[AV]Adventures in Pre-Stack Depth Migration*

James Allen[1]

Search and Discovery Article #110121 (2010)
Posted June 28, 2010

*Adapted from oral presentation at Session, Geophysical Integration: A Road Map to Exploration Success, at AAPG Annual Convention and Exhibition, New Orleans, April 11-14, 2010

[1]Allen-Hoffman Exploration, Houston, TX (jimallen@jlaev.com)

Abstract

Pre-stack depth migration (PSDM) has made significant progress in the past several years, but some problems still resist complete resolution. One problem is the fault-shadow, exposed by Tucker and Yorston in 1971, where strong velocity contrasts across faults can produce time maps that do not correspond to true depth and sometimes disrupt reflectivity severely. An excellent detailed description of the fault shadow problem and its solution has been published by Fagin (1996).

It should be noted that sometimes the fault shadow can create the opposite effect illustrated above. A time map might show a closure against the fault when none exists, due to velocities on the downthrown side of the fault being faster than on the upthrown side. Other examples of PSDM, both successful and not, are used to demonstrate the following conclusions:

1. PSDM requires a detailed and accurate velocity model, although this means that a PSDM result is actually a verification of the interpretation of velocities. Fagin (1995) says, “Valid depth imaging results are only possible with a velocity model accurate to within a few percent.” Consequently, smoothing the velocities across faults can cause erroneous results.
2. Modern PSDM usually works well when reflectivity is good, but performs poorly when reflectivity in the fault shadow is poor. Consequently, using the best pre-stack time imaging available is suggested.
3. The choice of PSDM method, Kirchhoff or Wave-Equation, can be a factor. [1]provide guidelines for choosing.
4. While modern PSDM can often resolve large velocity problems in general, detailed accuracy is sometimes missing. In the Wilcox, 50 ft of closure can provide profitable traps, but PSDM is usually not that accurate. Allen et al. (1993) demonstrated such inaccuracy, using PSDM methods of that era on synthetic data. Recent examples show the same problems persist. However, Hall and See (2009) have shown outstanding results with modern anisotropic Kirchhoff PSDM.

Selected References

Allen, J.L. and J.M.Bruso, 1989, A case history of velocity problems in the shadow of a large growth fault in the Frio Formation, Texas Gulf Coast: Bulletin of the South Texas Geological Society, v. 30/1, p. 39.

Allen, J., C. Peddy and T. Fasnacht, 1993, Some AVO failures and what (we think) we have learned: The Leading Edge, p. 163-167.

Fagin, S., 1996, The fault shadow problem: Its nature and elimination: The Leading Edge, p.1005-1014.

Lee, W.B. and L. Zhang Lin, 1992, Residual shot profile migration: Geophysics, v. 57/6, p. 815-822.

Tucker, P.M. and H.J. Yorston, 1971, Pitfalls in seismic interpretation, *in* Exploration today; energy tomorrow: SEG 41st Annual International Meeting, Program and Abstracts, p. 67-68.

Some Adventures in Pre-Stack Depth Migration

James L. Allen

Allen-Hoffman
Exploration Company

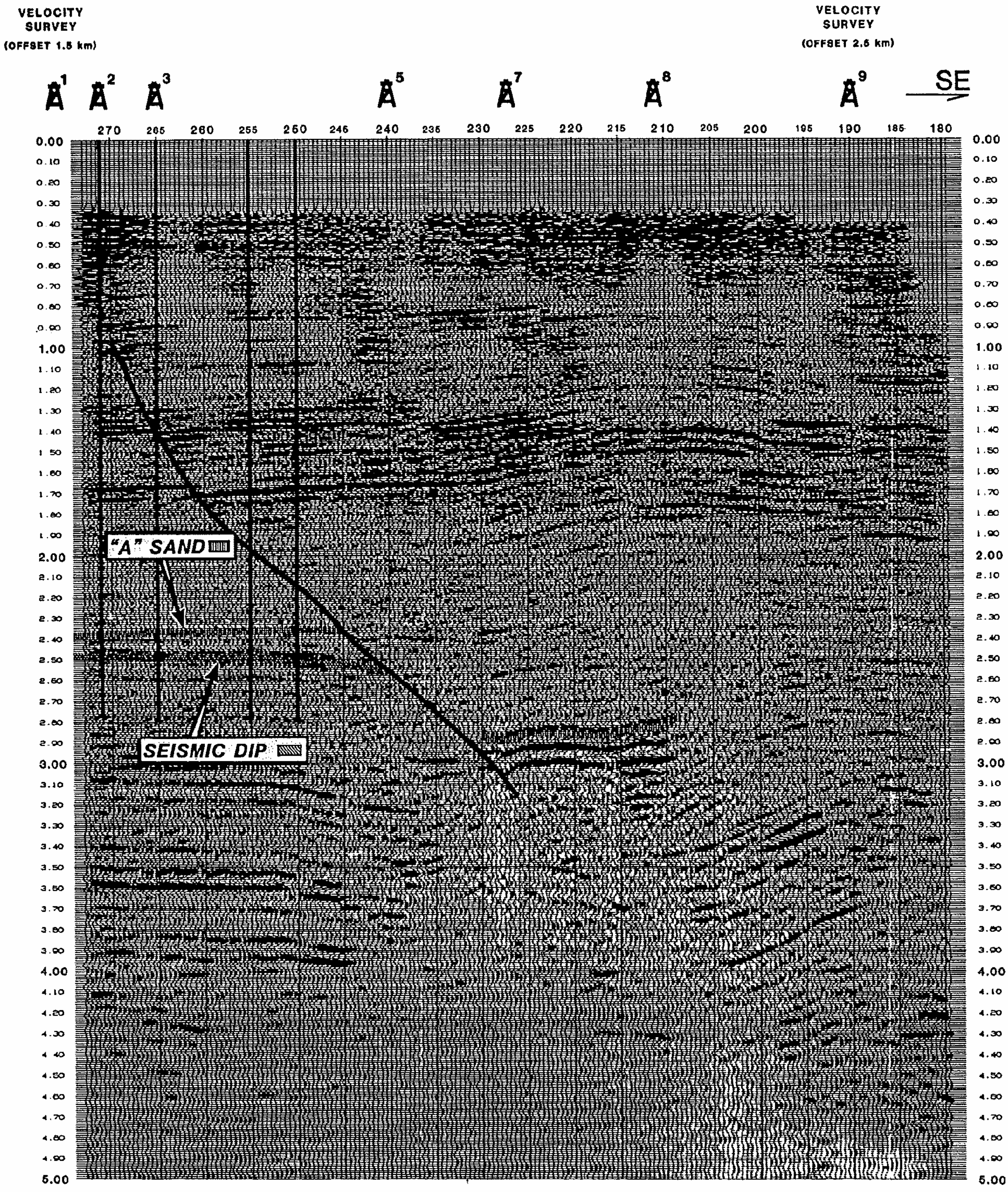
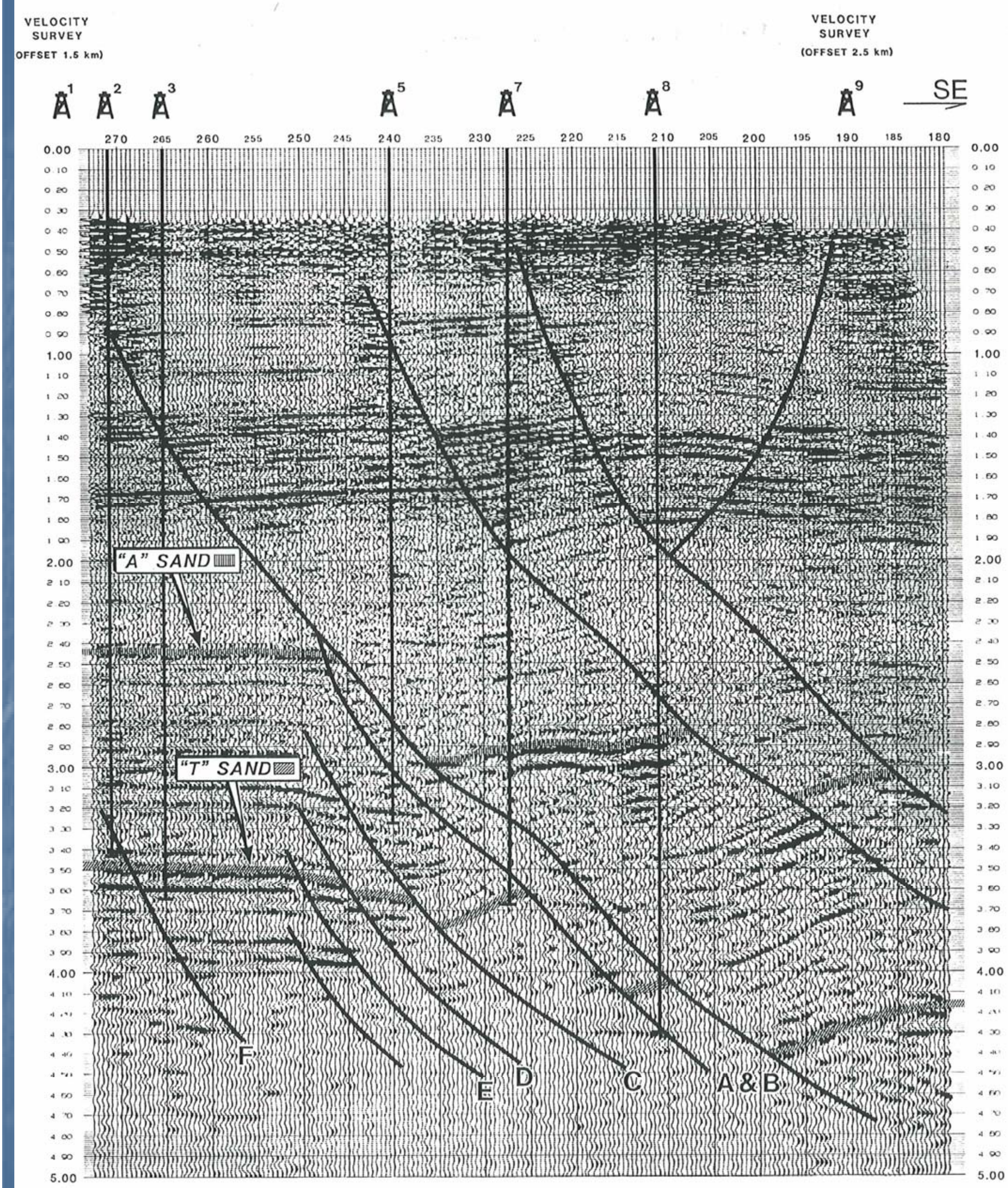


FIG. 5. Substantiation of the velocity problem under the fault is demonstrated at the A sand. Subsurface data at this level display the northwesterly dipping relationship shown, clearly contradicting the southeasterly dipping, good seismic reflector near 2.5 s.



Interpretation of line in first figure. From Allen and Bruso, 1989

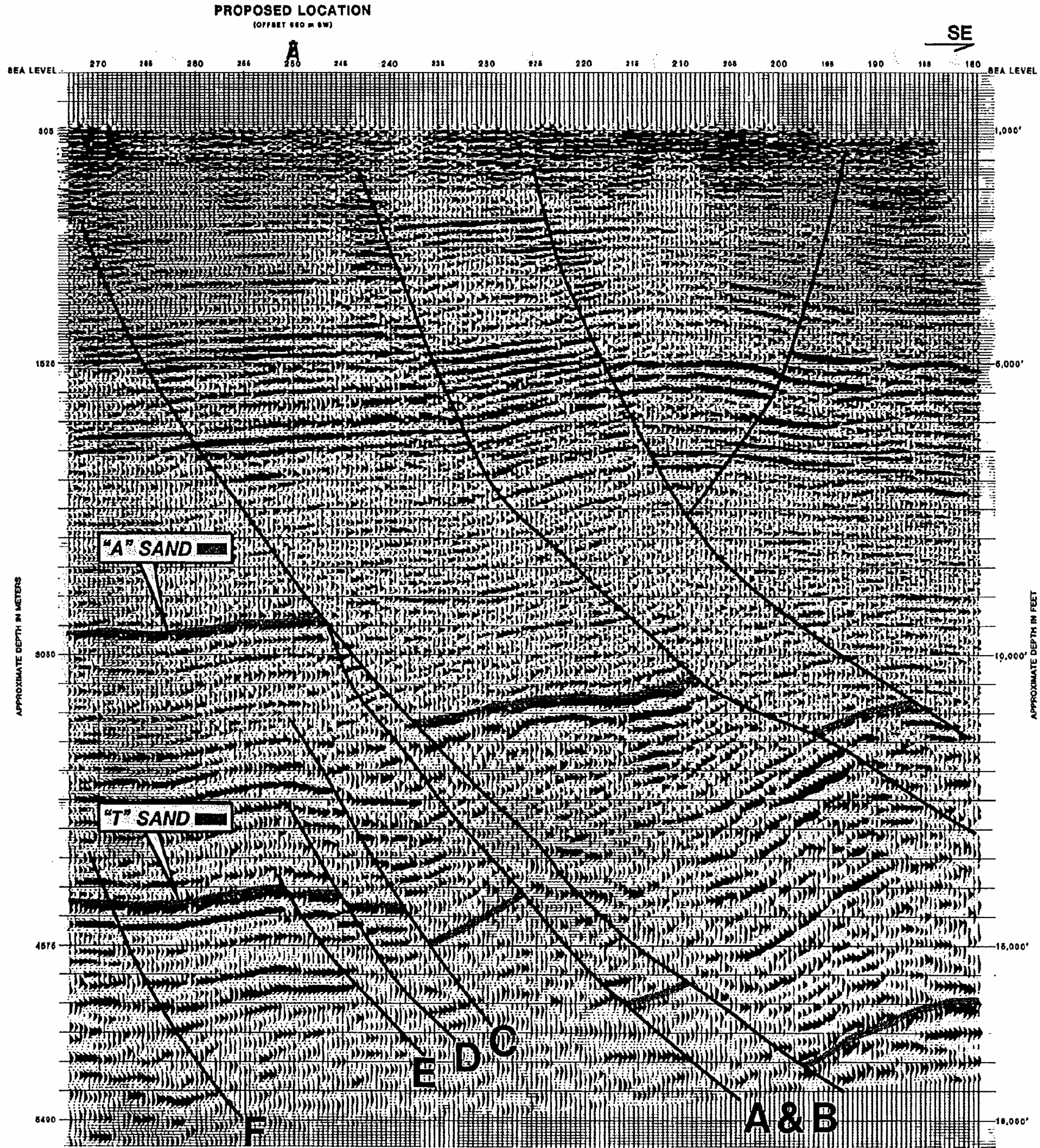
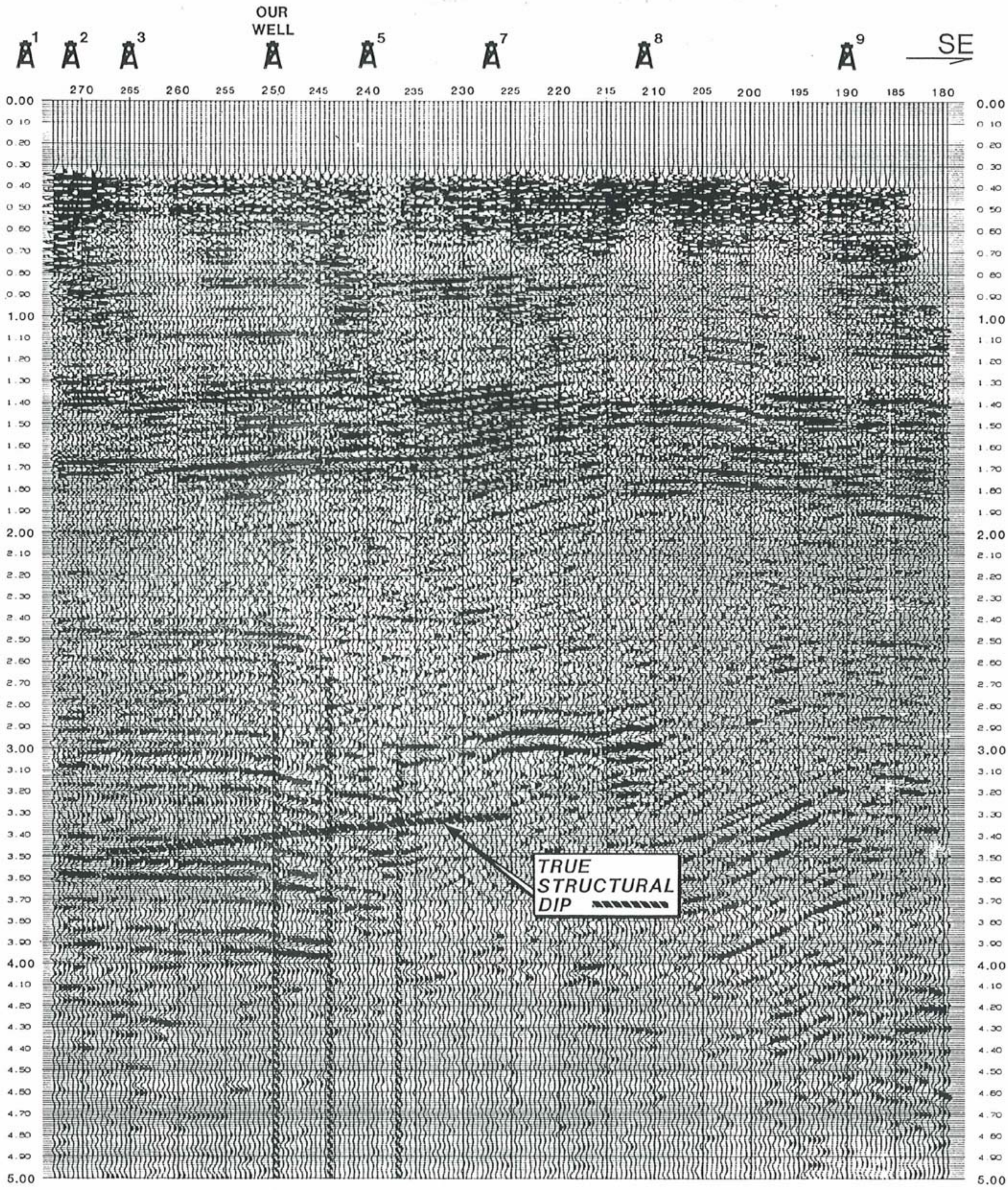
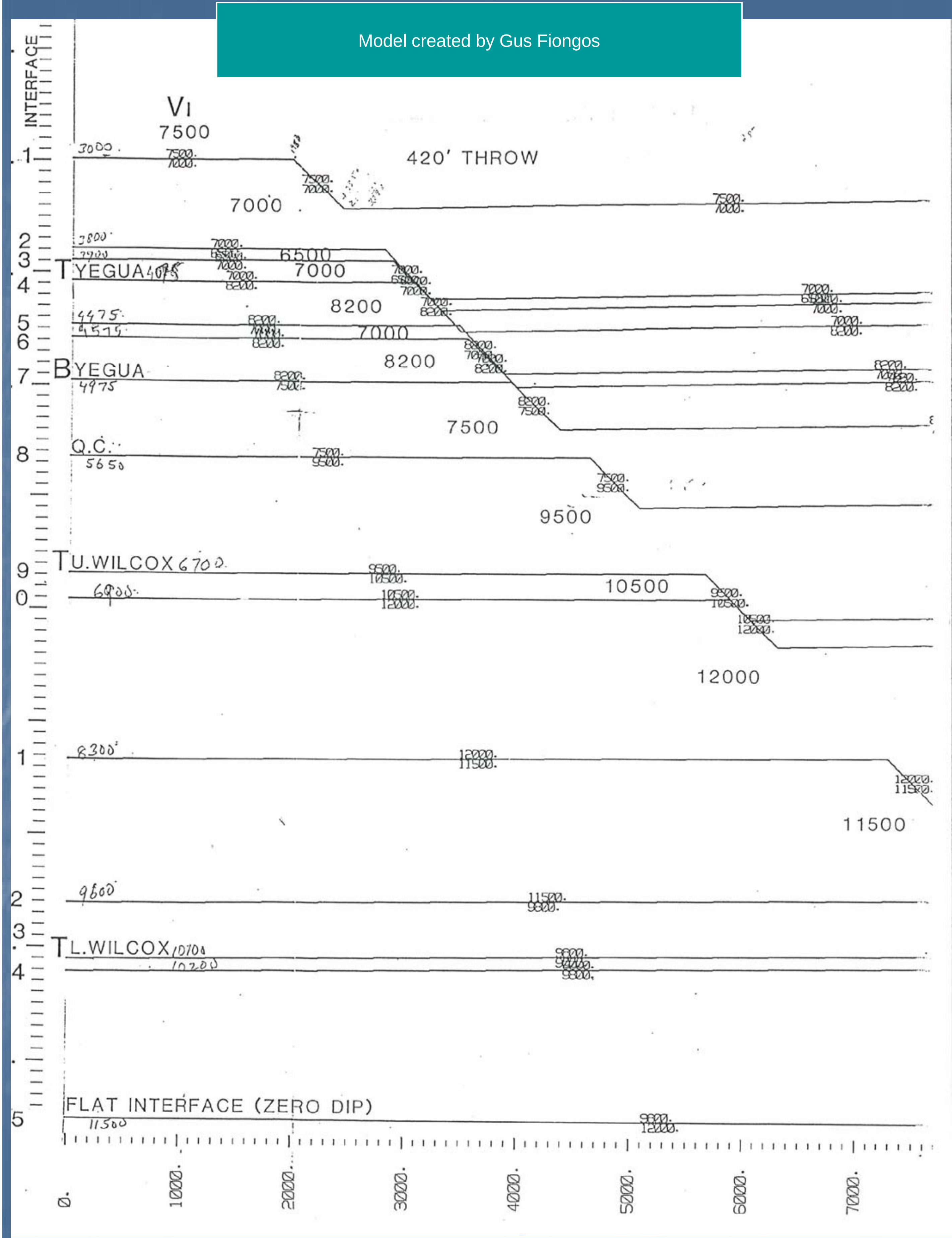


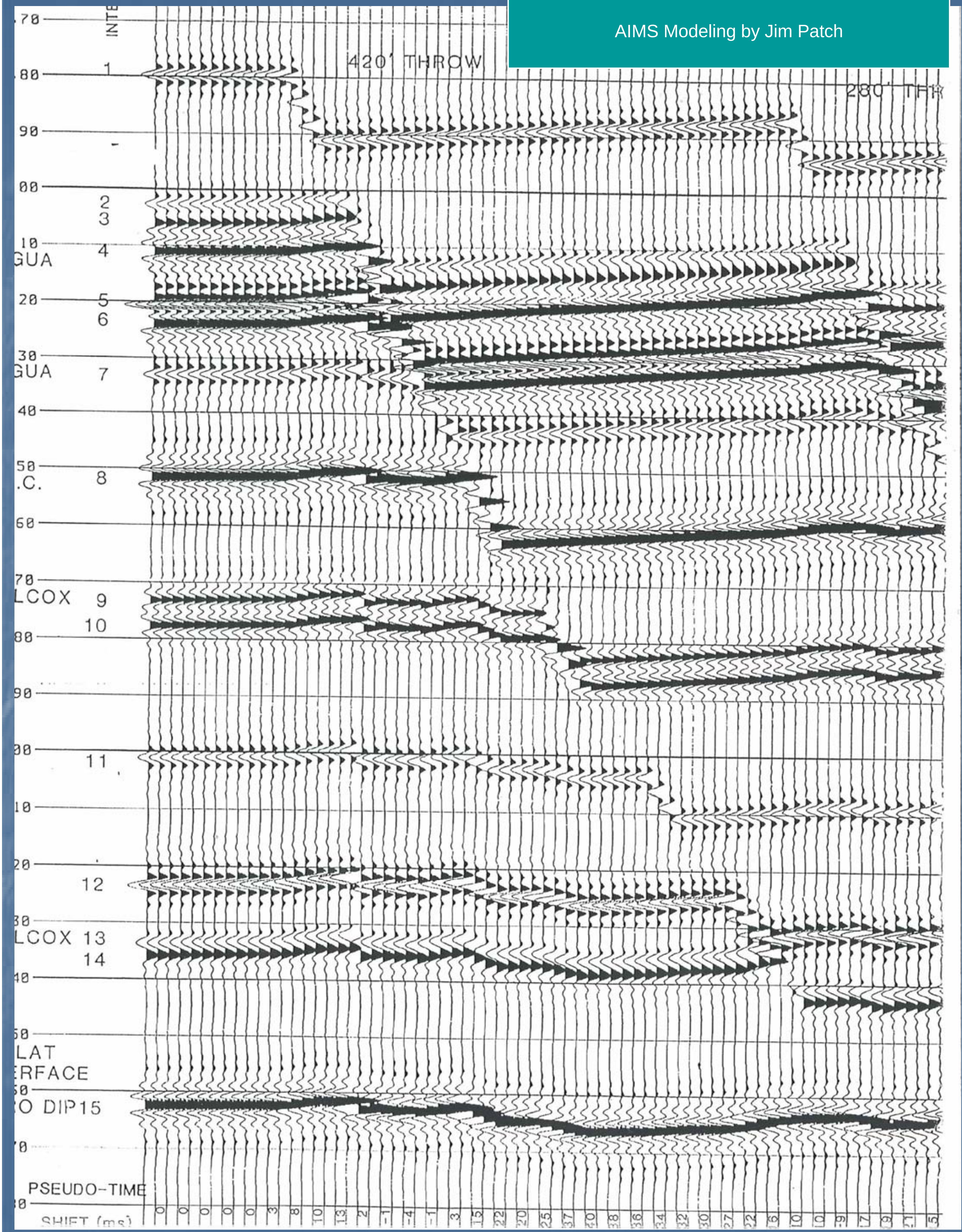
FIG. 10. Depth section constructed from smoothed stacking velocities shown in Figure 9. Notice the reversal in seismic dip at the A sand and deeper between shotpoints 260–245 as compared to dip on Figures 3 and 7. The proposed location is shown at shotpoint 250.

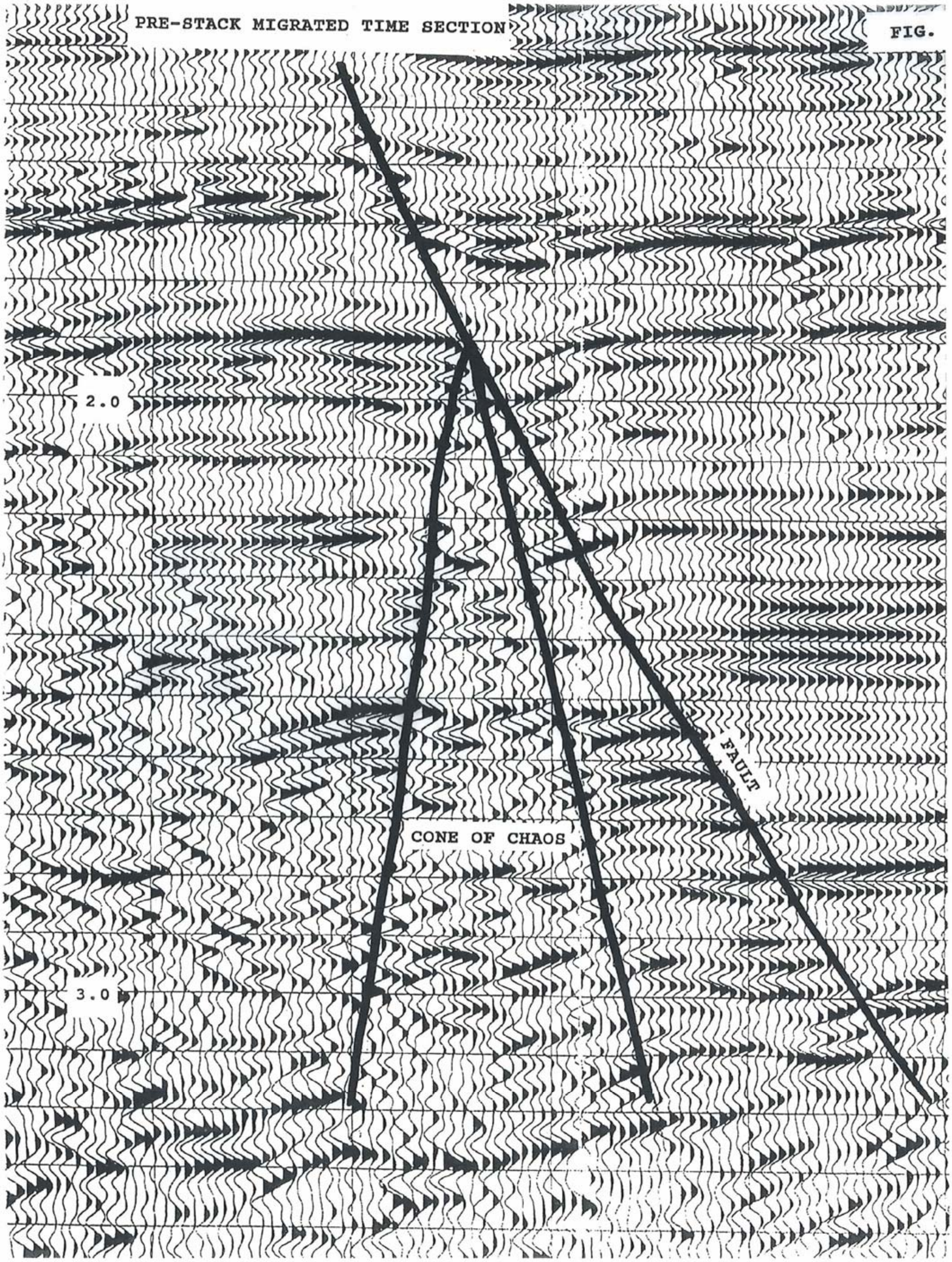


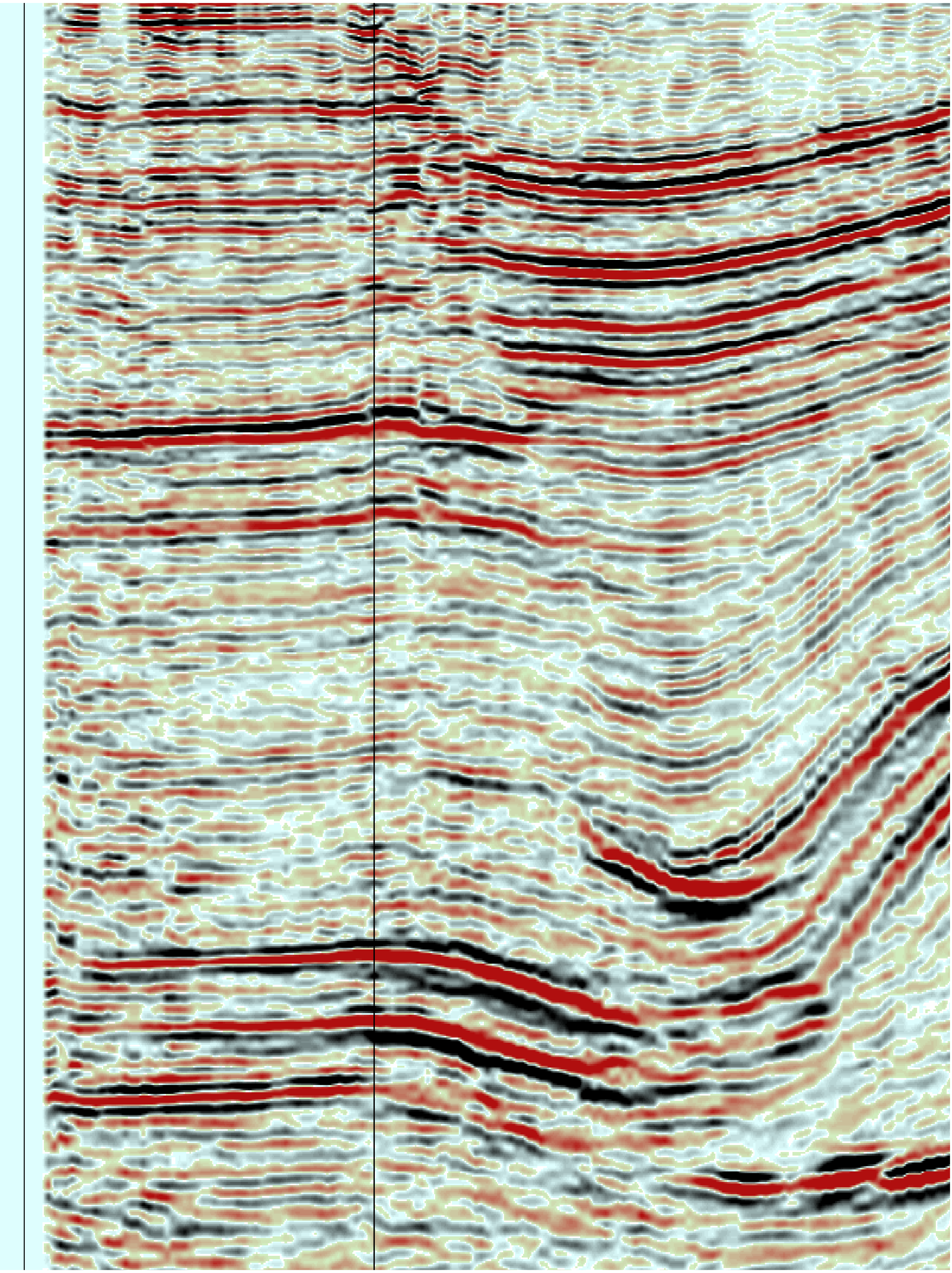
Depth structure superimposed on time section.
Note the vertical alignment of horizon breaks. From Allen and Bruso. 1989

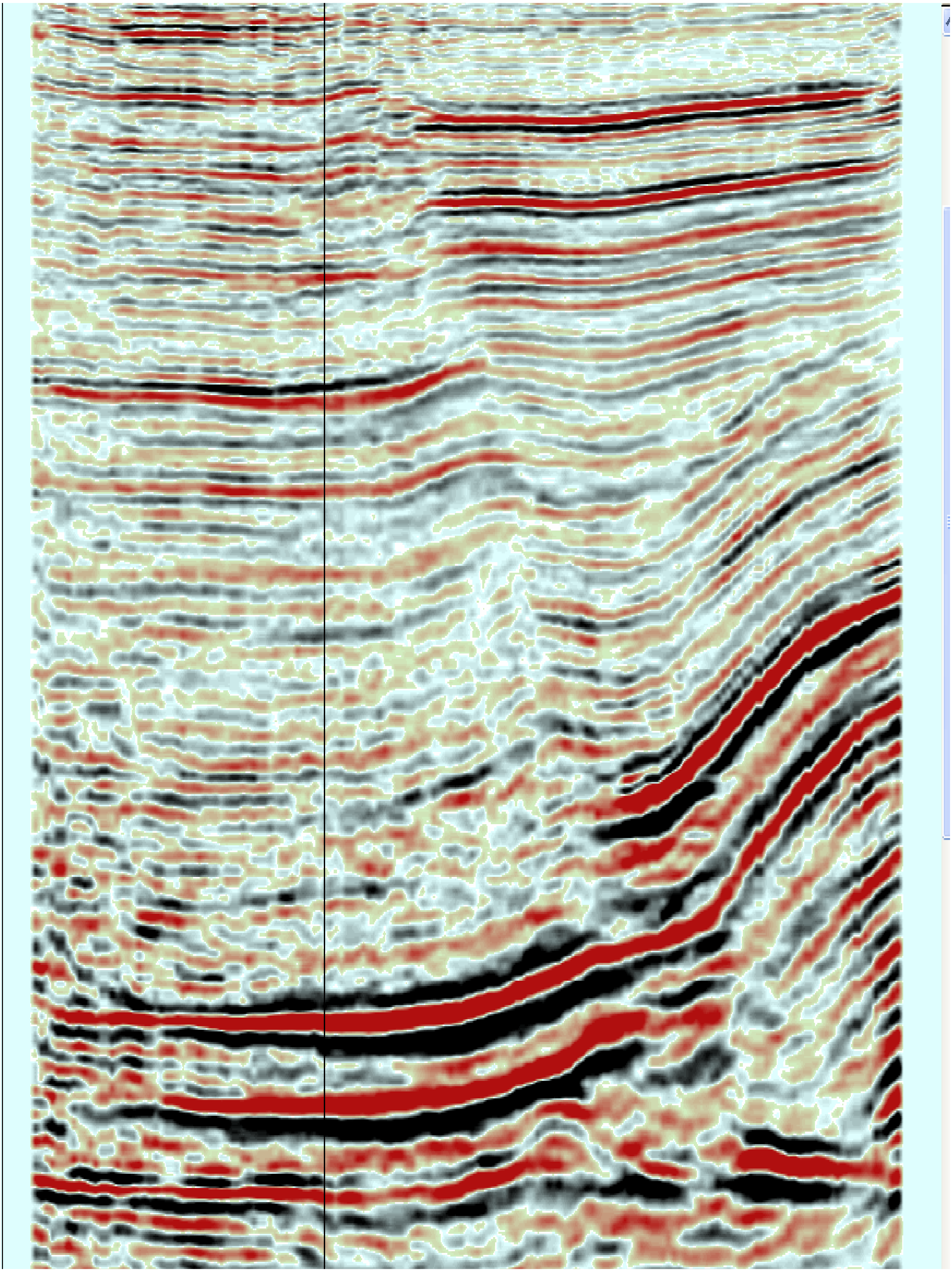

Model created by Gus Fiongos
INTERFACE
V1
7500
420' THROW
7000
6500
7000
TYEGUA
8200
7000
BYEGUA
8200
7500
Q.C.
9500
TU.WILCOX
10500
12000
11500
TL.WILCOX
FLAT INTERFACE (ZERO DIP)
0.
1000.
2000.
3000.
4000.
5000.
6000.
7000.

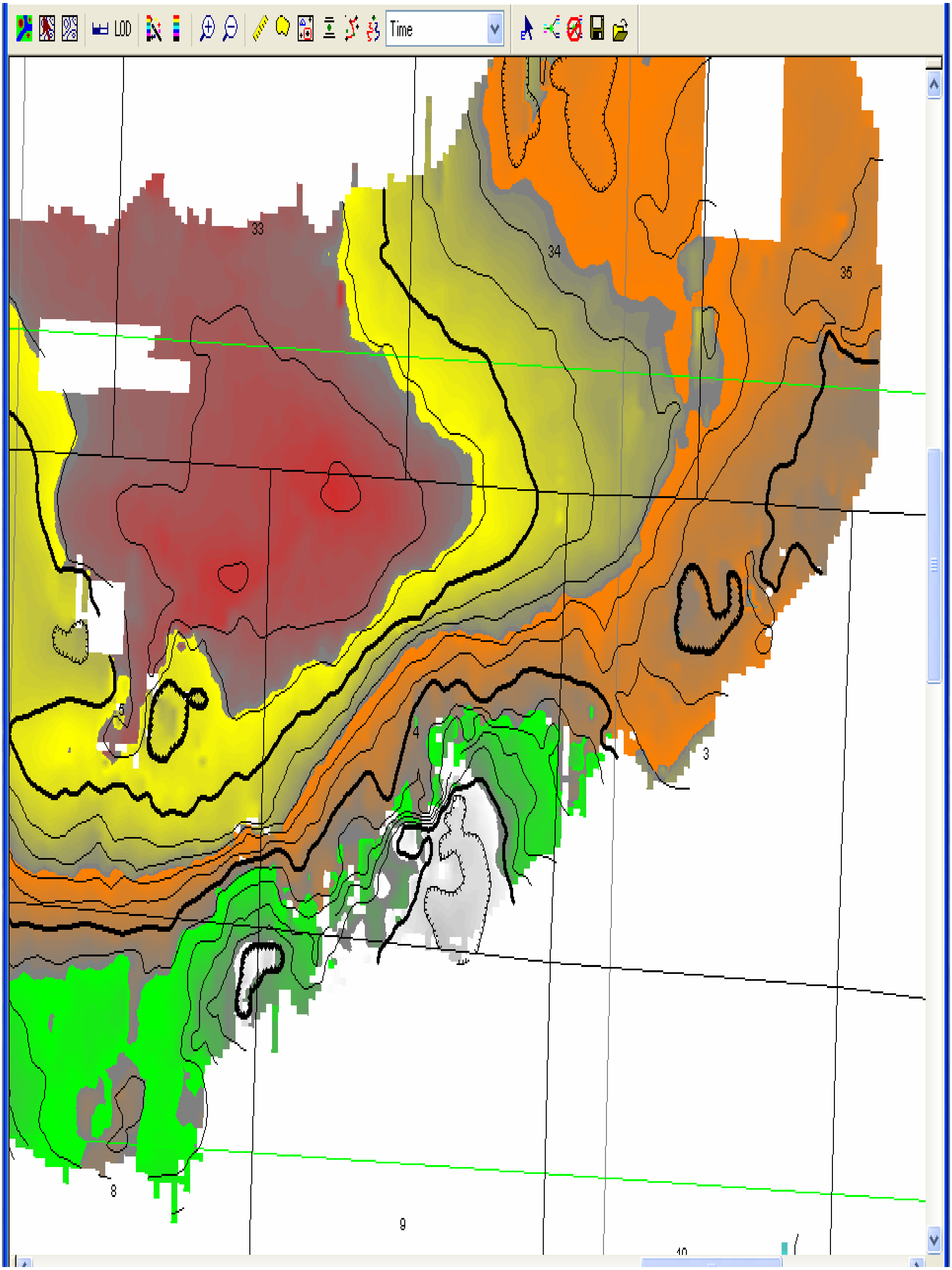
AIMS Modeling by Jim Patch

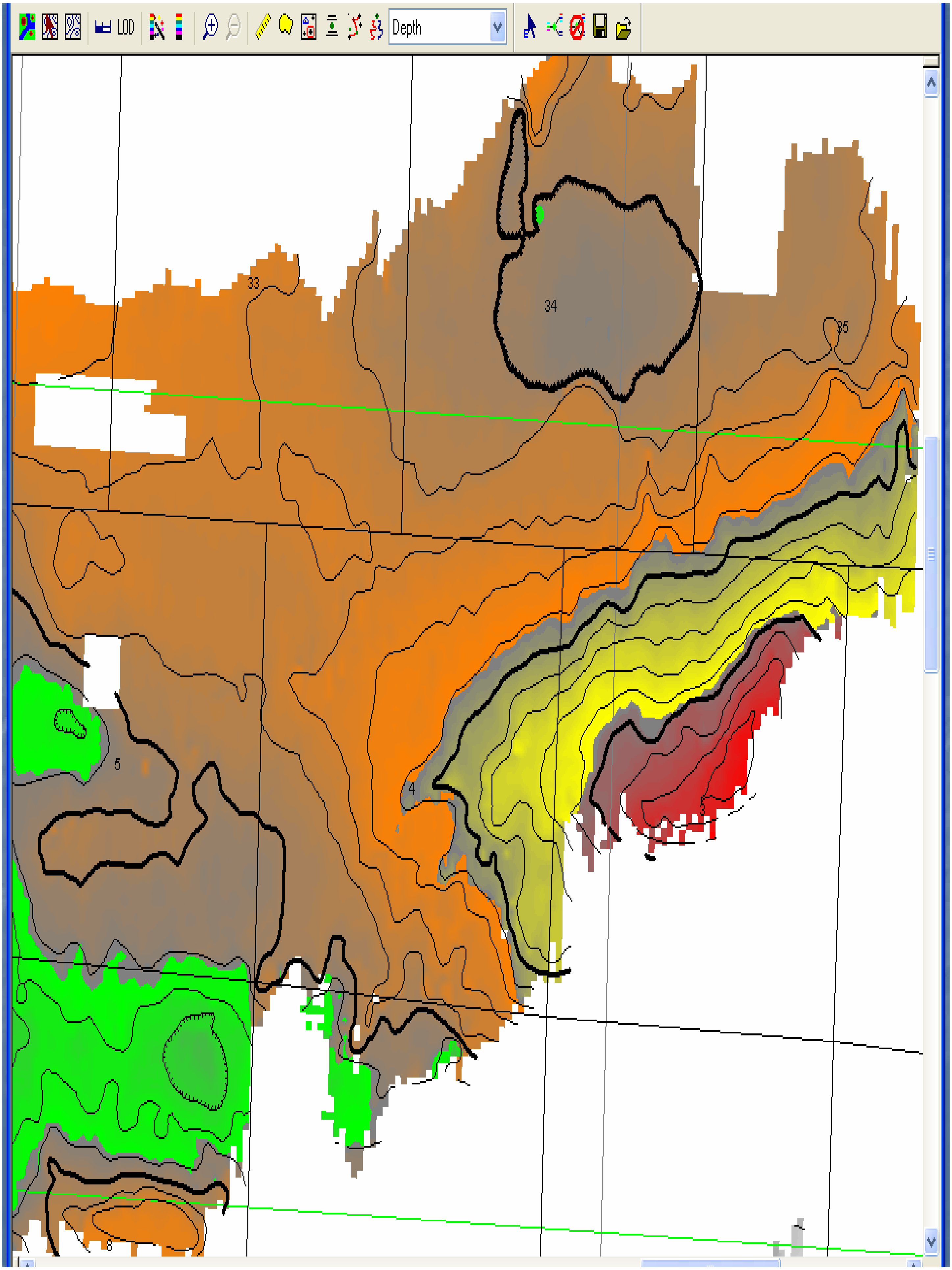



PRE-STACK MIGRATED TIME SECTION
FIG.
2.0
3.0
FAULT
CONE OF CHAOS






LOD
Time
33
34
35
5
4
3
8
9


LOD
Depth
33
34
35
5
4
8

Note left-most fault seen in time processed data.
From Lee and Zhang, 1992

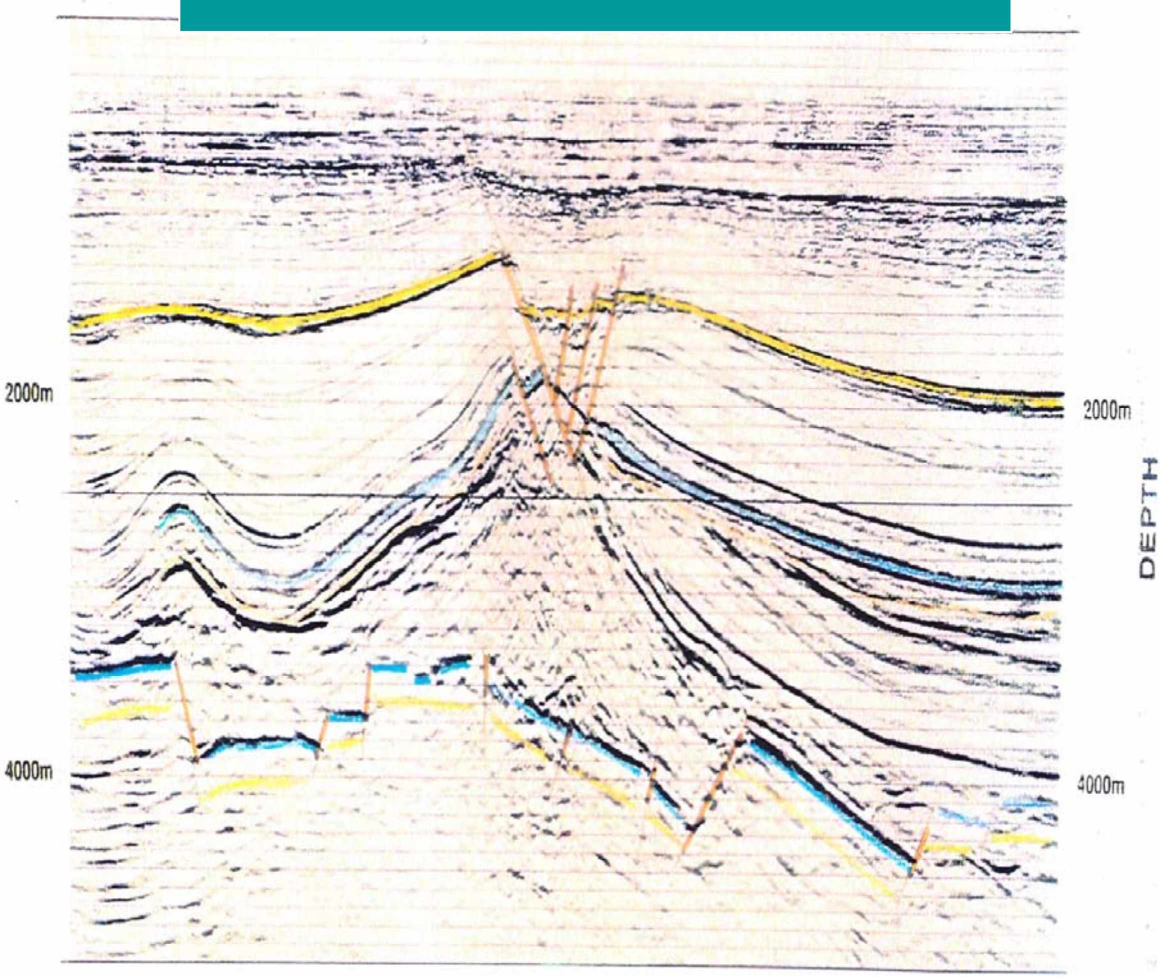


FIG. 9(a). The depth section of poststack time migration.

Left-most time fault has disappeared on depth processing.
From Lee and Zhang, 1992.

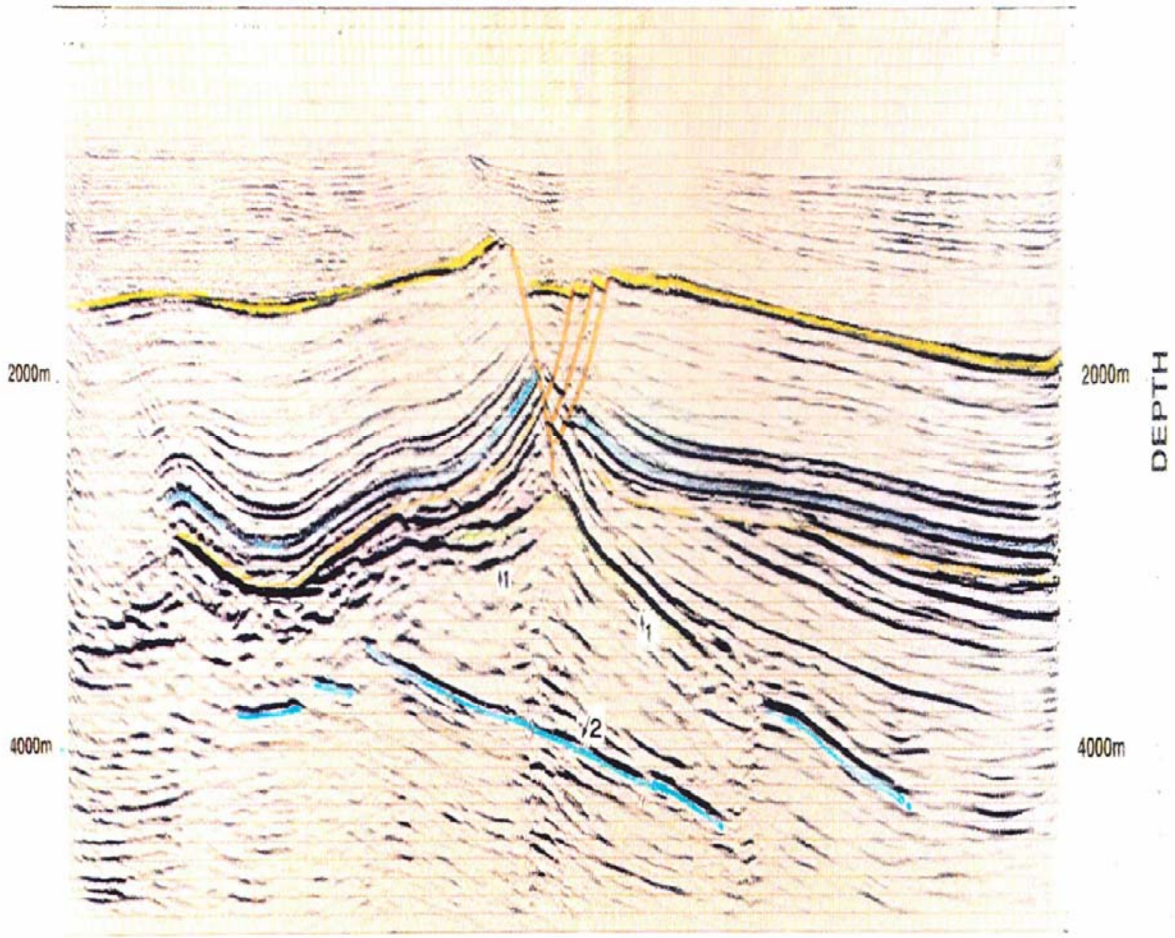
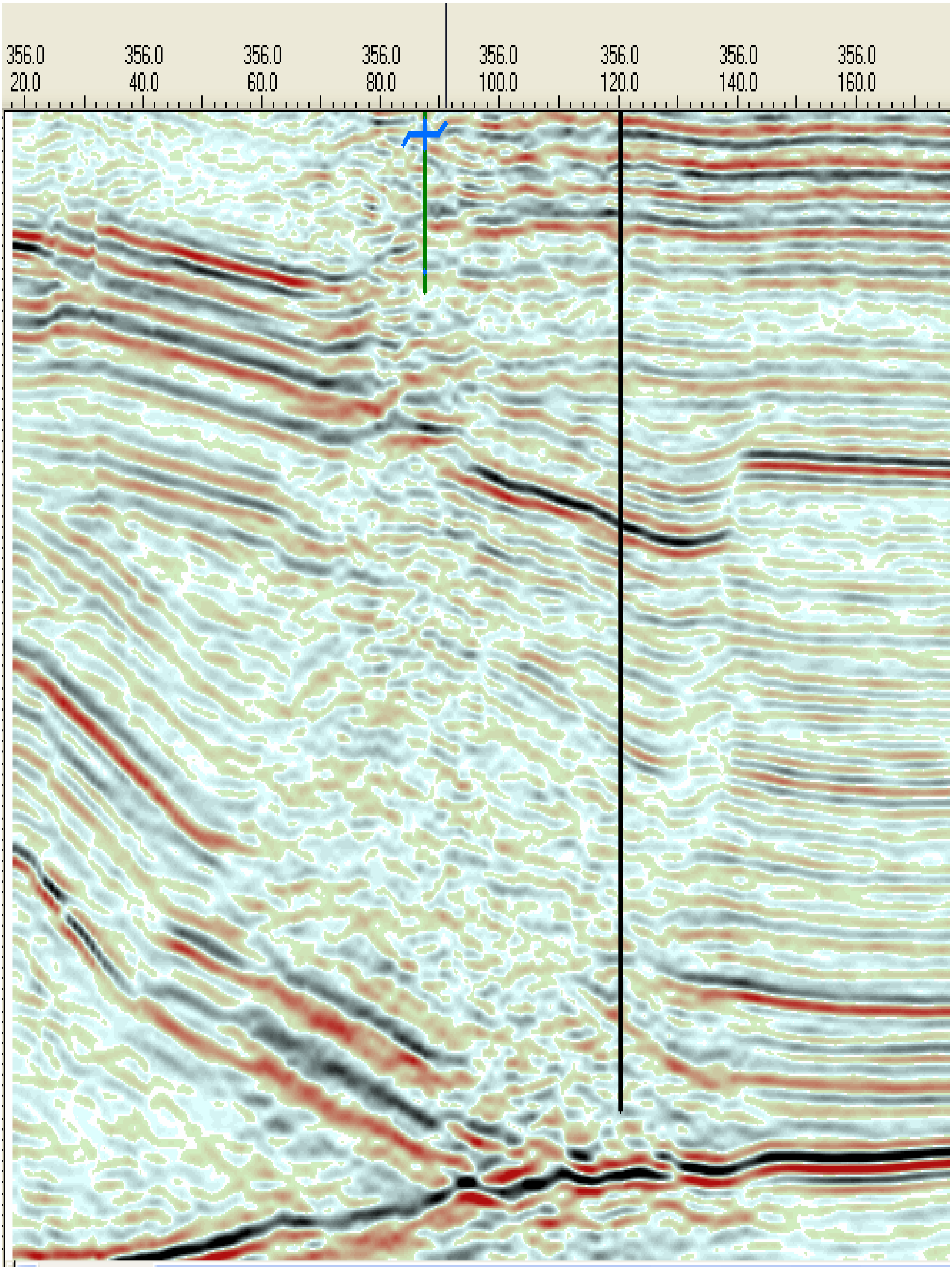
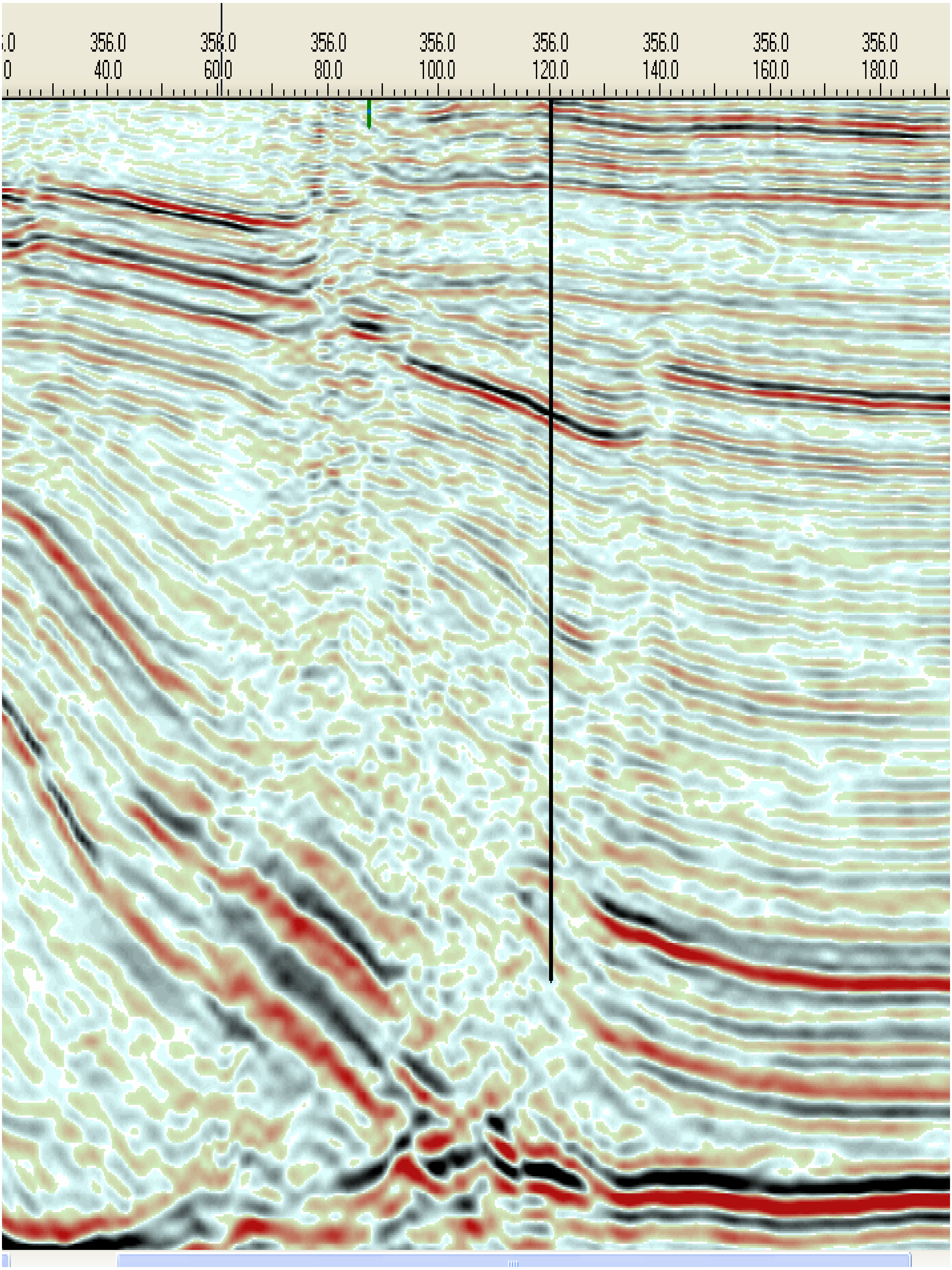


FIG. 9(c). The depth section of prestack depth migration plus residual migration.


356.0
20.0
356.0
40.0
356.0
60.0
356.0
80.0
356.0
100.0
356.0
120.0
356.0
140.0
356.0
160.0


356.0
356.0
356.0
356.0
356.0
356.0
356.0
356.0
40.0
60.0
80.0
100.0
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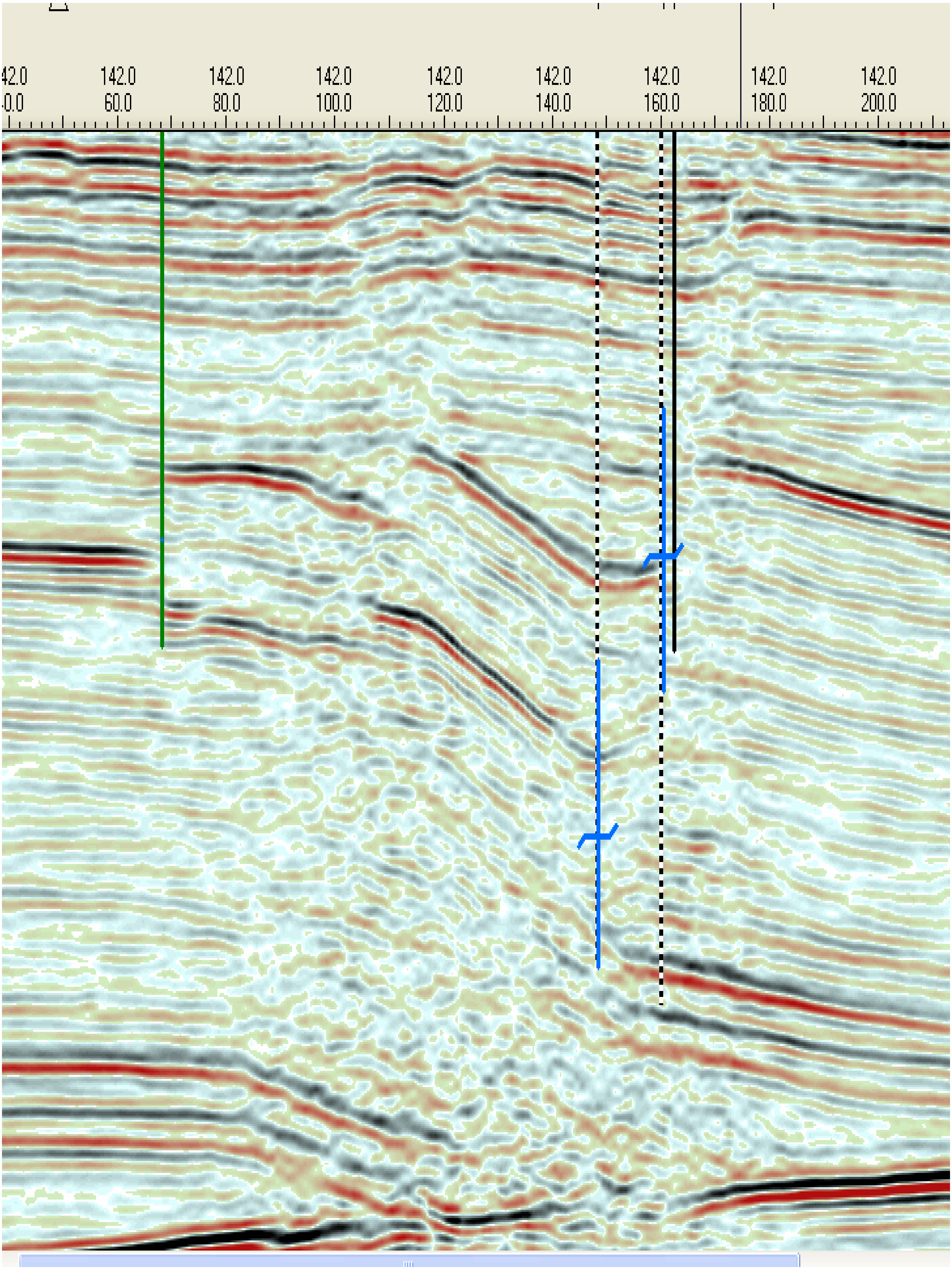
140.0
160.0
180.0


142.0
40.0
142.0
60.0
142.0
80.0
142.0
100.0
142.0
120.0
142.0
140.0
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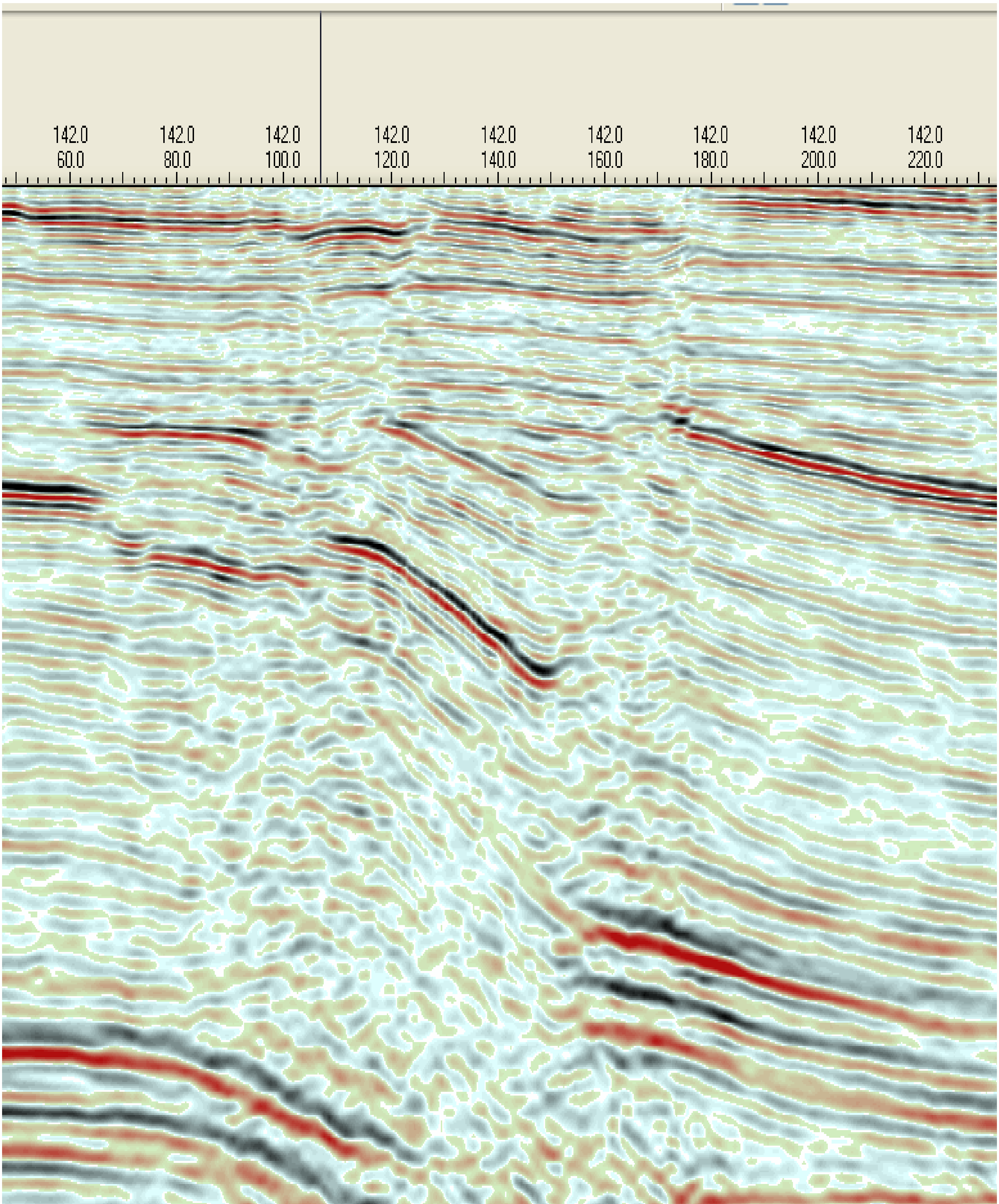
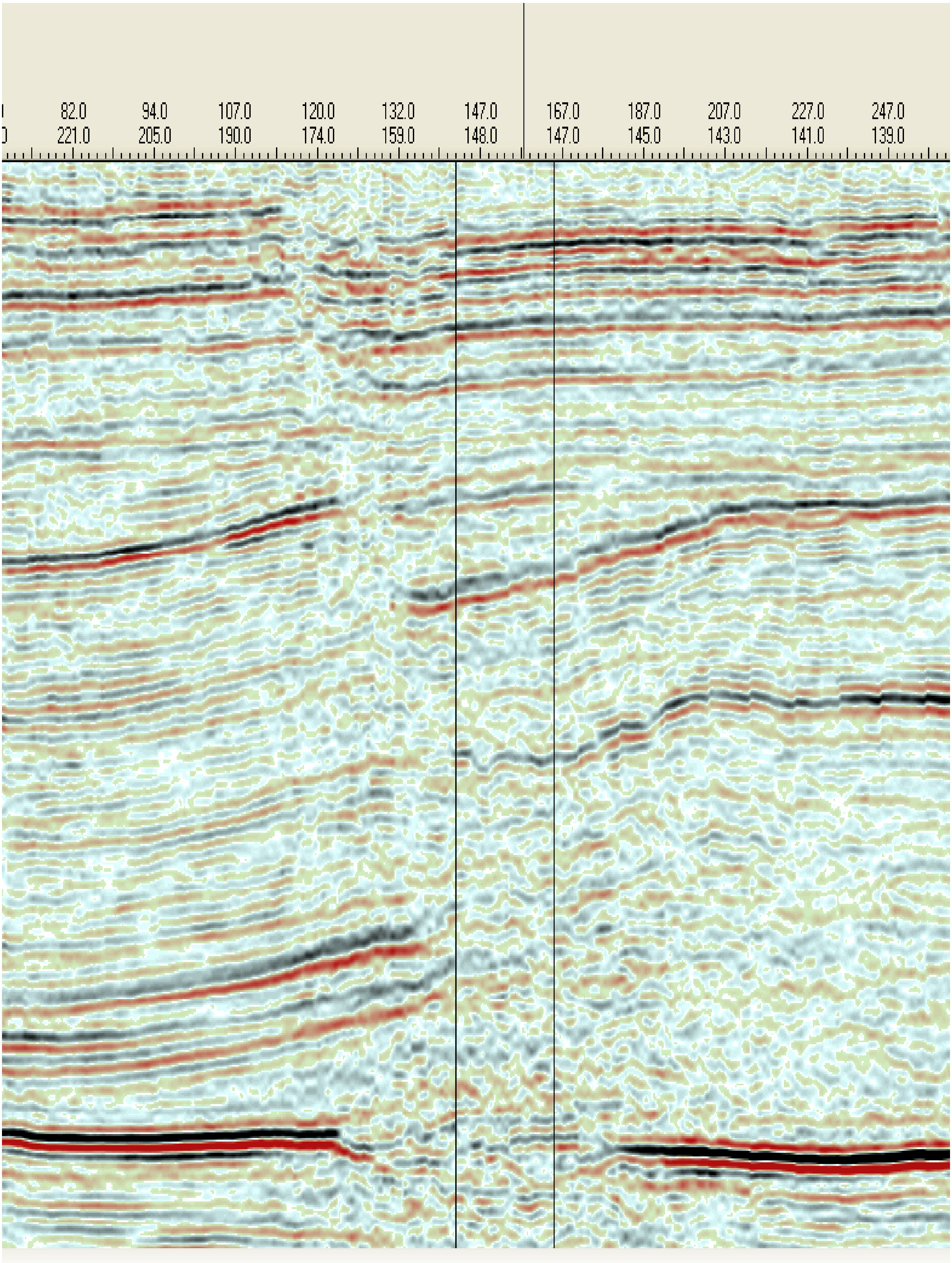
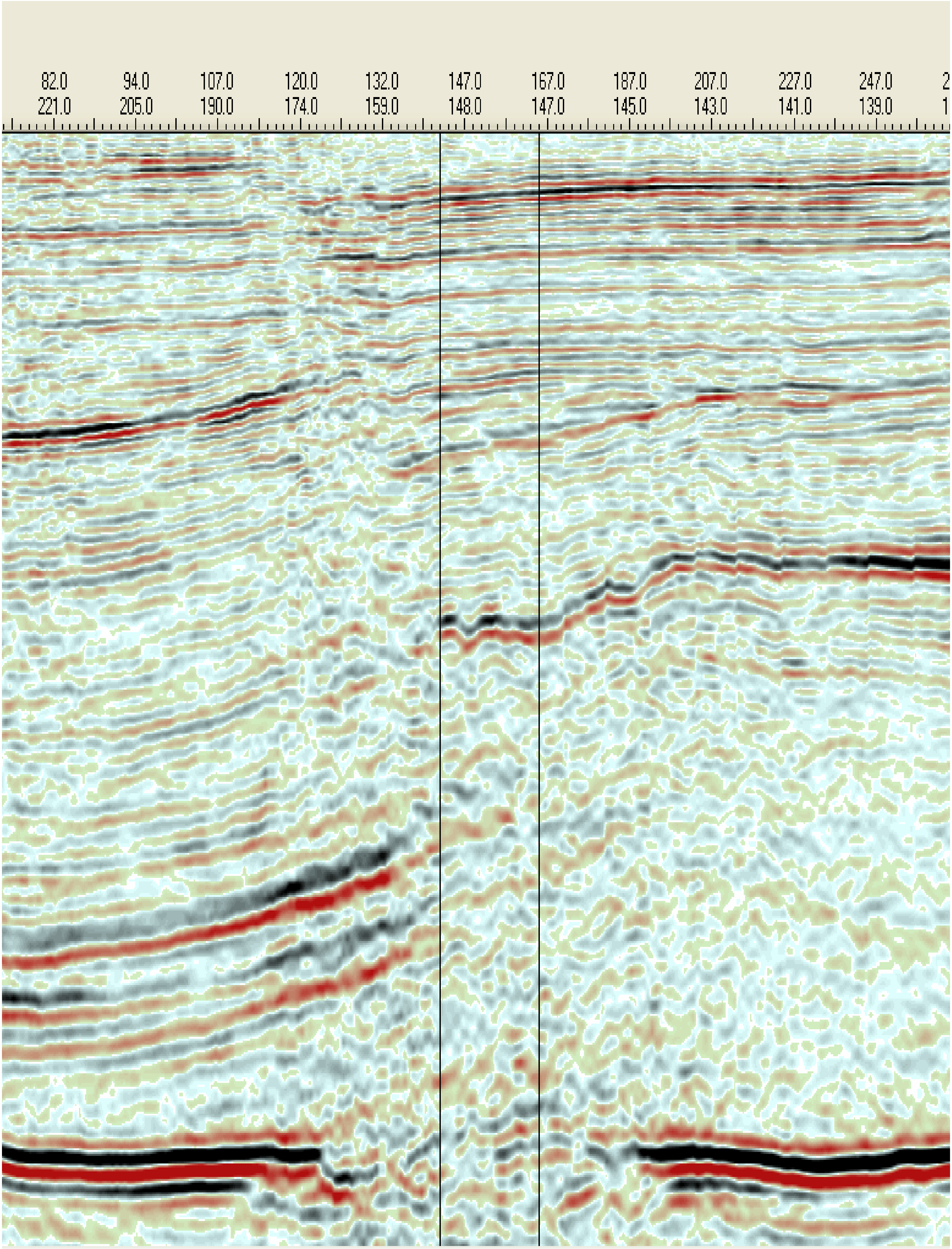
180.0
142.0
200.0


142.0 60.0
142.0 80.0
142.0 100.0
142.0 120.0
142.0 140.0
142.0 160.0
142.0 180.0
142.0 200.0
142.0 220.0



82.0 94.0 107.0 120.0 132.0 147.0 167.0 187.0 207.0 227.0 247.0
221.0 205.0 190.0 174.0 159.0 148.0 147.0 145.0 143.0 141.0 139.0


82.0
221.0
94.0
205.0
107.0
190.0
120.0
174.0
132.0
159.0
147.0
148.0
167.0
147.0
187.0
145.0
207.0
143.0
227.0
141.0
247.0
139.0

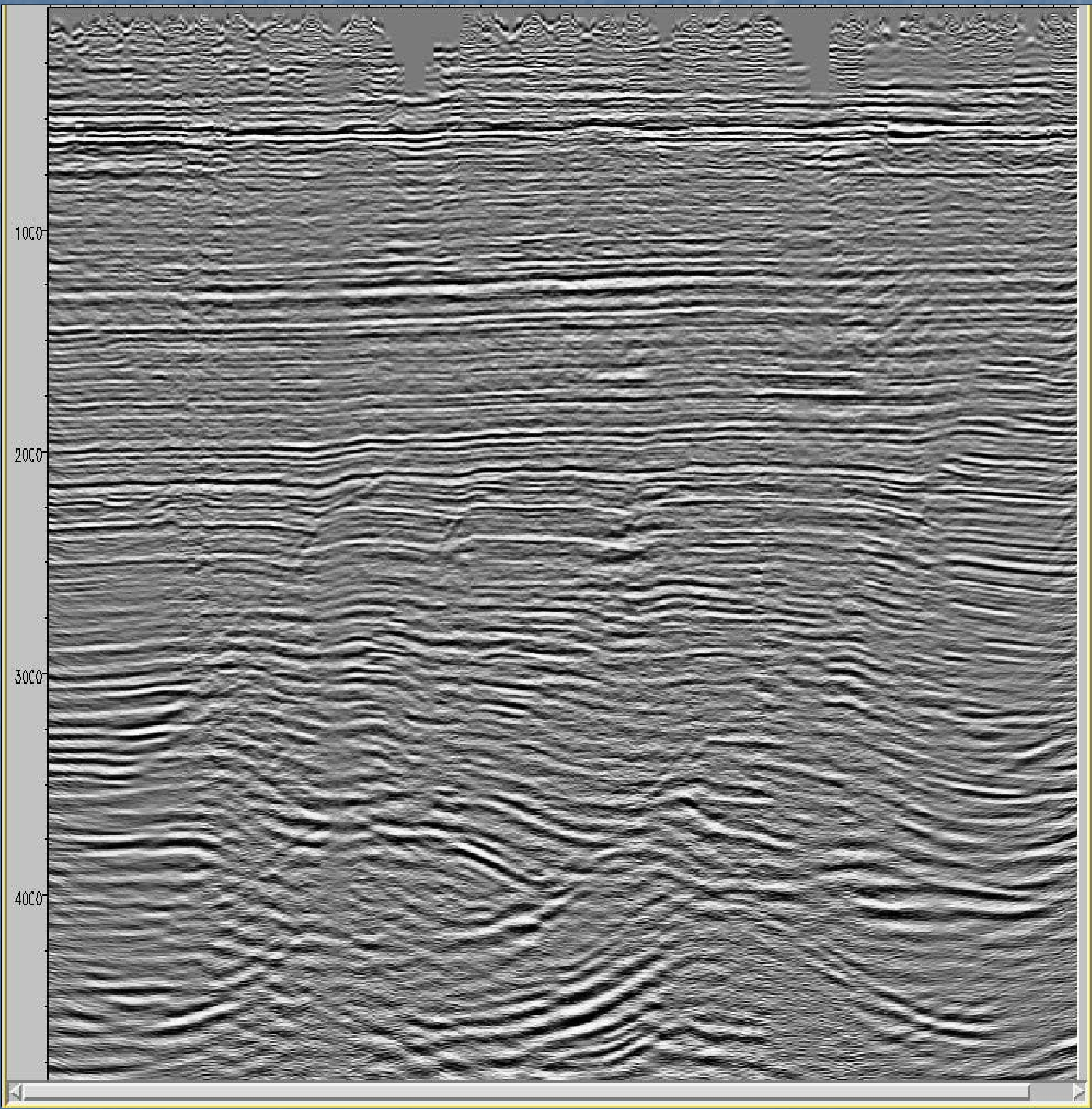
Following Seismic by Courtesy of
Seitel, Inc.

Processing Provided by
Geokinetics

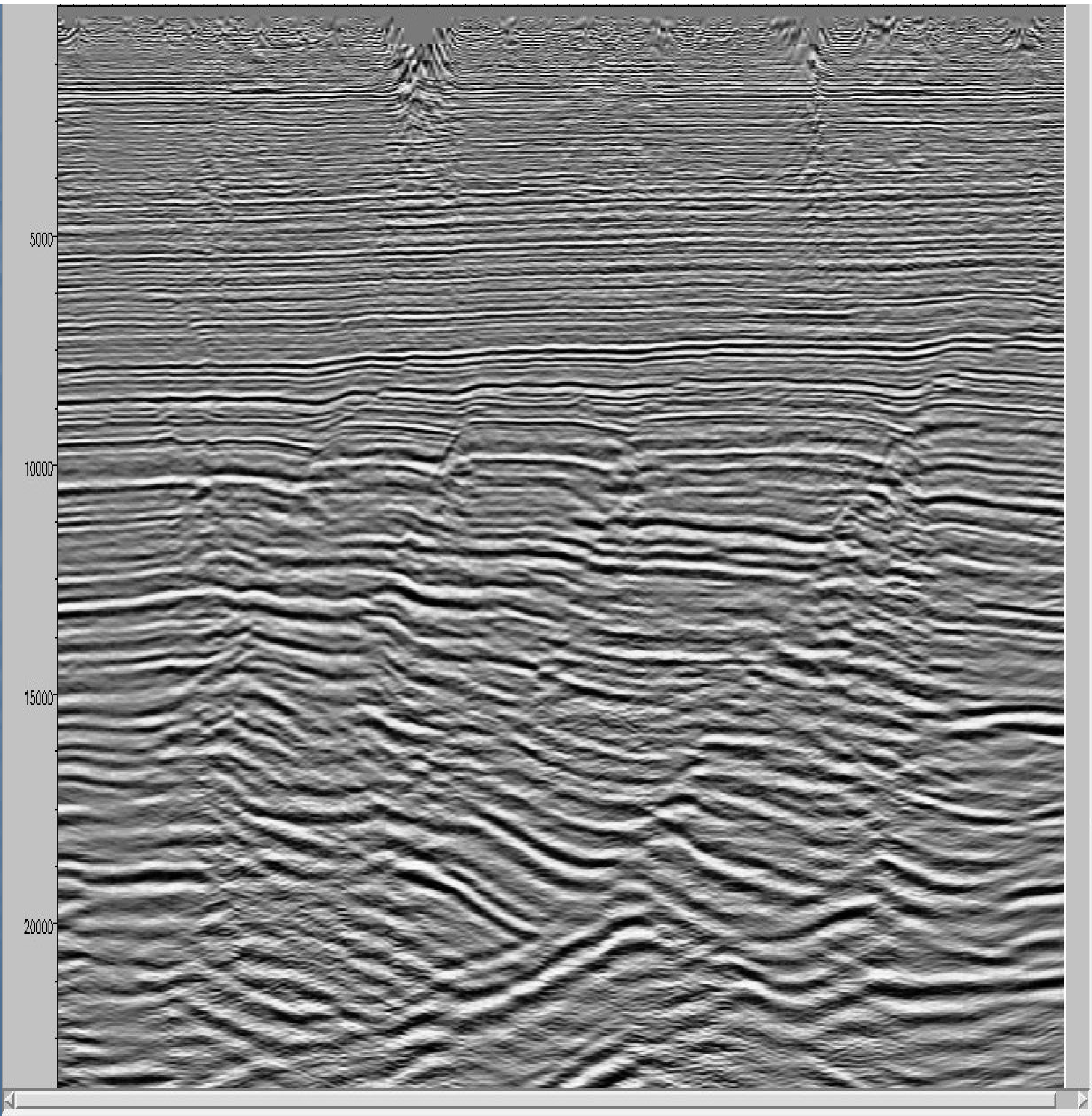
Kirchhoff – Wave Equation Migration:

Comparison of Anisotropic Migration Results

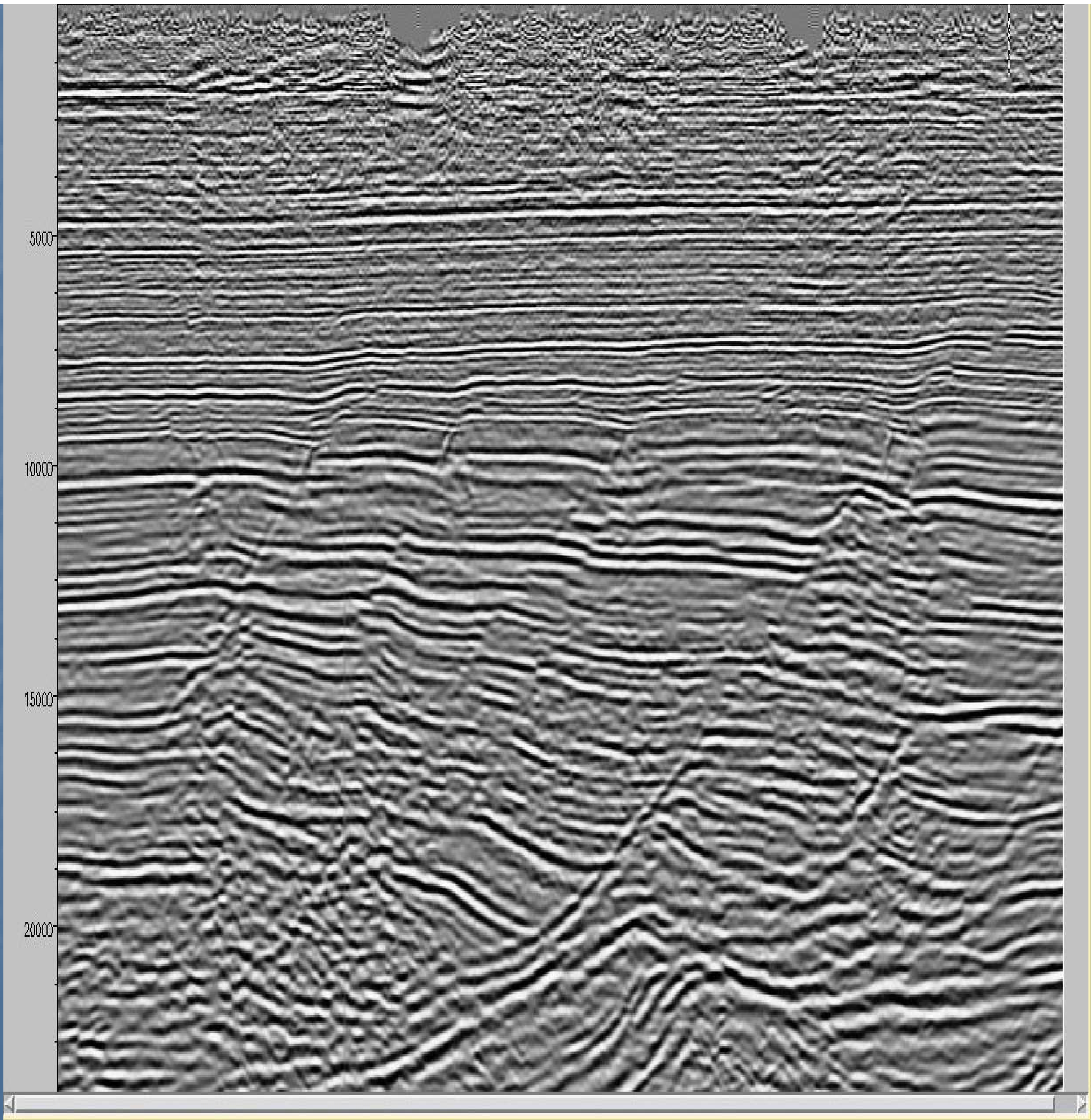
PSTM: Line #1



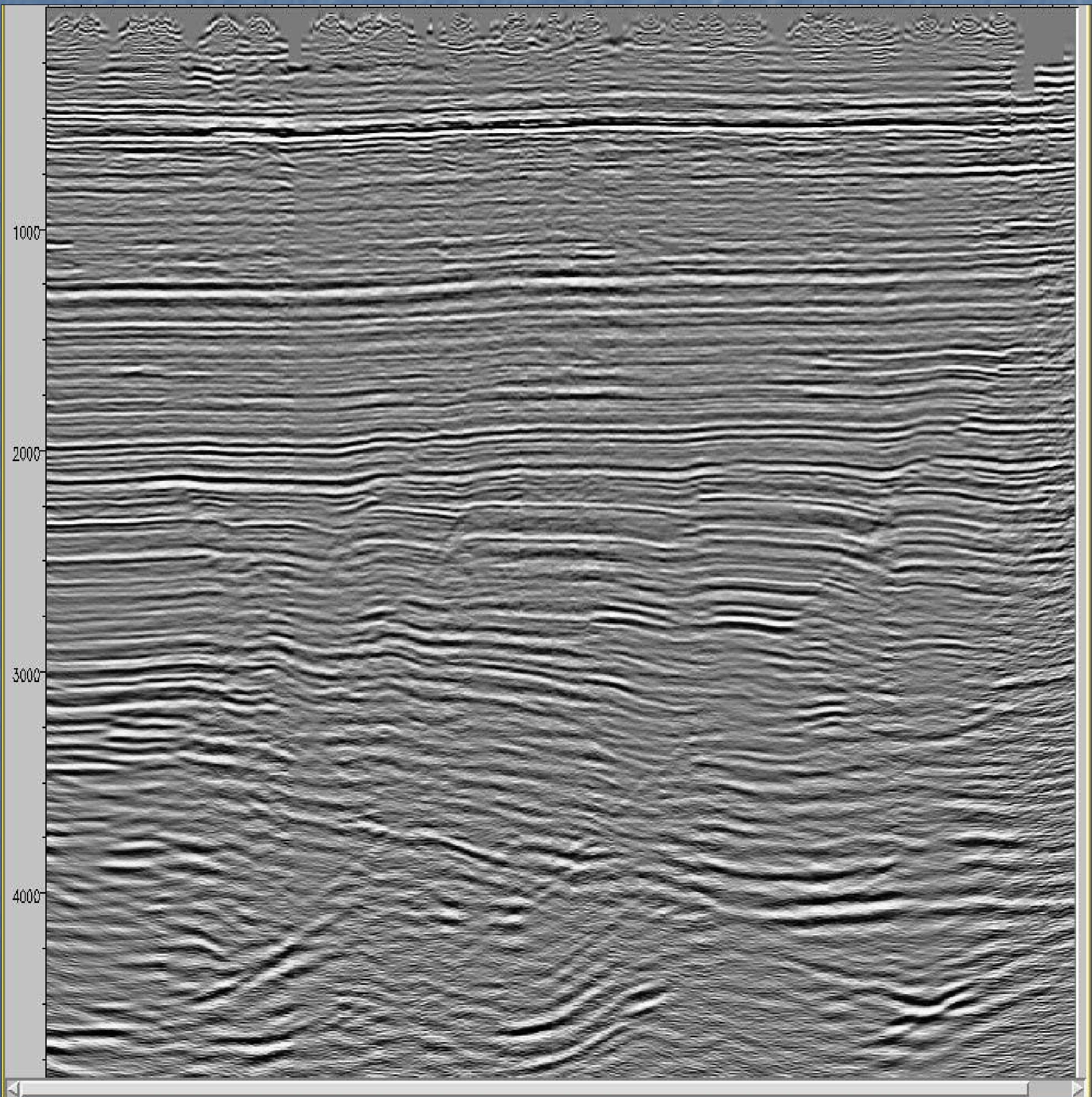
Kmig: Line #1



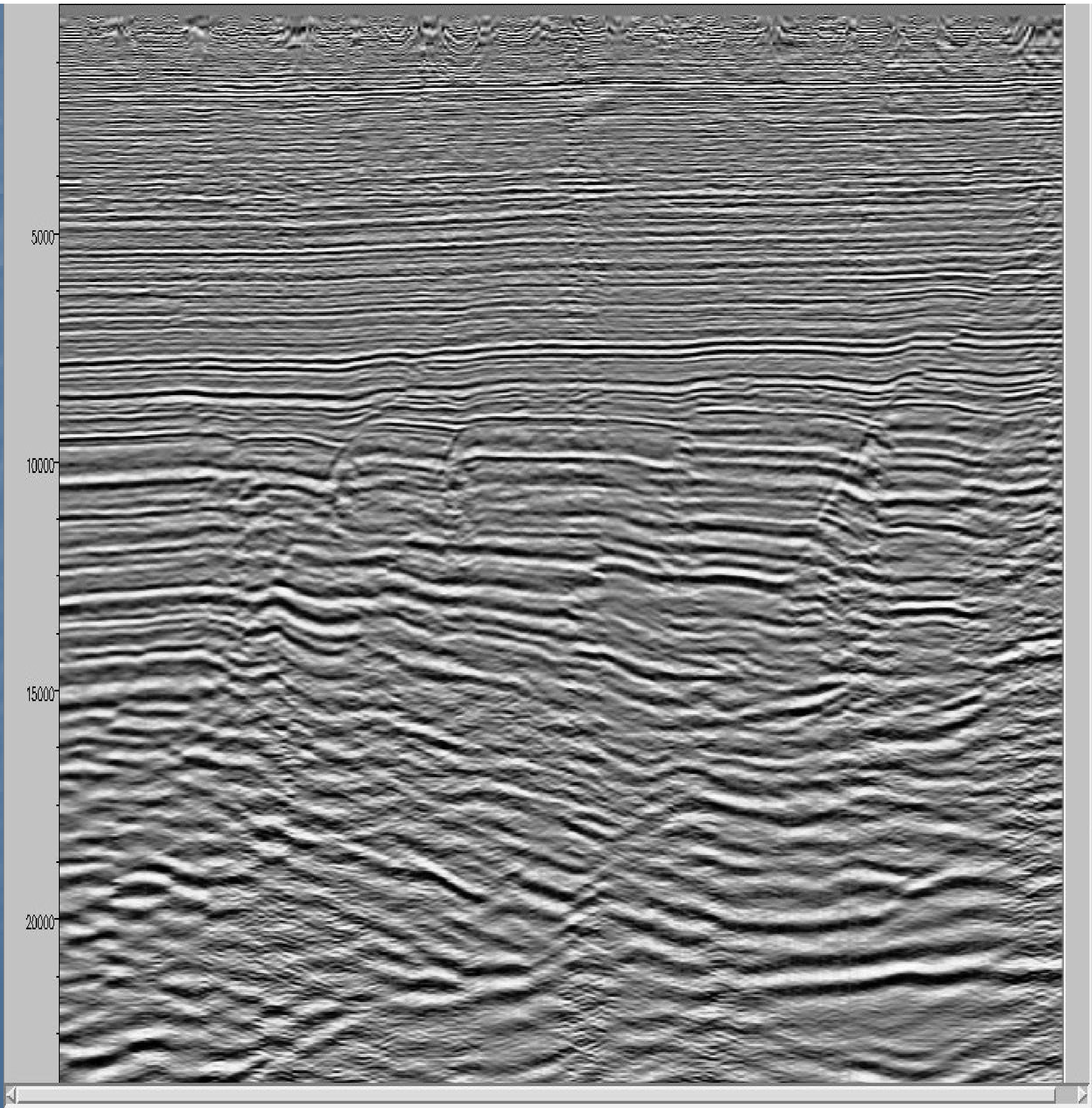
WEM: Line #1



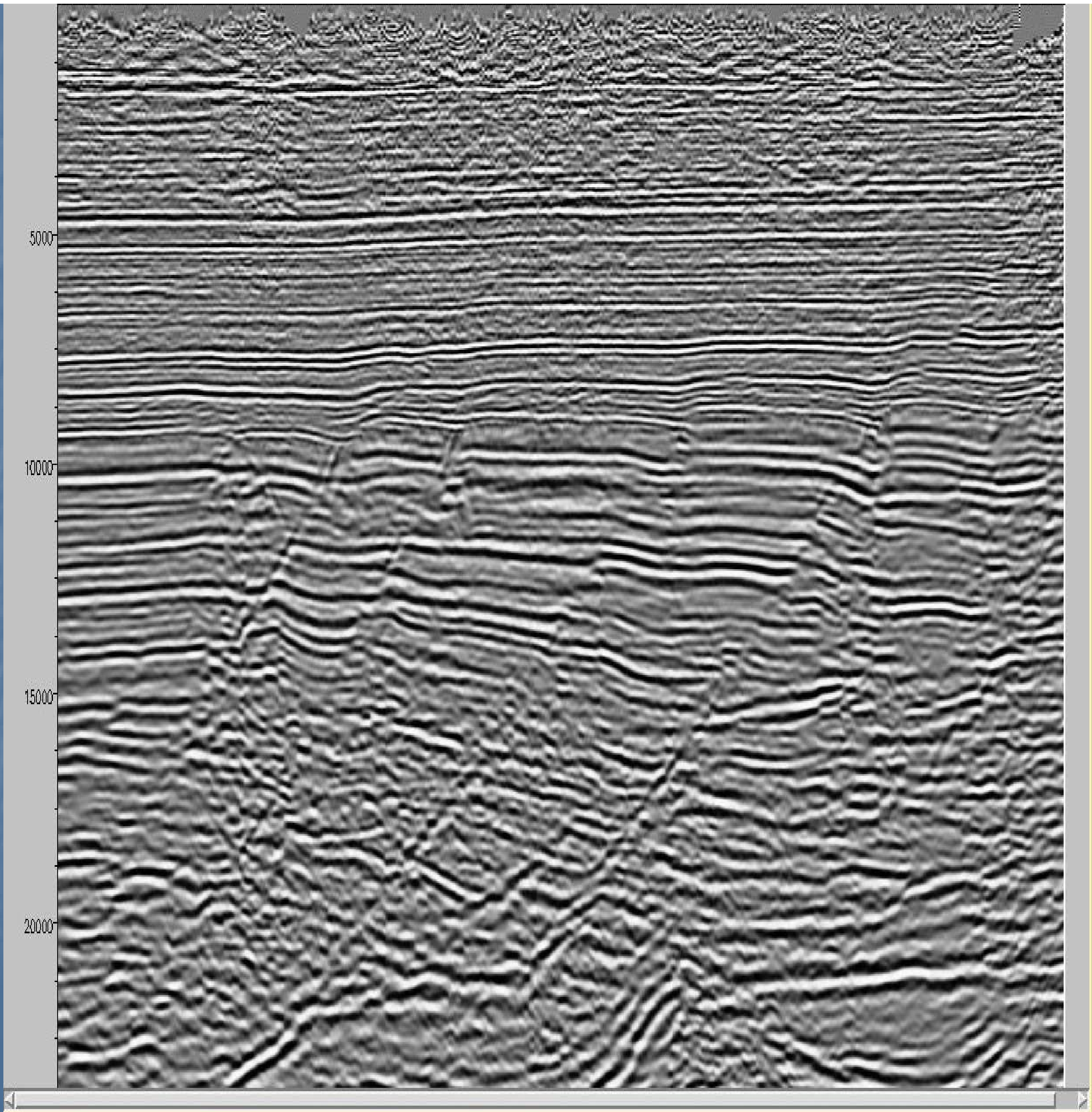
PSTM: Line #6



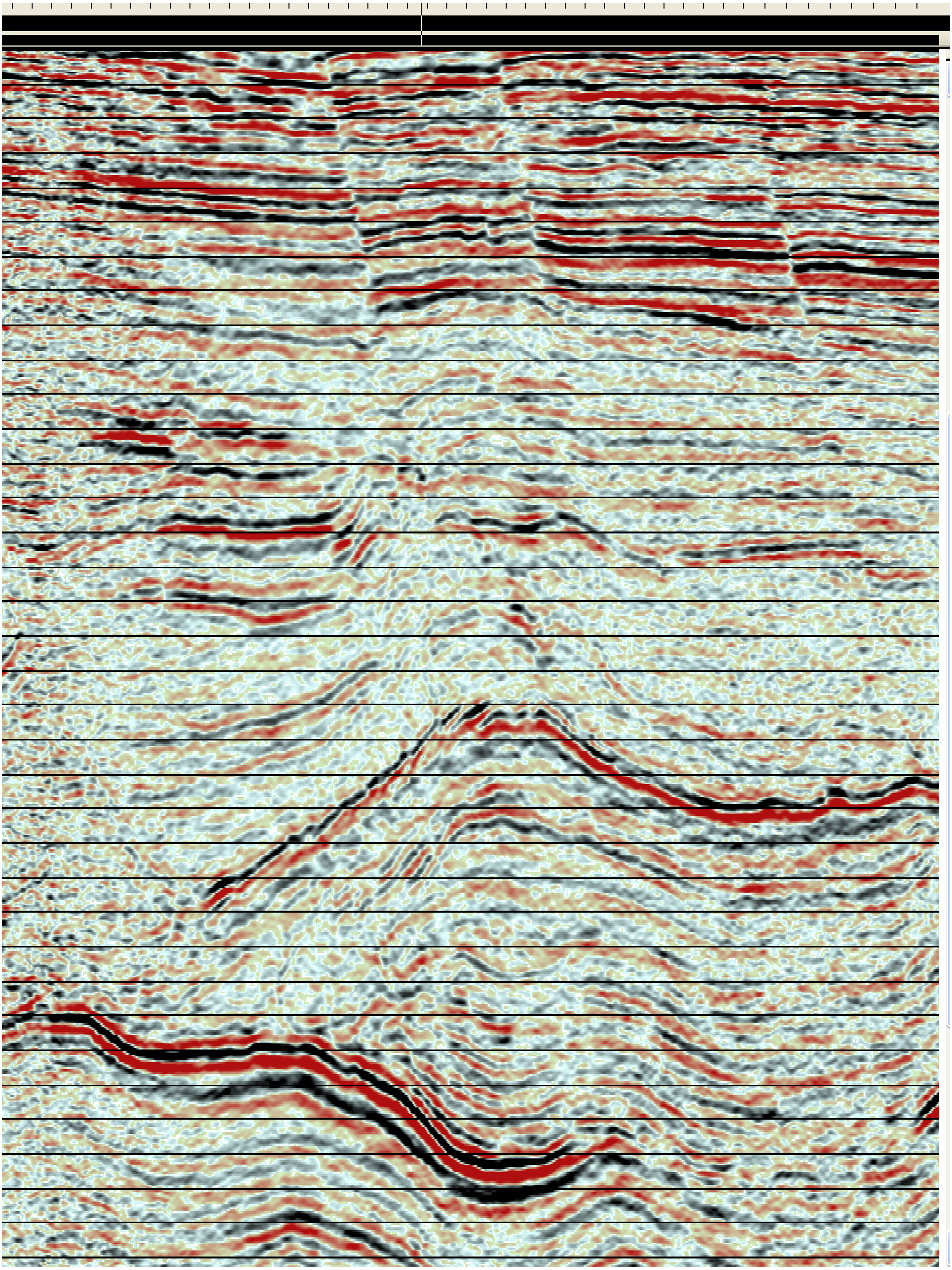
Kmig: Line #6

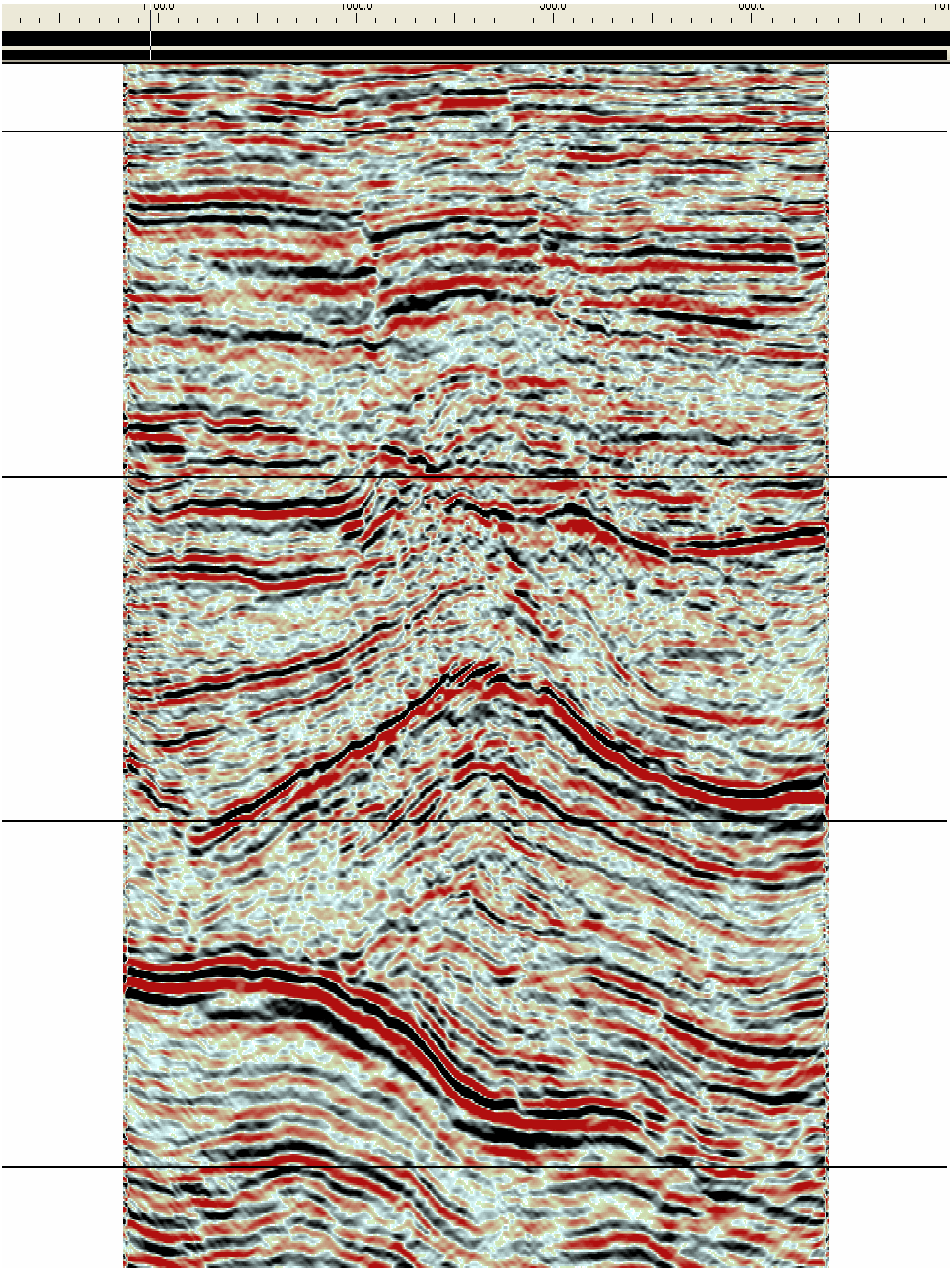


WEM: Line #6



- Building Velocity Models:
- Layer Cake?
- Tomographic?

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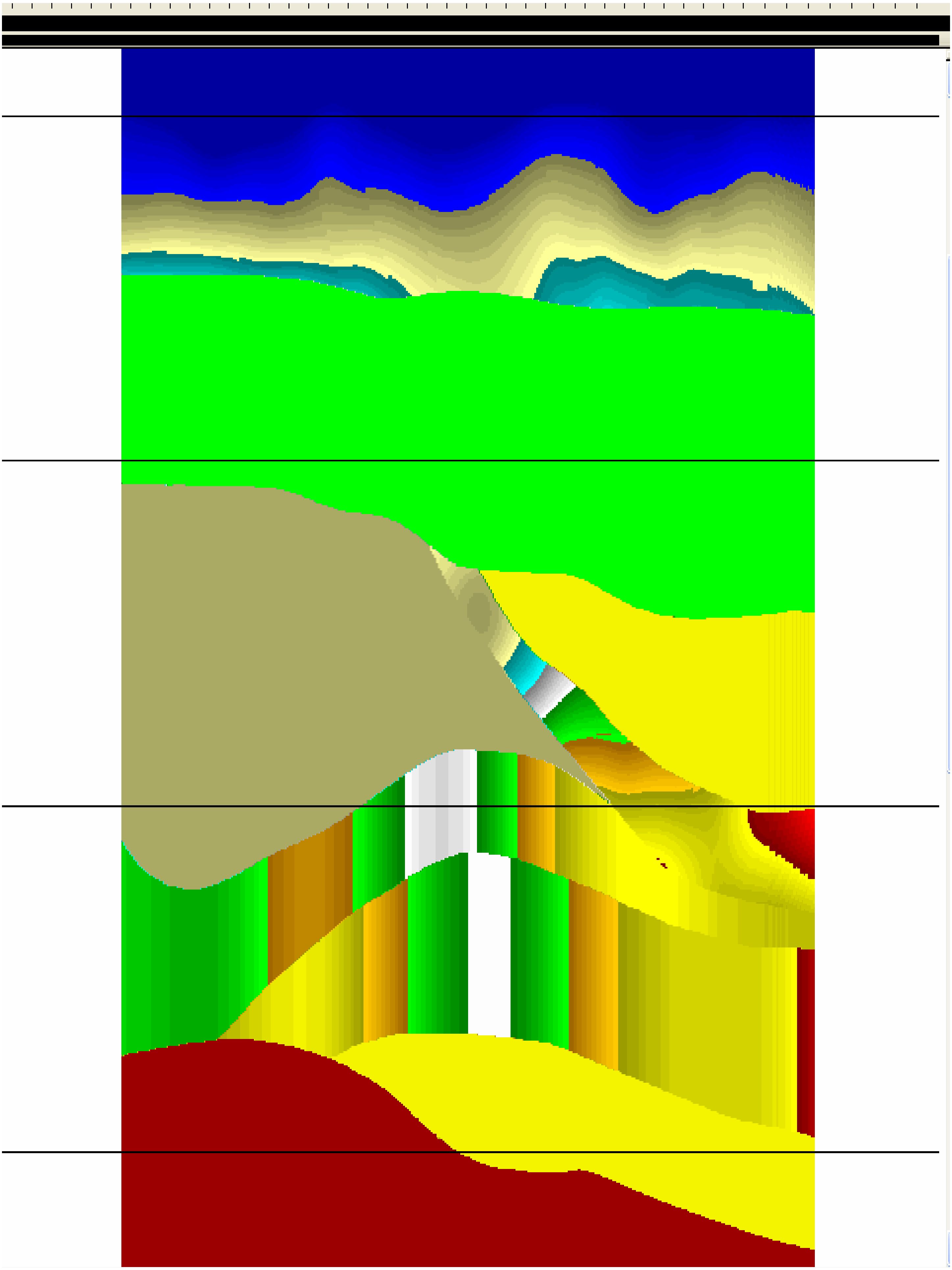
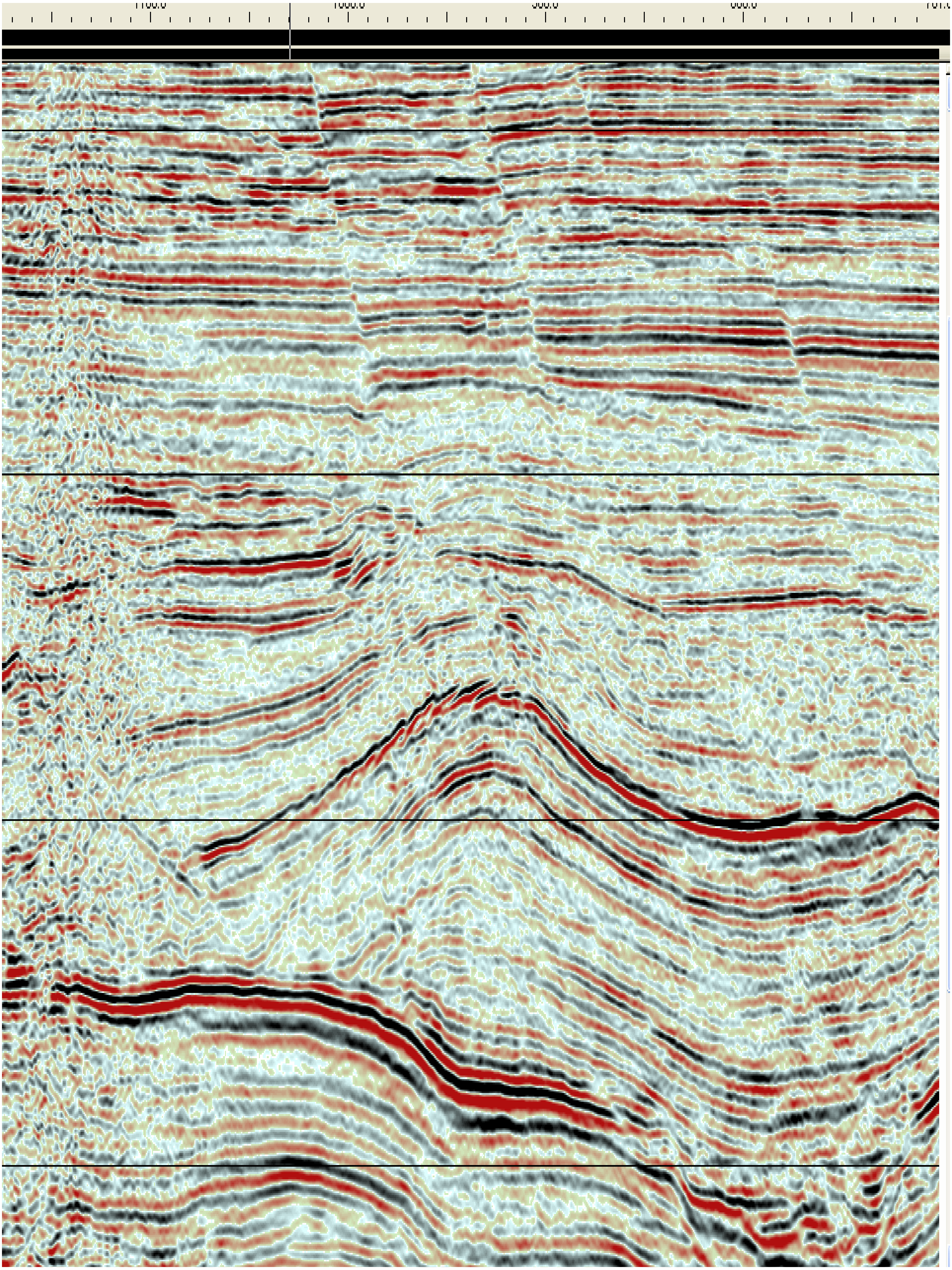
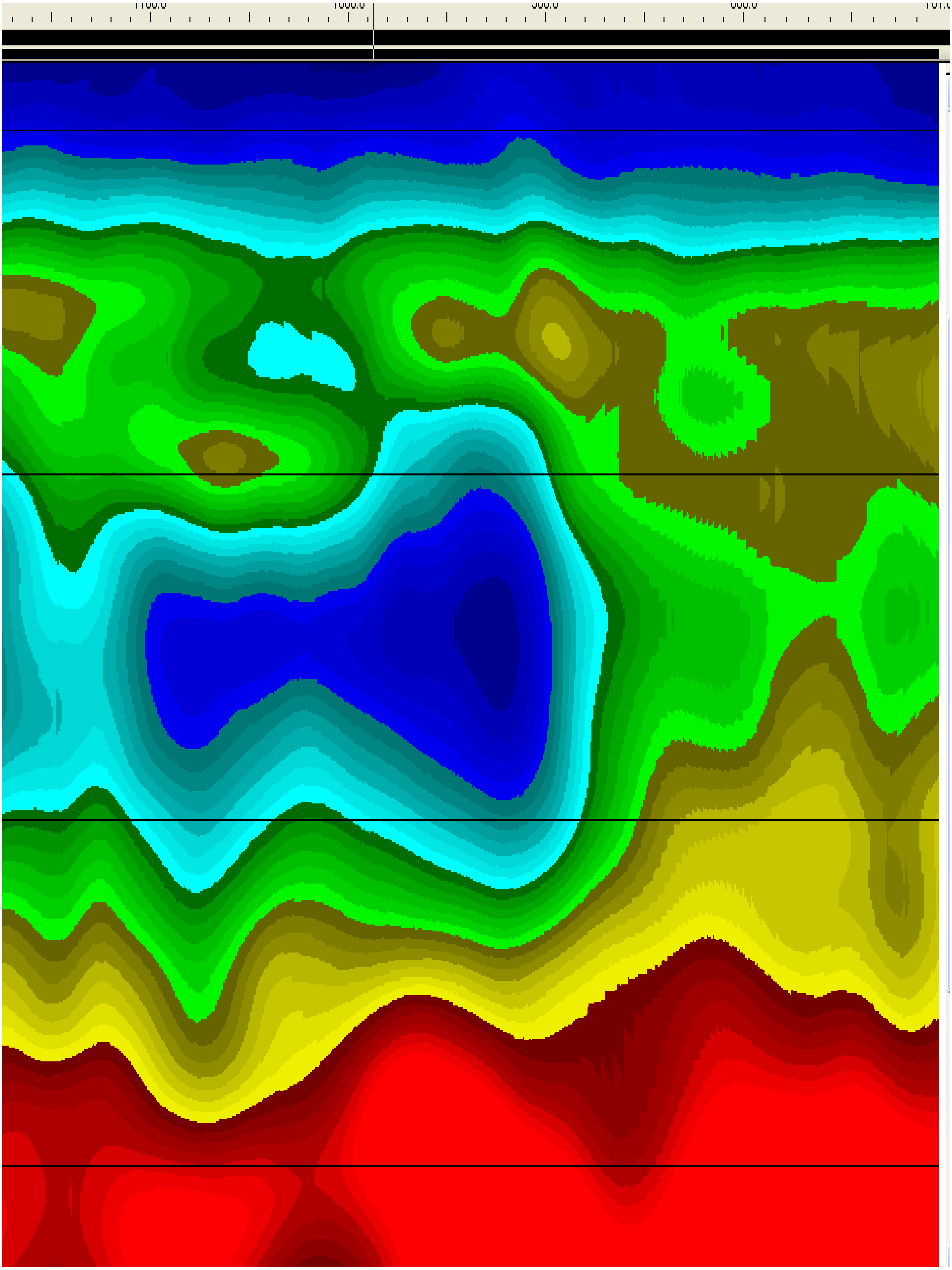
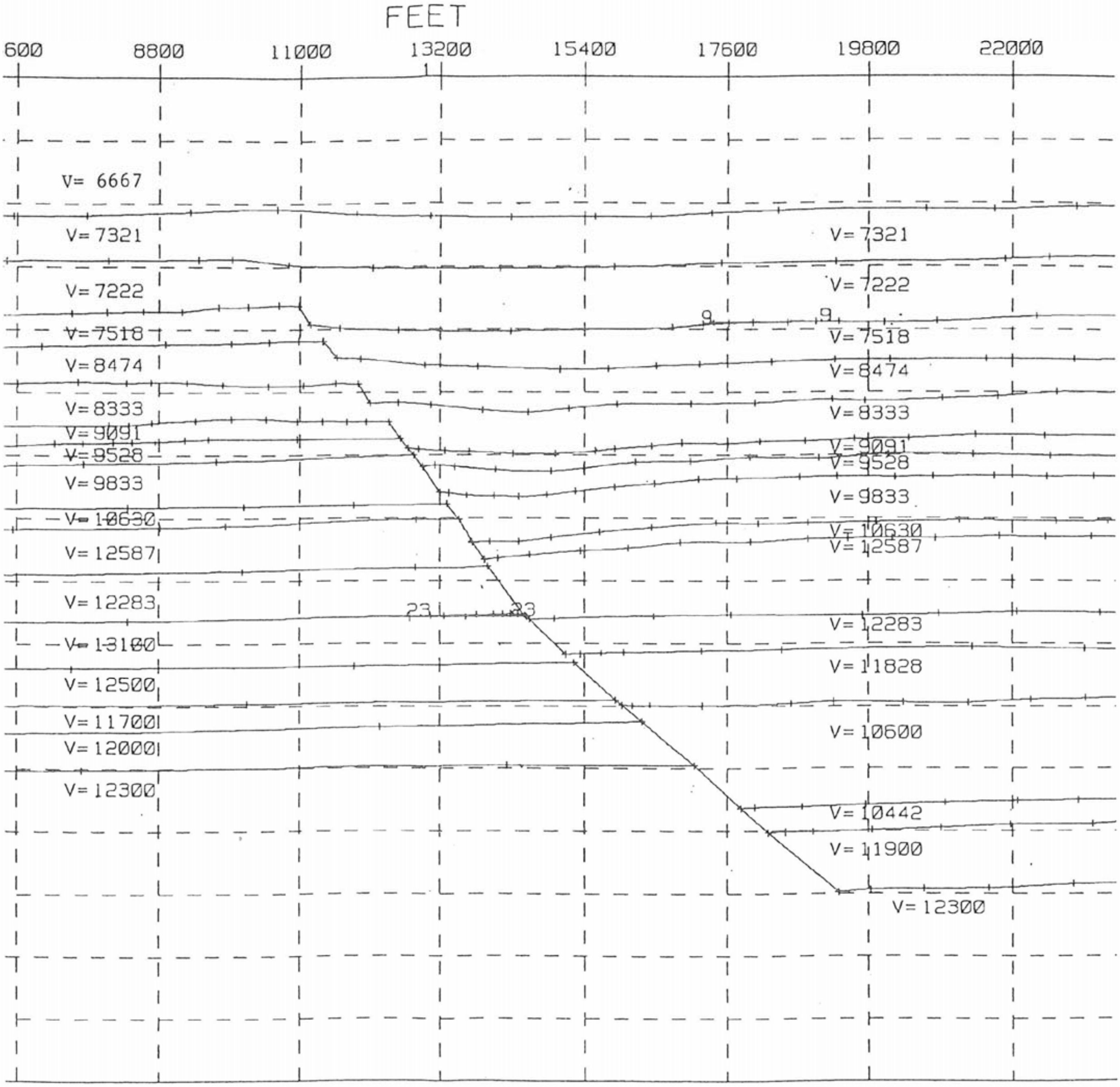


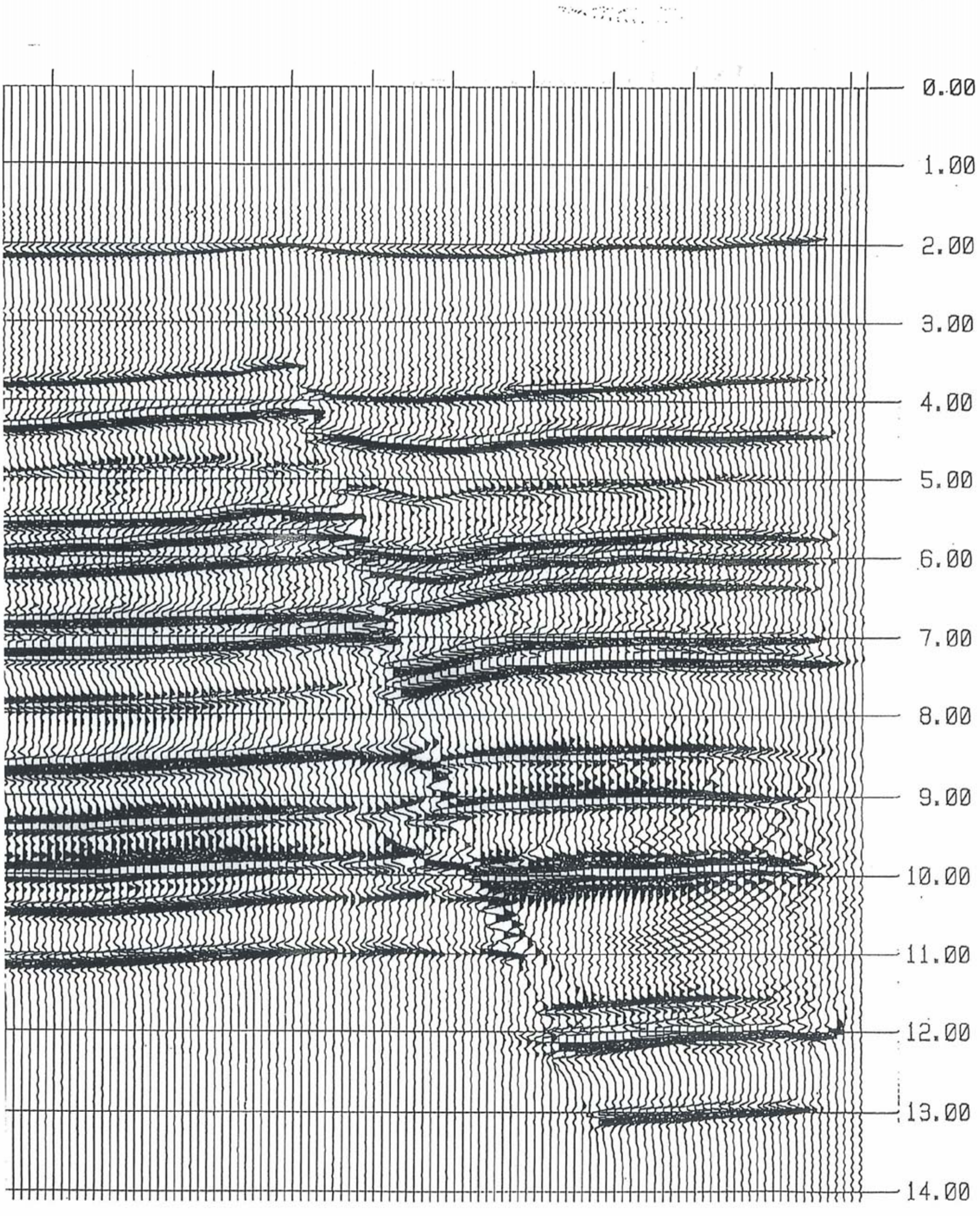


1100.0
1000.0



Model created by Jim Patch (with help from Pat Lindsey).
From Allen et al., 1993




0.00
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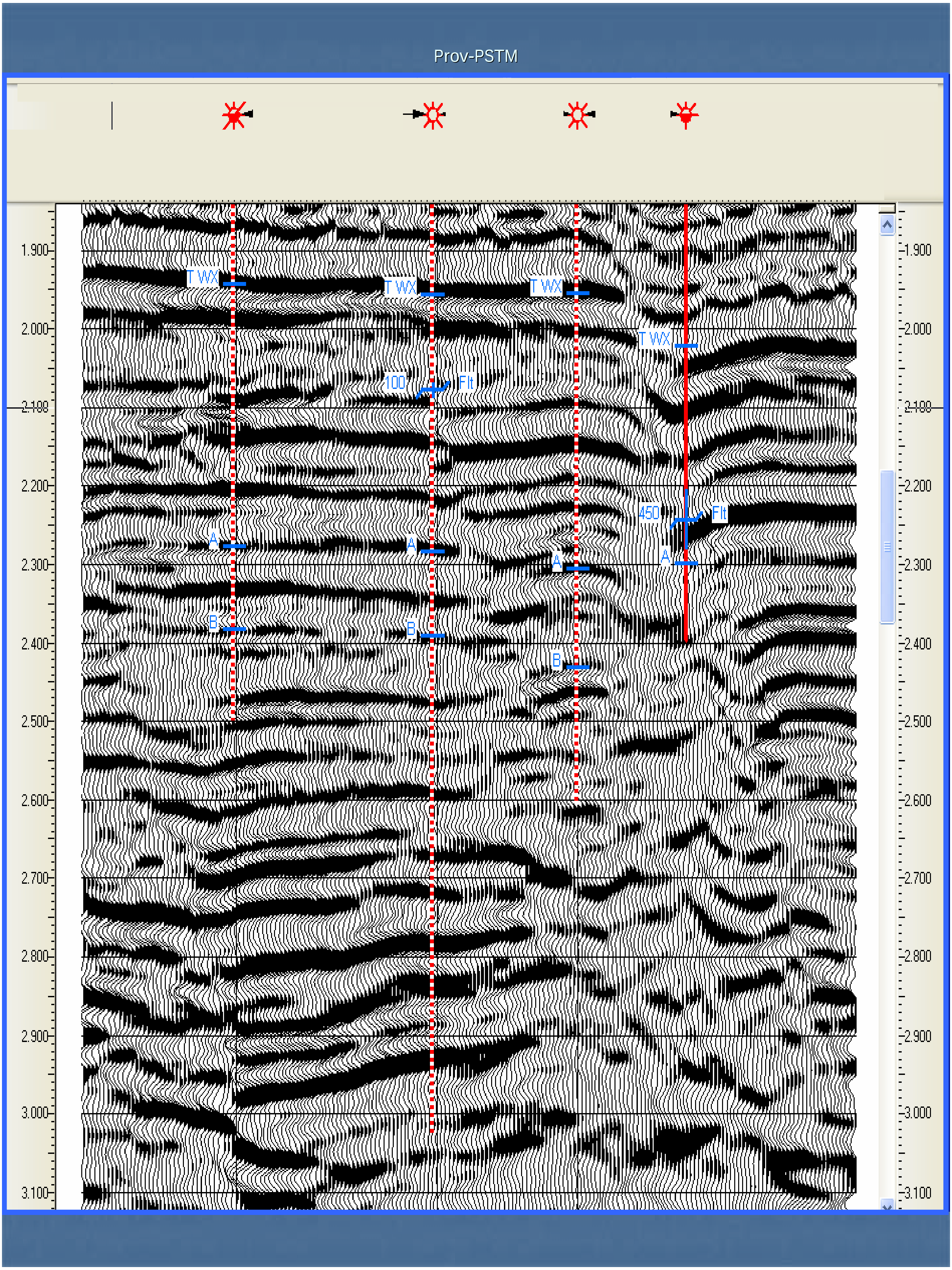
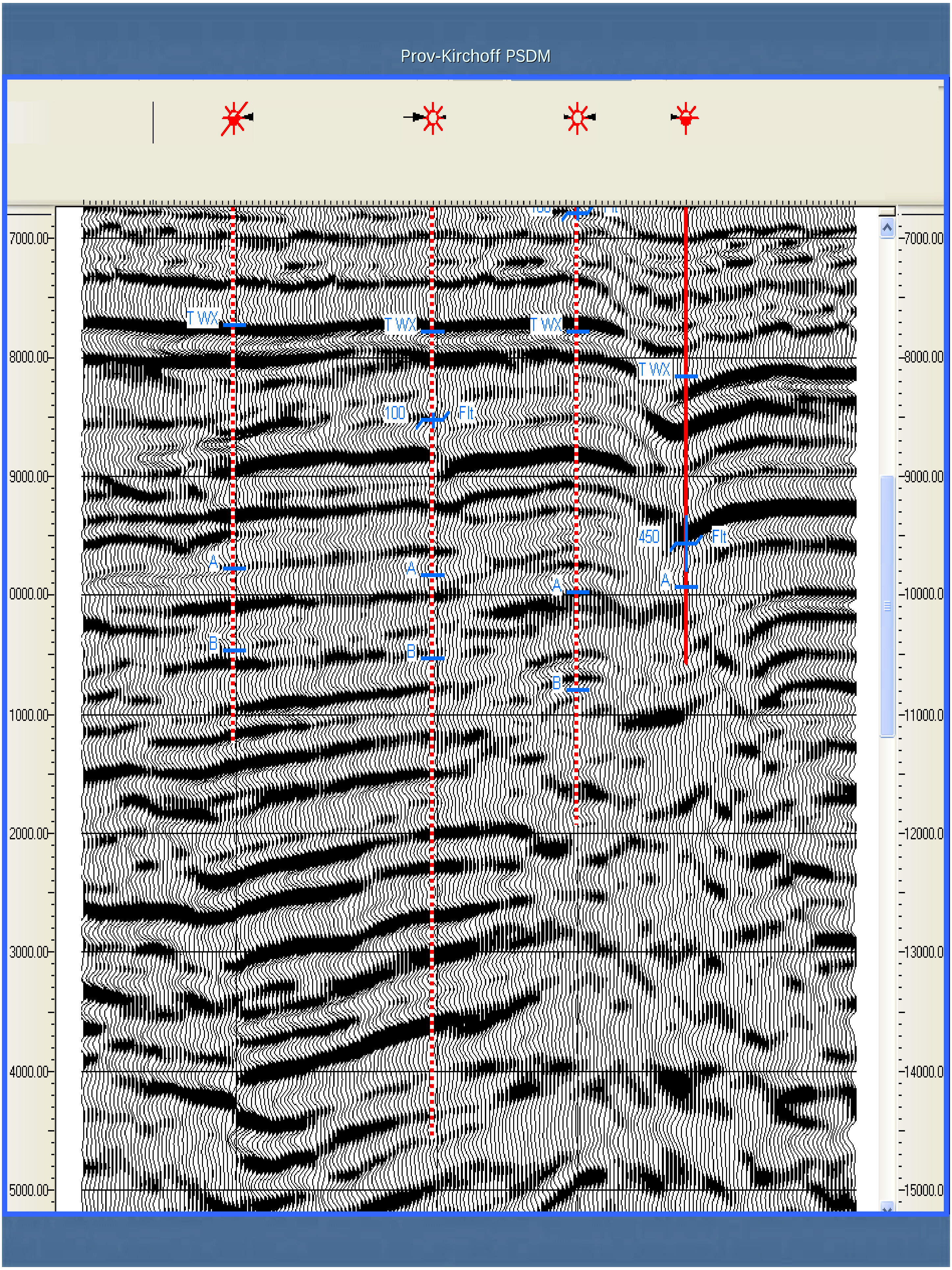

Prov-PSTM
T WX
T WX
T WX
T WX
100
Flt
450
Flt
A
A
A
A
B
B
B
1.900
2.000
2.100
2.200
2.300
2.400
2.500
2.600
2.700
2.800
2.900
3.000
3.100



Prov-Kirchoff PSDM
T WX
T WX
T WX
T WX
100
Flt
450
Flt
A
A
A
A
B
B
B
7000.00
8000.00
9000.00
0000.00
1000.00
2000.00
3000.00
4000.00
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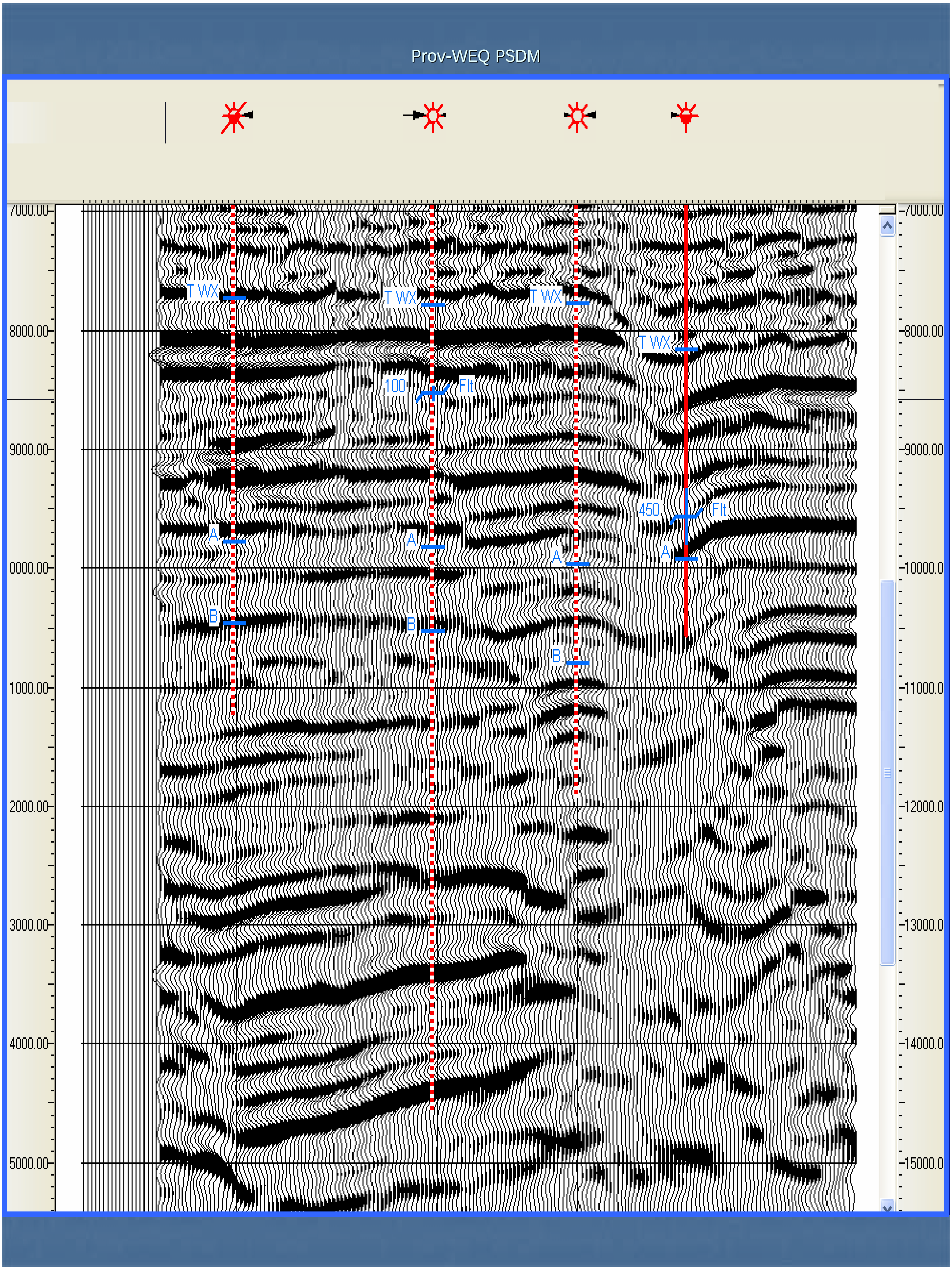
Prov-WEQ PSDM
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Flt
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9000.00
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1000.00
2000.00
3000.00
4000.00
5000.00
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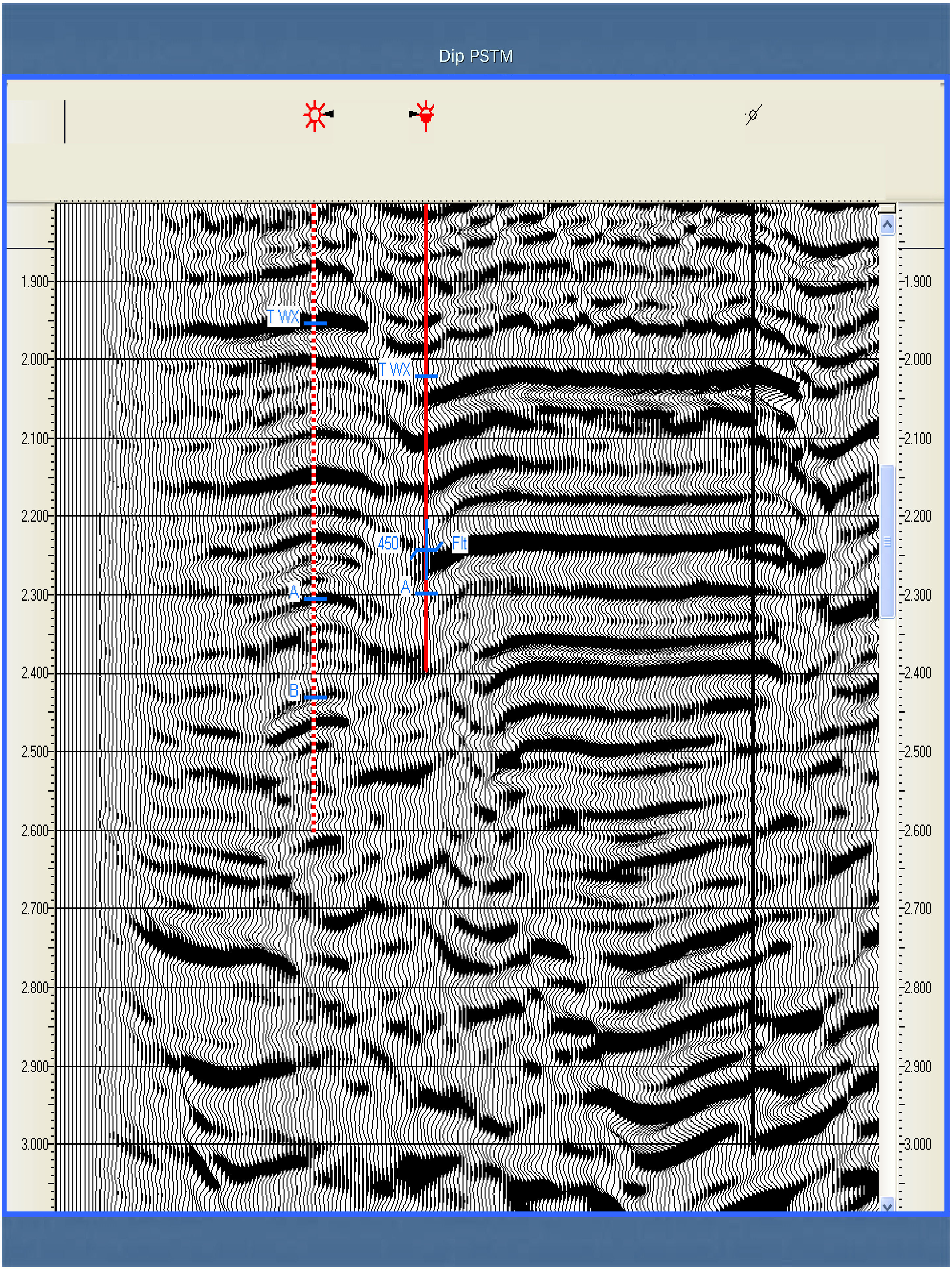
Dip PSTM
T WX
T WX
450
Flt
A
A
B
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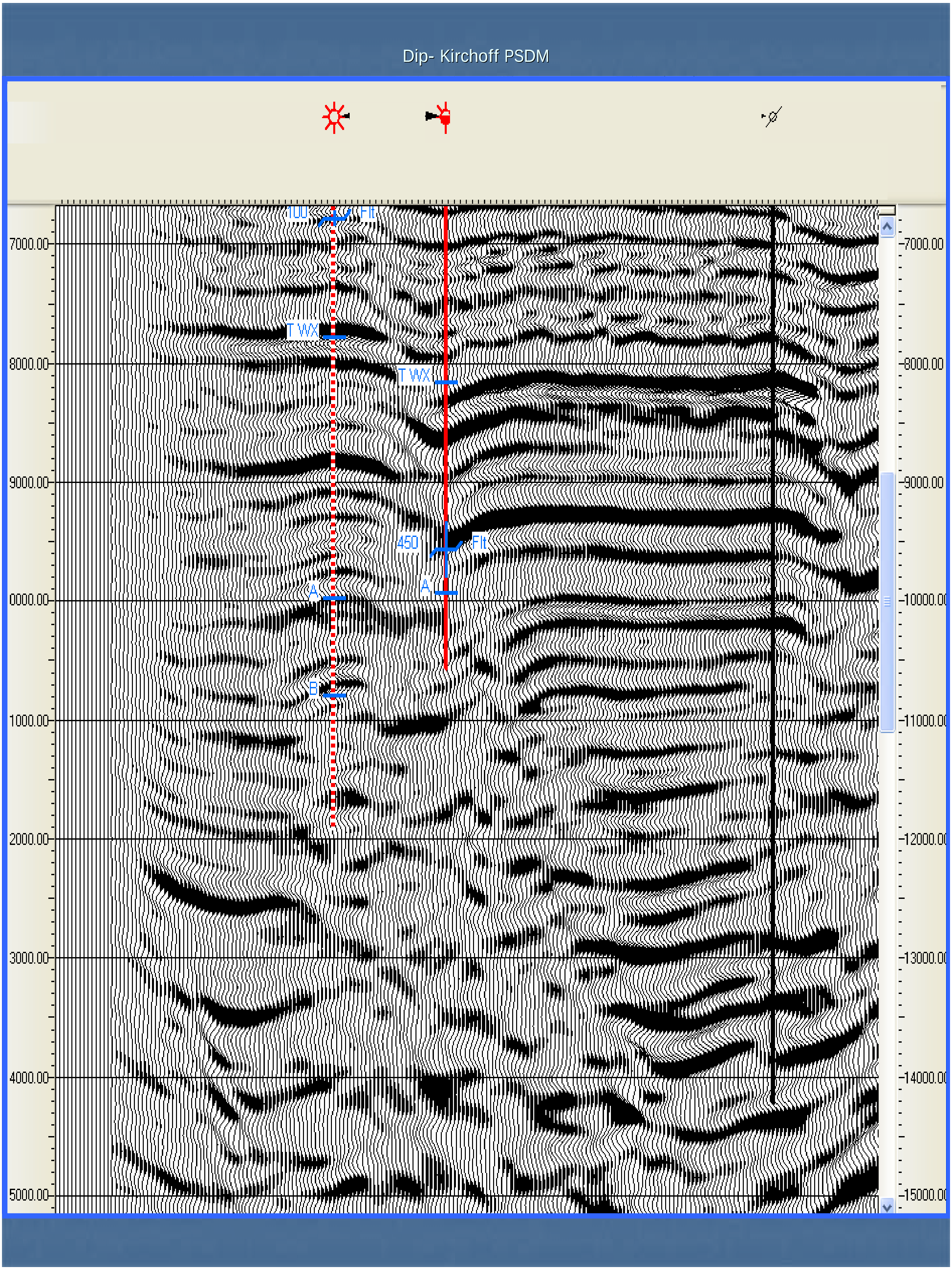
2.800
2.900
3.000



Dip- Kirchoff PSDM
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Flt
T WX
T WX
450
Flt
A
A
B
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8000.00
9000.00
0000.00
1000.00
2000.00
3000.00
4000.00
5000.00
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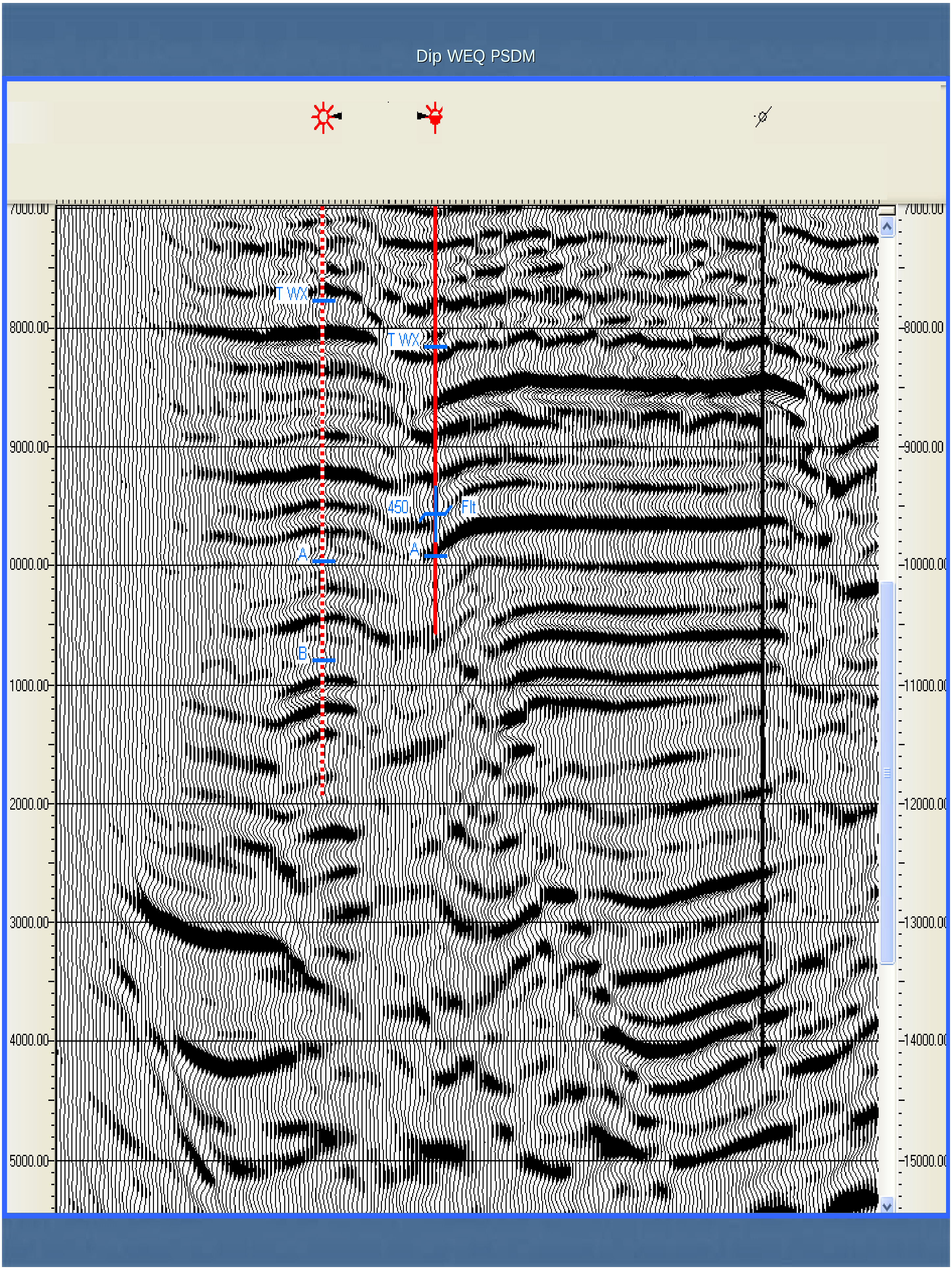
Dip WEQ PSDM
T WX
T WX
450
Flt
A
A
B
7000.00
8000.00
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0000.00
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2000.00
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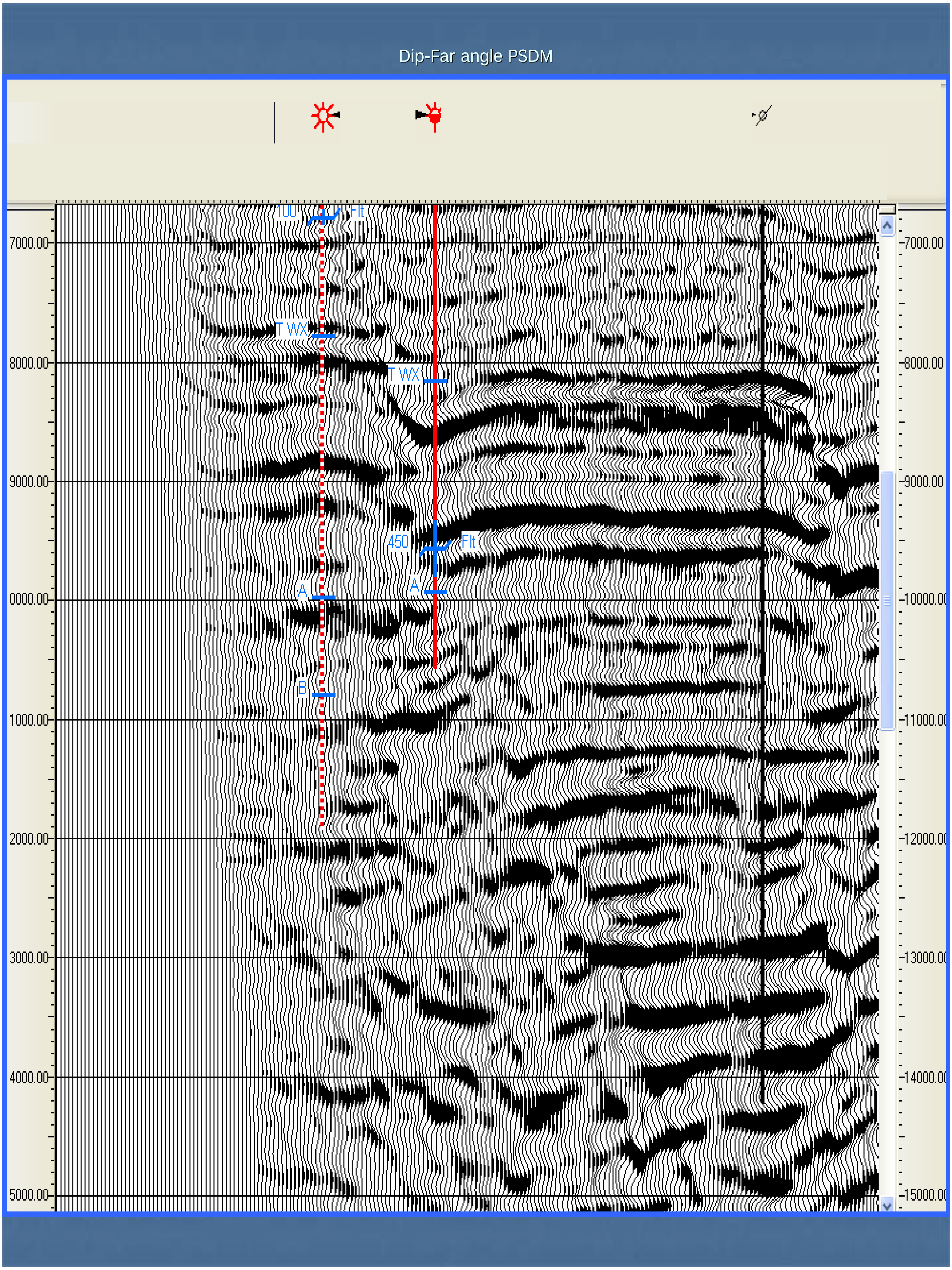

Dip-Far angle PSDM
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T WX
T WX
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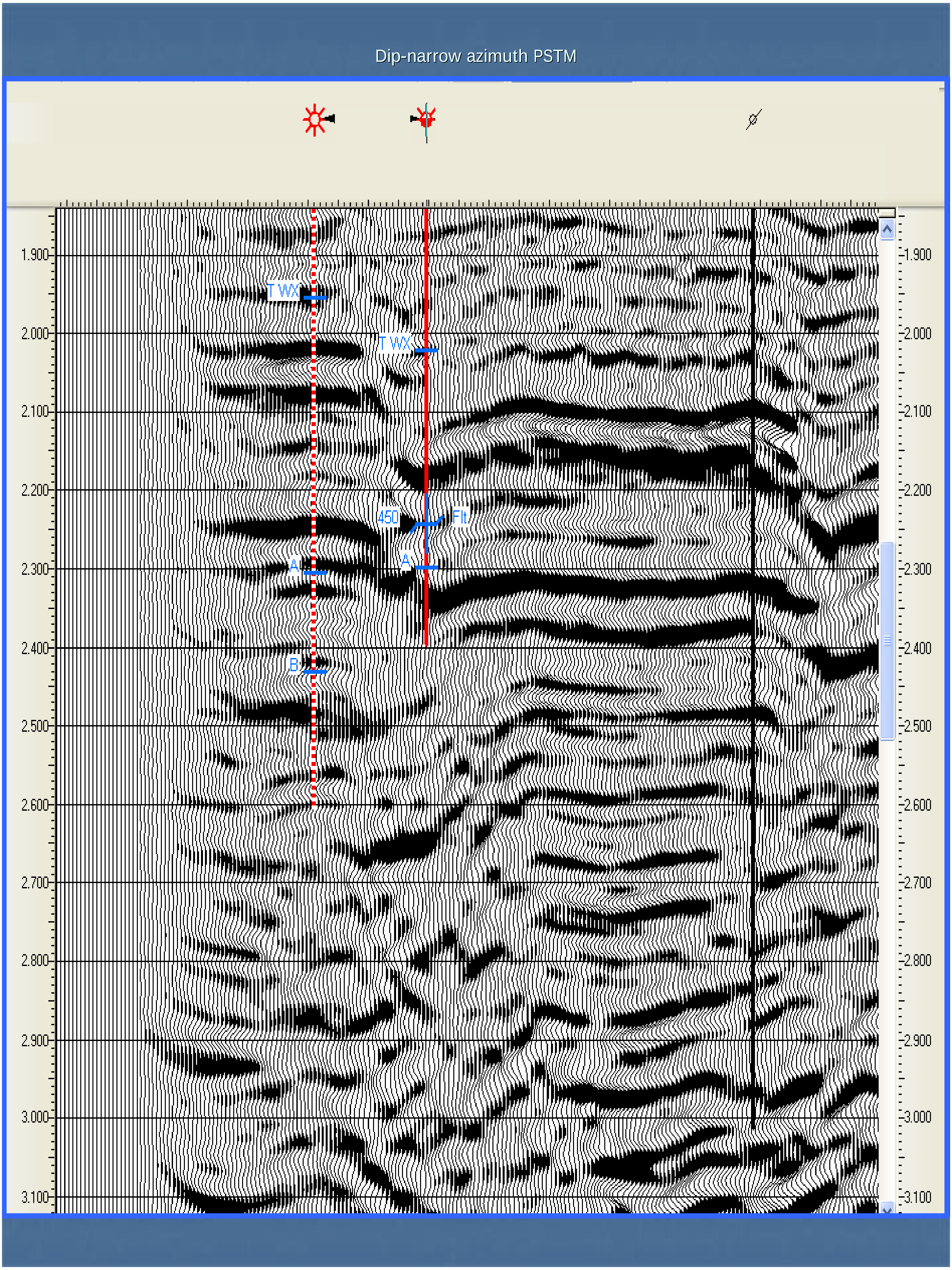
-9000.00



Dip-narrow azimuth PSTM
T WX
T WX
450
Flt
A
A
B
1.900
2.000
2.100
2.200
2.300
2.400
2.500
2.600
2.700
2.800
2.900
3.000
3.100

In Seismic Interpretation,

"Time is Fact,
Depth is Opinion."

(Bob Evans, Shell Oil, 1952)