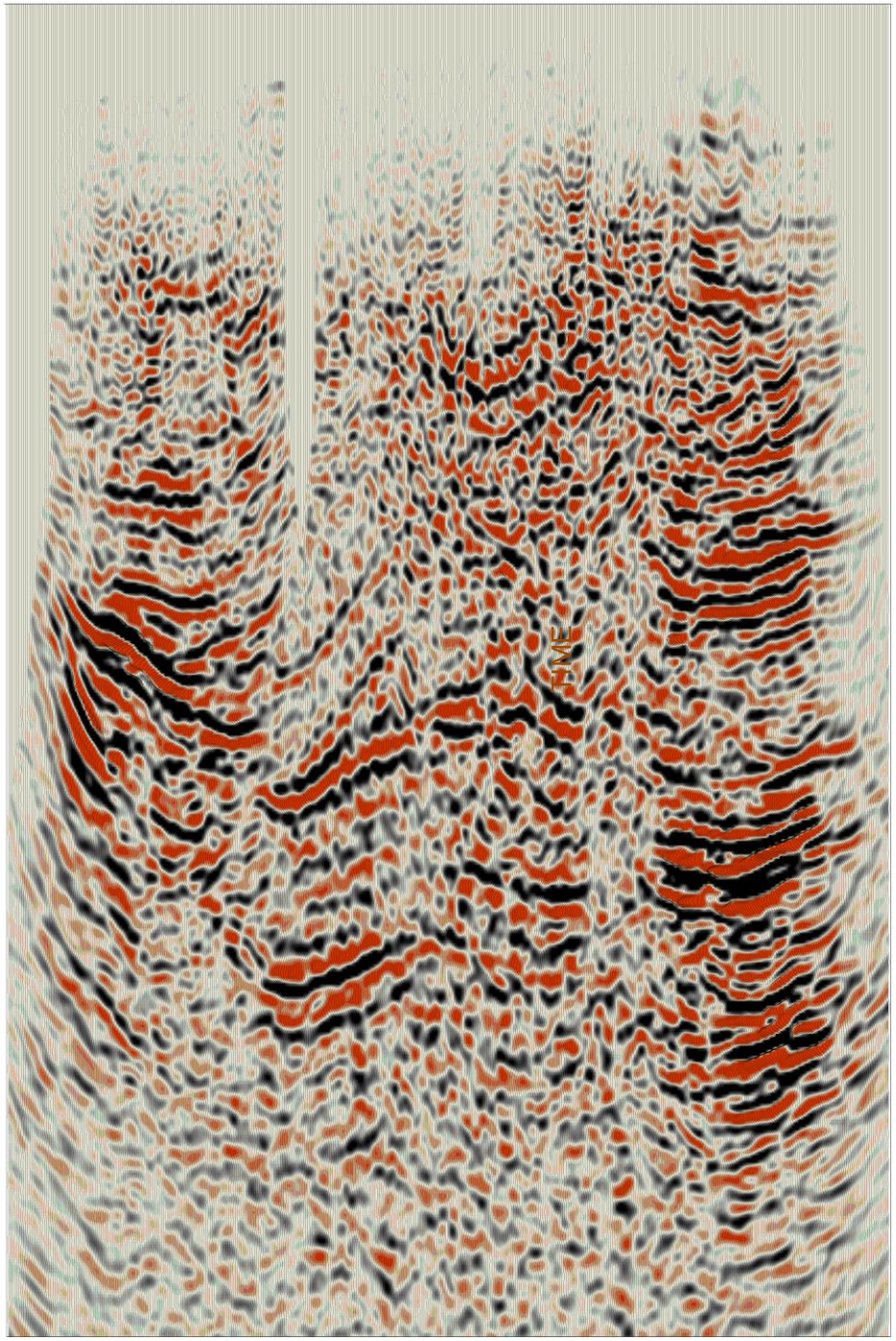
MultiFocusing Technologies

Dr. Marianne Rauch-Davies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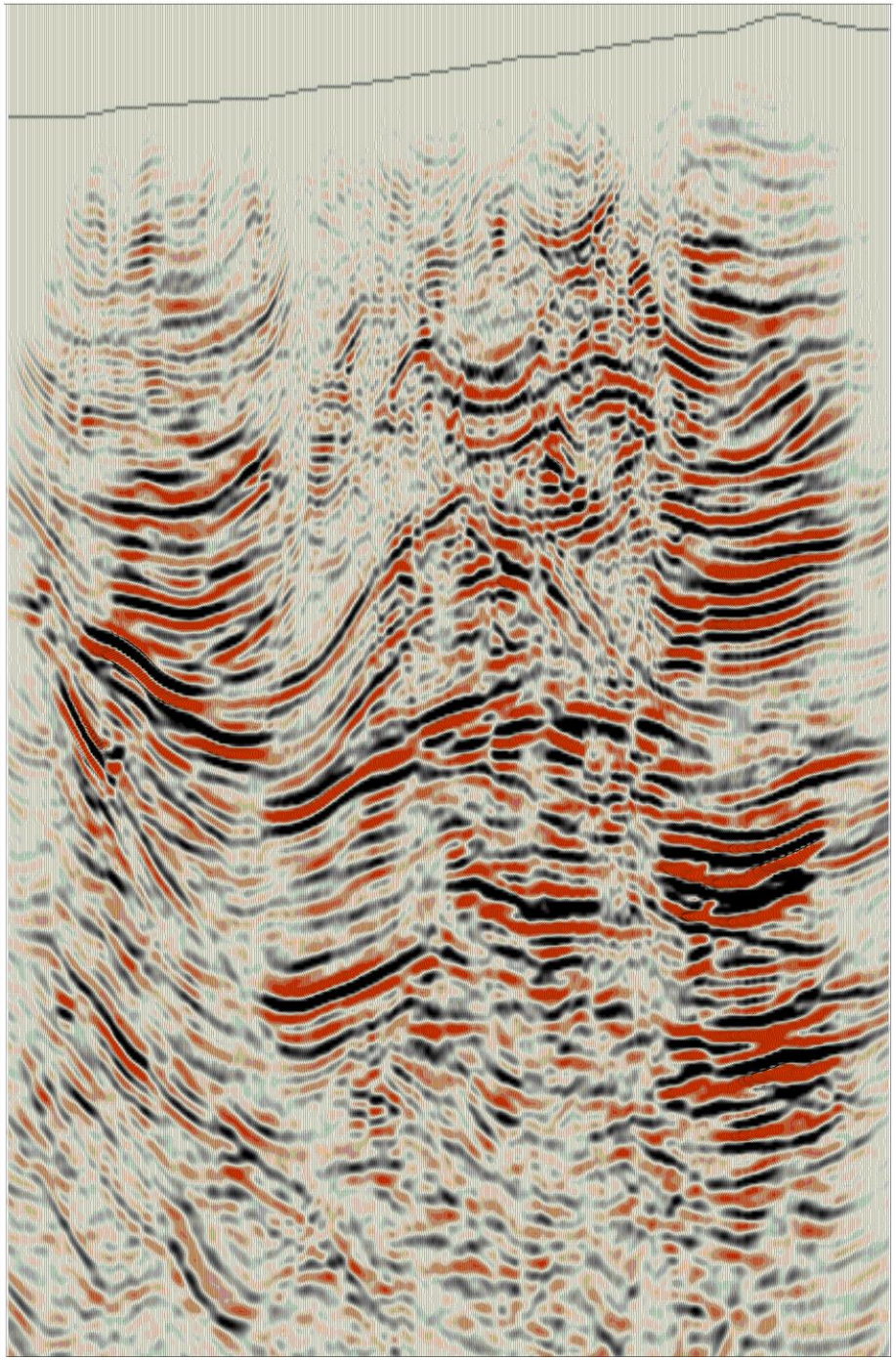


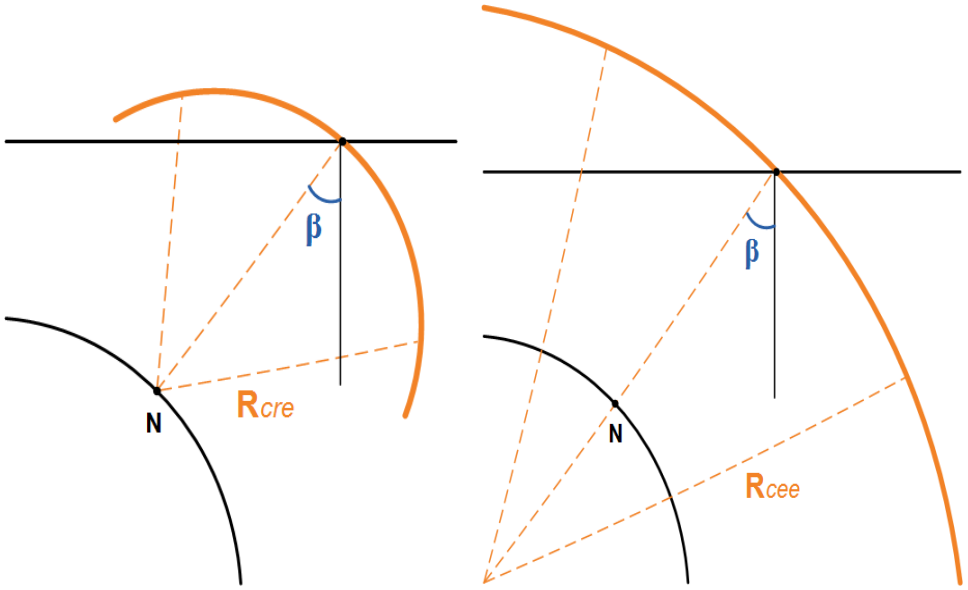
Geomage products

based on MultiFocusing

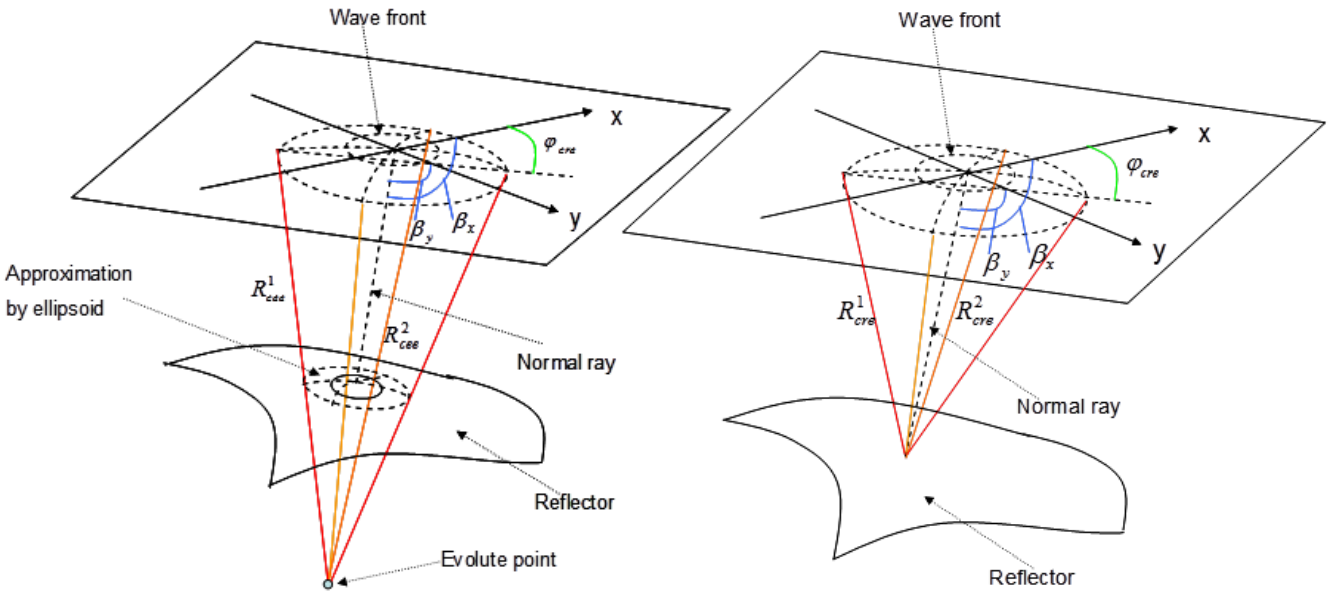
- MF PSTM Imaging
- MF Data Enhancement, including:
  - *Original or Regularized geometry*
  - *Preserved Amplitude*
  - *Preserved Azimuthal information*
- MF Multiple Attenuation
- MF Diffraction Imaging, including:
  - Diffractivity vs. Azimuth
  - Diffraction Wavefront Anisotropy
- MF Depth Imaging

2D MultiFocusing

CRE radius / CEE radius / Emergence angle

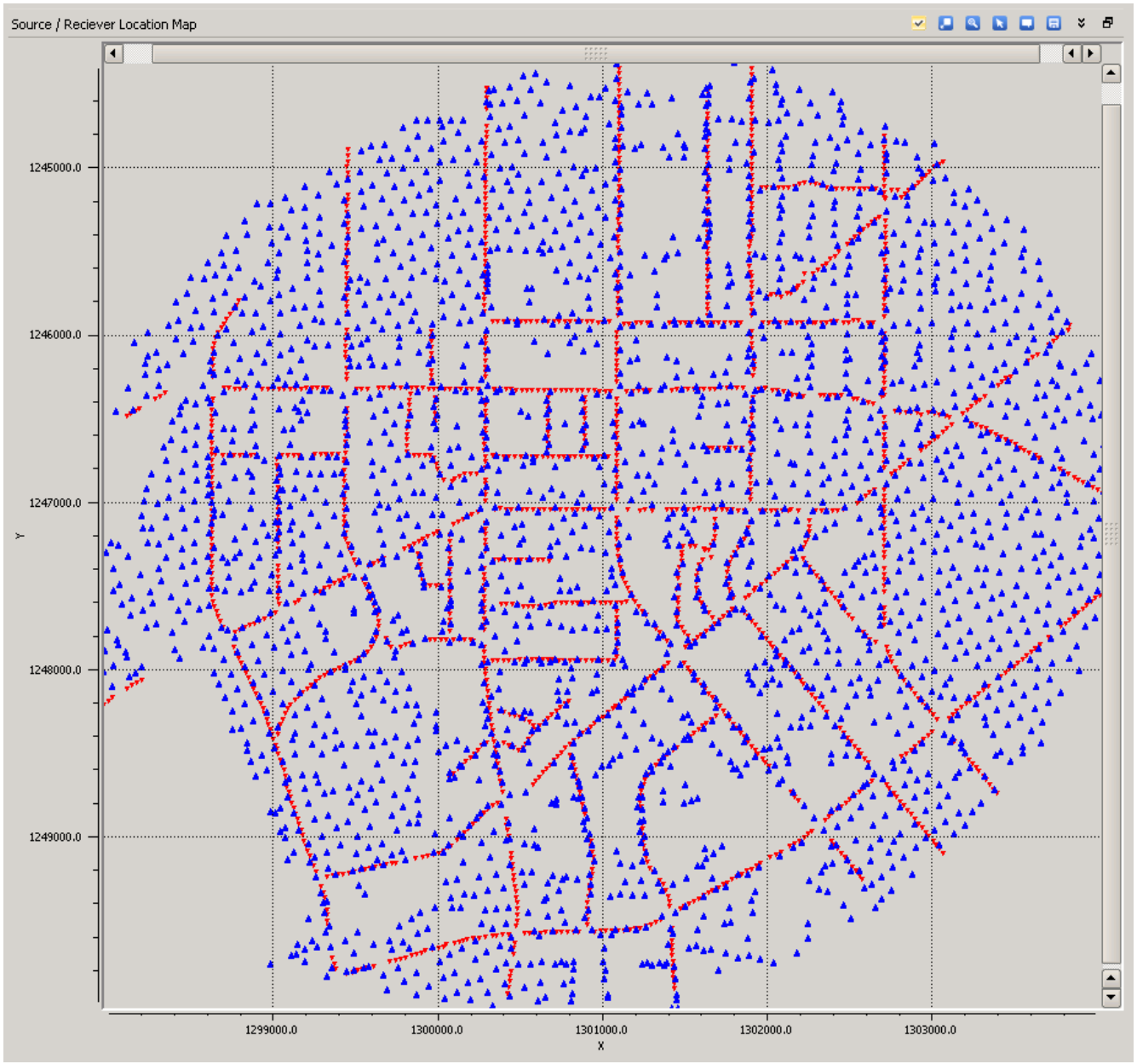


3D MultiFocusing

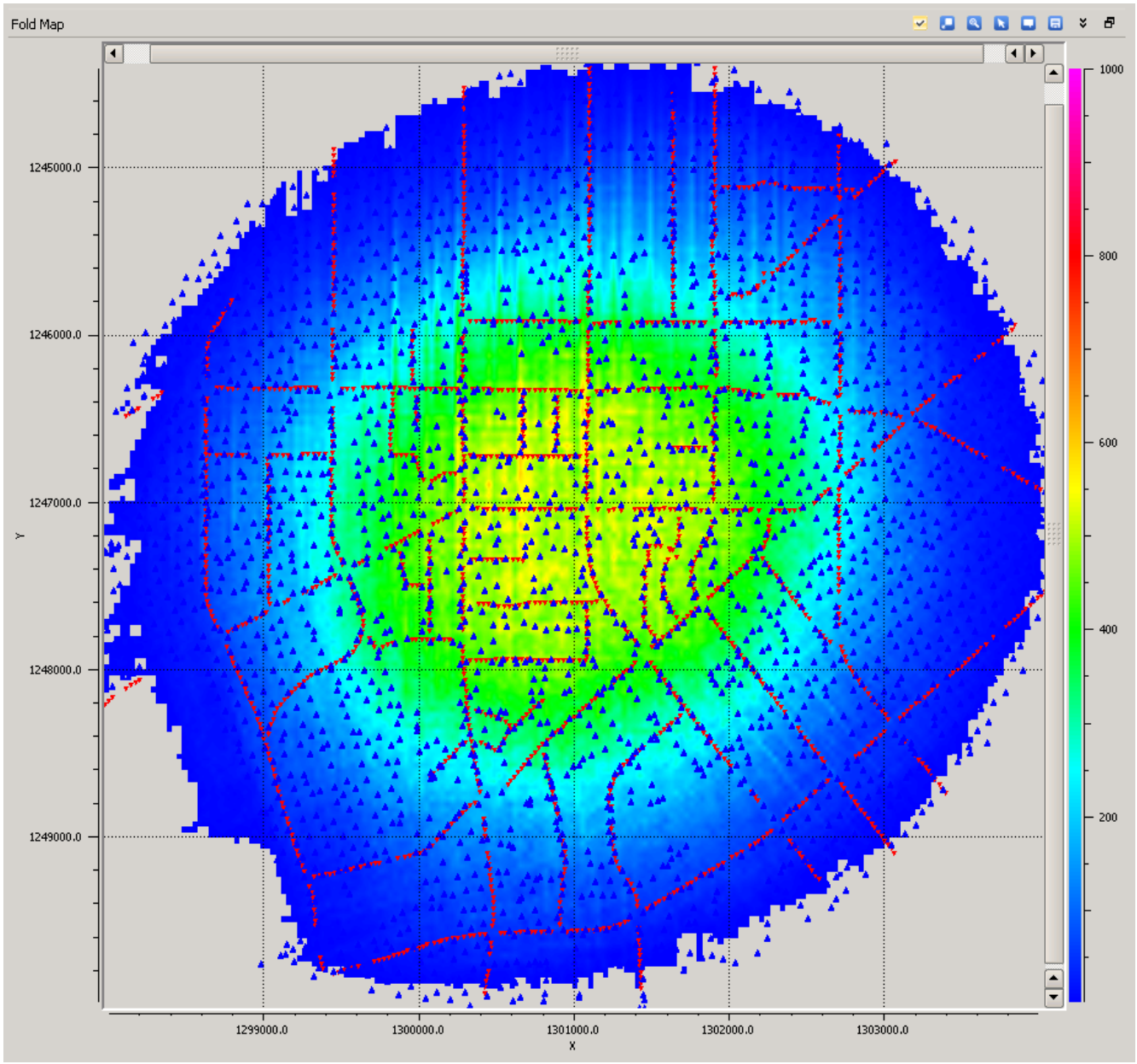


MultiFocusing applications

Acquisition design



CDP fold map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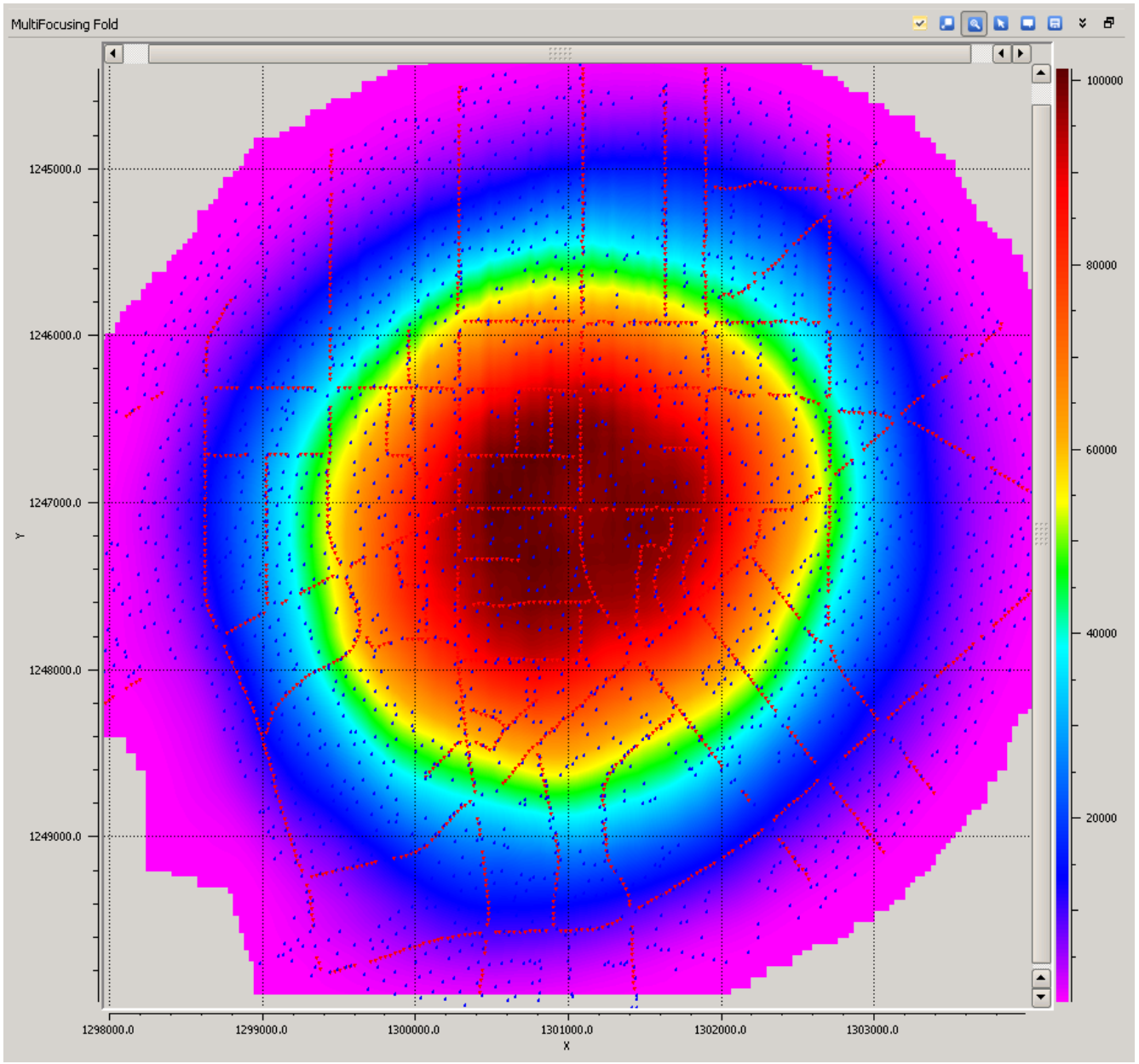
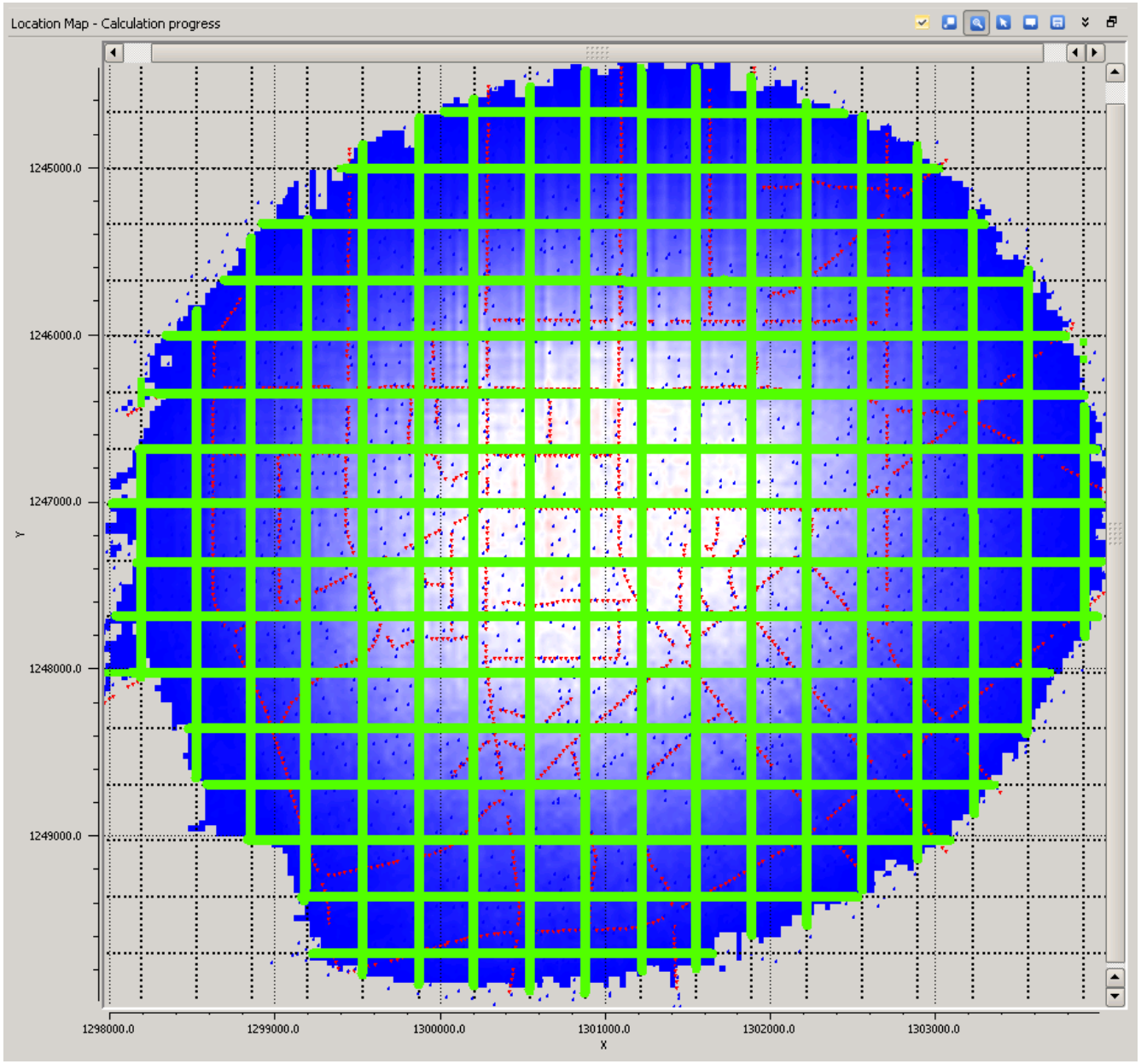
1246000.0
1247000.0
1248000.0
1249000.0
Y
1299000.0
1300000.0
1301000.0
1302000.0
1303000.0
X
1000
800
600
400
200

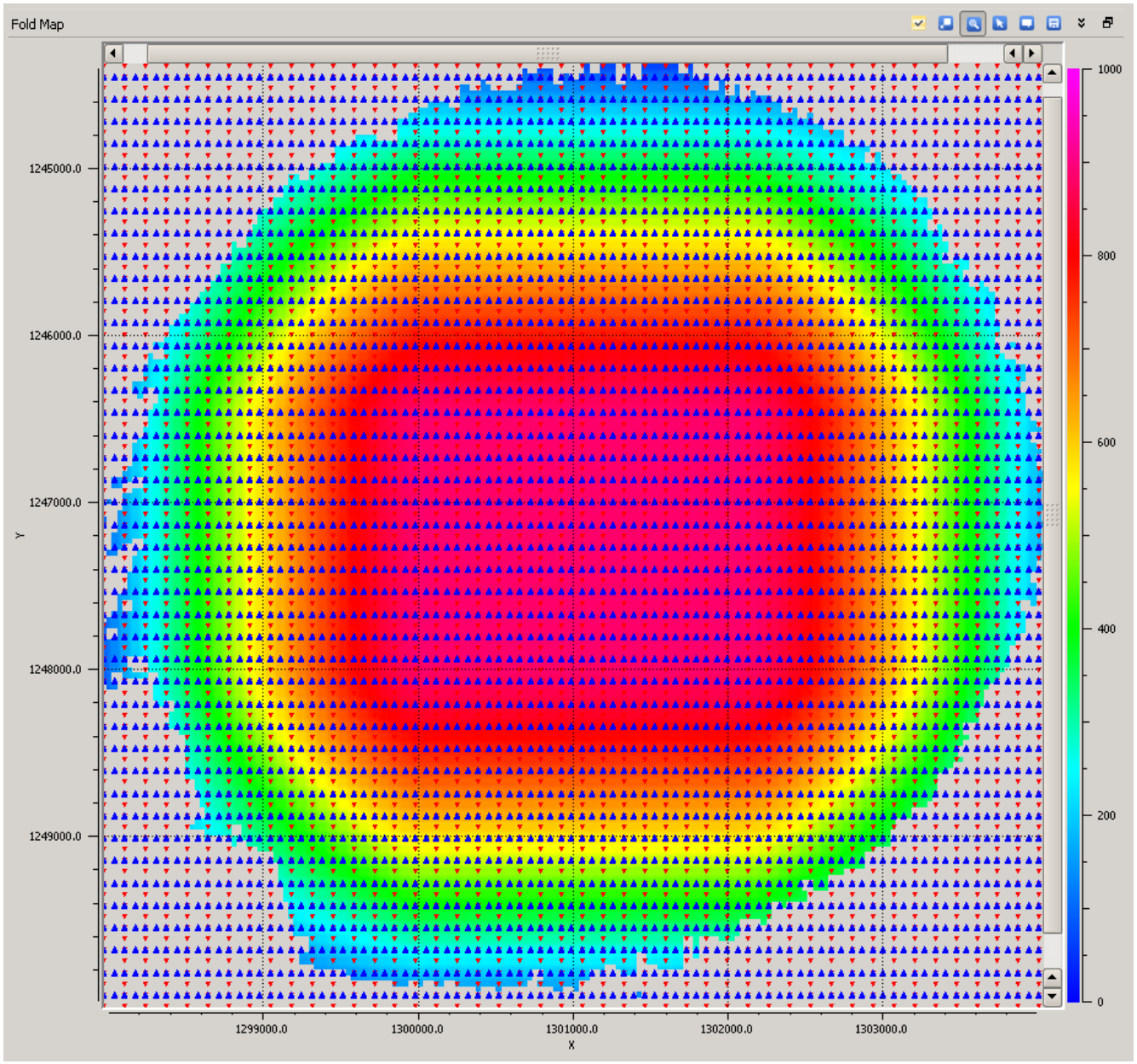
MF fold map


MultiFocusing Fold
1245000.0
1246000.0
1247000.0
1248000.0
1249000.0
Y
1298000.0
1299000.0
1300000.0
1301000.0
1302000.0
1303000.0
X
100000
80000
60000
40000
20000

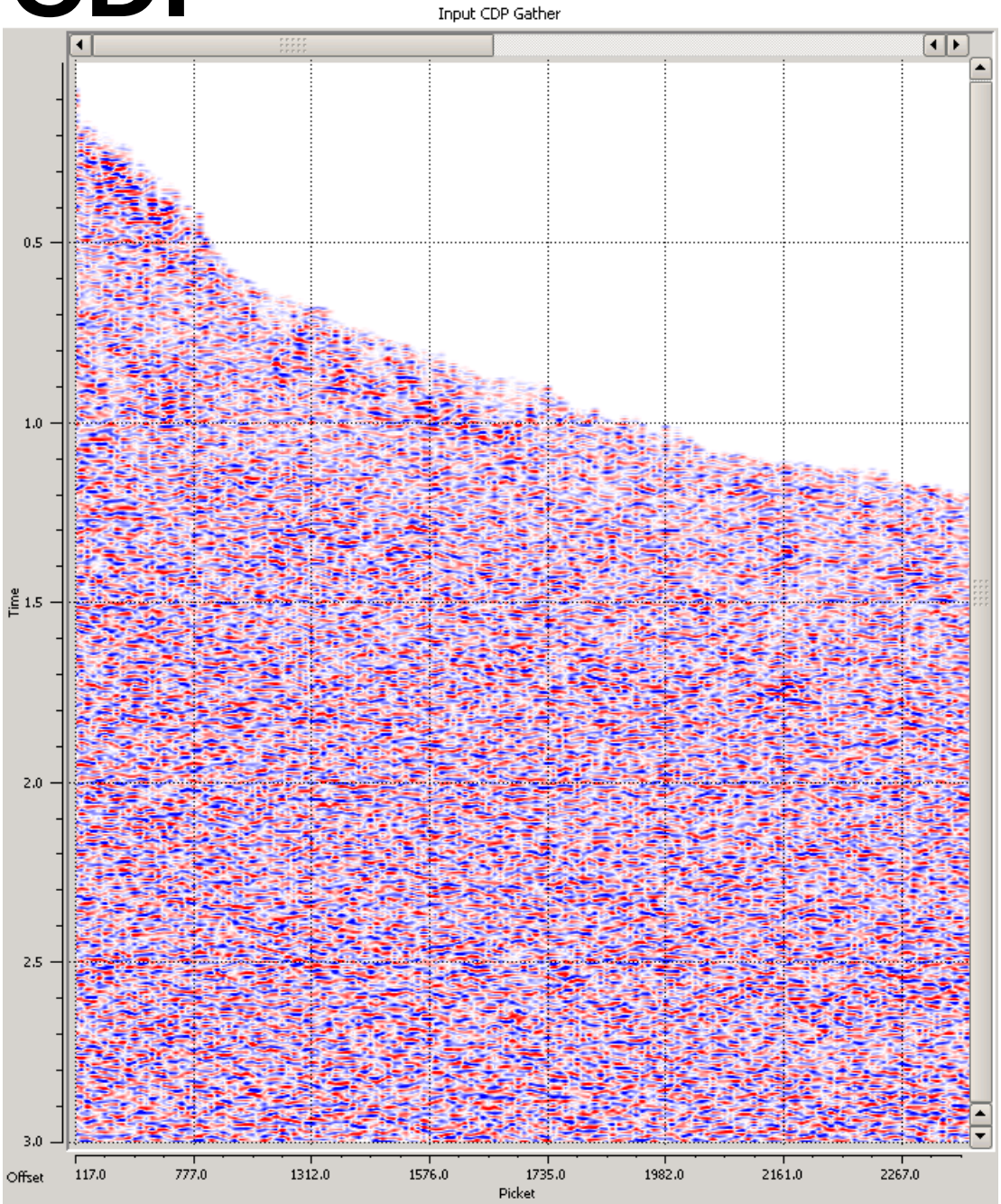
MF velocity picking



MF regularization



Input CDP


Input CDP Gather
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1.0
1.5
2.0
2.5
3.0
Offset
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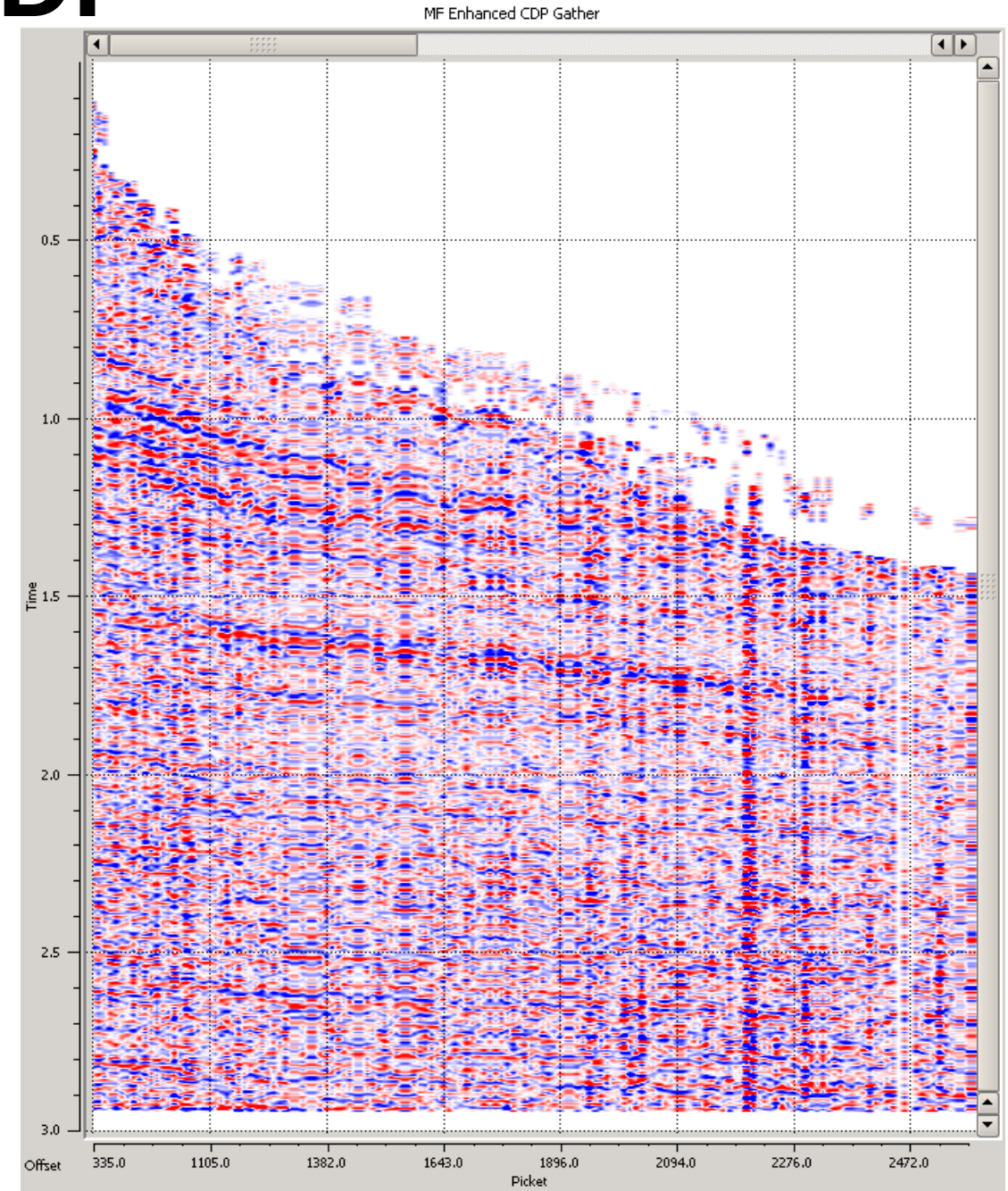
777.0
1312.0
1576.0
1735.0
1982.0
2161.0
2267.0
Picket

MF CDP


MF Enhanced CDP Gather
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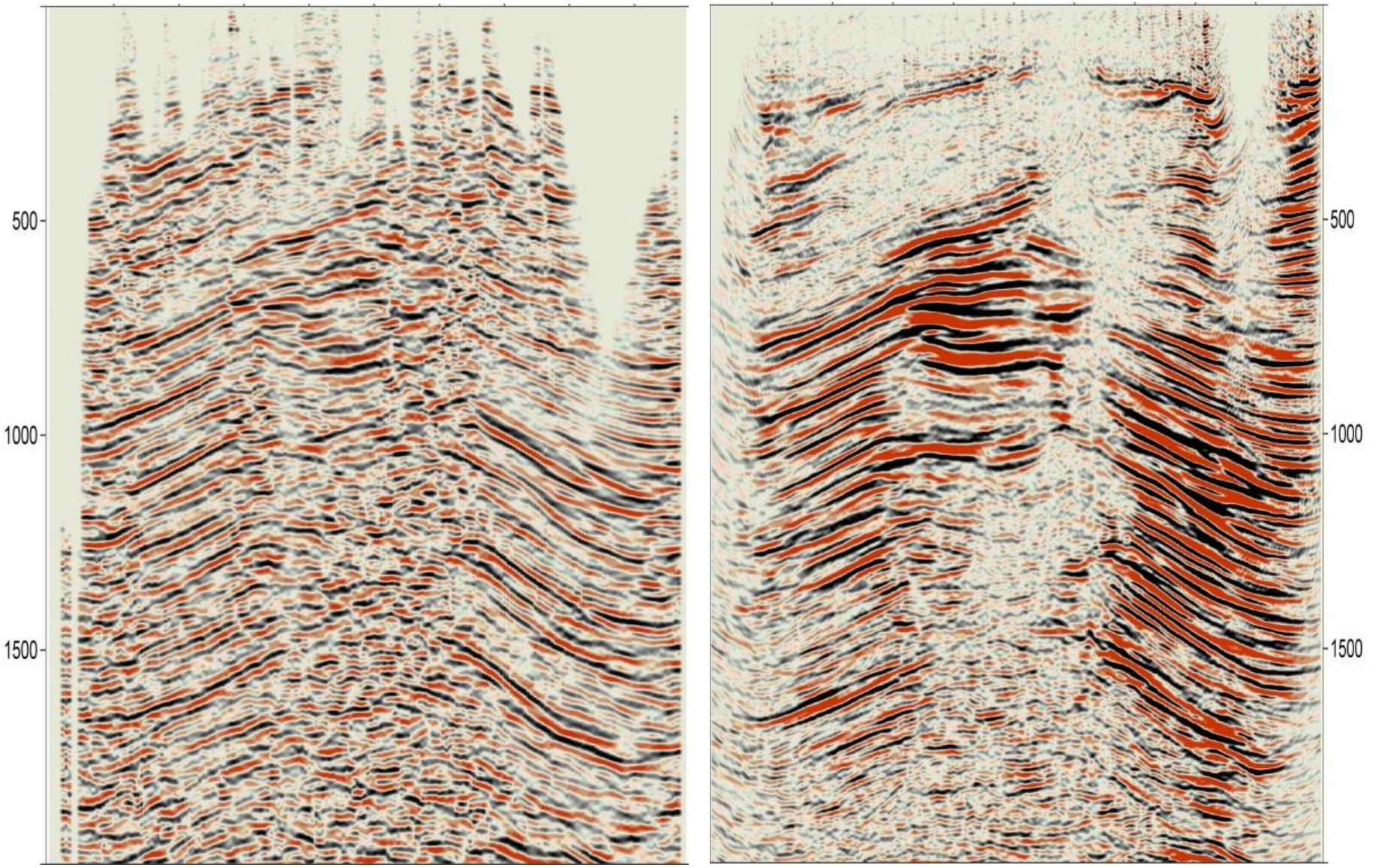
2094.0
2276.0
2472.0
Picket

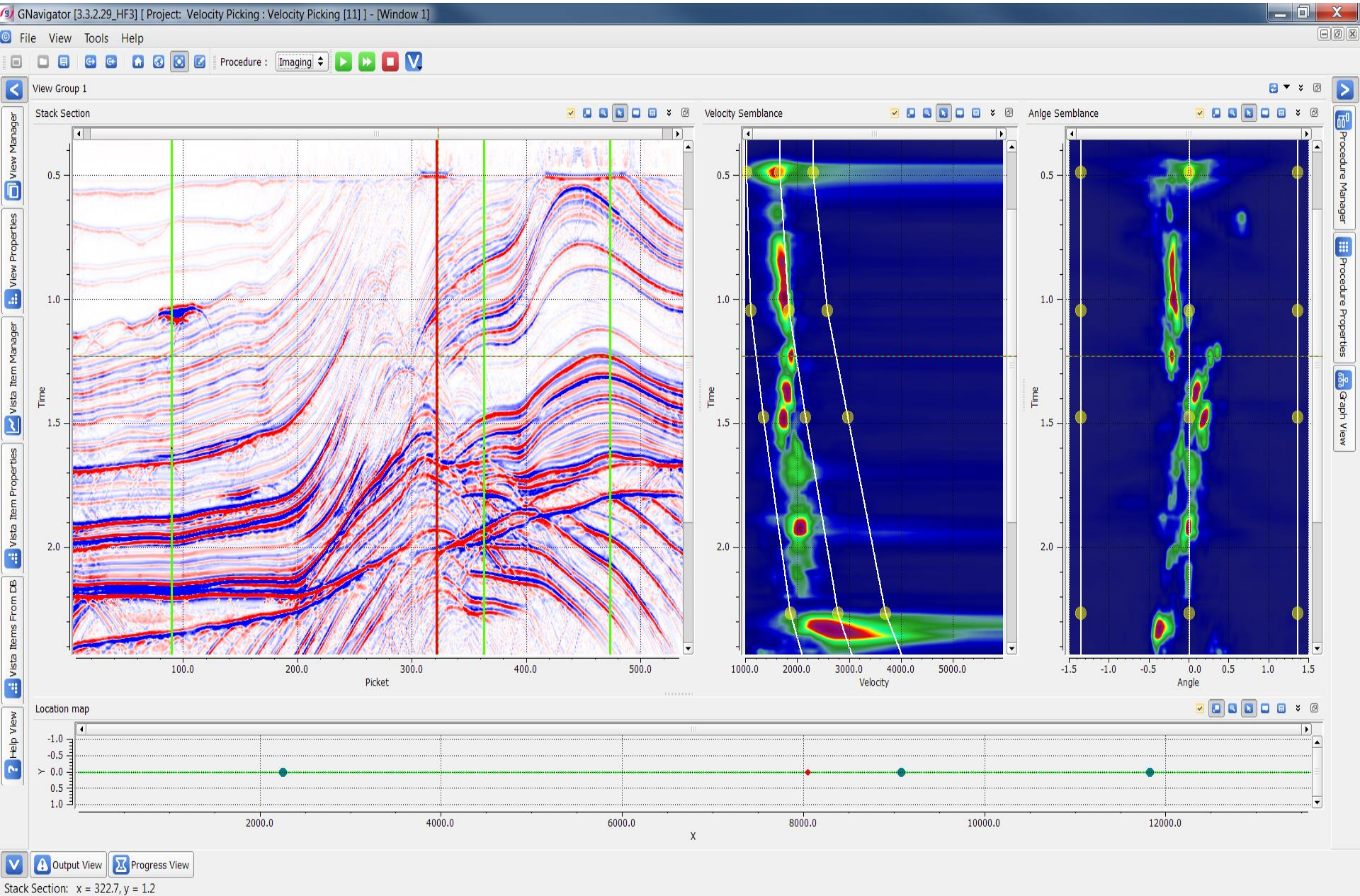
PSTM results



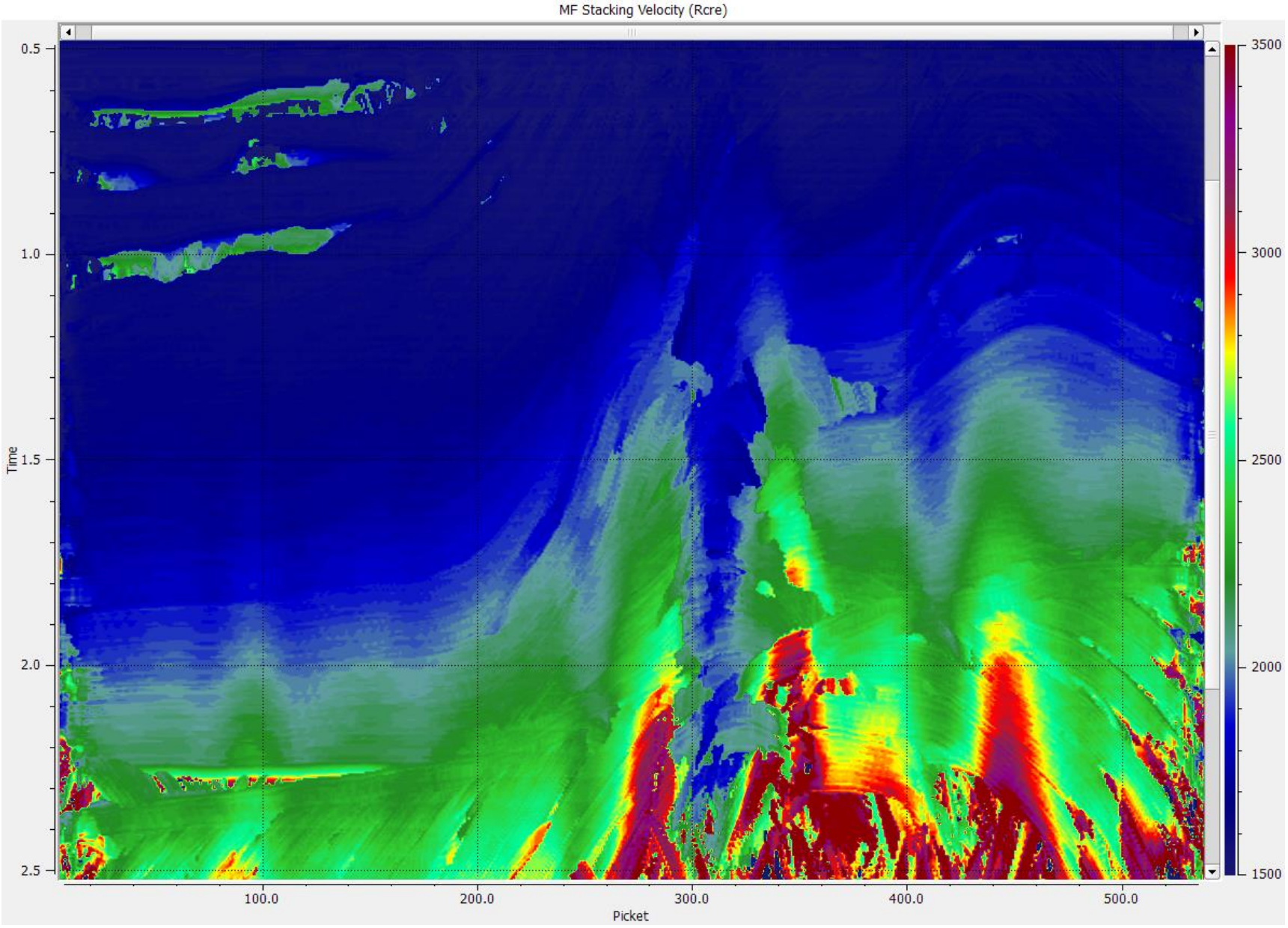
conventional

MultiFocusing

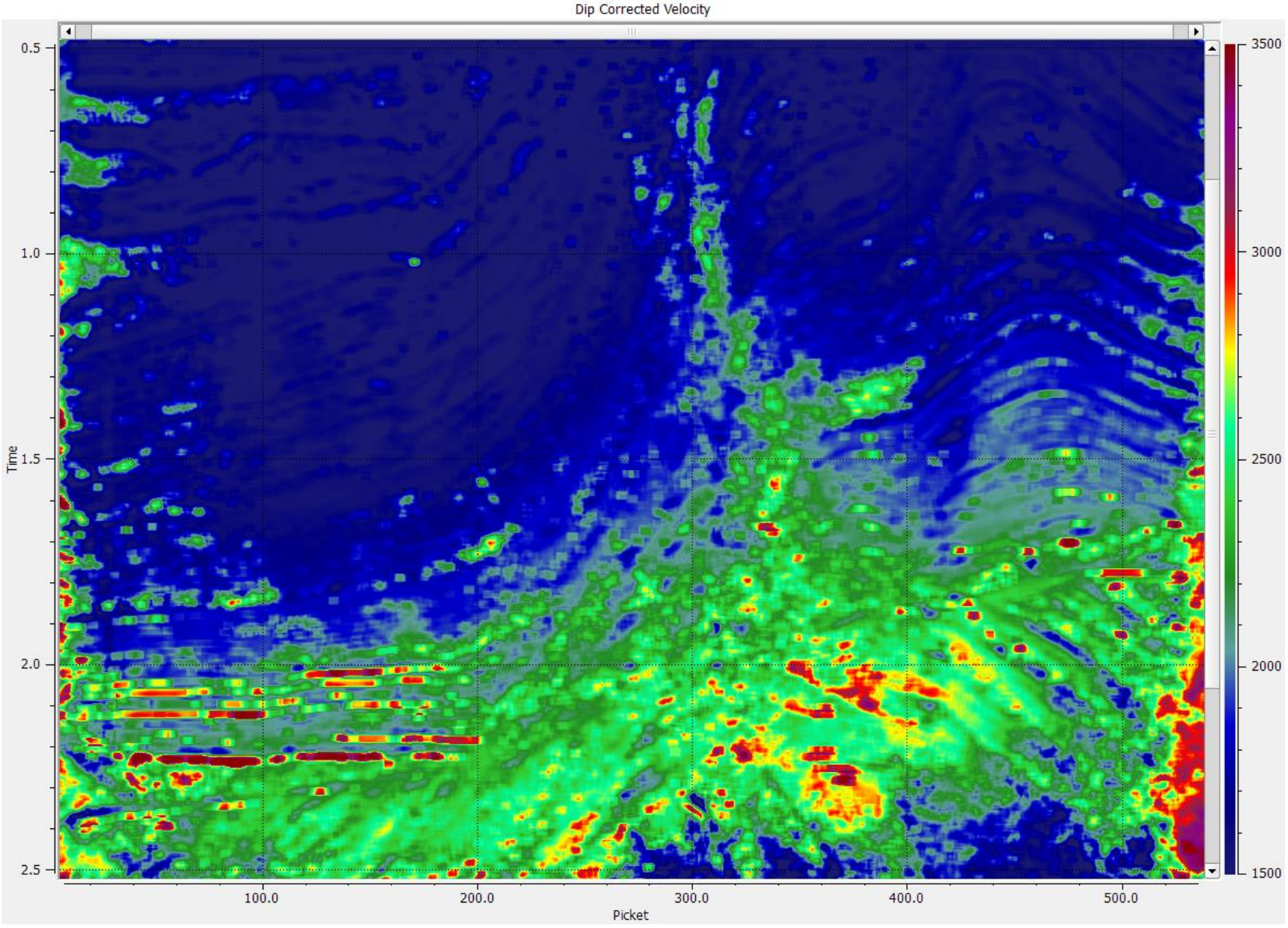
Velocity analysis



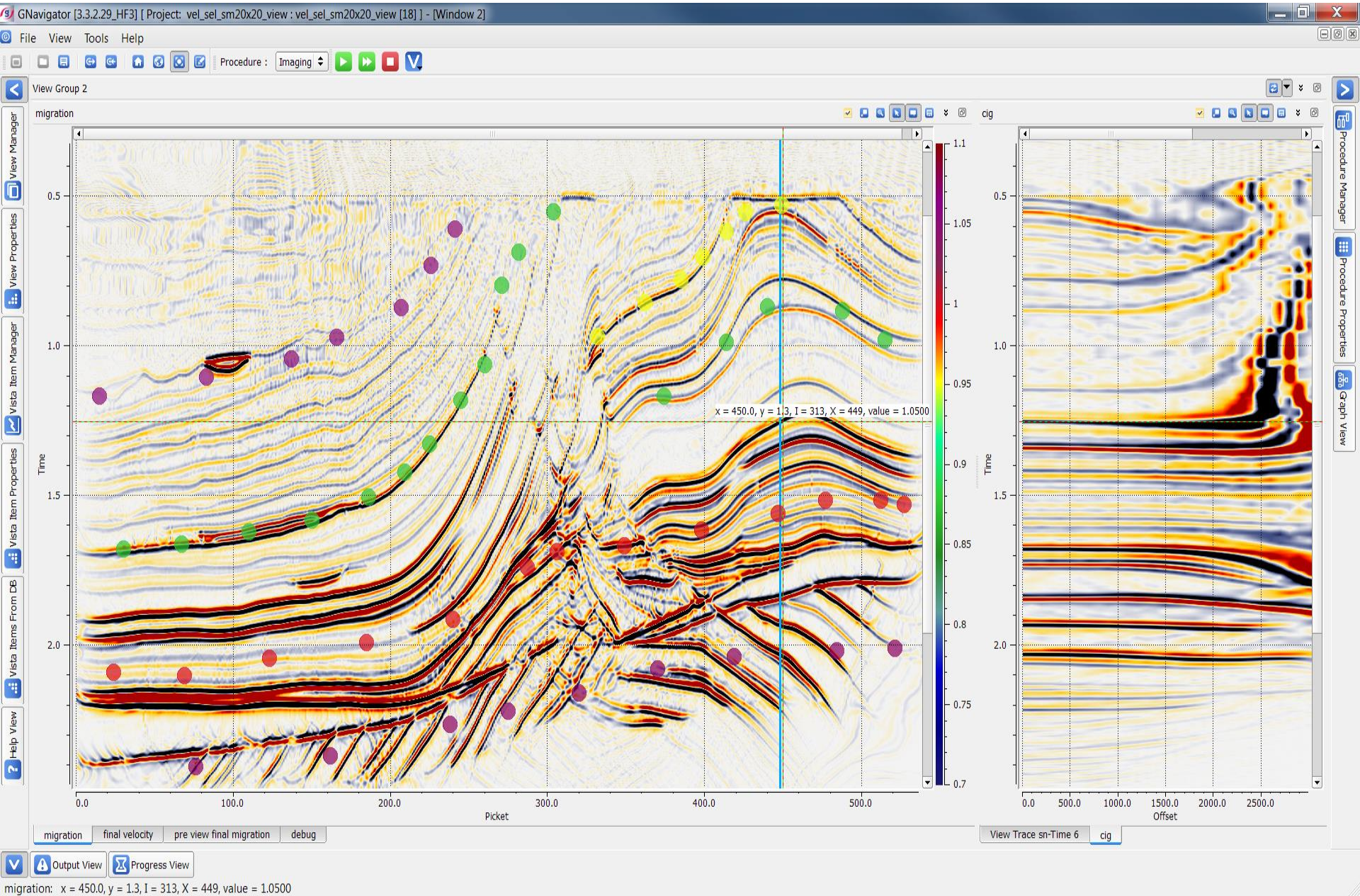
MF stacking velocities



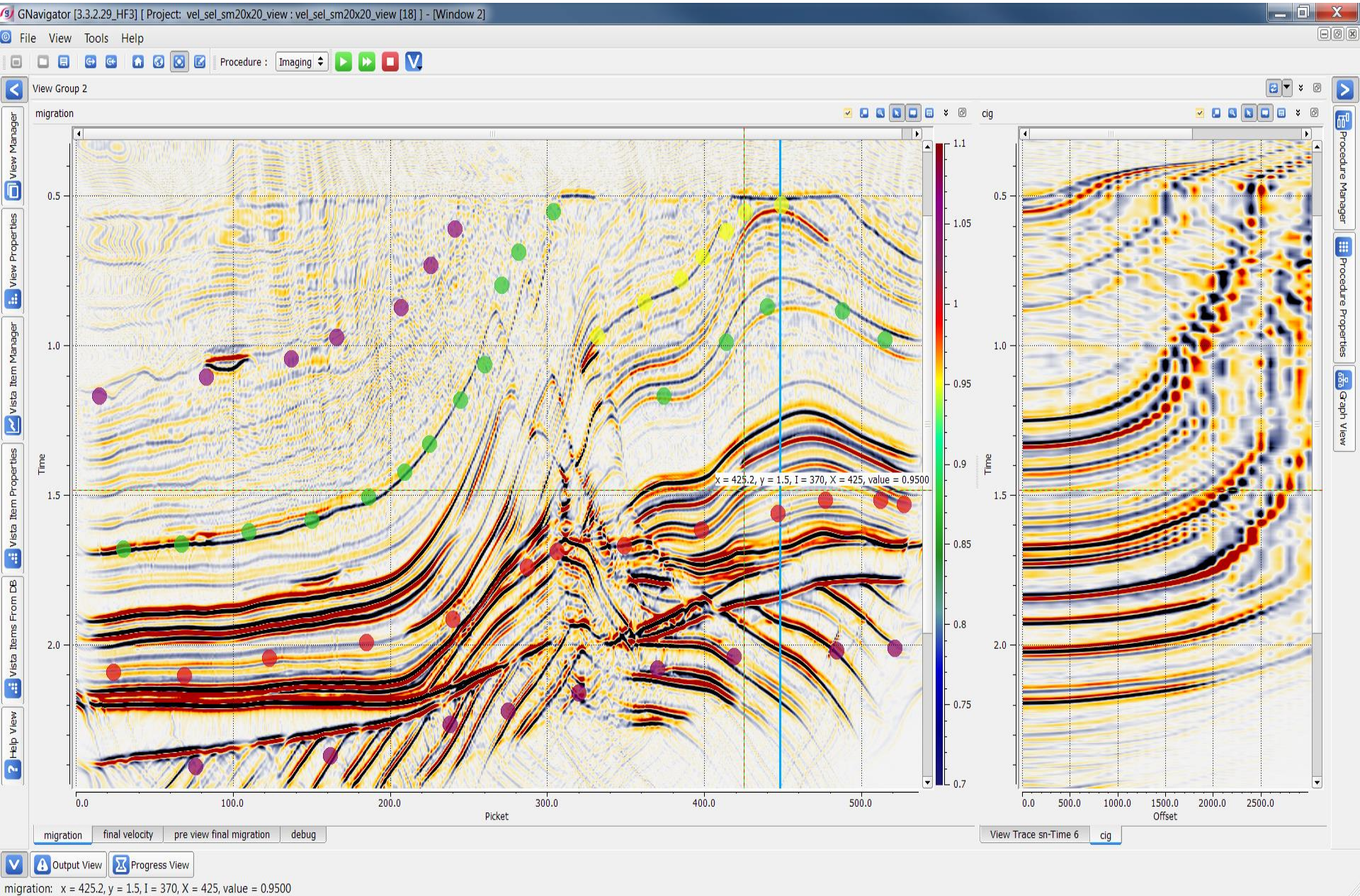
MF dip corrected vels



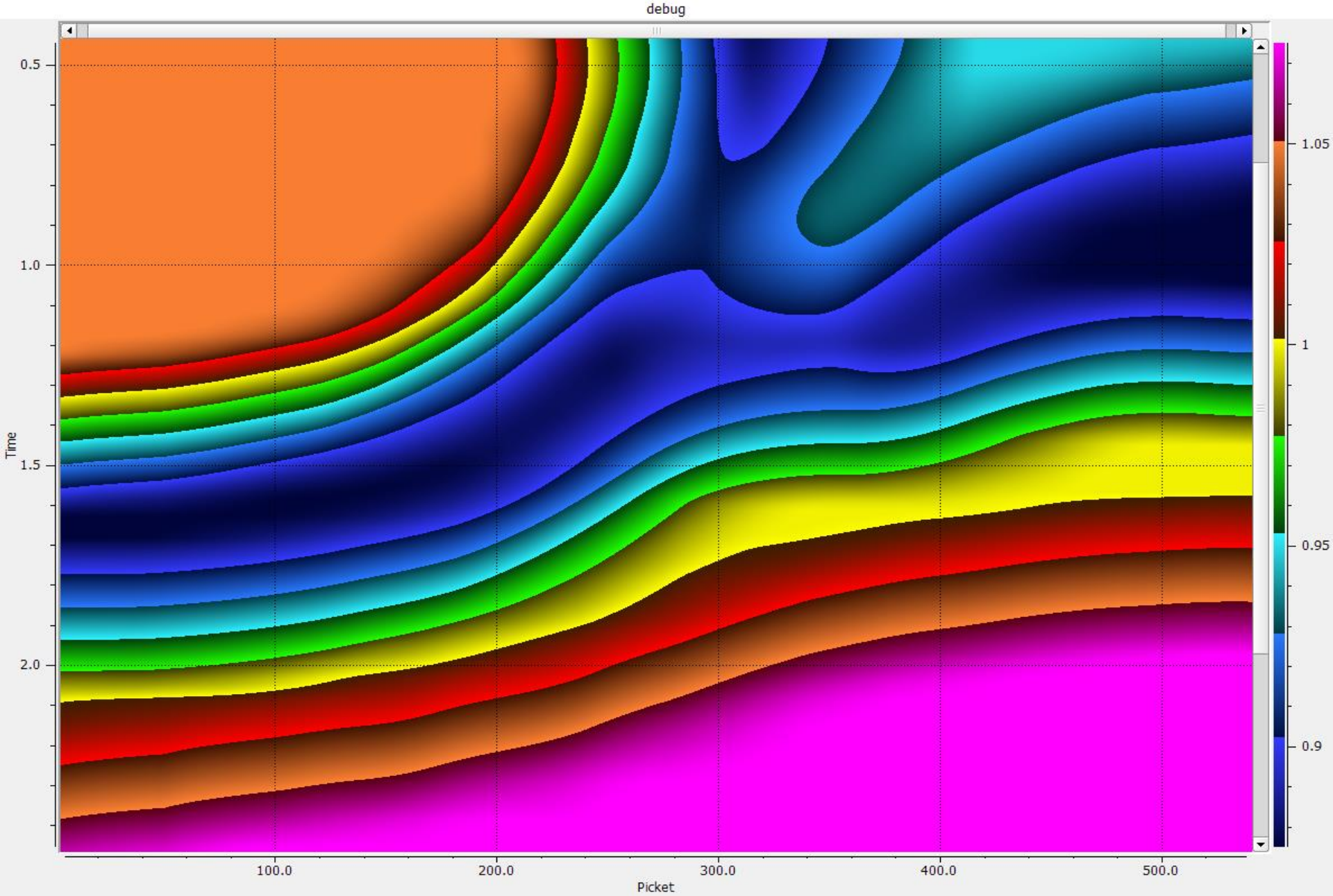
Velocity selector



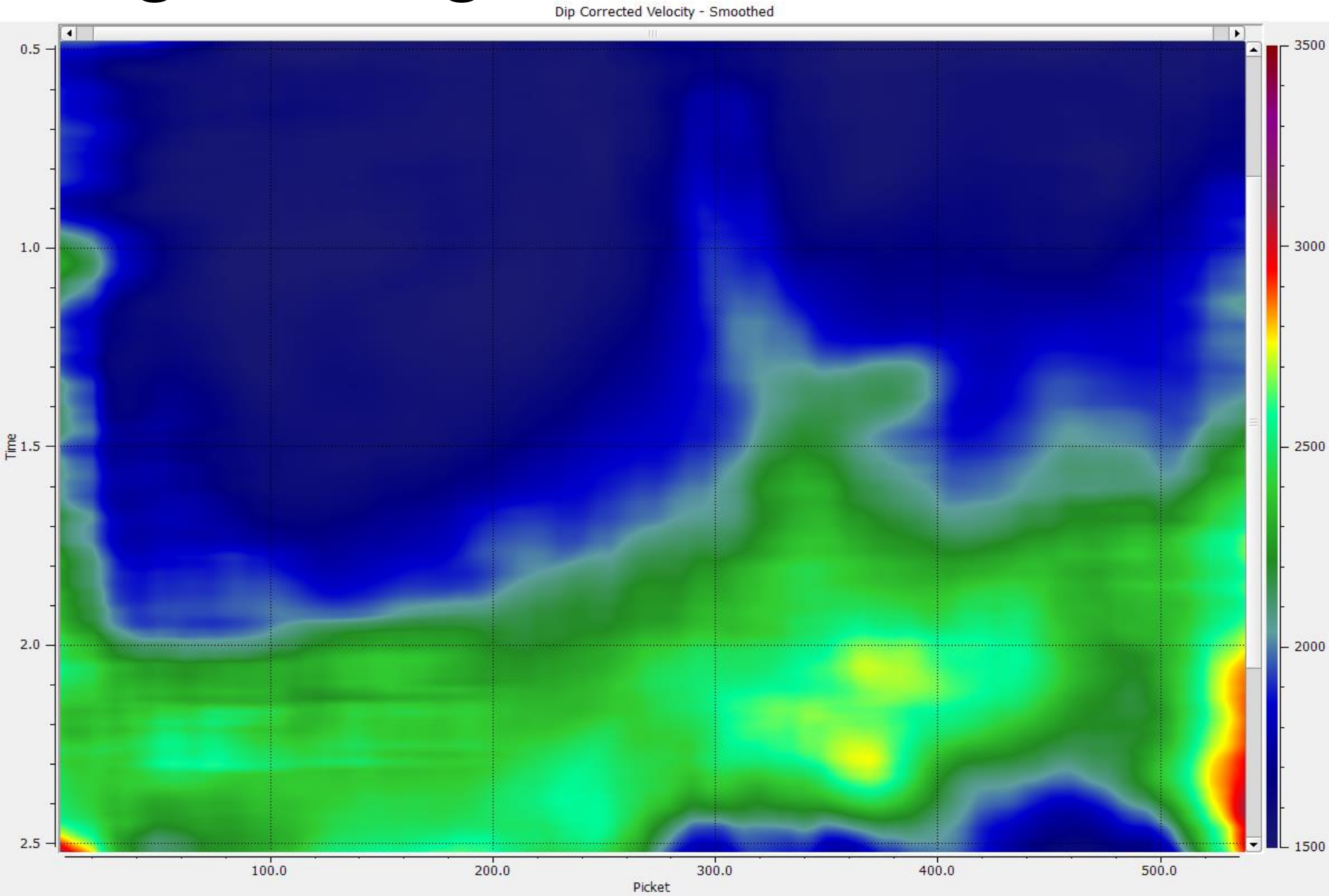
Velocity selector



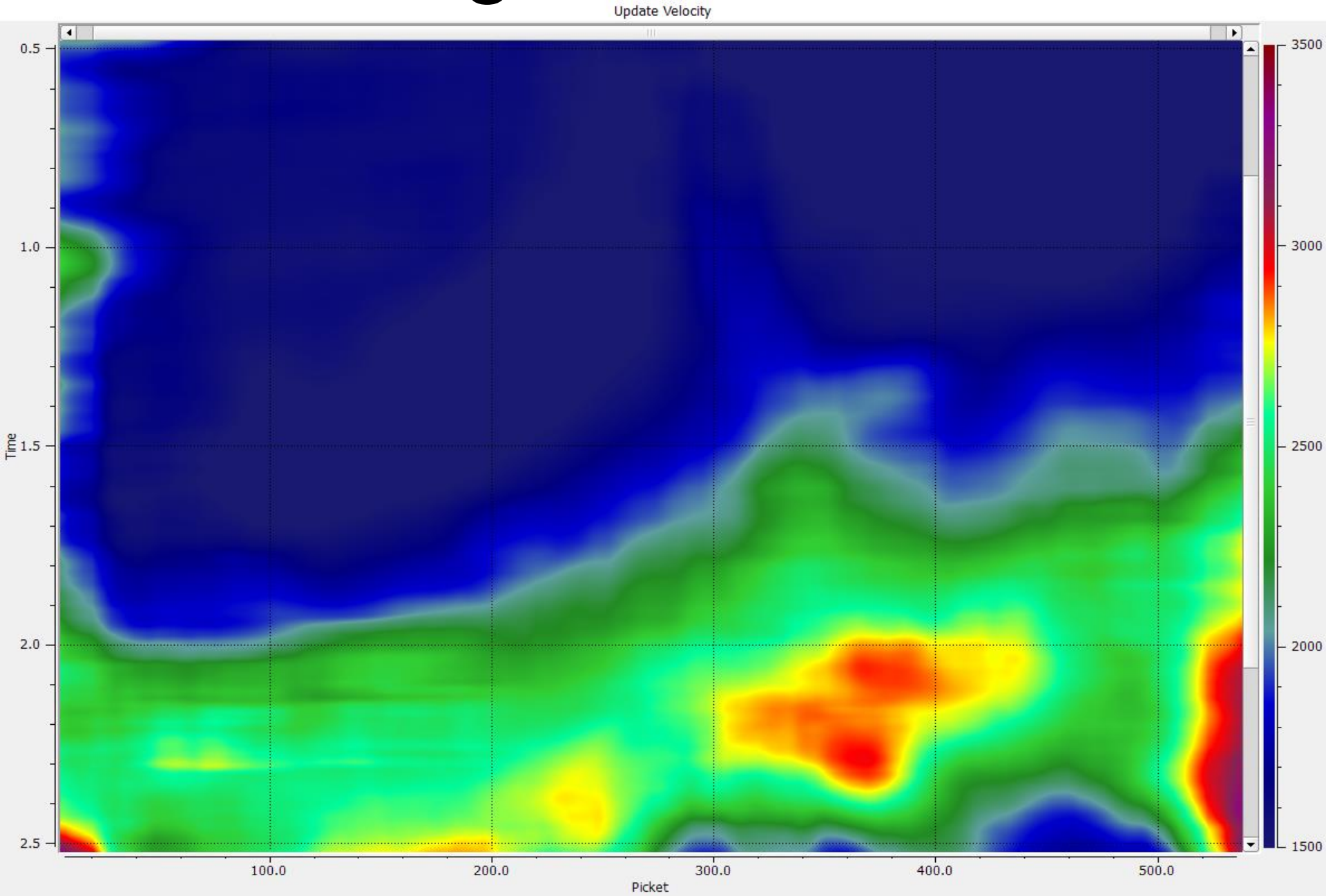
Velocity percentage



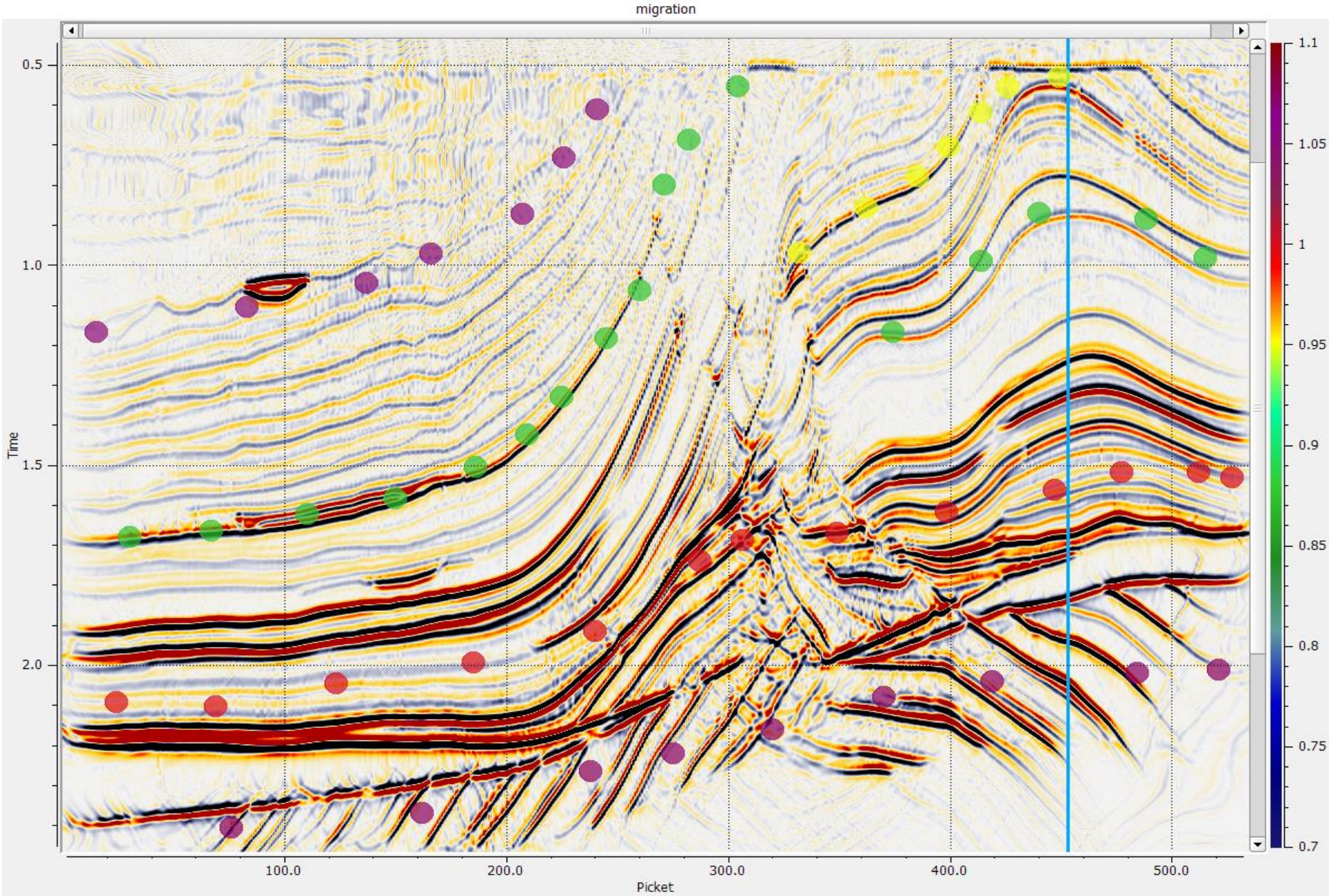
Original migration vels



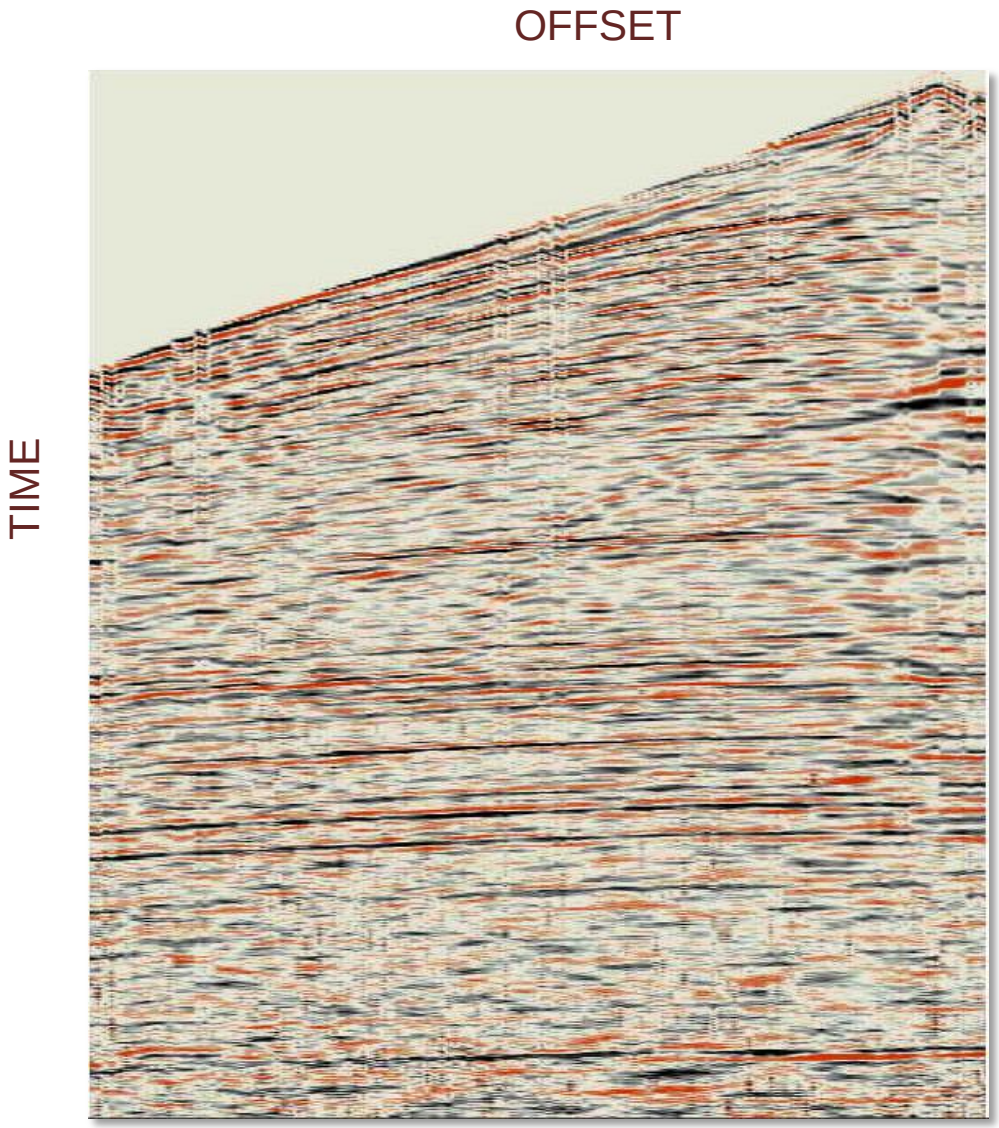
Modified migration vels



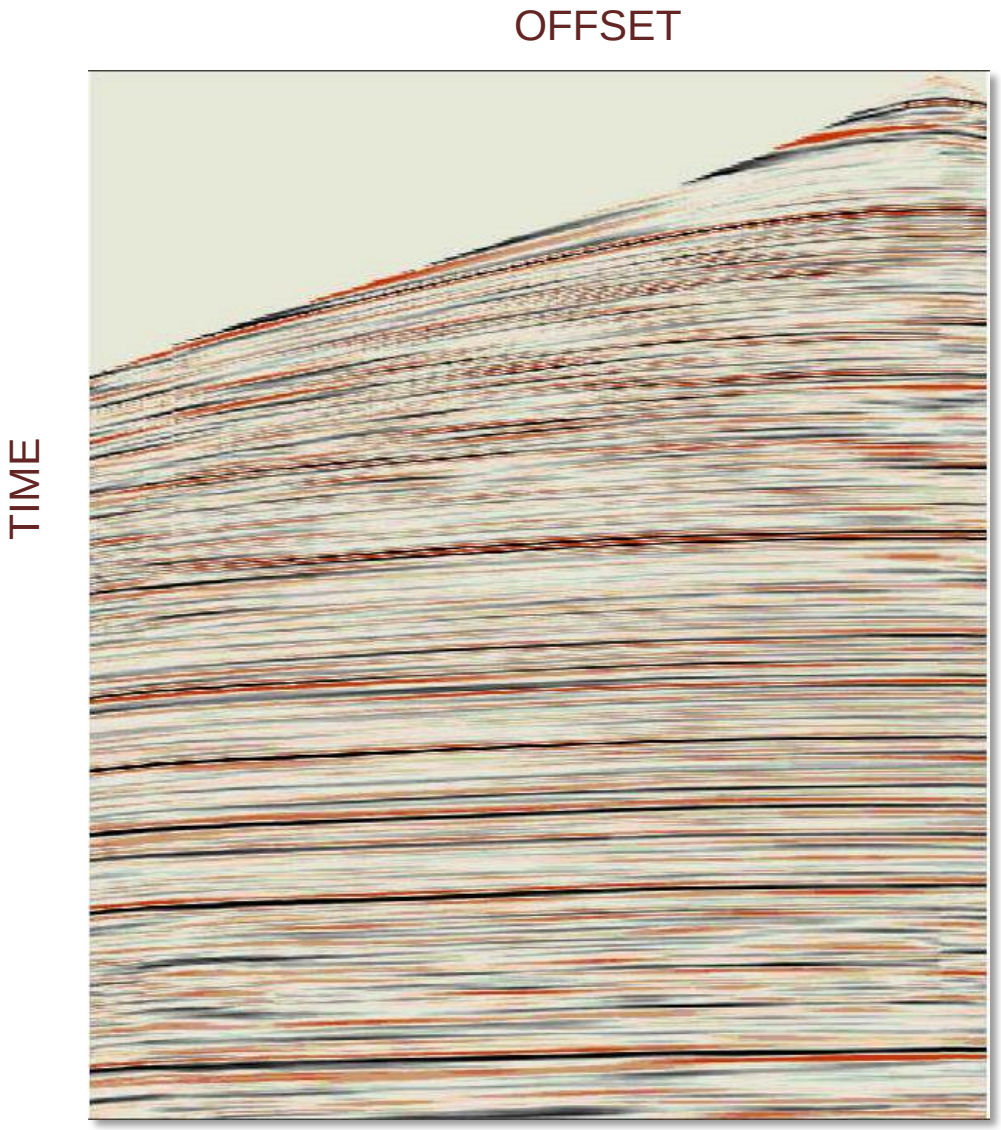
Updated PSTM



Original gather



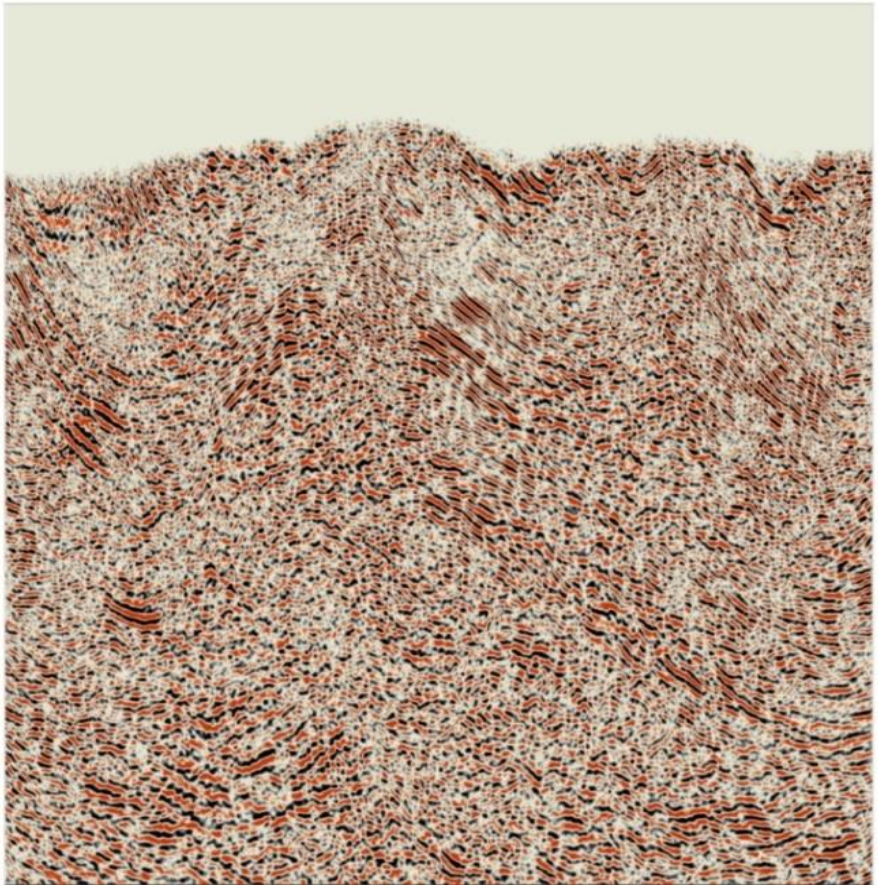
MF enhanced gather



On-Shore

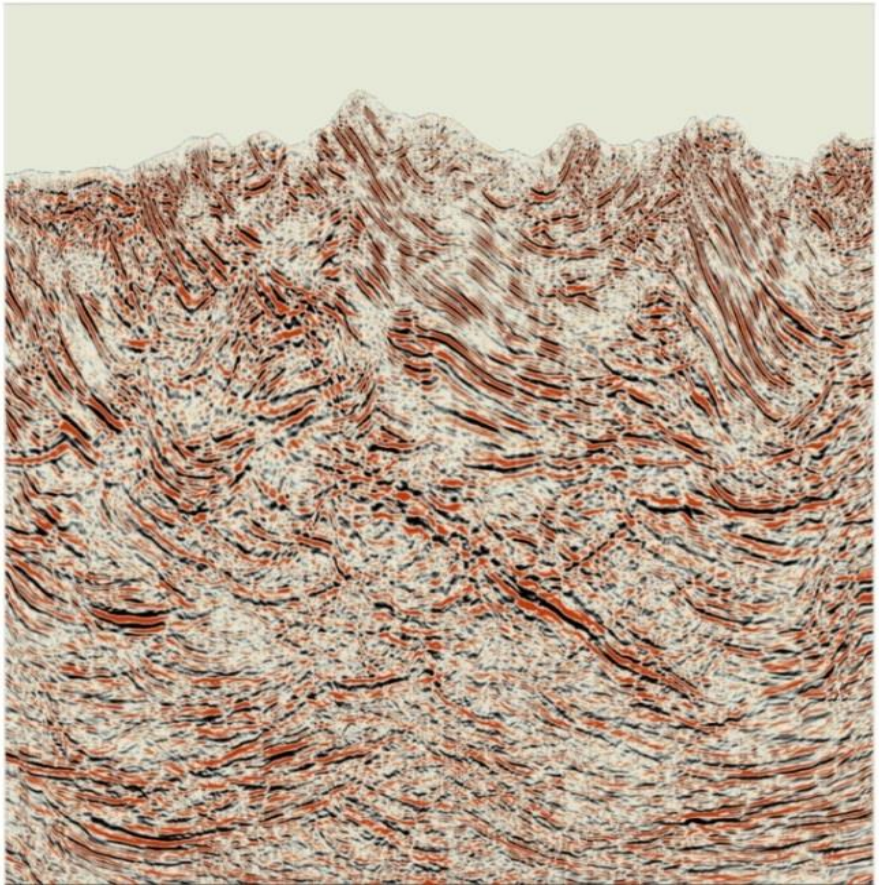
South-East Asia

CMP Location



conventional PSTM processing

CMP Location

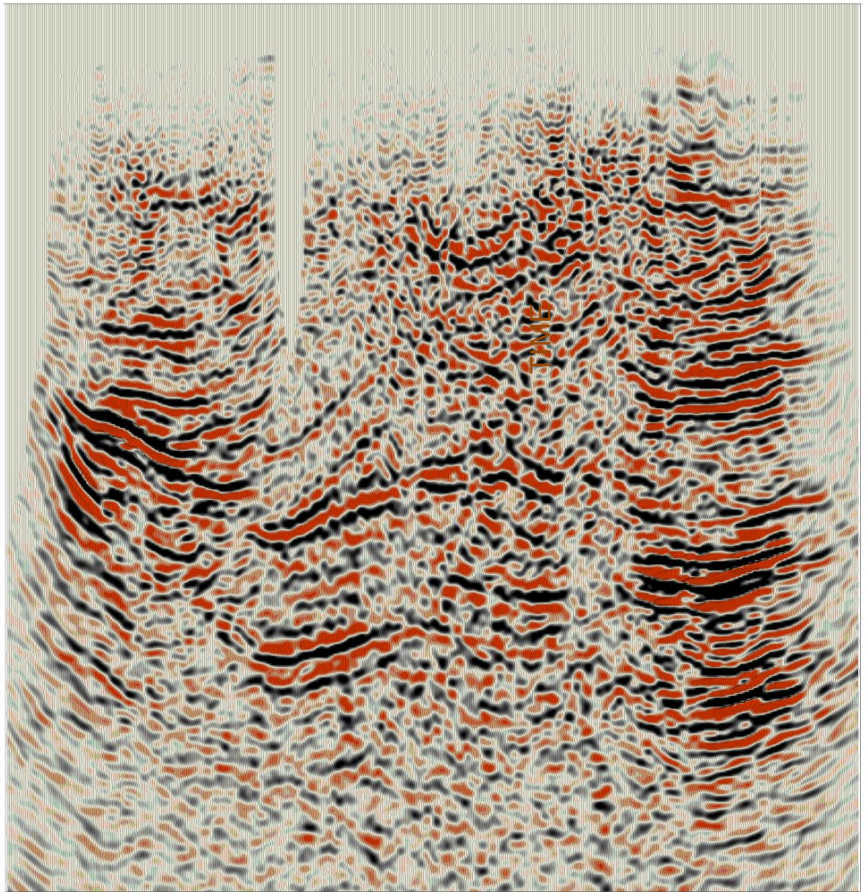


MultiFocusing PSTM processing

On-Shore

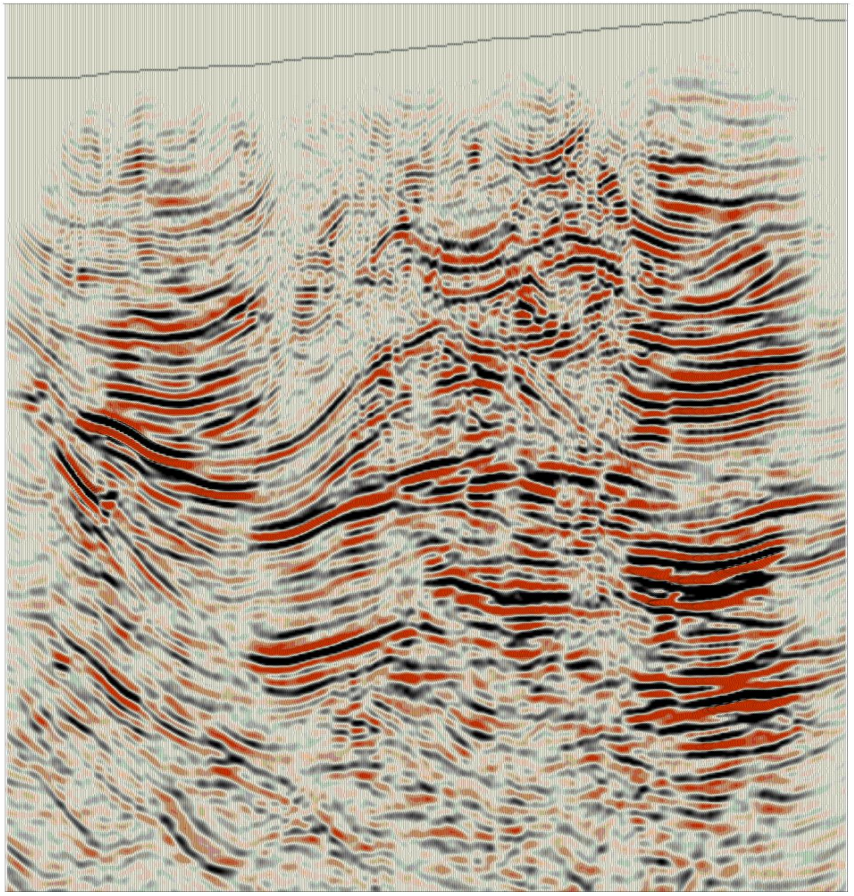
USA

CMP Location



conventional PSTM processing

CMP Location



MultiFocusing PSTM processing

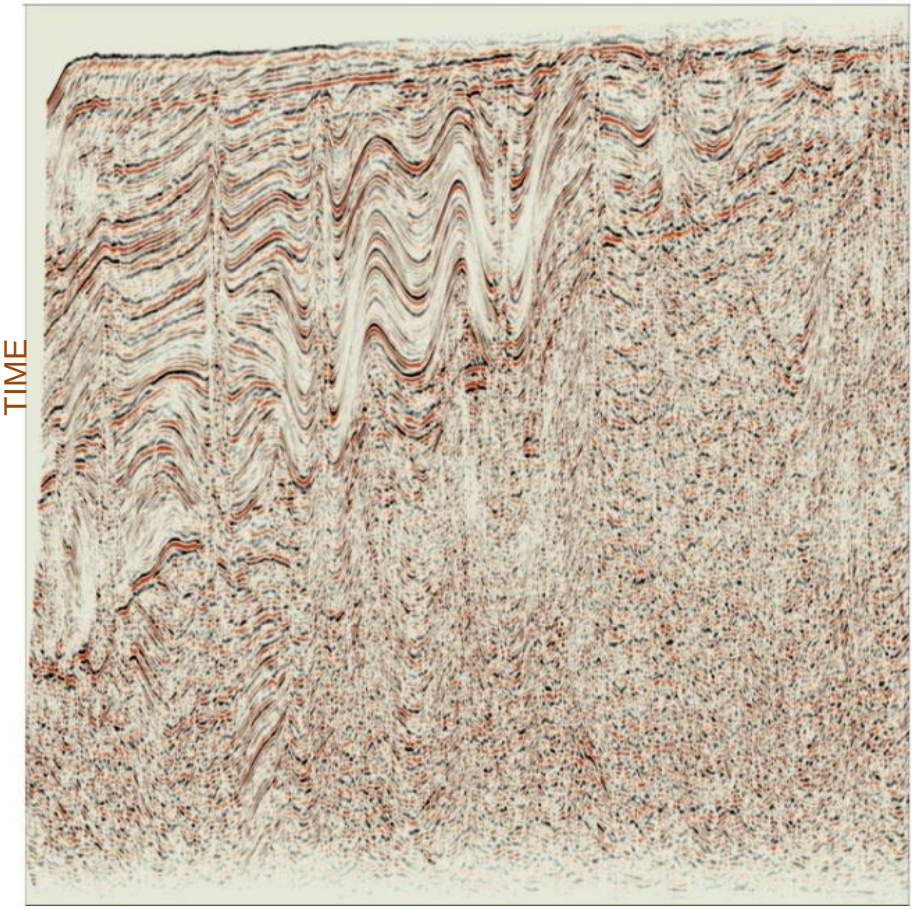
Off-Shore

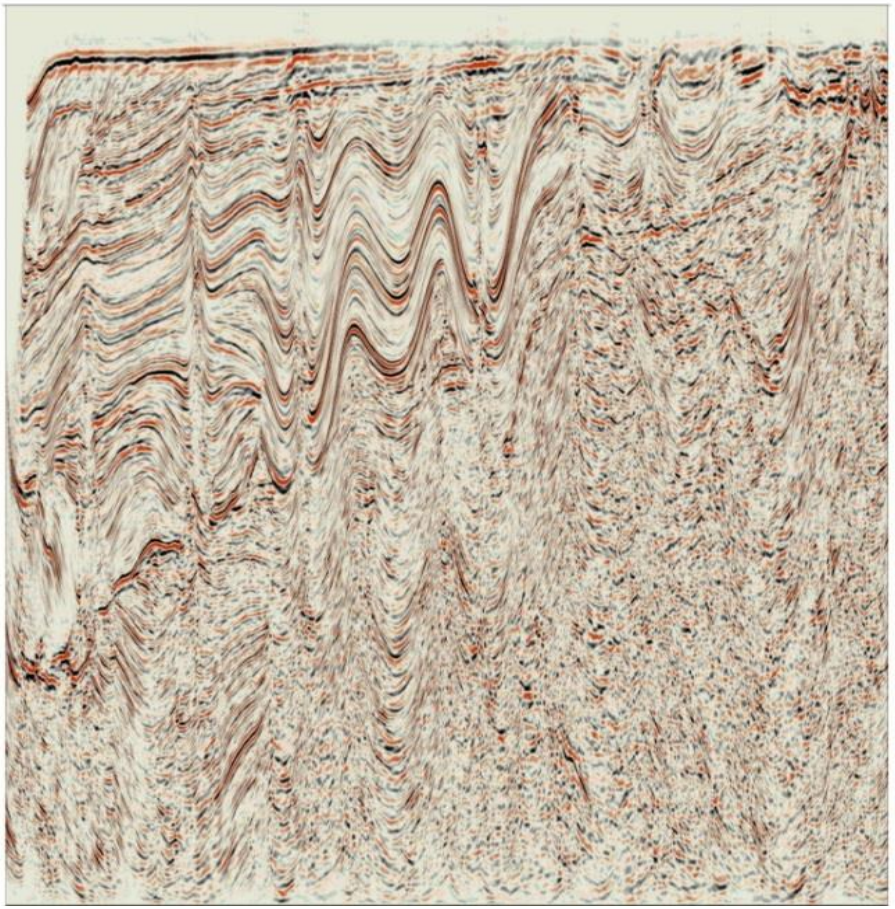
West Central Africa

CMP Location

CMP Location

TIME





conventional PSTM processing

MultiFocusing PSTM processing

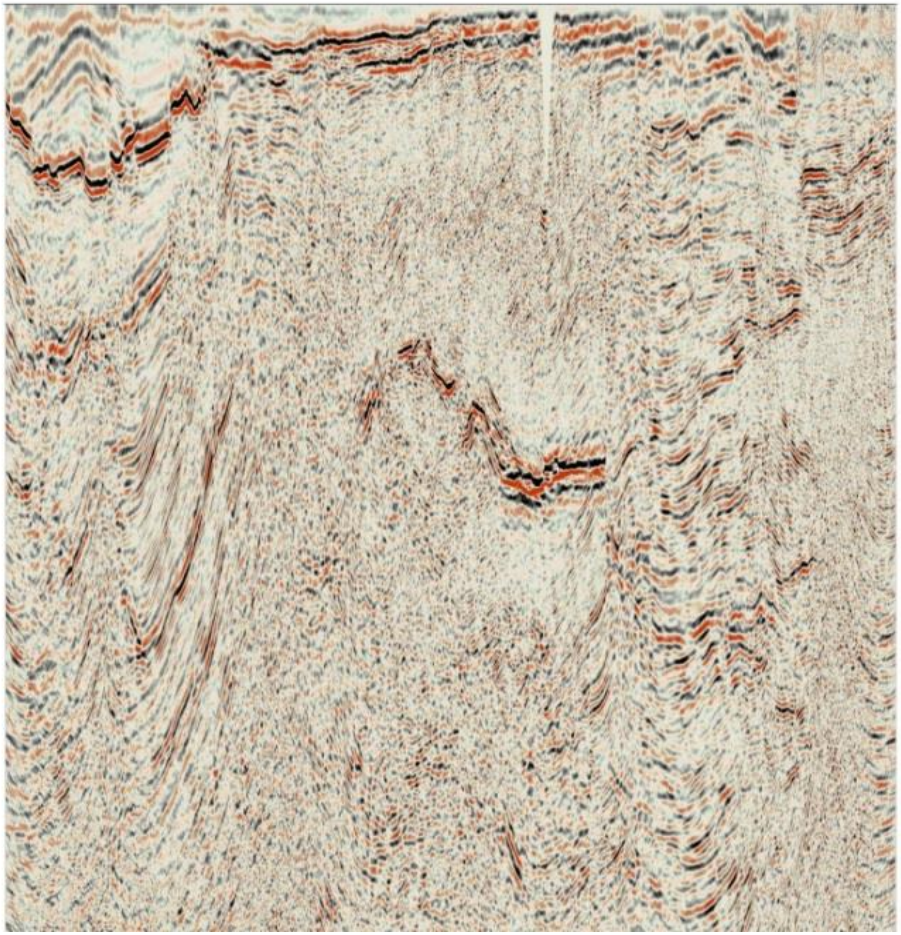
On-Shore

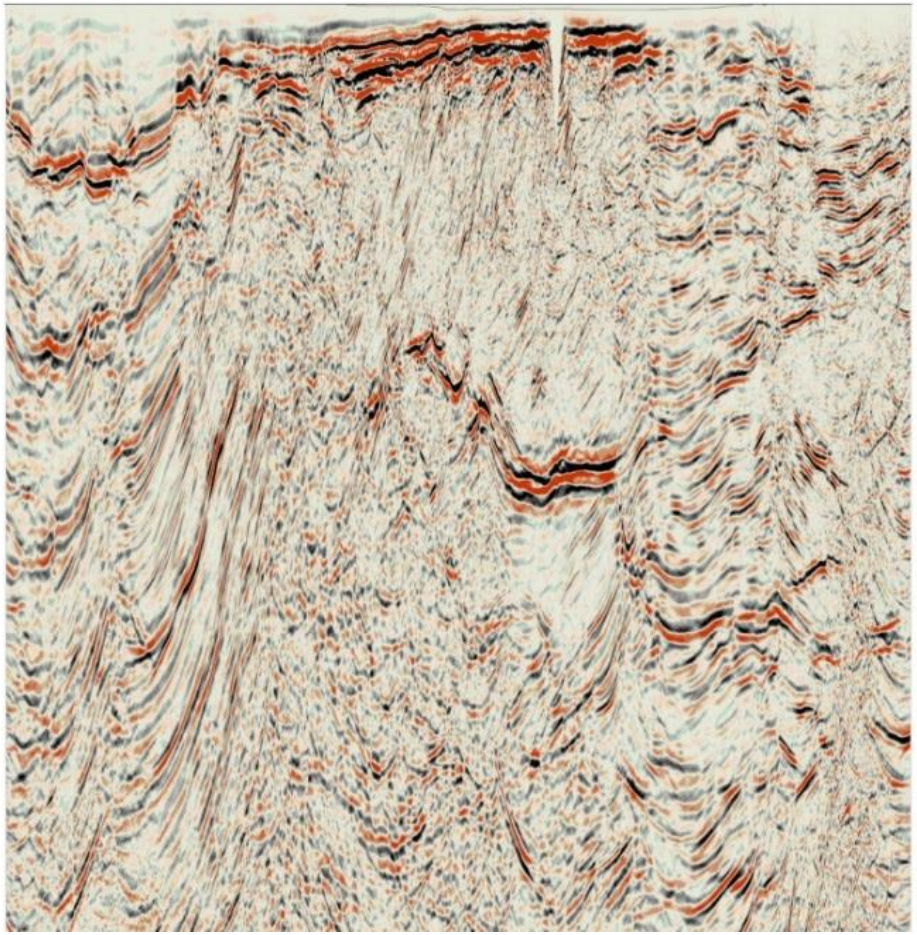
Argentina

CMP Location

CMP Location

TIME





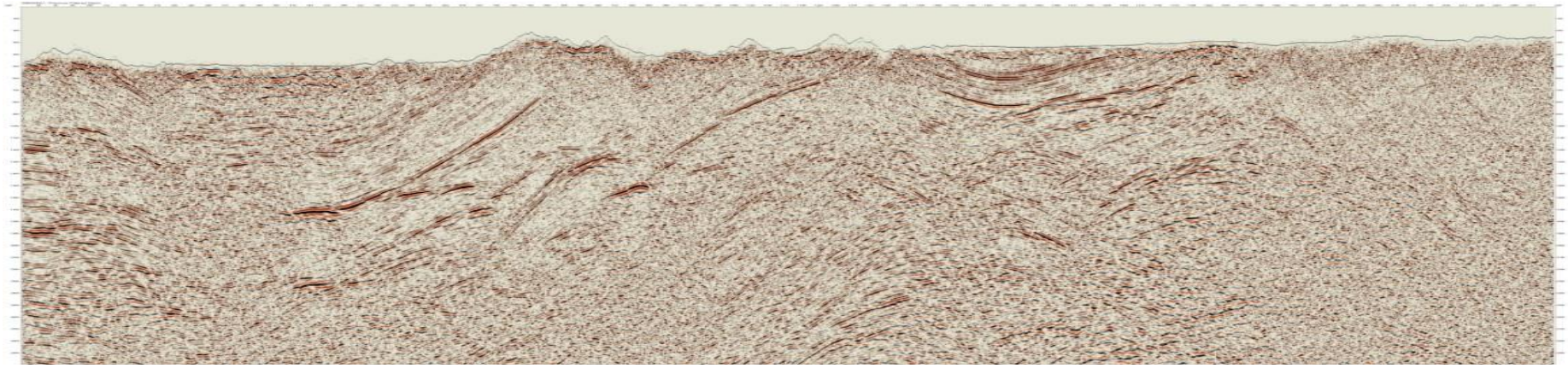
conventional PSTM processing

MultiFocusing PSTM processing

Pakistan

CMP Location

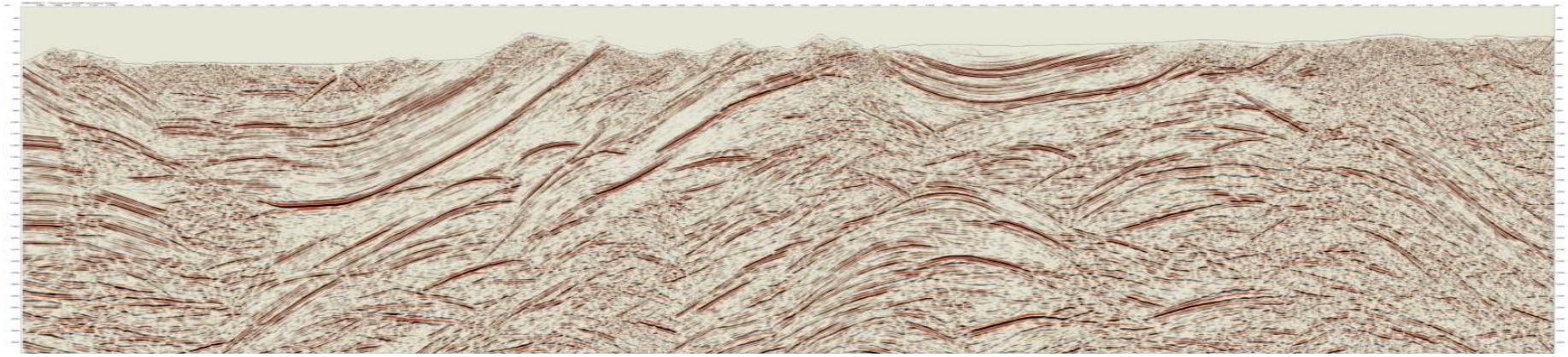
TIME



conventional Processing

CMP Location

TIME

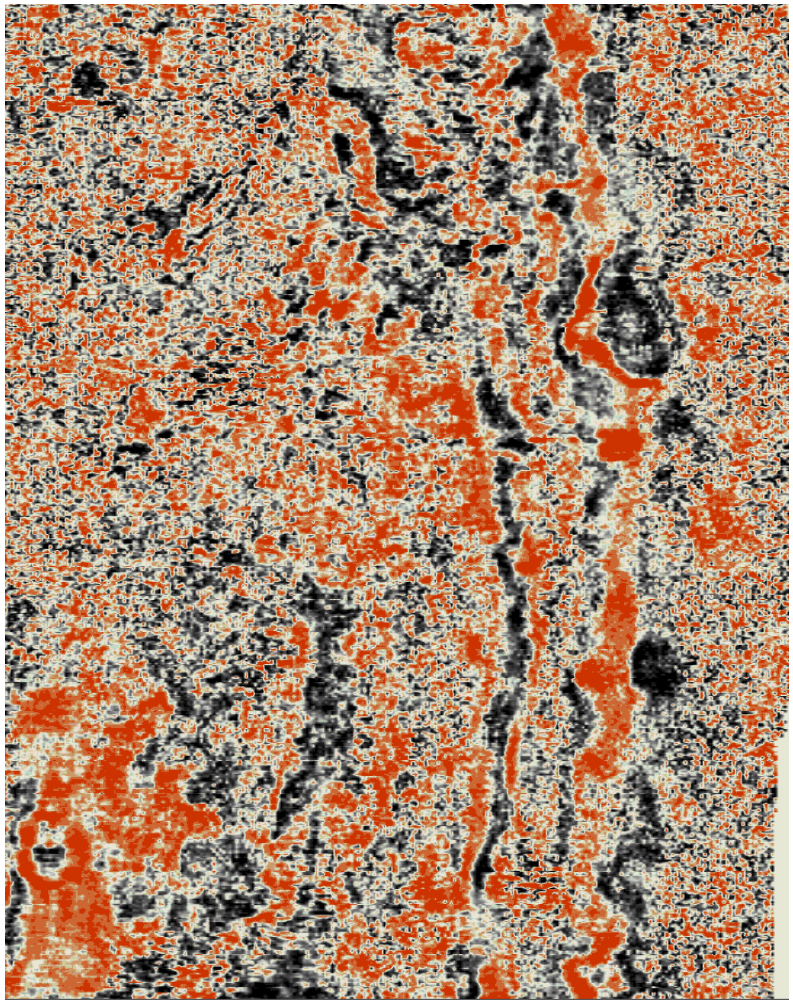


GeoMage MF Processing

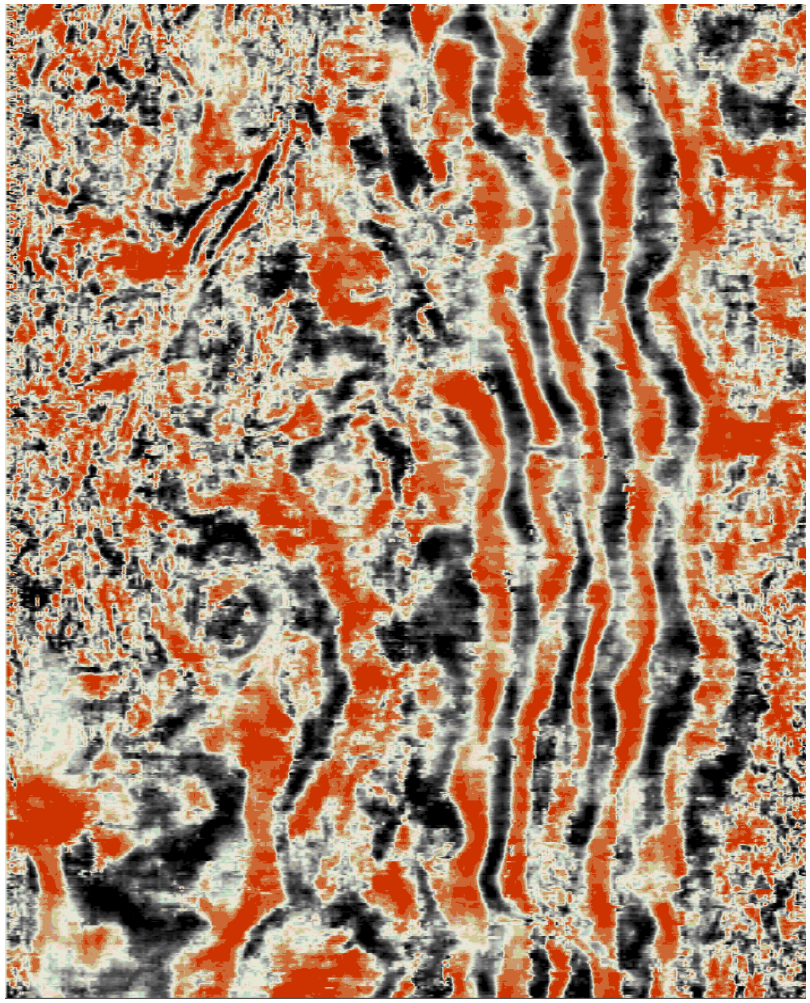
Time Slice

Russia

Time slice at 550 ms



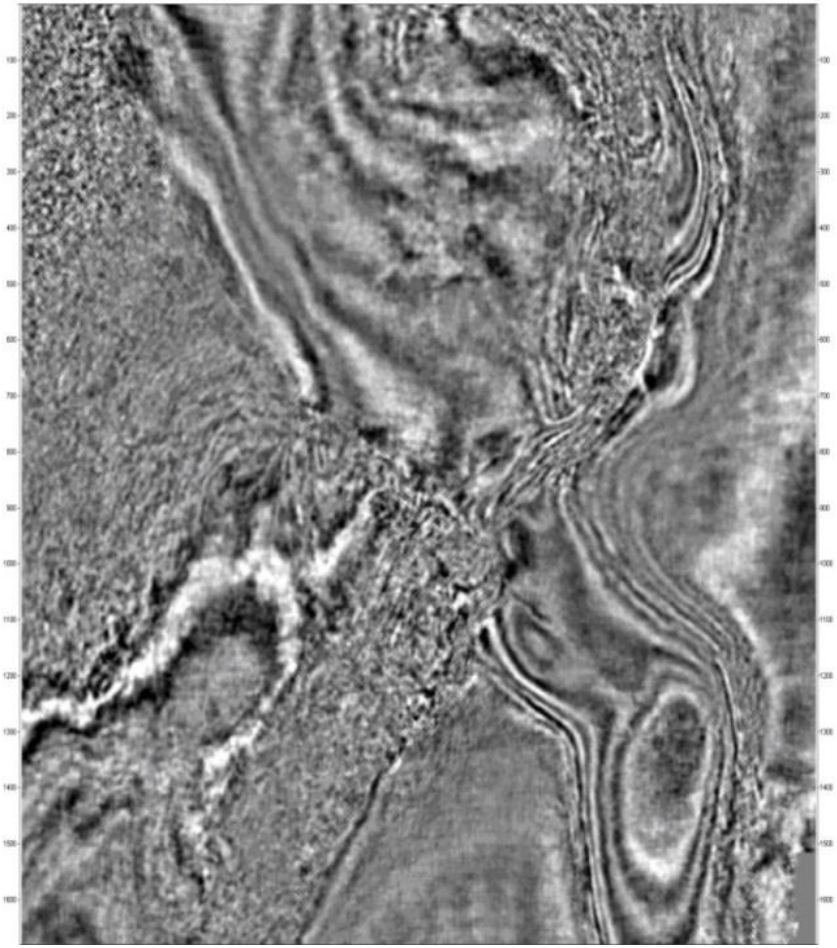
conventional



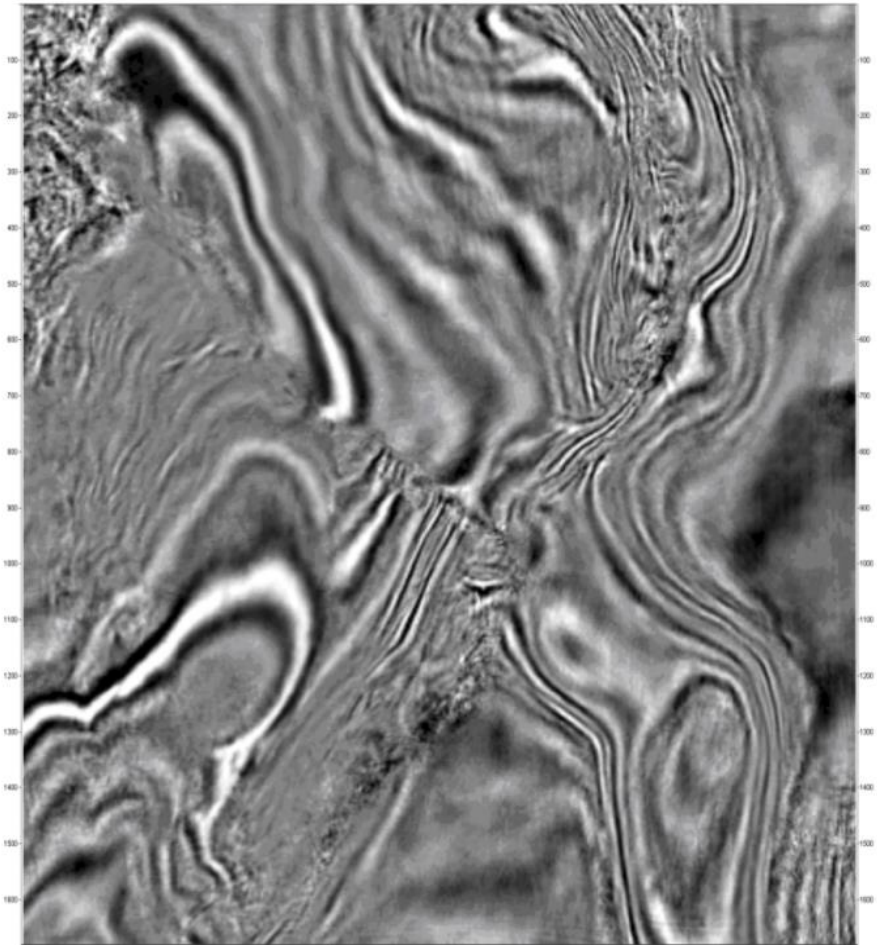
MultiFocusing

Depth Slice

Kazakhstan



conventional PreSDM



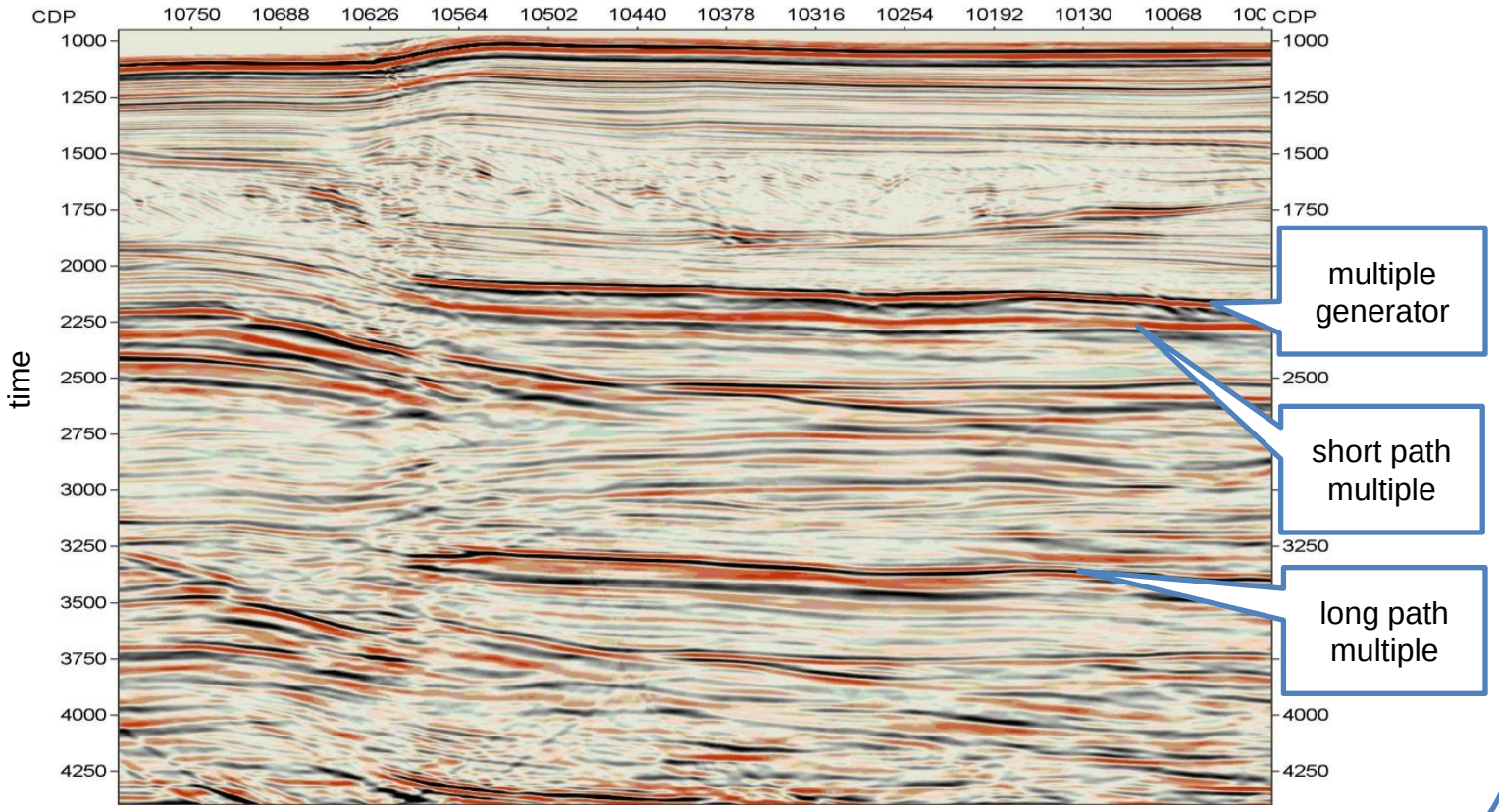
MF-PostSDM

MultiFocusing multiple attenuation

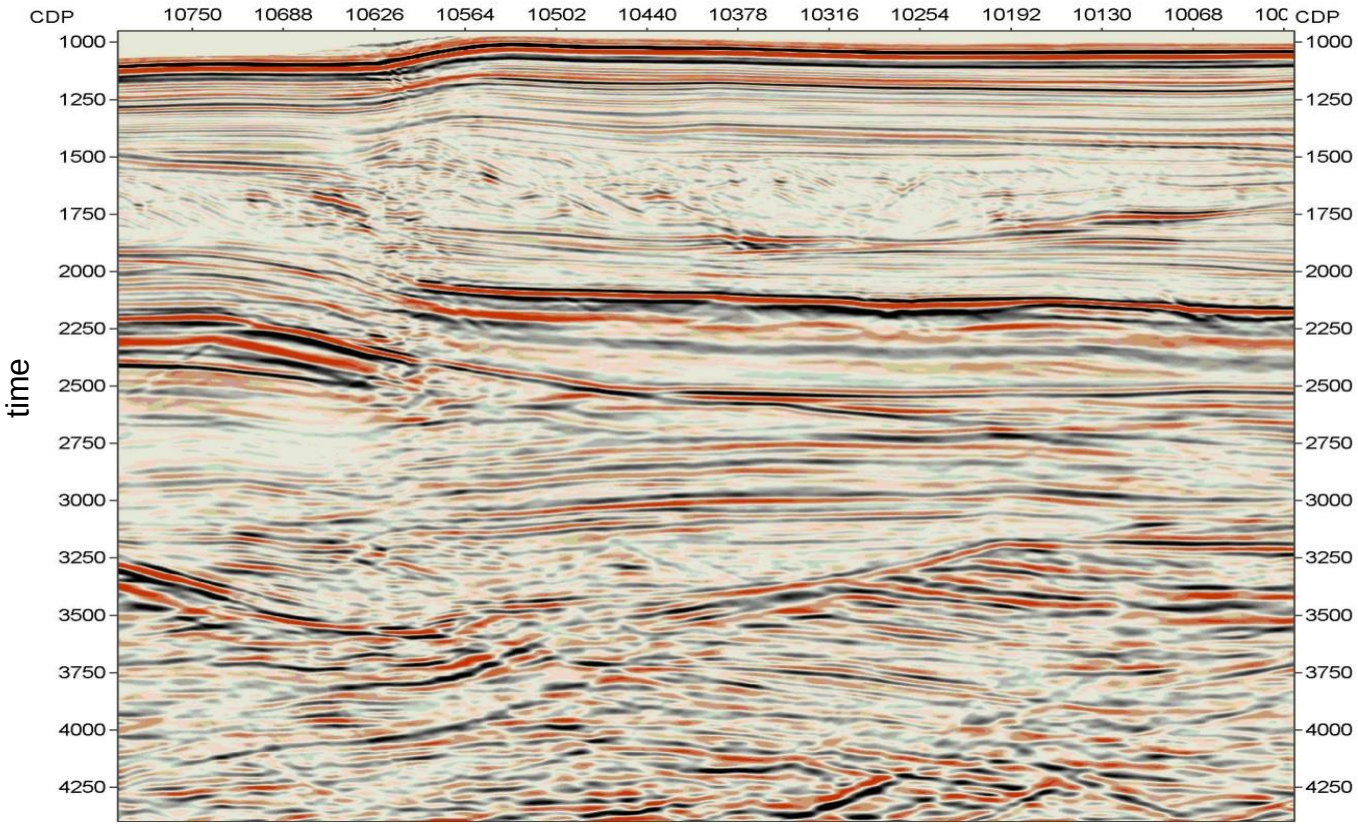
MF multiple attenuation

- multiples can be separated from the primary events by
  - velocities
  - emergence angle
- modeled multiples are subtracted using an adaptive least squares method in the pre-stack domain

Multiple Attenuation



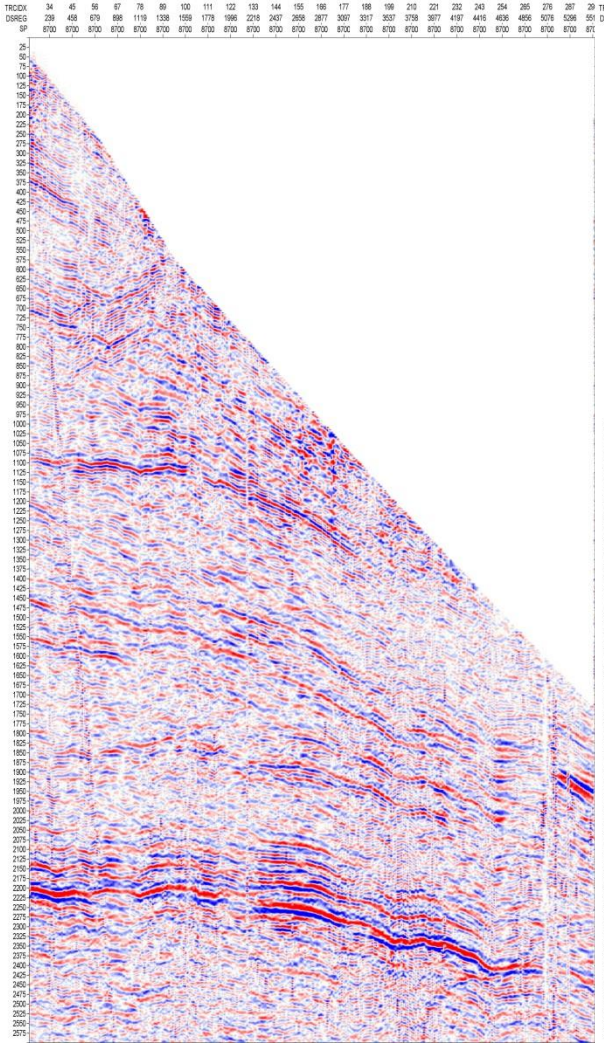
Multiple Attenuation



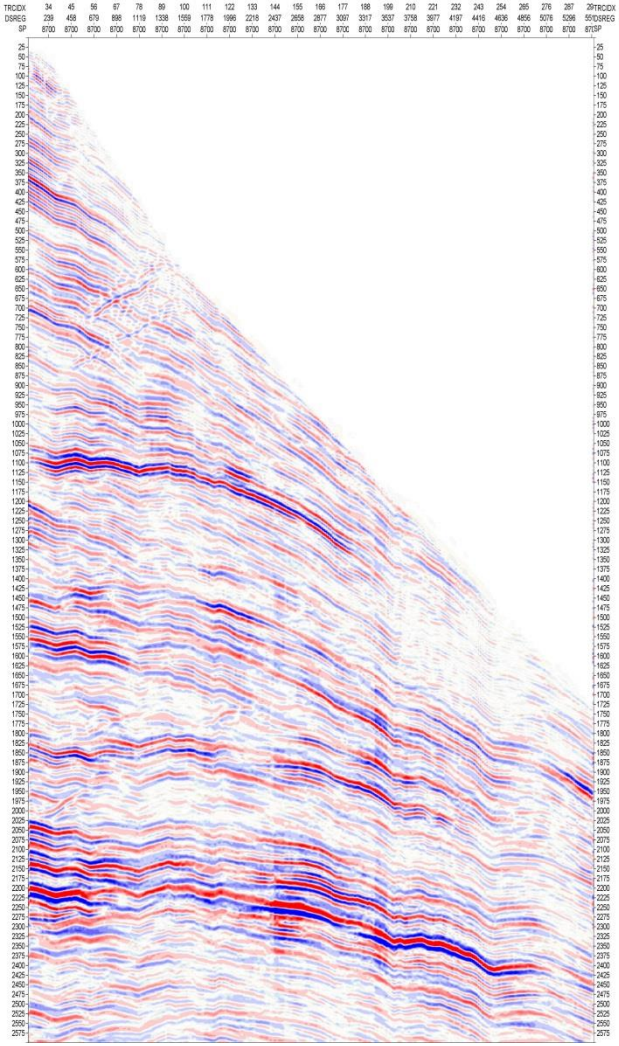
Common offset MF

COMF

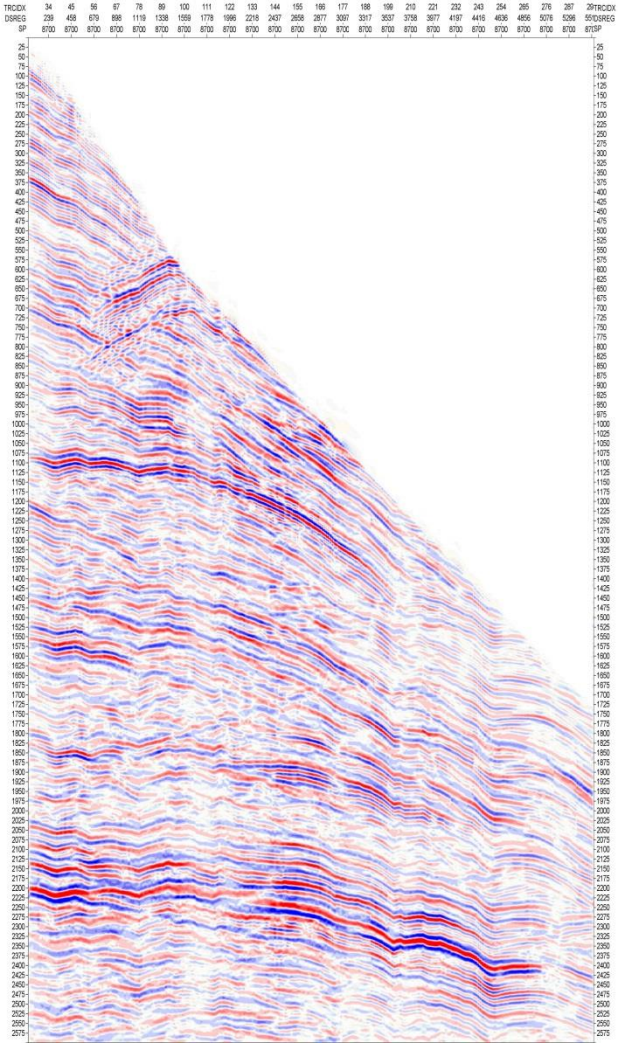
Pre-stack



Original data

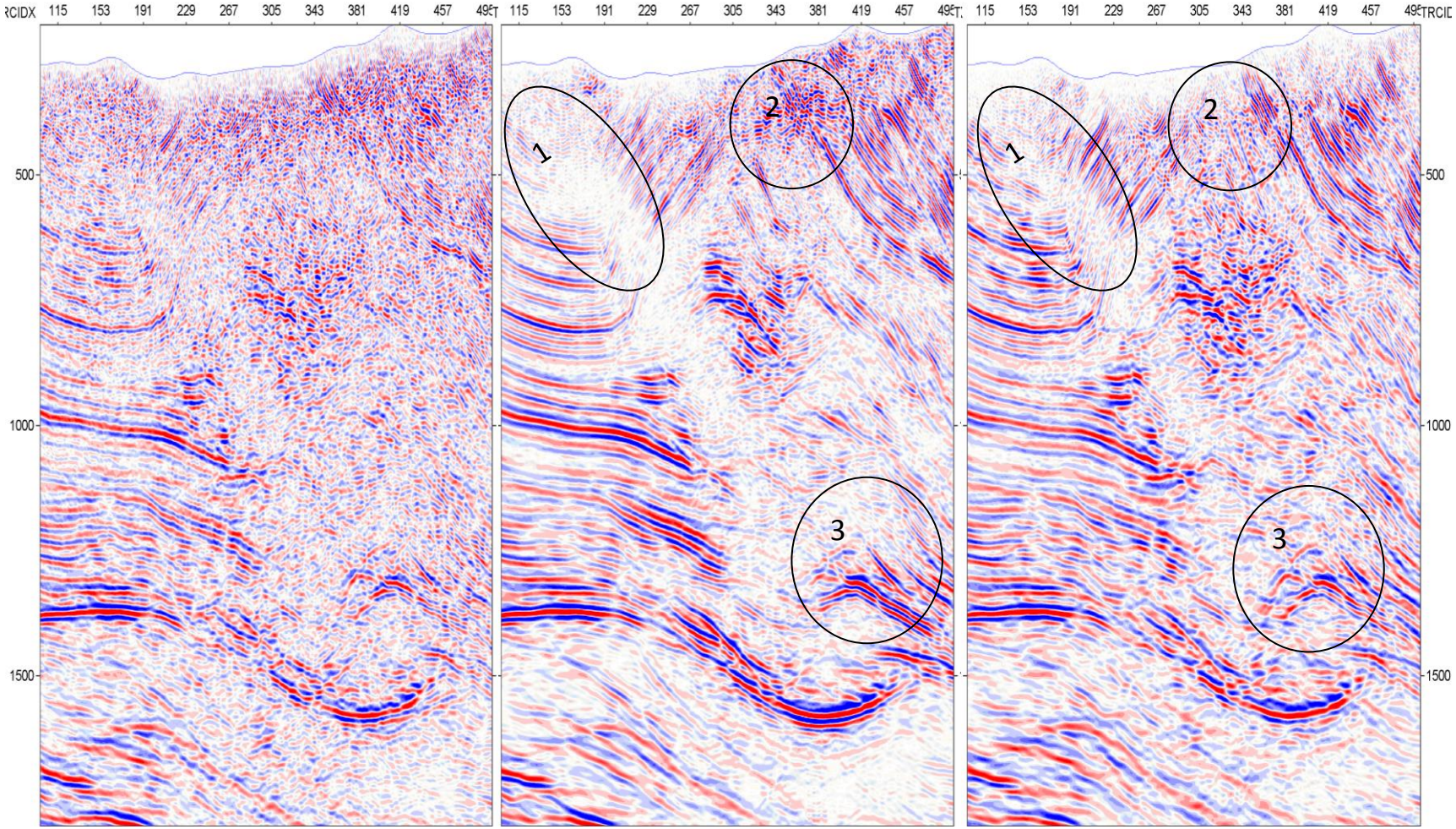


zero offset MF



common offset MF

PSTM



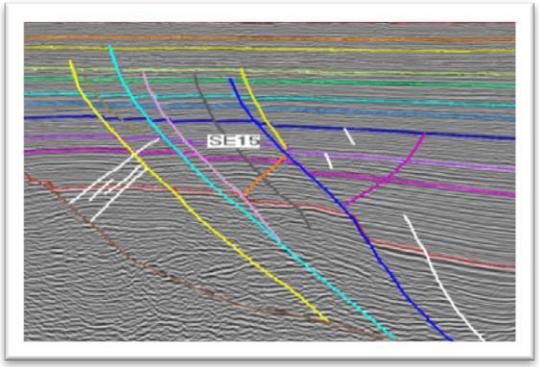
Reservoir Characterization:

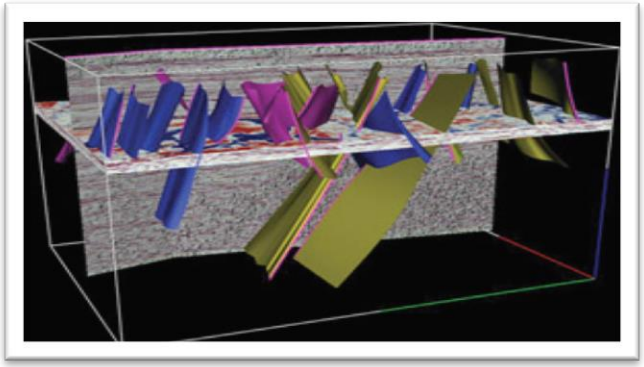
MF Diffraction Imaging

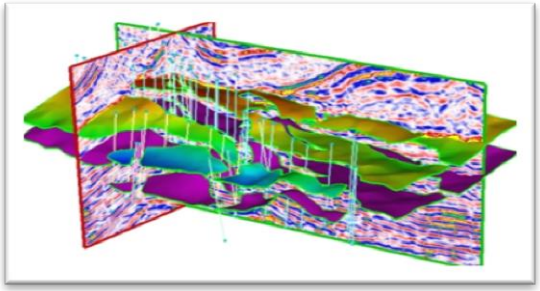
How do

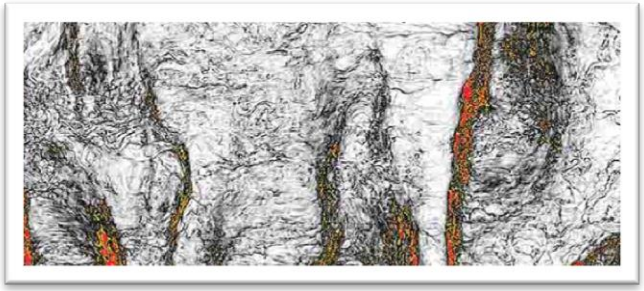
we identify discontinuities?

All these methods are indirect indicators of small scale subsurface features



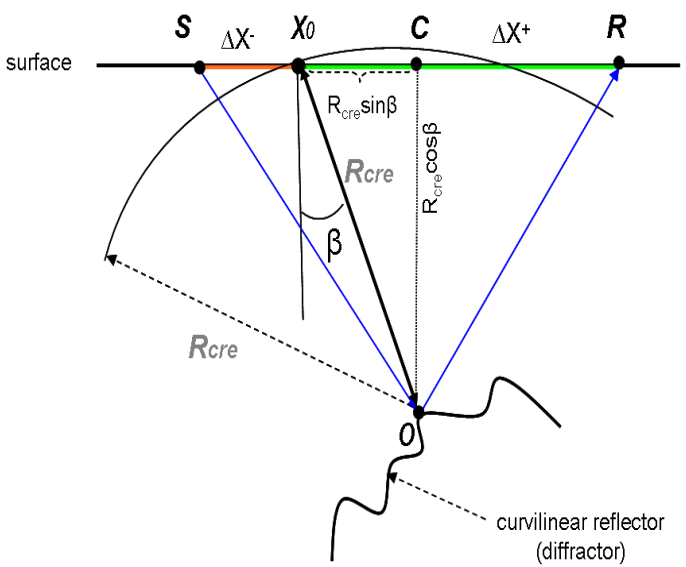


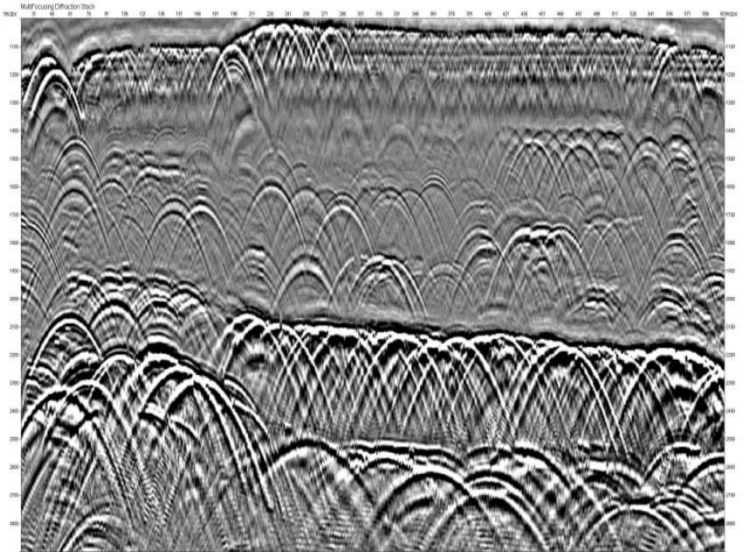




Diffraction stacking

a special case of MultiFocusing stacking





Diffraction moveout coincides with MultiFocusing moveout when the reflection interface shrinks to a point, i.e., when $R_{CRE} = R_{CEE}$.

Diffraction MultiFocusing

The MF diffraction operator is derived from the MF operator assuming emergence angle to be equal to 0 and radii for normal incident point and normal waves are equal:

$$\vec{\beta} = 0$$

$$\vec{R}_{CRE} = \vec{R}_{CEE}$$

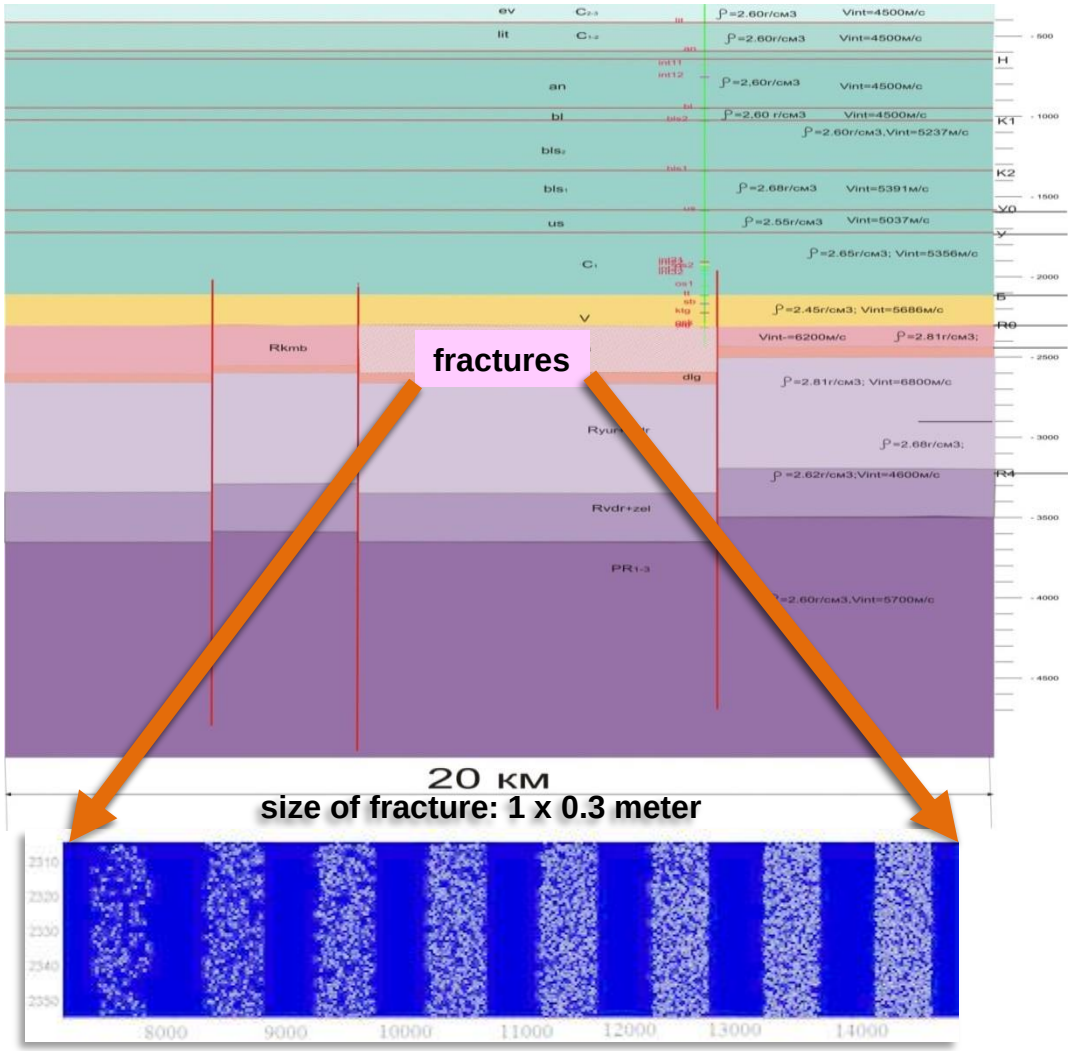
$$T(\vec{x}_0, \vec{x}_s, \vec{x}_r) = F(\Delta\vec{x}_s, \Delta\vec{x}_r, \vec{R}, V_0)$$

Synthetic model

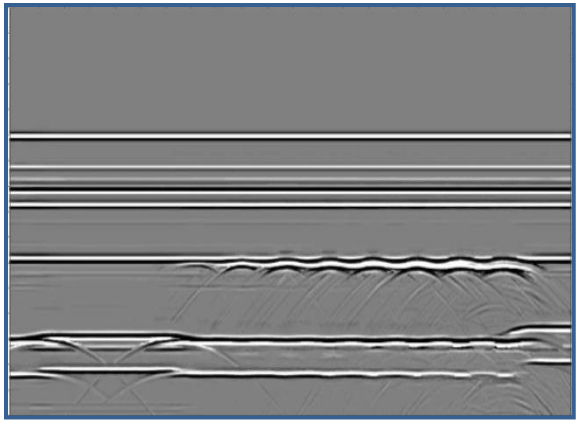
- Elastic model
- Finite difference with varying cell size over zone of interest

CMP

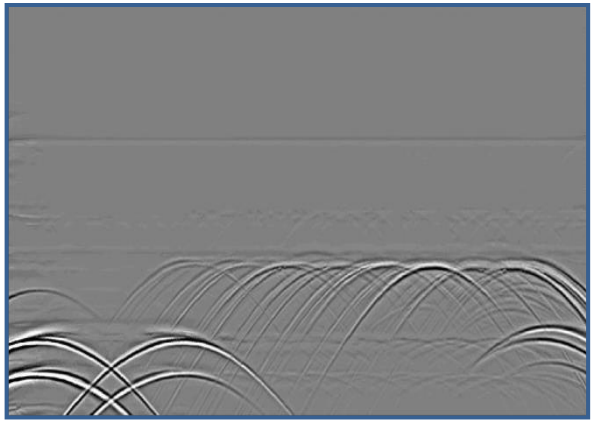
depth


ev
lit
an
bl
us
Rkmb
Rvdr+zel
PR1-3
fractures
20 km
size of fracture: 1 x 0.3 meter

MultiFocusing stack



MultiFocusing diffraction stack



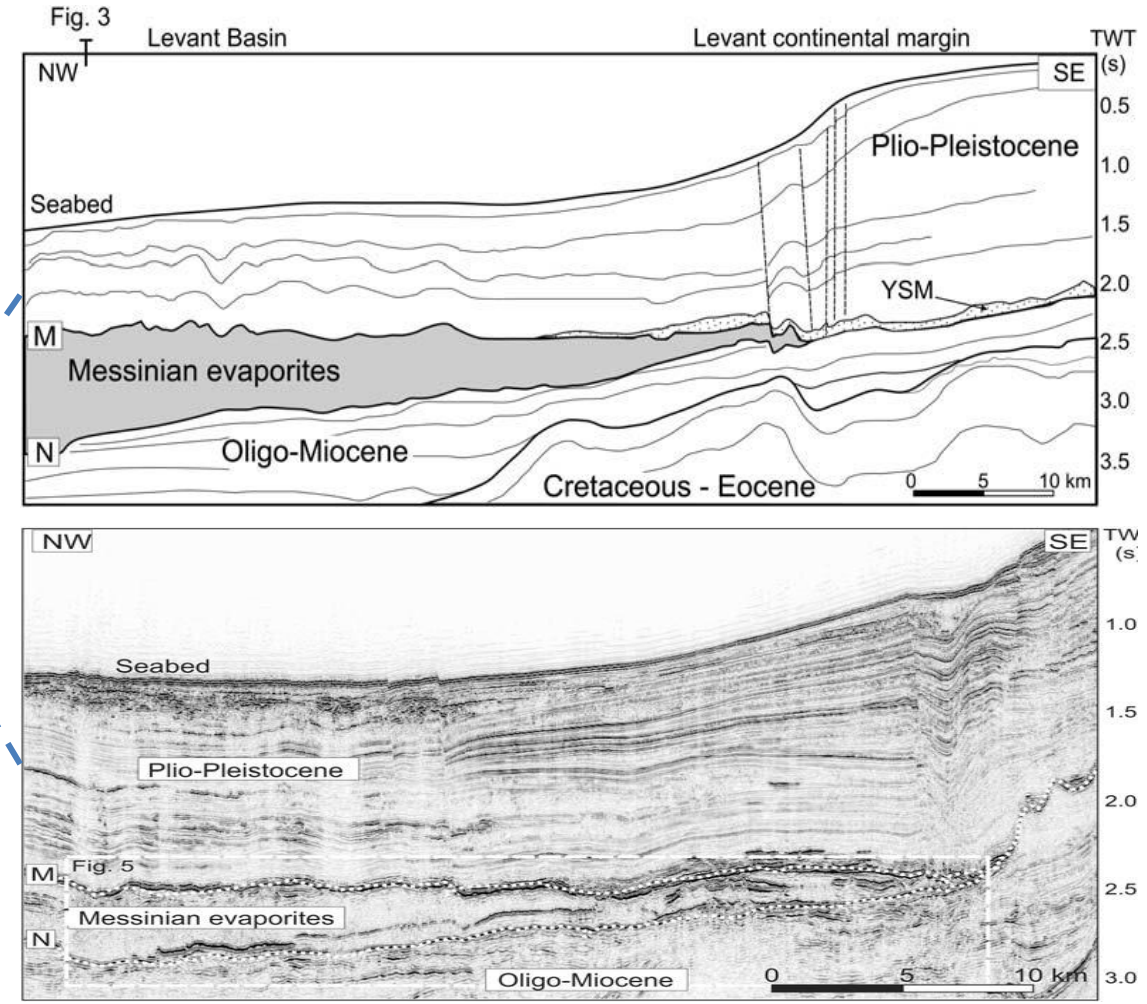
MultiFocusing diffraction migration

Case 1

Mediterranean

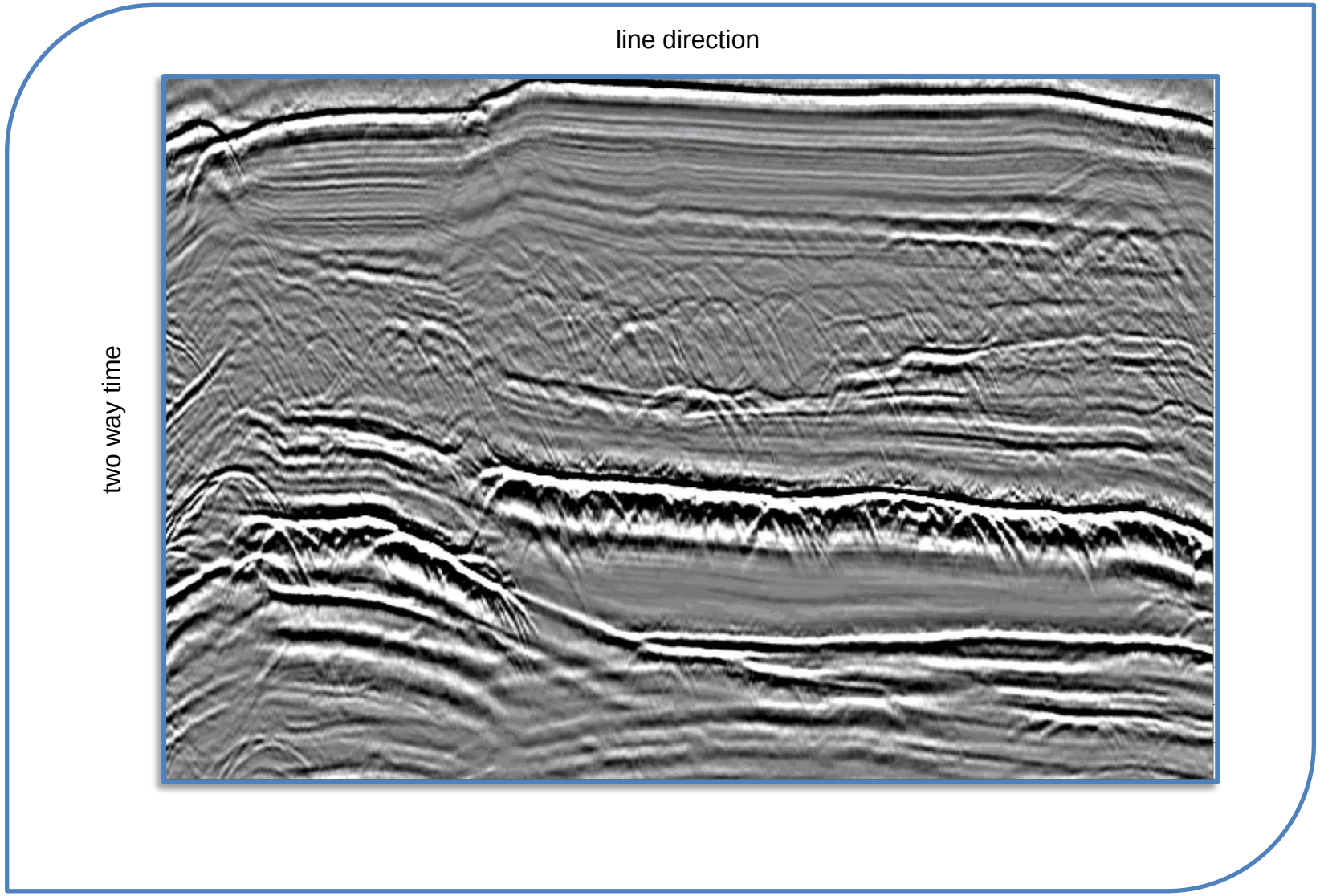
Case study 1:

Levant Basin



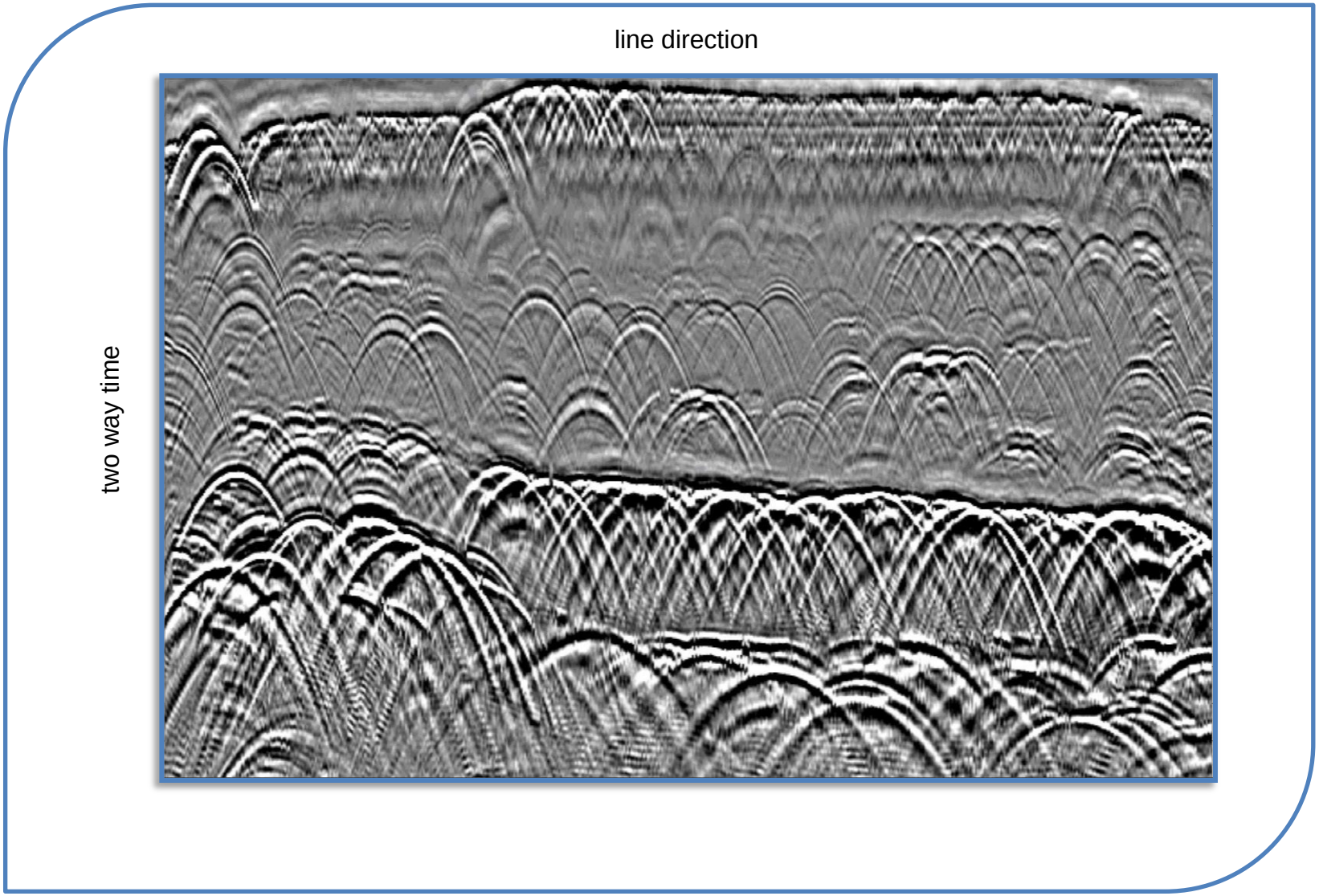
MultiFocusing

structure stack



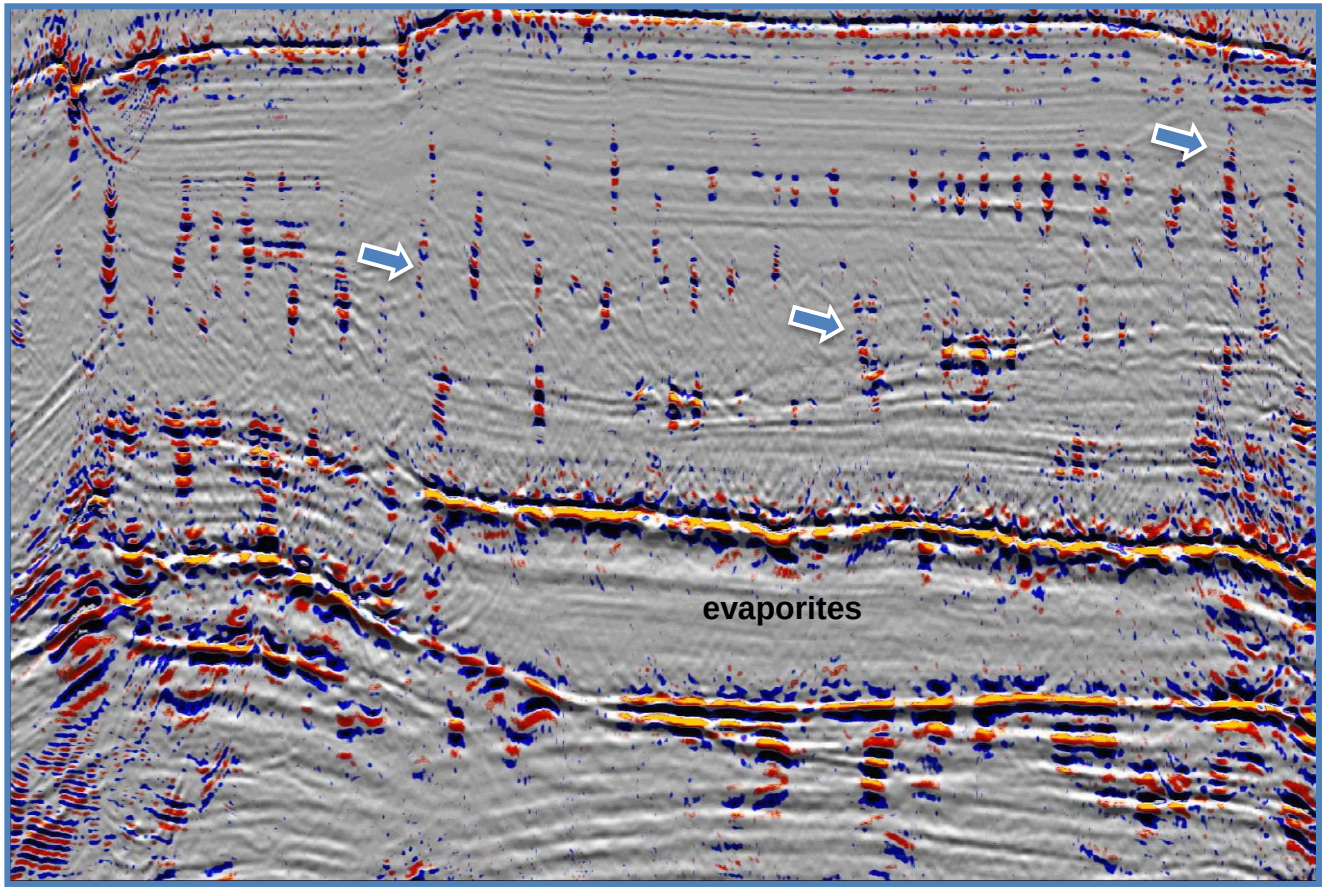
MultiFocusing

diffraction stack



MultiFocusing

diffractivity with PSTM



diffractivity in color on migrated MF stack

Case 2

Siberia

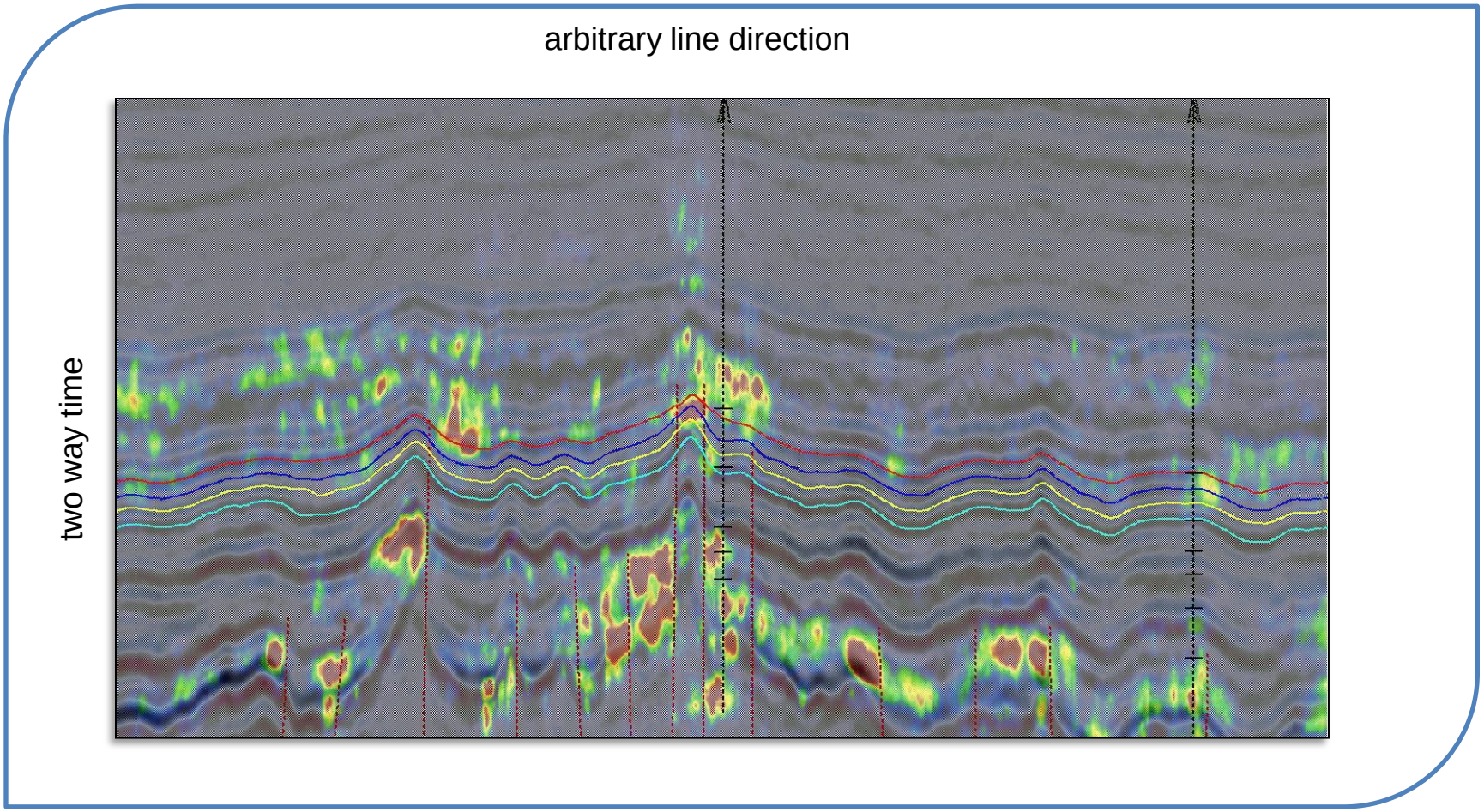
Bazhenov Formation

Geology

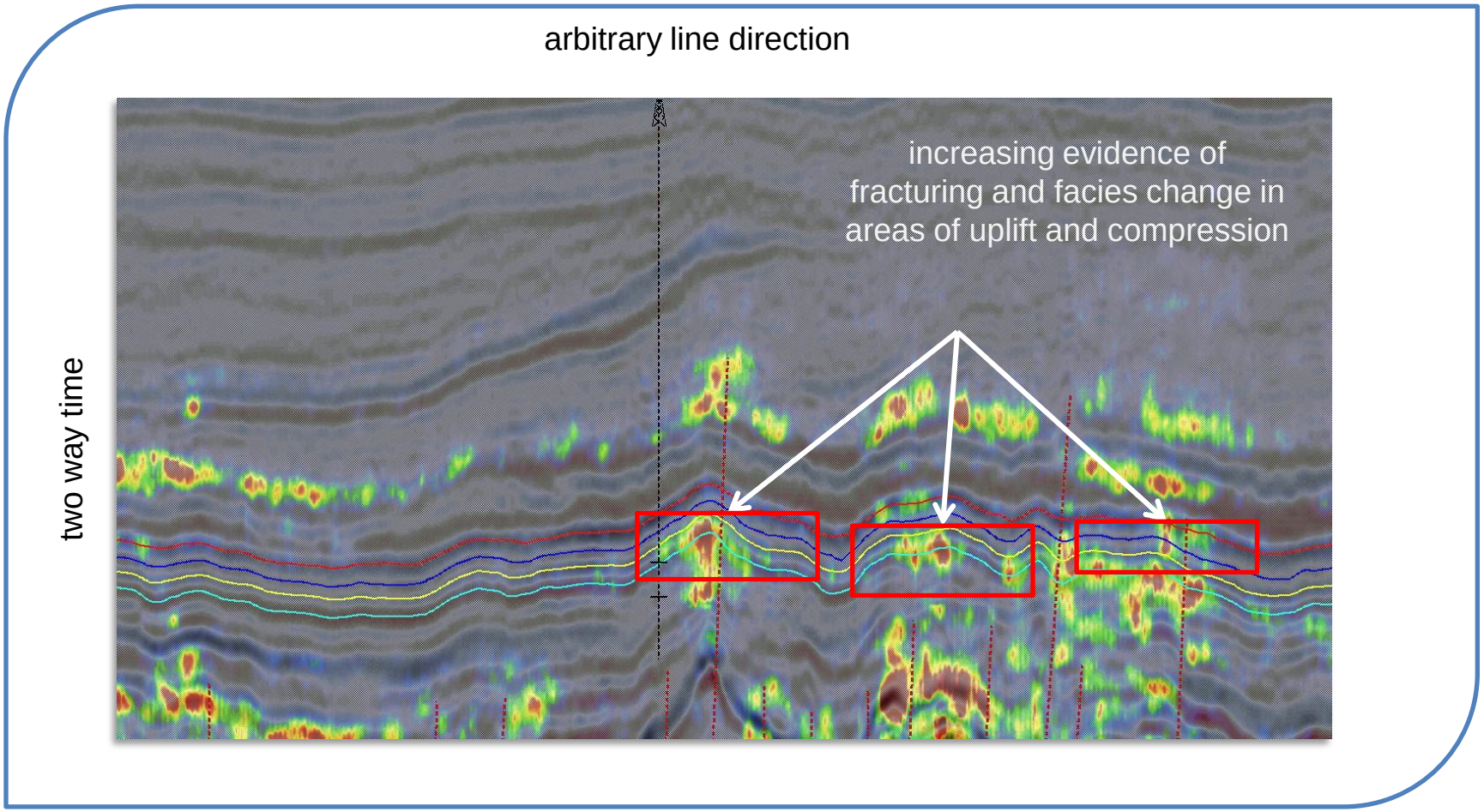
Bazhenov formation – upper Jurassic

- 2.3 million square kilometers
- at a depth of 2700 m – 2800 m
- average thickness of 40 m
- inter-bedded reservoir beds 0.5-3 meters thick
- rich in organic matter
- estimated 126 trillion barrels of oil in place
- natural fractures produce better flow rates

PSTM in background diffractivity in color

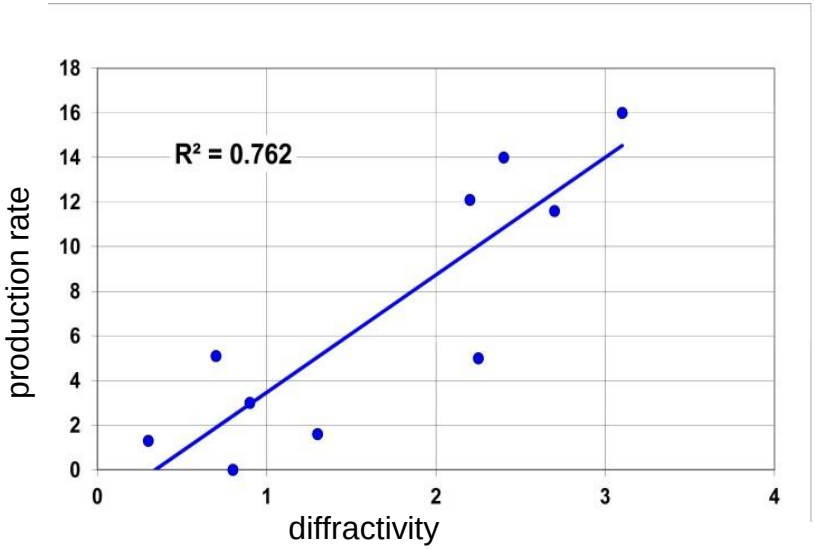


PSTM in background diffractivity in color



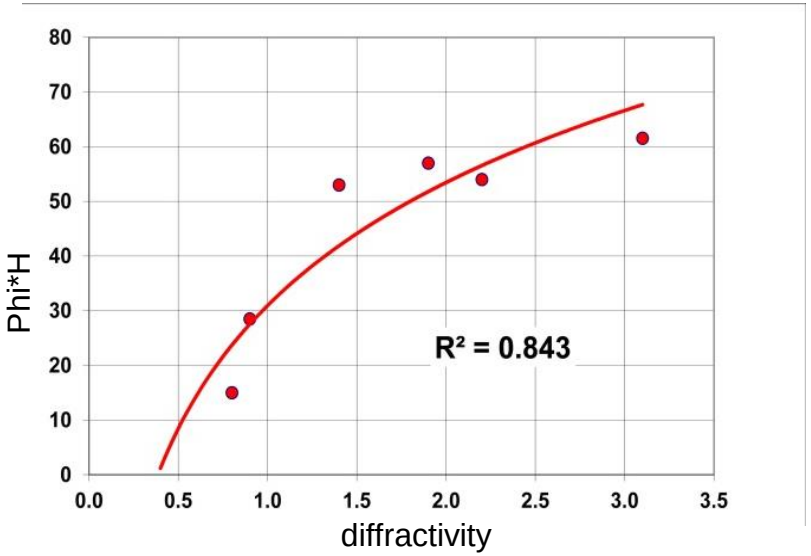
Diffraction cross-plots

production rate vs diffractivity



correlation coefficient: 0.8

calculated fracture ϕ over column height (Phi*H) vs diffractivity

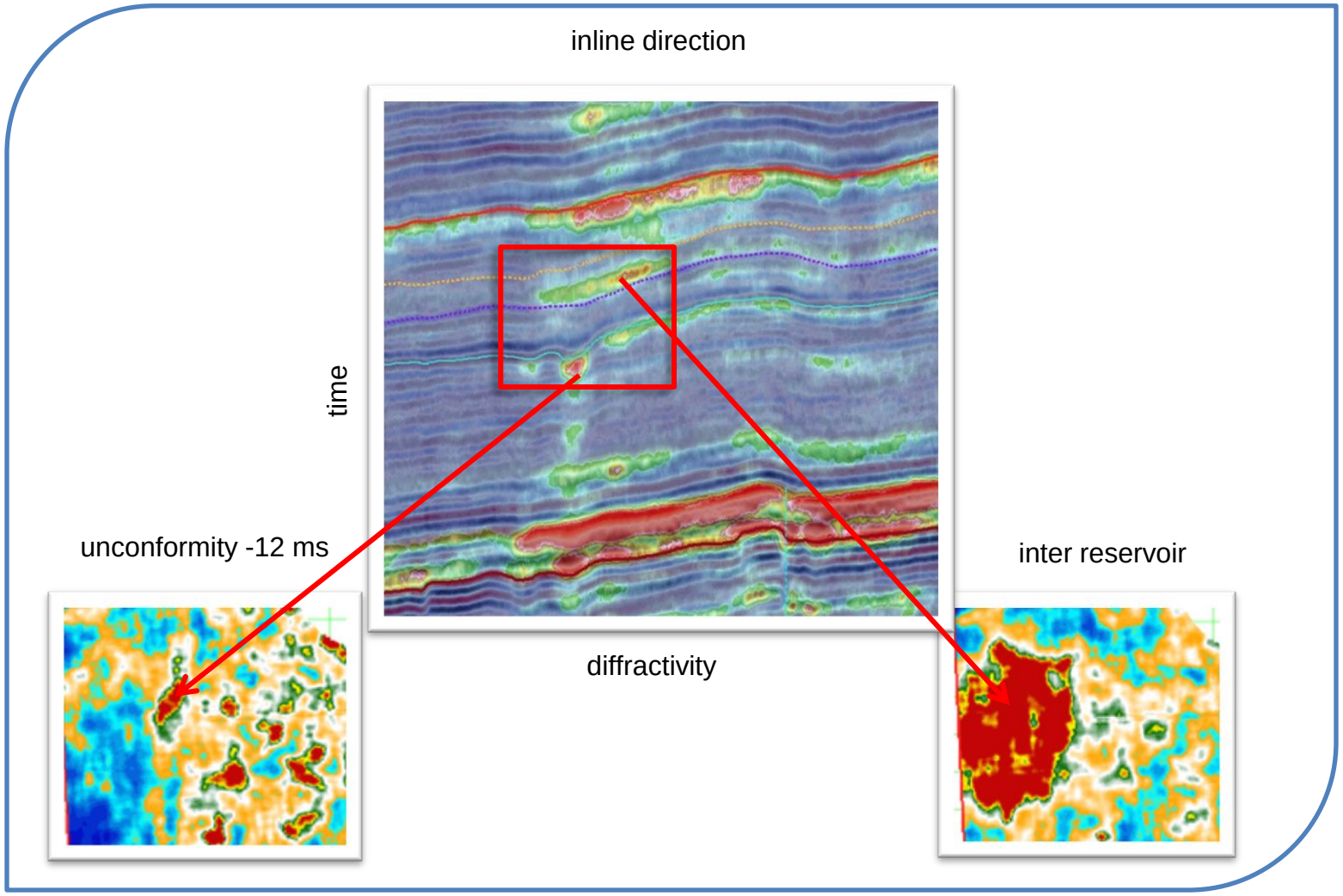


correlation coefficient: 0.8

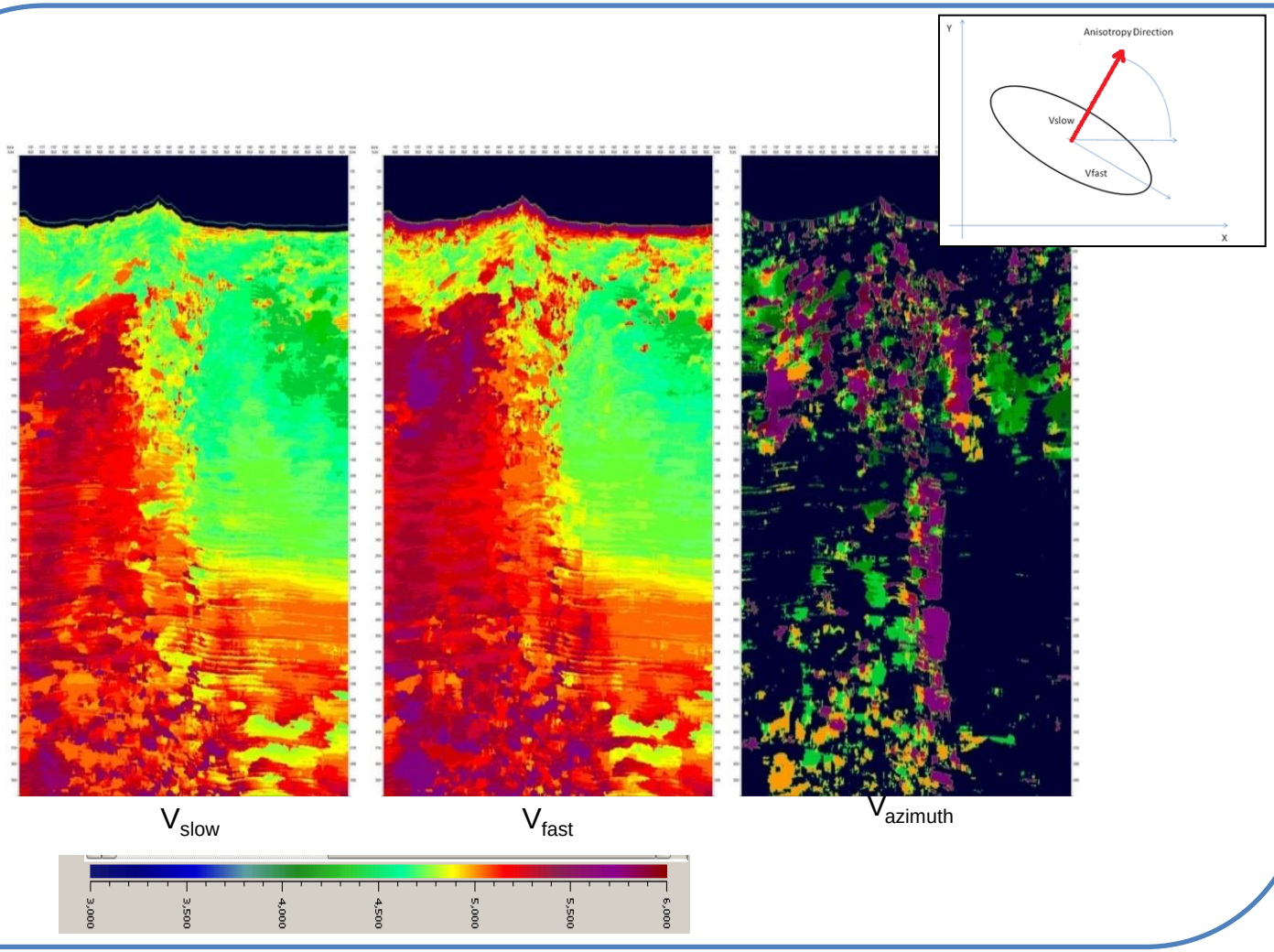
Case 3

North American shale formation

Diffraction interpretation



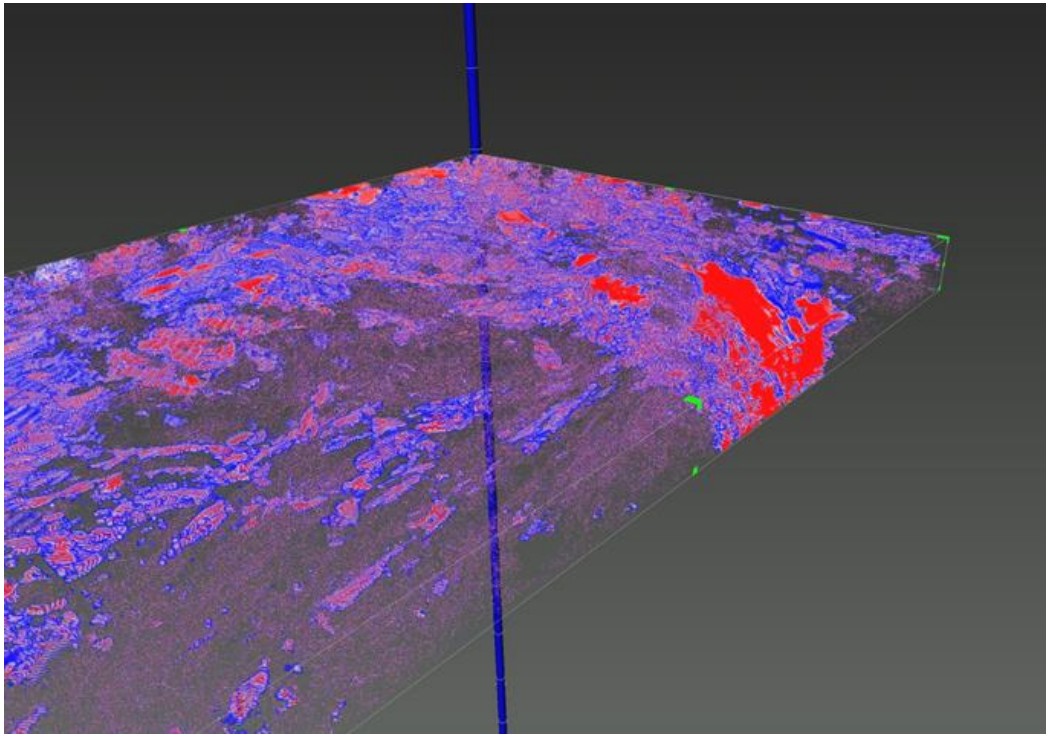
Anisotropy $V_{azimuth}$



V_{slow} V_{fast} $V_{azimuth}$

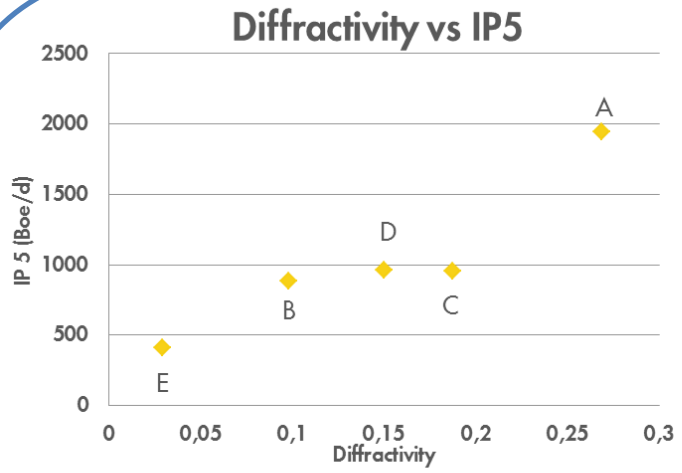
Anisotropy attributes

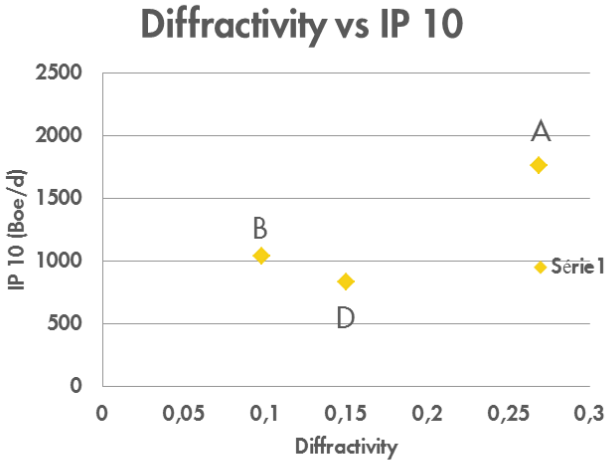
3D view of reservoir

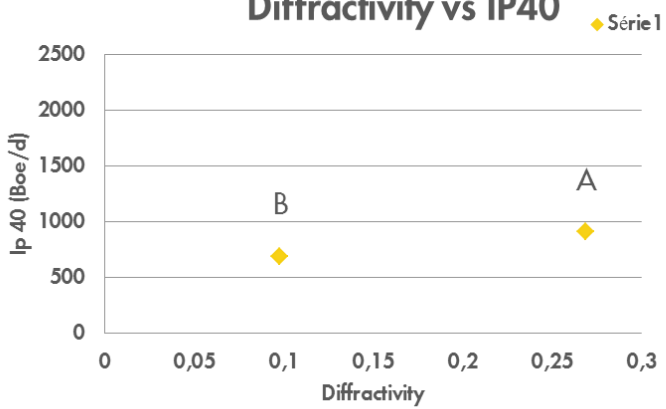


V_{slow} / V_{fast}

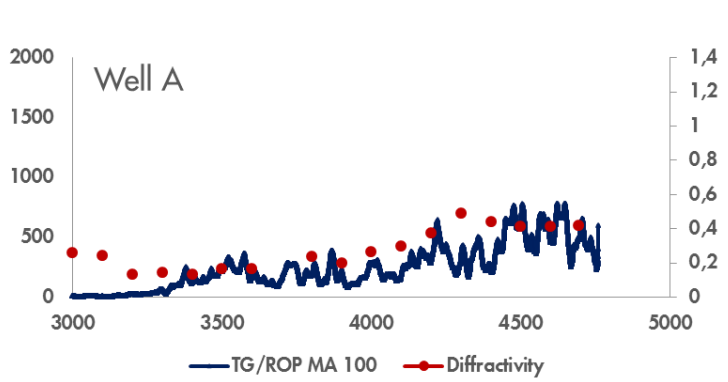
Cross-plot production data and diffractivity

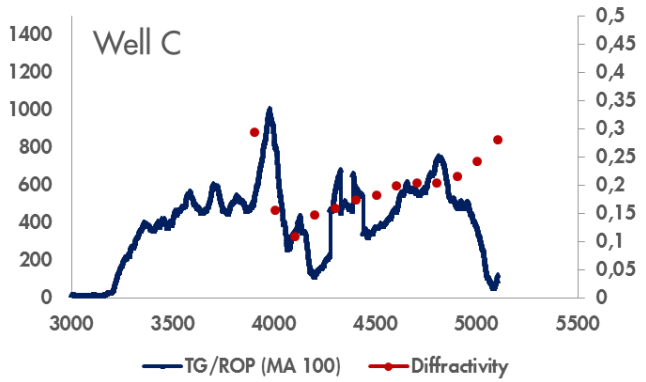


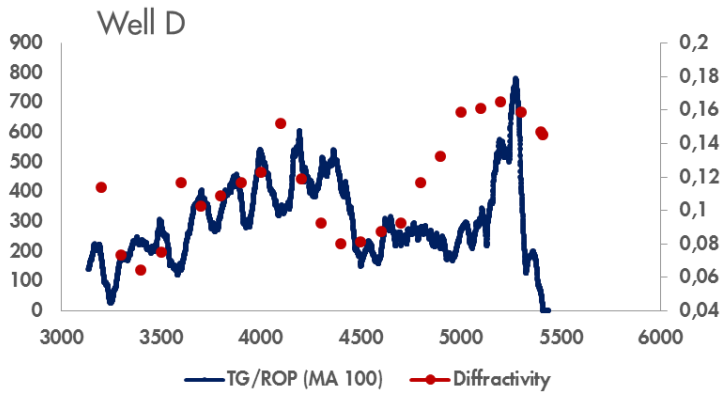




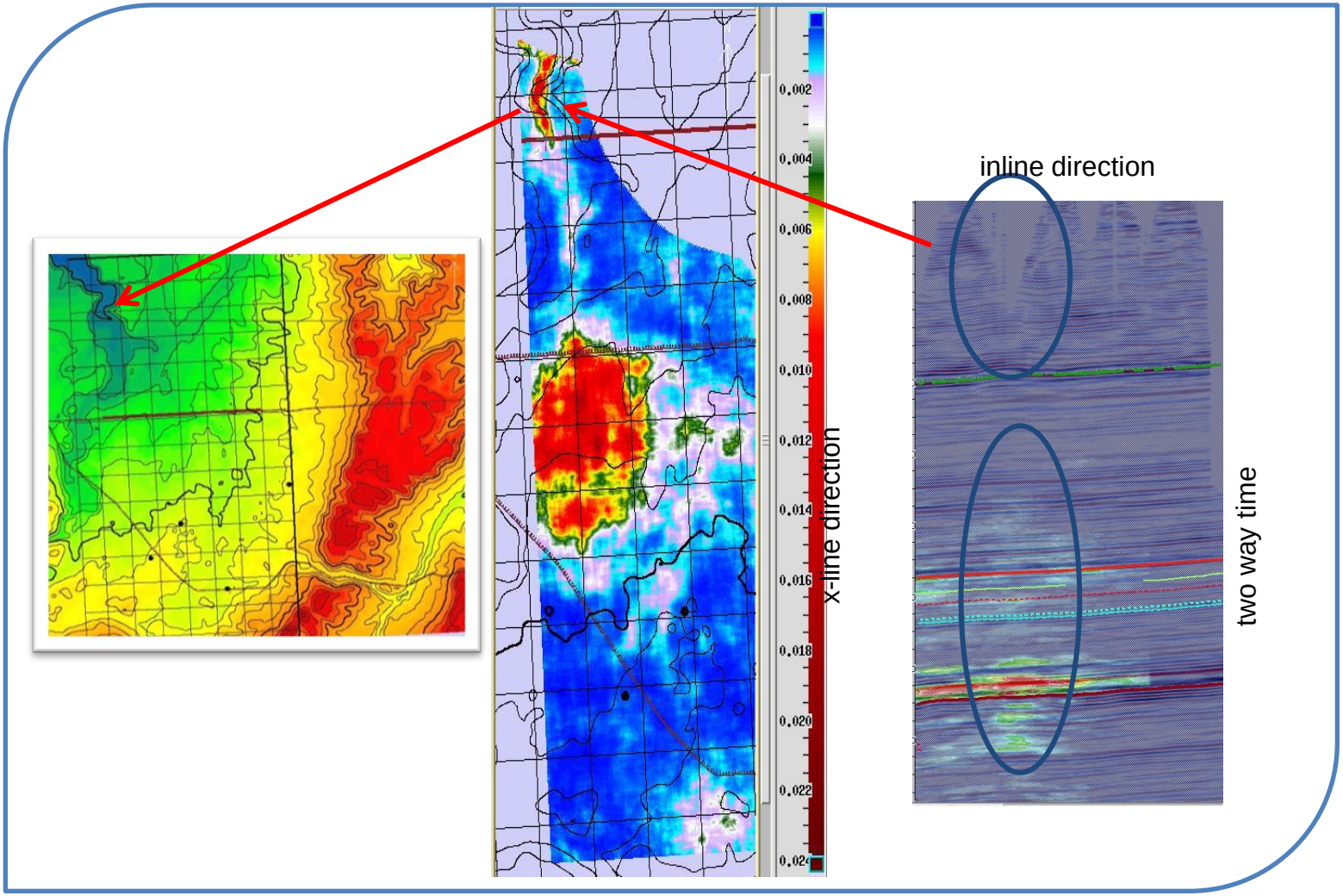
Gas shows versus DI along well path



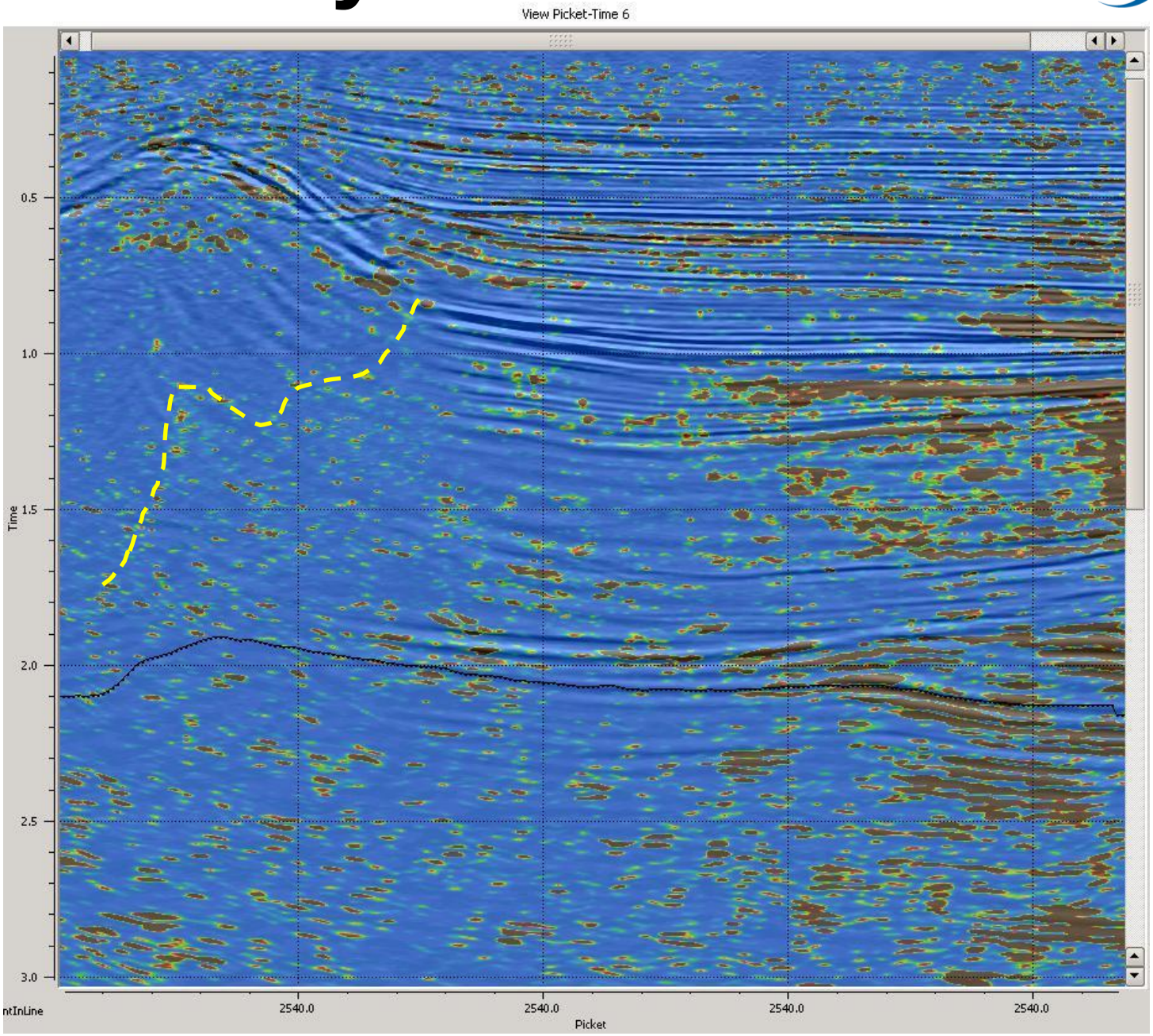




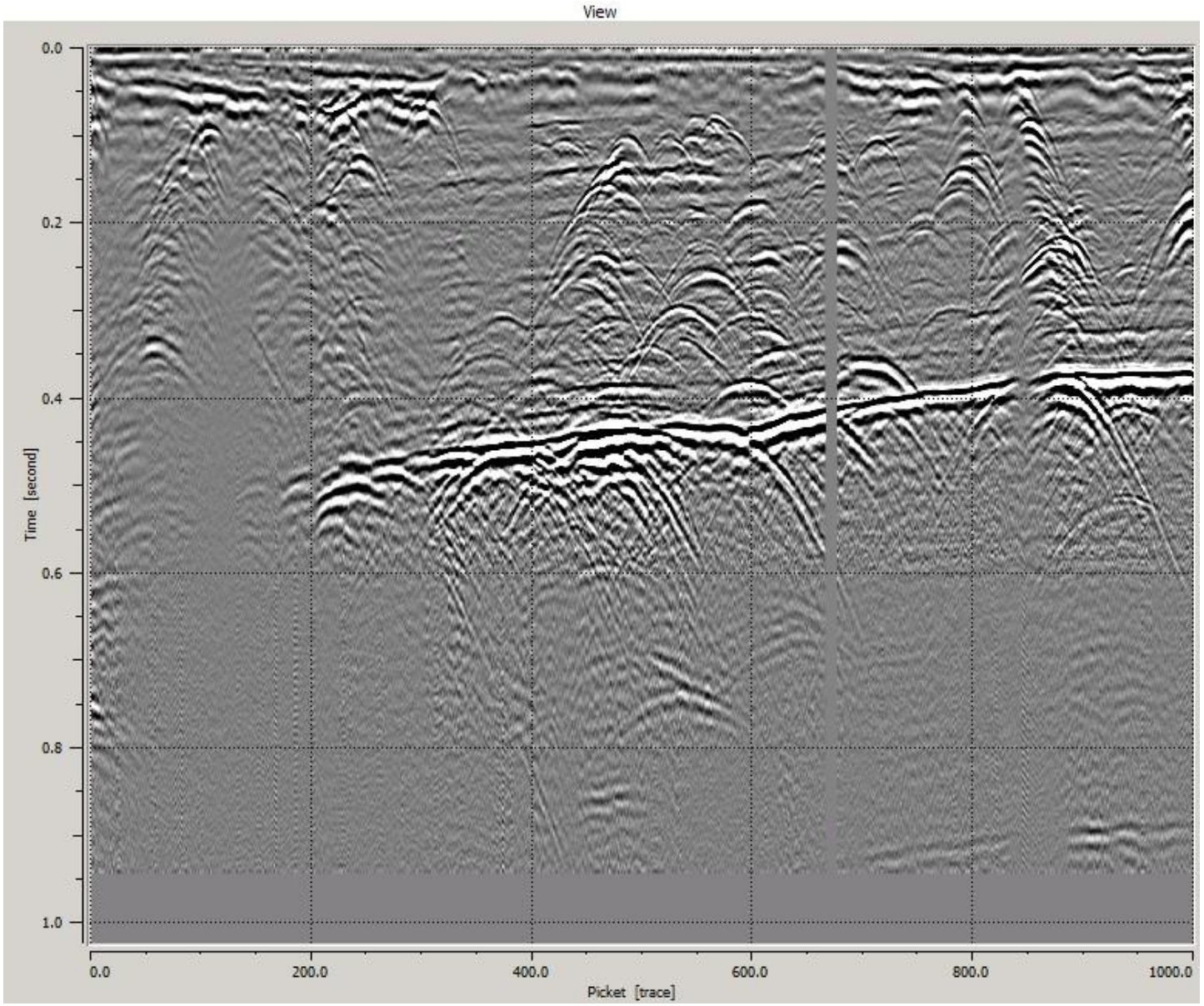
Integrating surface (DEM)



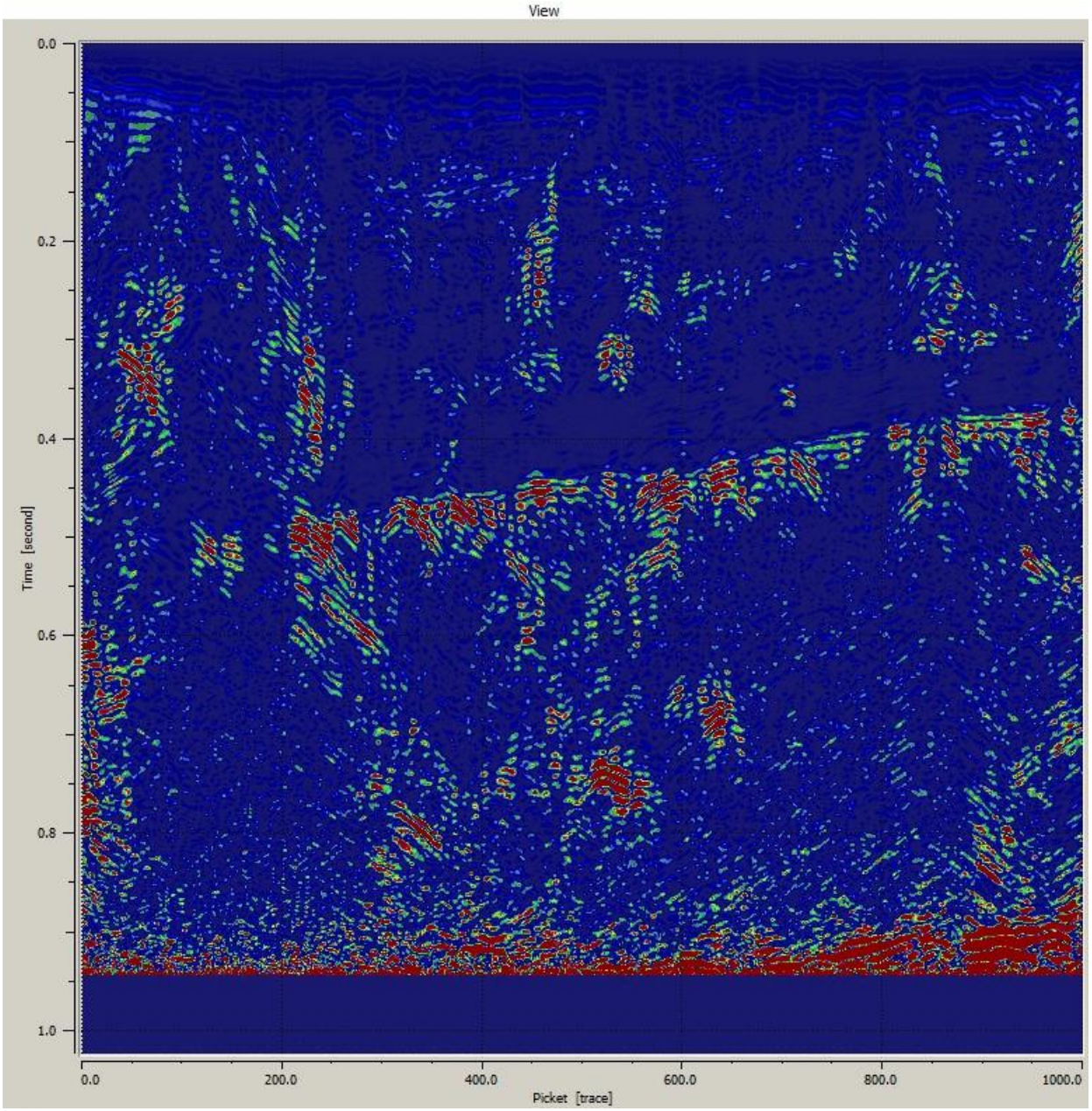
Diffractivity



MF structure stack



Azimuthal diffractivity



Conclusions

Conclusions

- MF is most powerful random noise attenuator. Especially useful in difficult terrain, low fold, vintage data
- Prediction of discontinuities such as fracture swarms, corridors, folds, salt overhangs using diffractivity
- Geomage is a technology and software development company and constantly develops new high end products