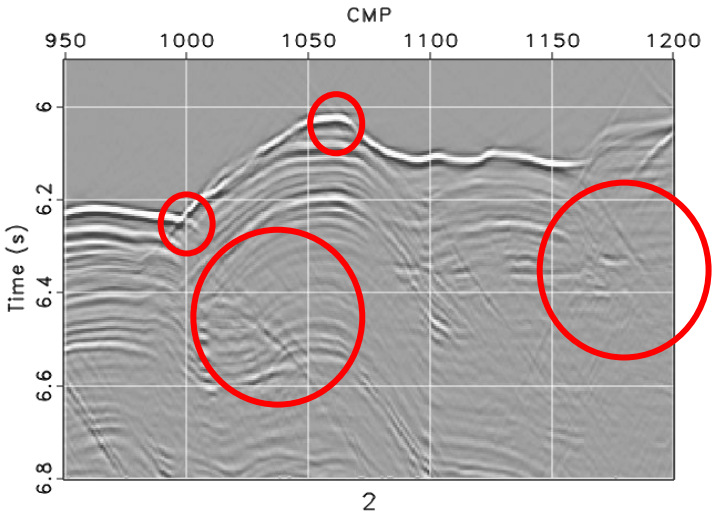
Split-step migration

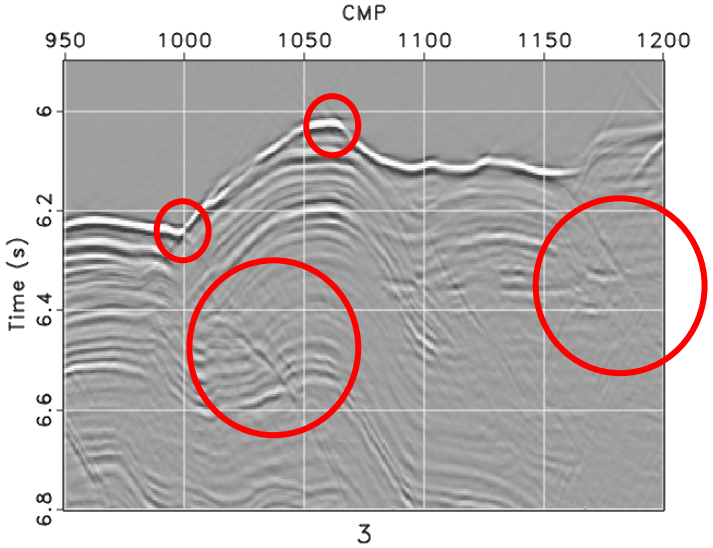




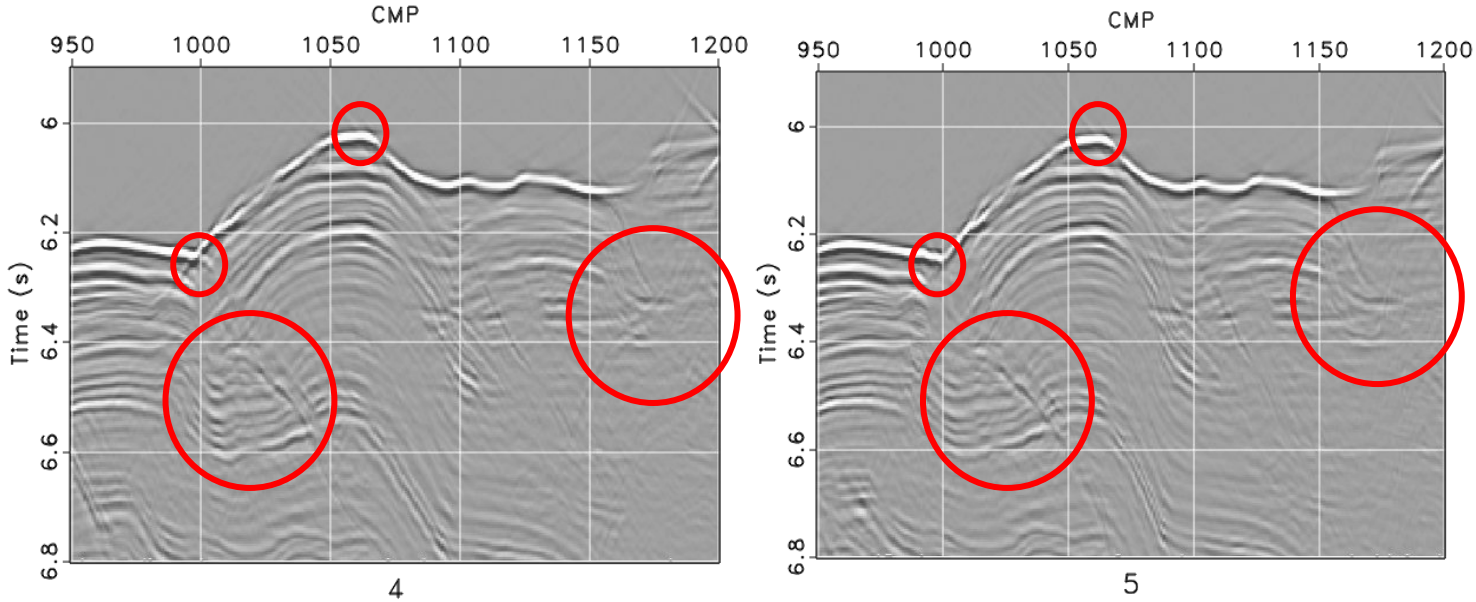
Migration comparison

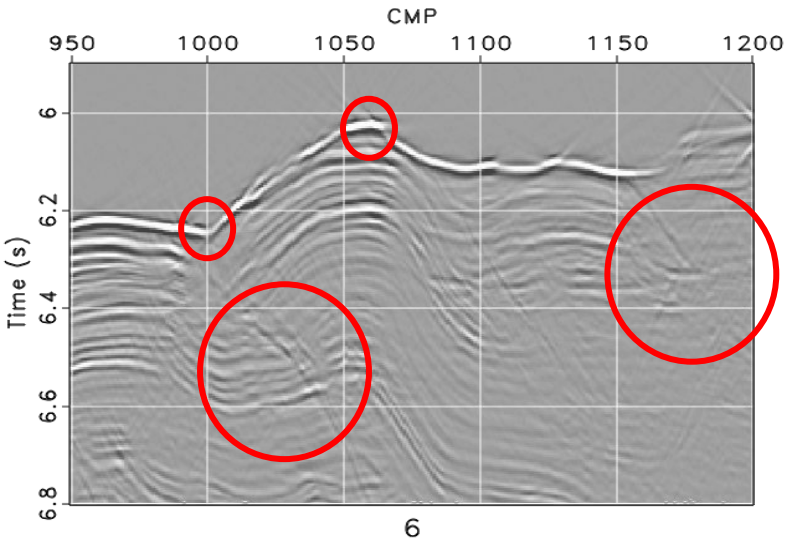




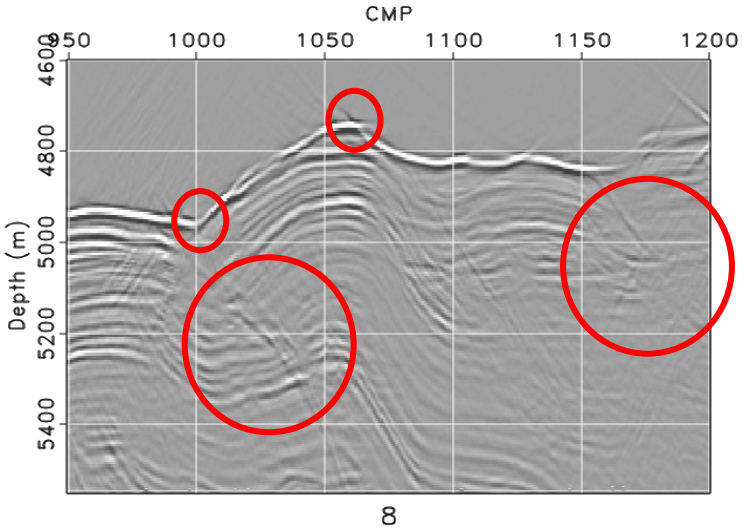


Migration comparison

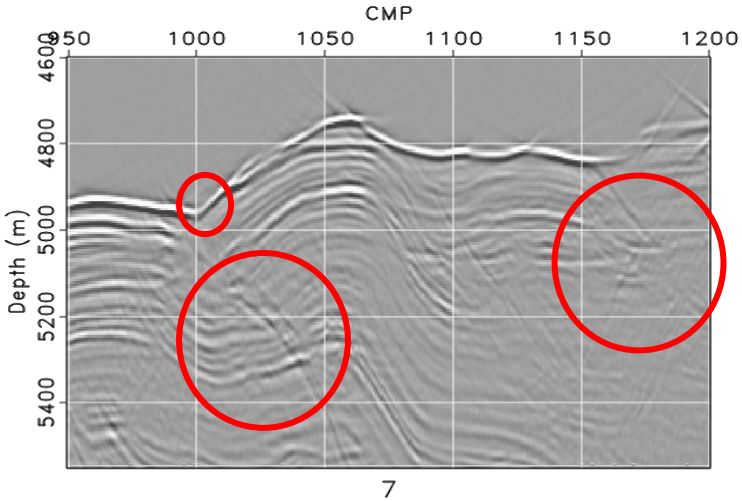



CMP
950
1000
1050
1100
1150
1200
Time (s)
6
6.2
6.4
6.6
6.8

6


CMP
950
1000
1050
1100
1150
1200
Depth (m)
4600
4800
5000
5200
5400

8


CMP
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1000
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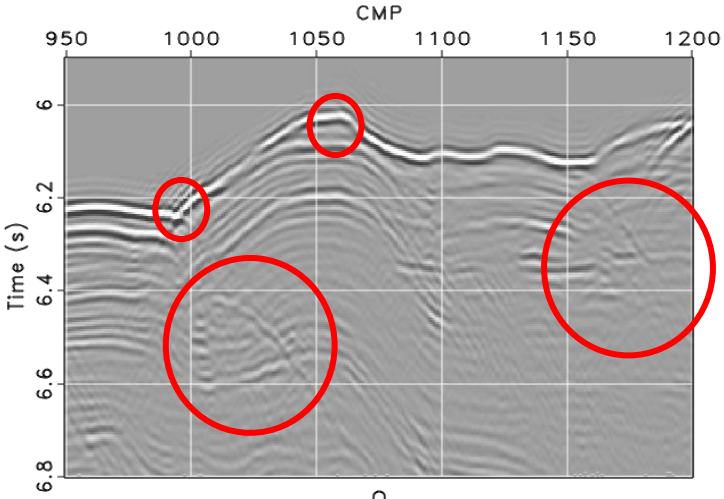
1100
1150
1200
Depth (m)
4600
4800
5000
5200
5400

7


CMP
950
1000
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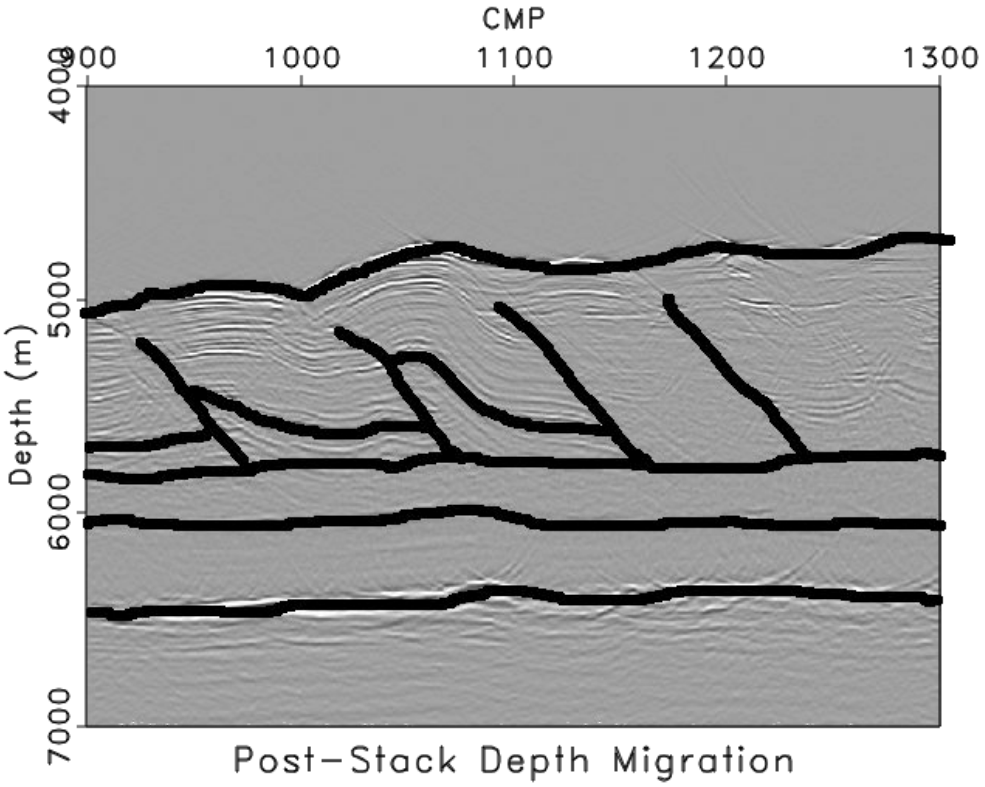
1100
1150
1200
Time (s)
6
6.2
6.4
6.6
6.8

0

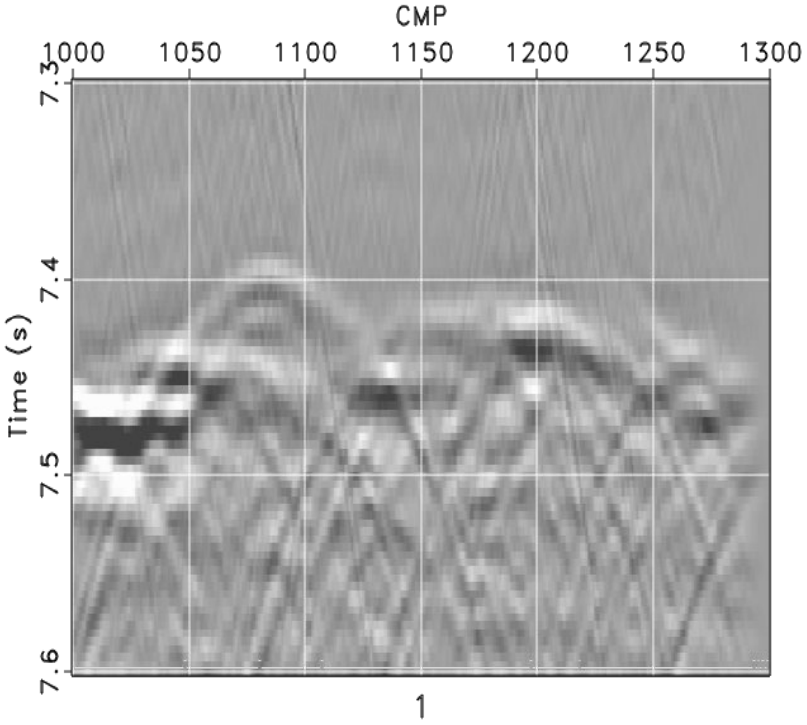
Interpretations

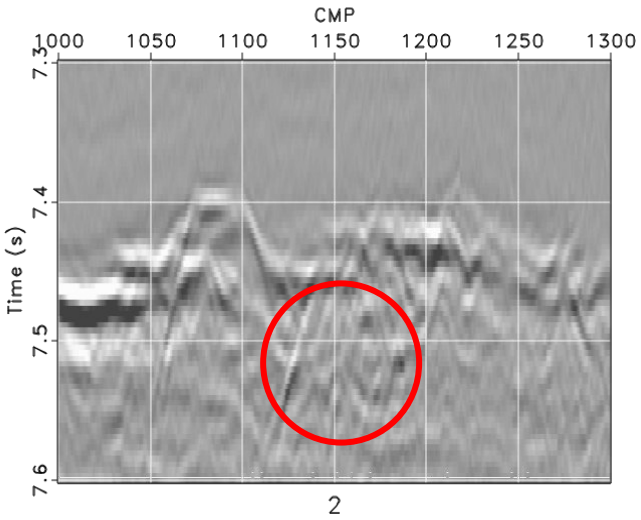


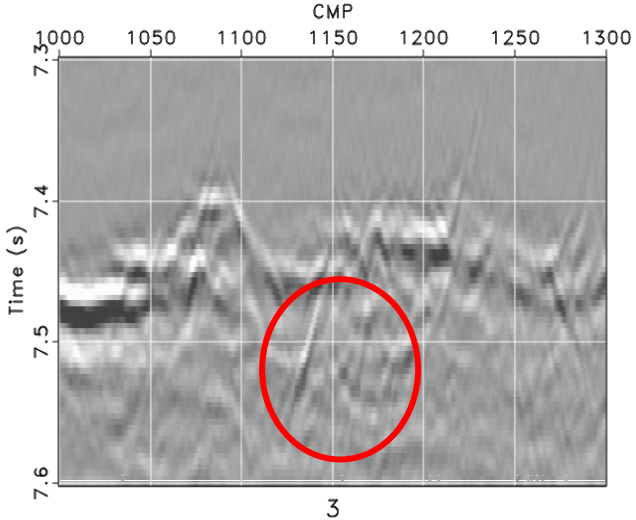
Conclusions

- Nankai data has many diffractions.
- The reflectors are generally flat geology.
- We processed from raw data to surface-consistent amplitude balancing, CMP sorting, velocity analysis, NMO, DMO, stack, and migration. The result can be used for interpretations.
- We improved the quality of the published migrated image by doing more detailed velocity analysis in migration to collapse the diffractions.

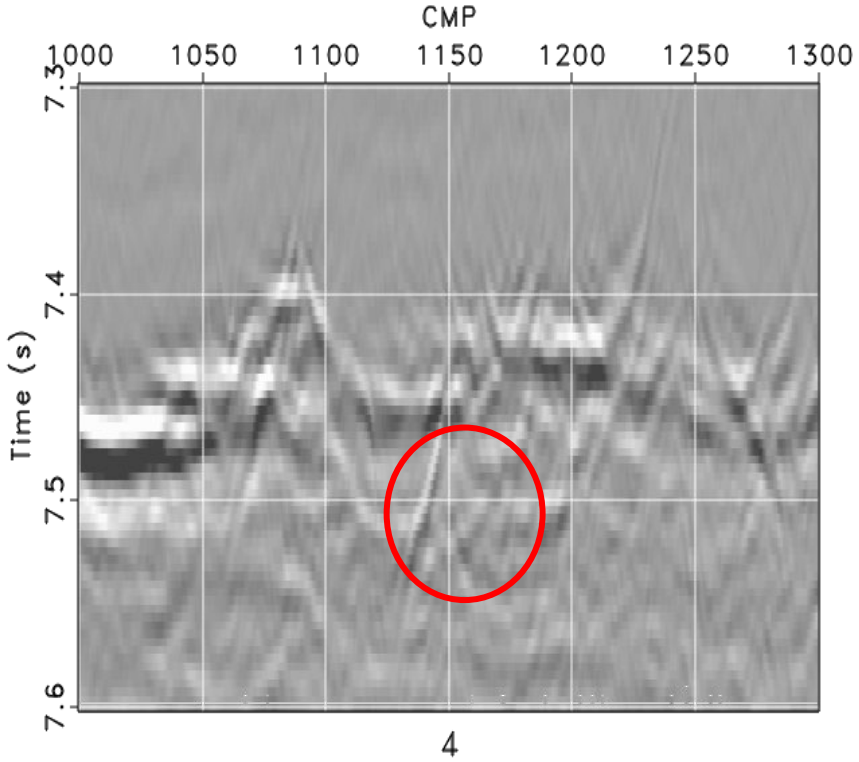
Migration comparison

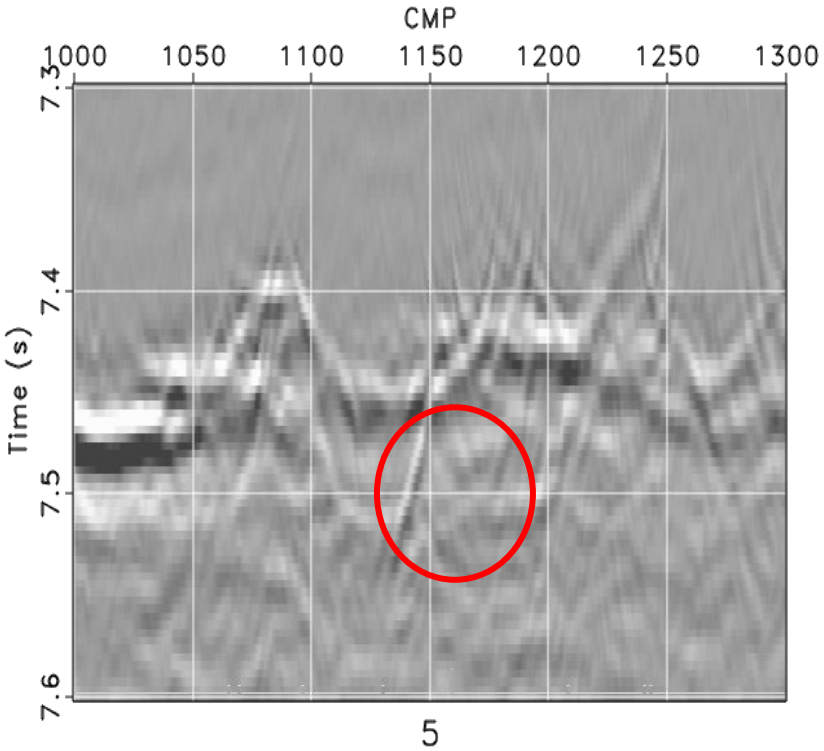


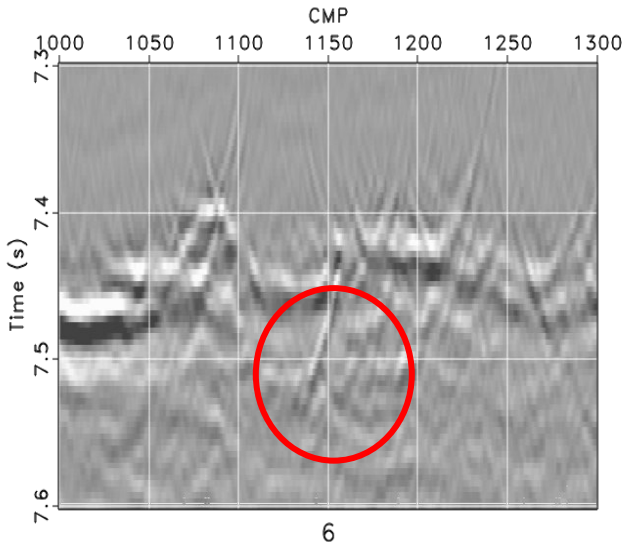




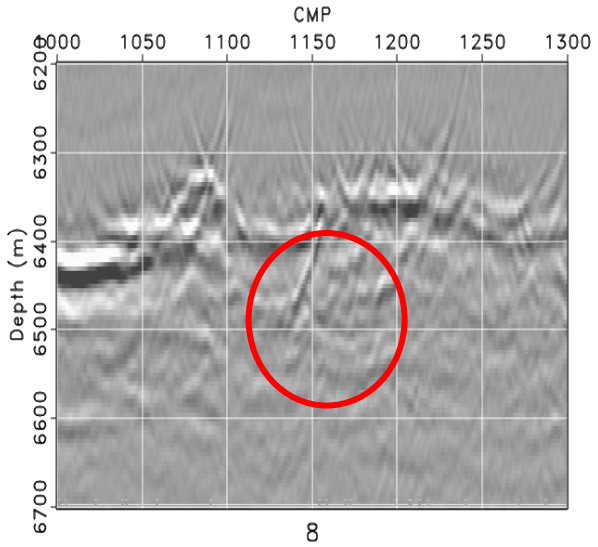
Migration comparison



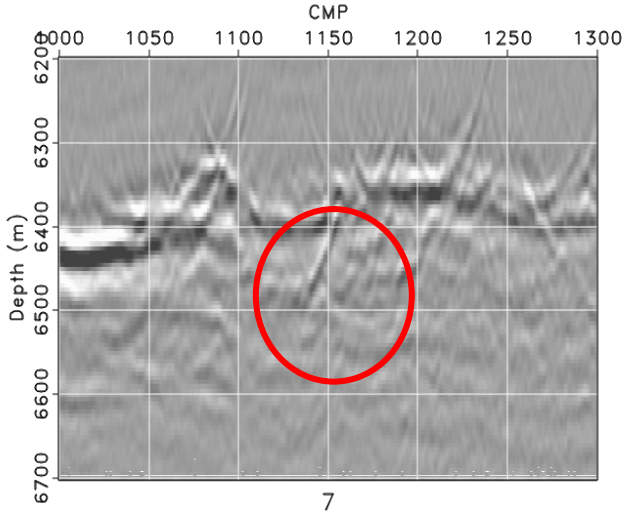



CMP
1000 1050 1100 1150 1200 1250 1300
Time (s)
7.3 7.4 7.5 7.6

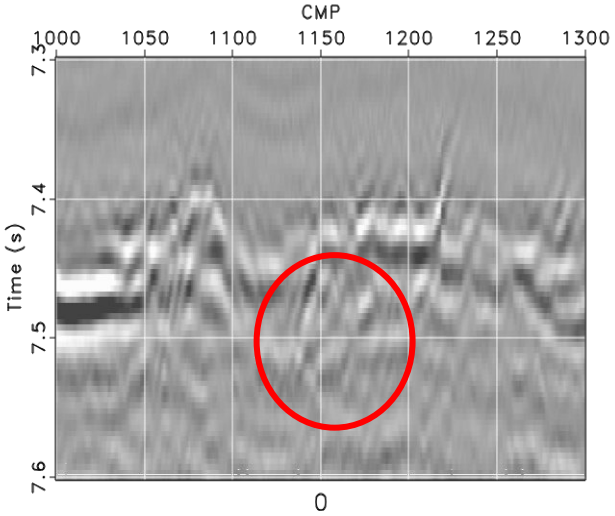
6


CMP
1000 1050 1100 1150 1200 1250 1300
Depth (m)
6200 6300 6400 6500 6600 6700

8


CMP
1000 1050 1100 1150 1200 1250 1300
Depth (m)
6200 6300 6400 6500 6600 6700

7


CMP
1000 1050 1100 1150 1200 1250 1300
Time (s)
7.3 7.4 7.5 7.6

0