SEISMIC IMAGING & INVERSION OF THE HUSSAR LOW FREQUENCY SEISMIC DATA

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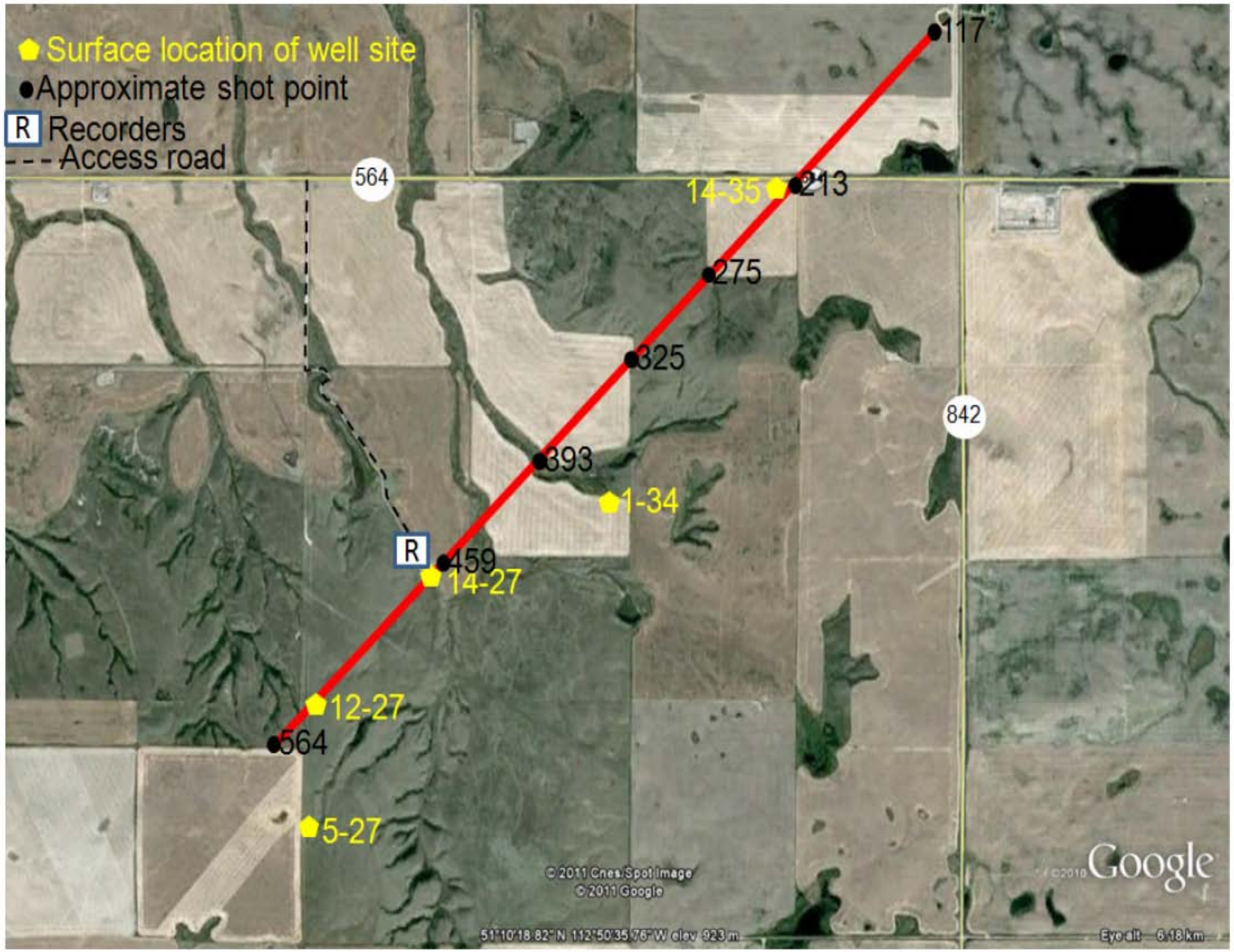
CREWES

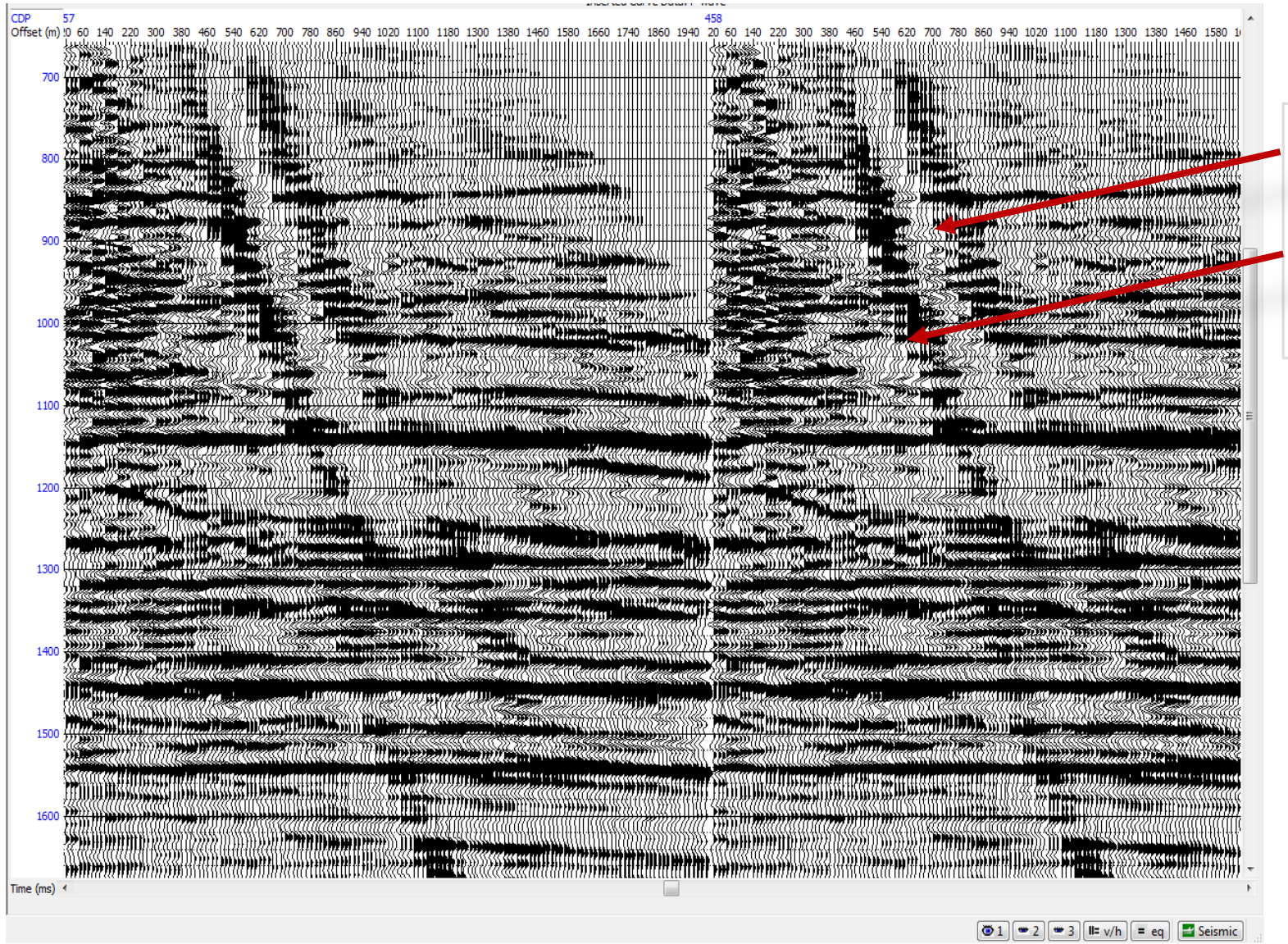
Outline

- Introduction
- Seismic processing flow
  - PSTM algorithms
  - Band signal analysis
- Well to seismic tie
- Post stack & Prestack inversion
- Conclusion
- Acknowledgments

Hussar Low-Frequency: only well 12-27 is dipole sonic



Contractor: PSTM Kirchhoff –CIG gather.



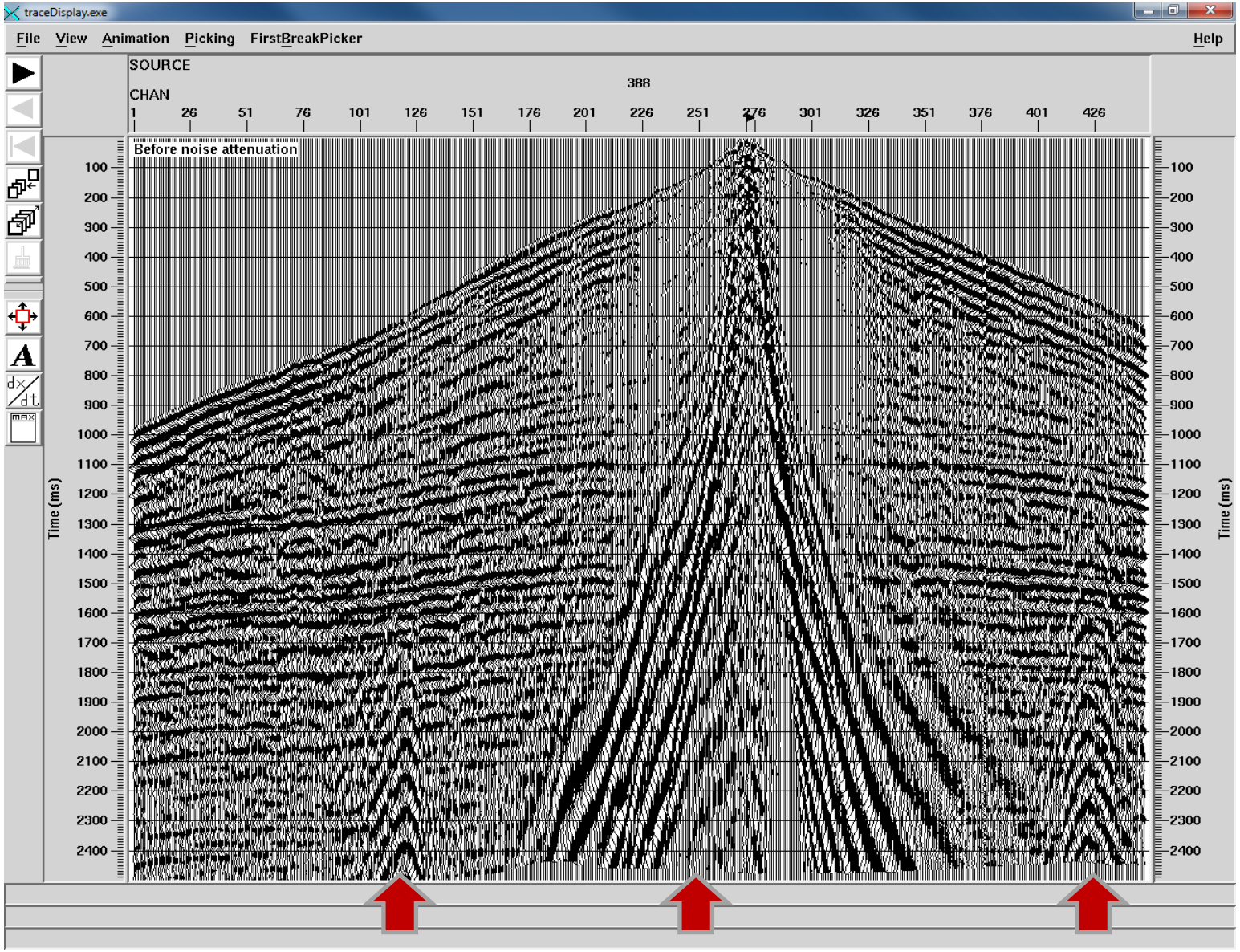
Note residual noise left in the CIG and pose as step ladder across the CIG.

Max Offset bin: 1980m

Processing flow: Hussar 2D line

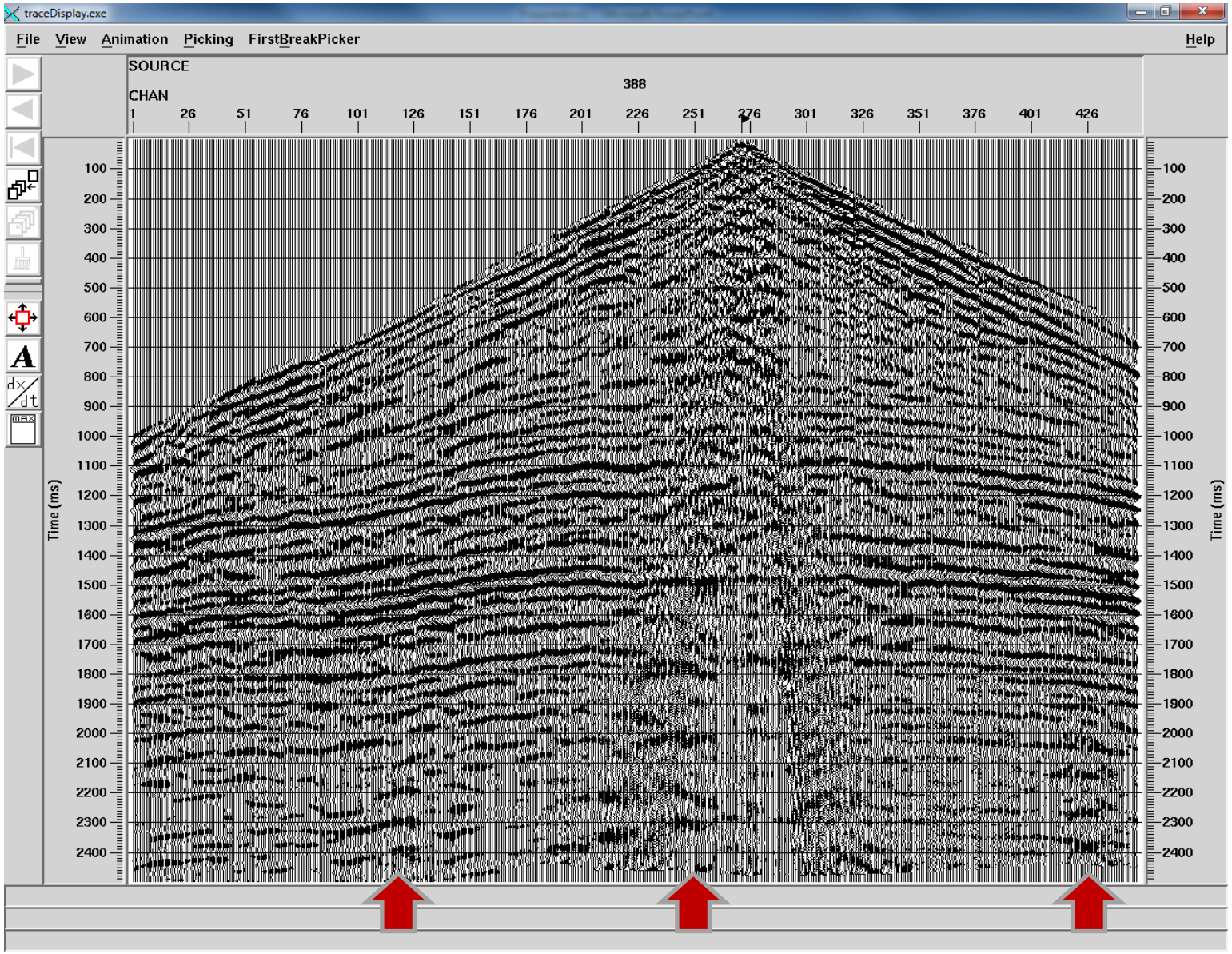
- Reformat & Geometry assignment
- Trace and shot edit
- Amplitude recovery
- Apply datum and refraction statics
- Noise suppression: Radial filter , air blast
- Surface Consistent Gabor Deconvolution
- Two passes of velocity analysis | Surface Consistent Residual Statics
- PSTM gathers preparation
- Pre Stack Time Migration
- Post migration Gabor Deconvolution
- FX noise attenuation
- Mute & Stack

Shot 388– Before noise attenuation



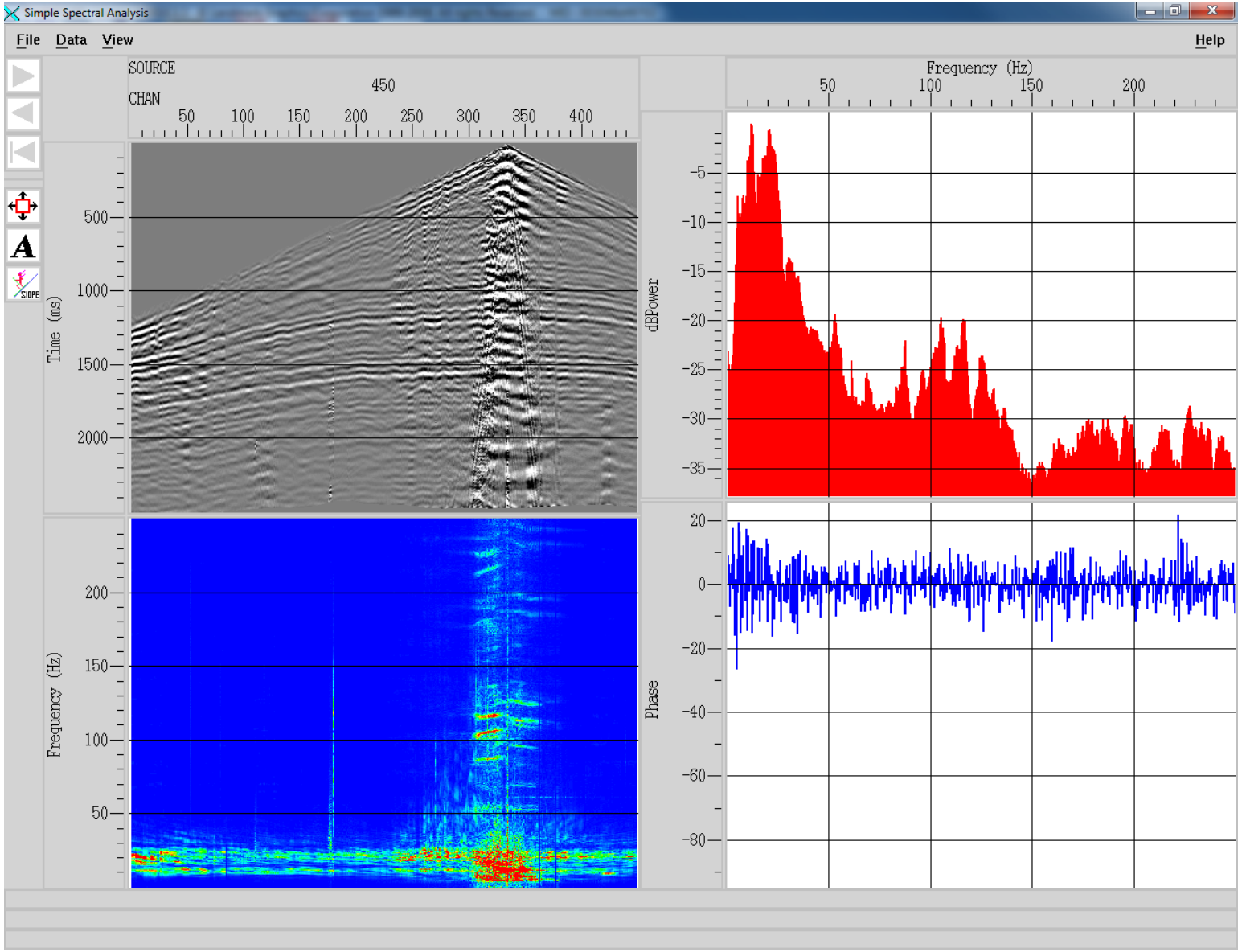
middle bottom arrow refers to noise from ground roll while two side arrows are for pump noise

Shot 388– After noise attenuation



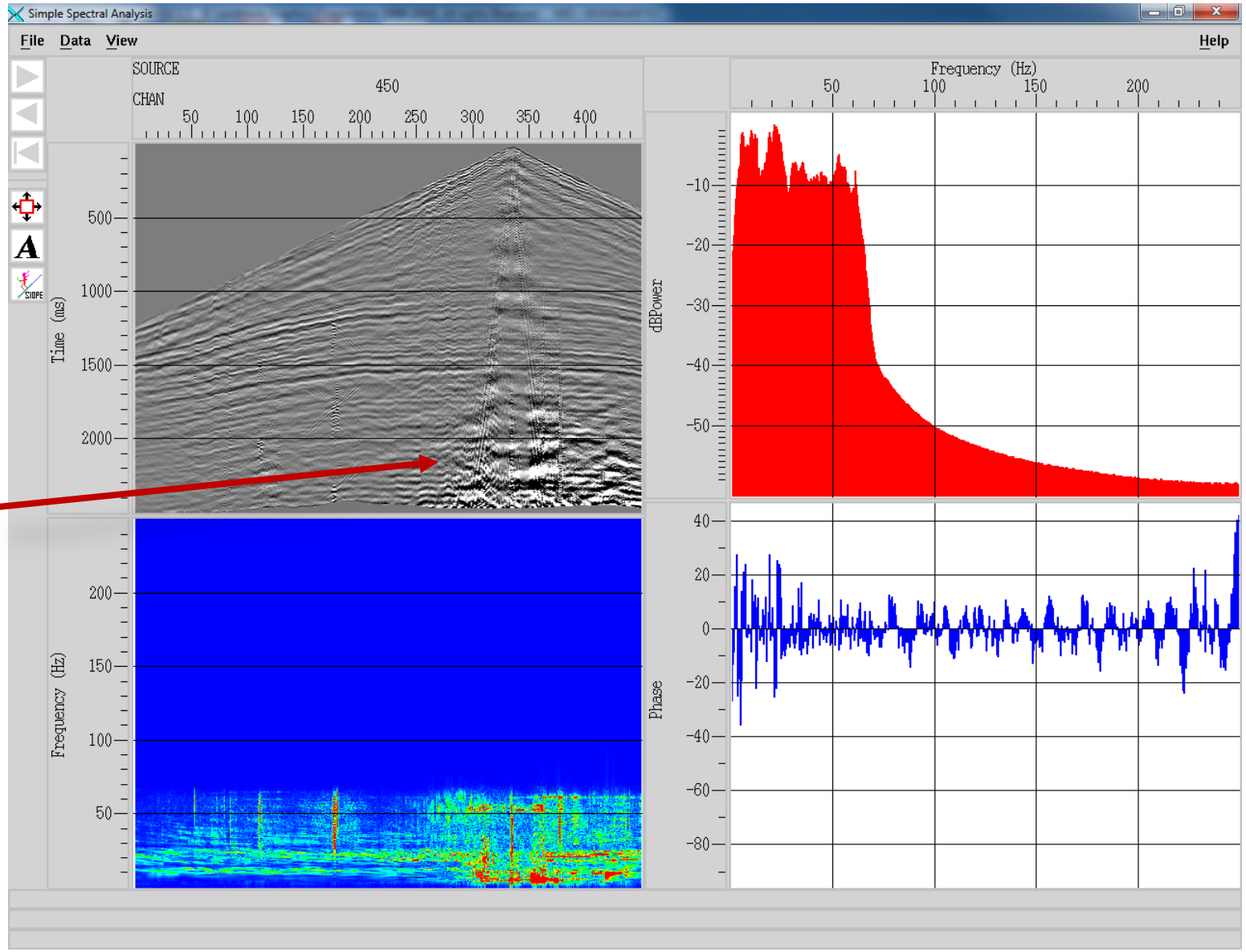
- Noise are noticeably attenuated.
- Reflectors at the middle of the shot gather are now visible after they were masking by ground roll and pump jack noise.
- Energy is now distributed better across the shot gather after they were mostly taken by ground roll and pump noise

Shot 450– Before Sc. Gabor Decon



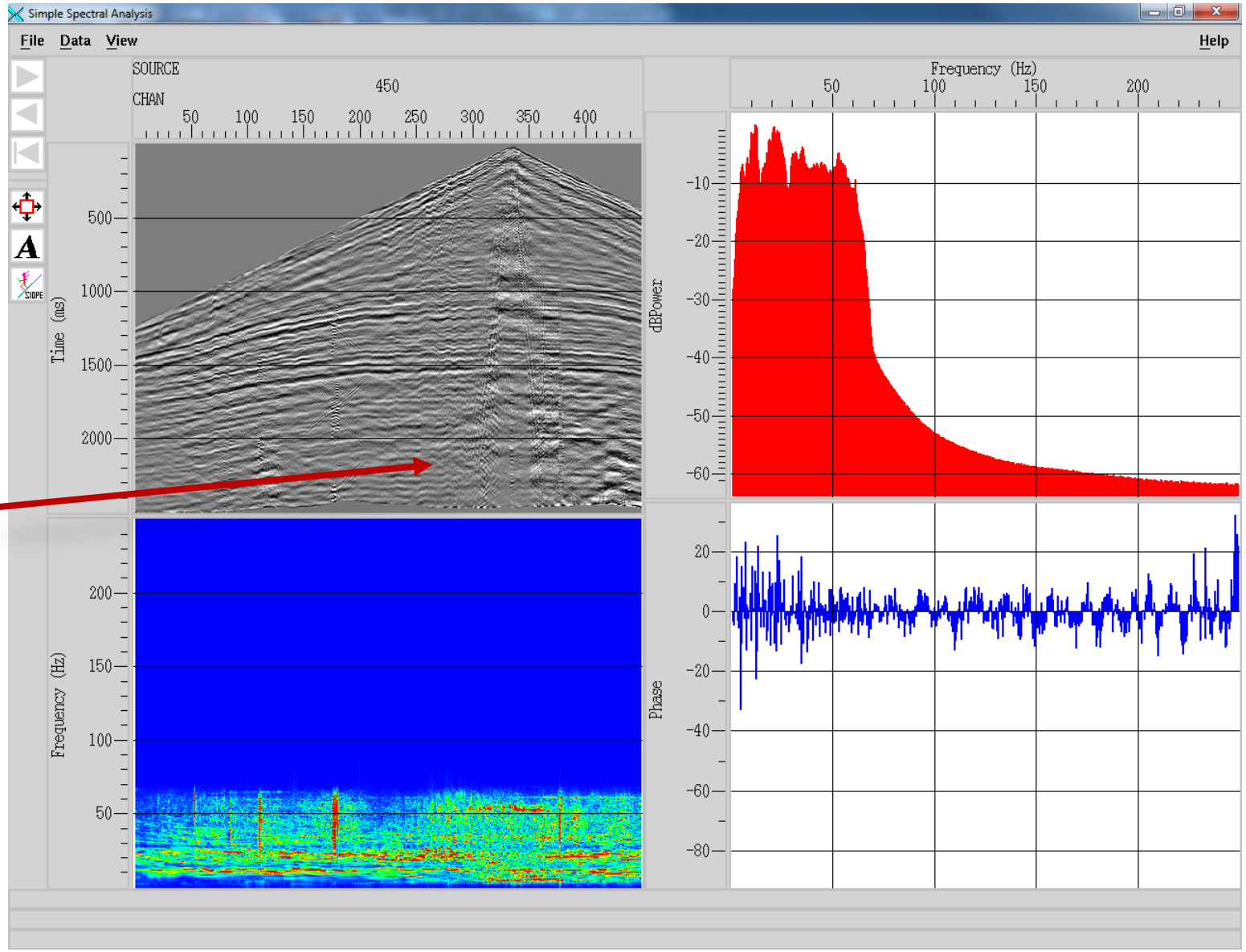
Shot 450– After 1st pass Sc. Gabor Decon

Some low frequency noise left at the lower side of the shot gather. The amplitude spectrum is broadened

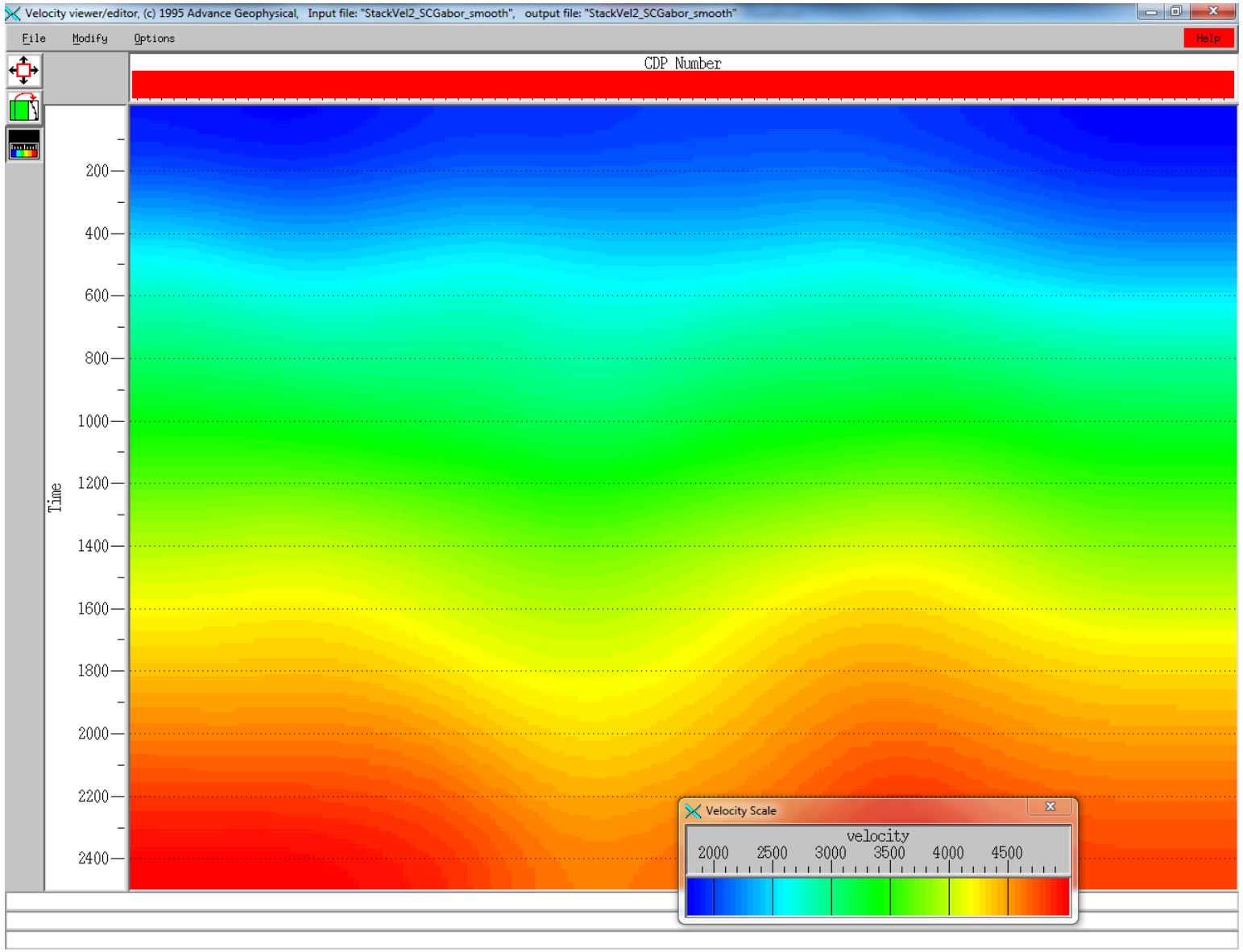


Shot 450– After 2nd pass Sc. Gabor Decon

Noise are further cleaned up. Amplitude spectrum is improved and broadened at -10db

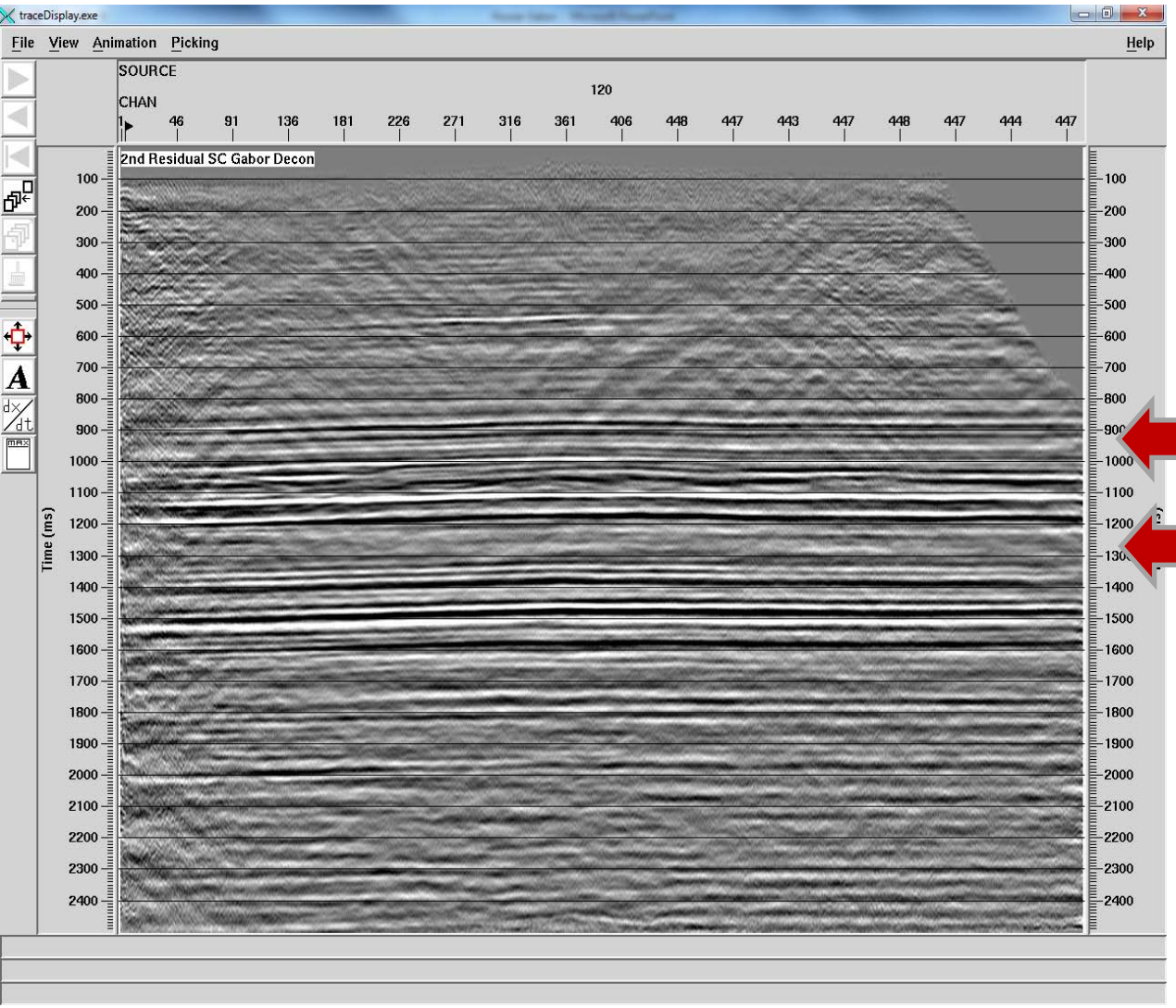


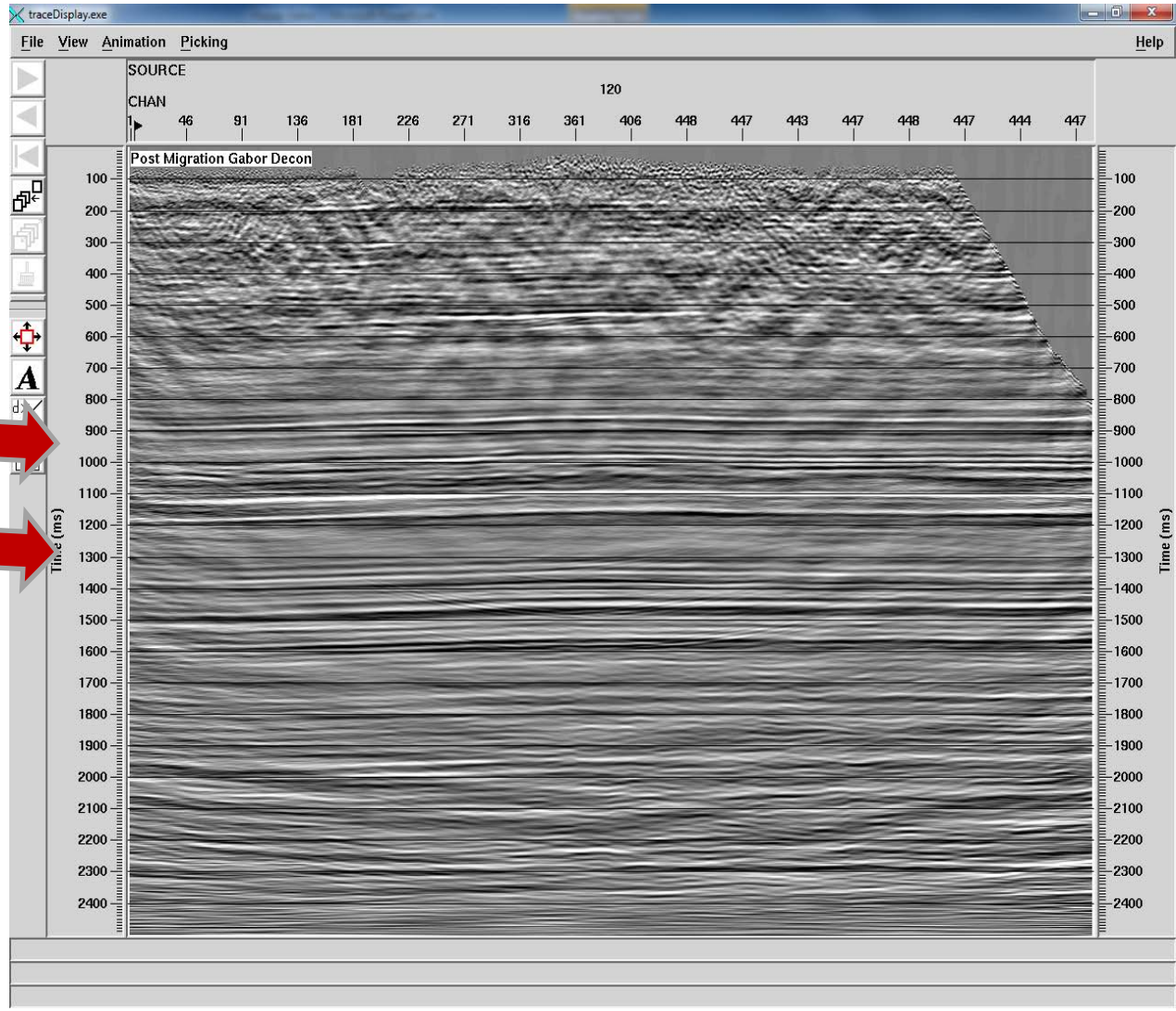
Stacking /Migration Velocity



STRUCTURE STACK

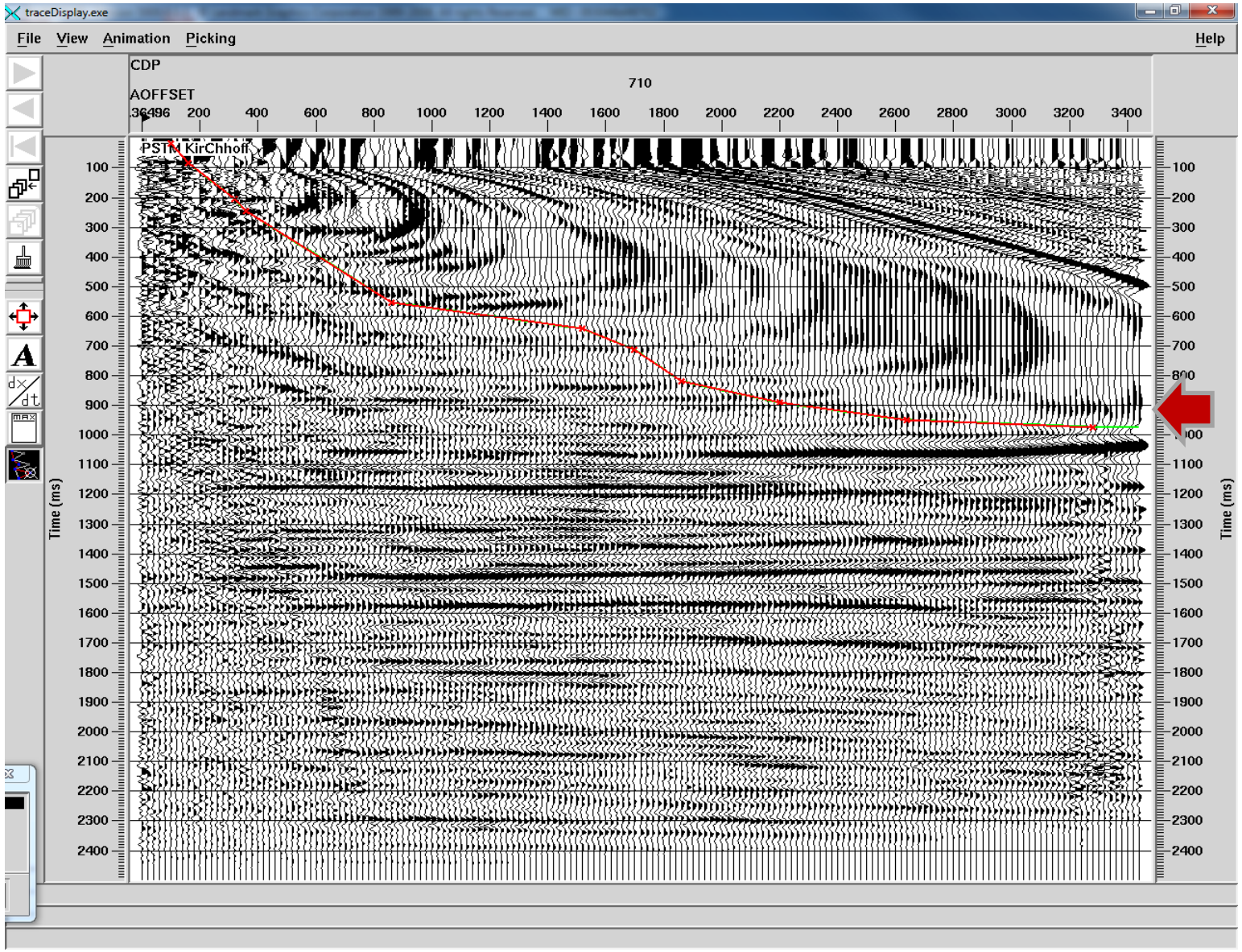
POST STACK MIGRATION





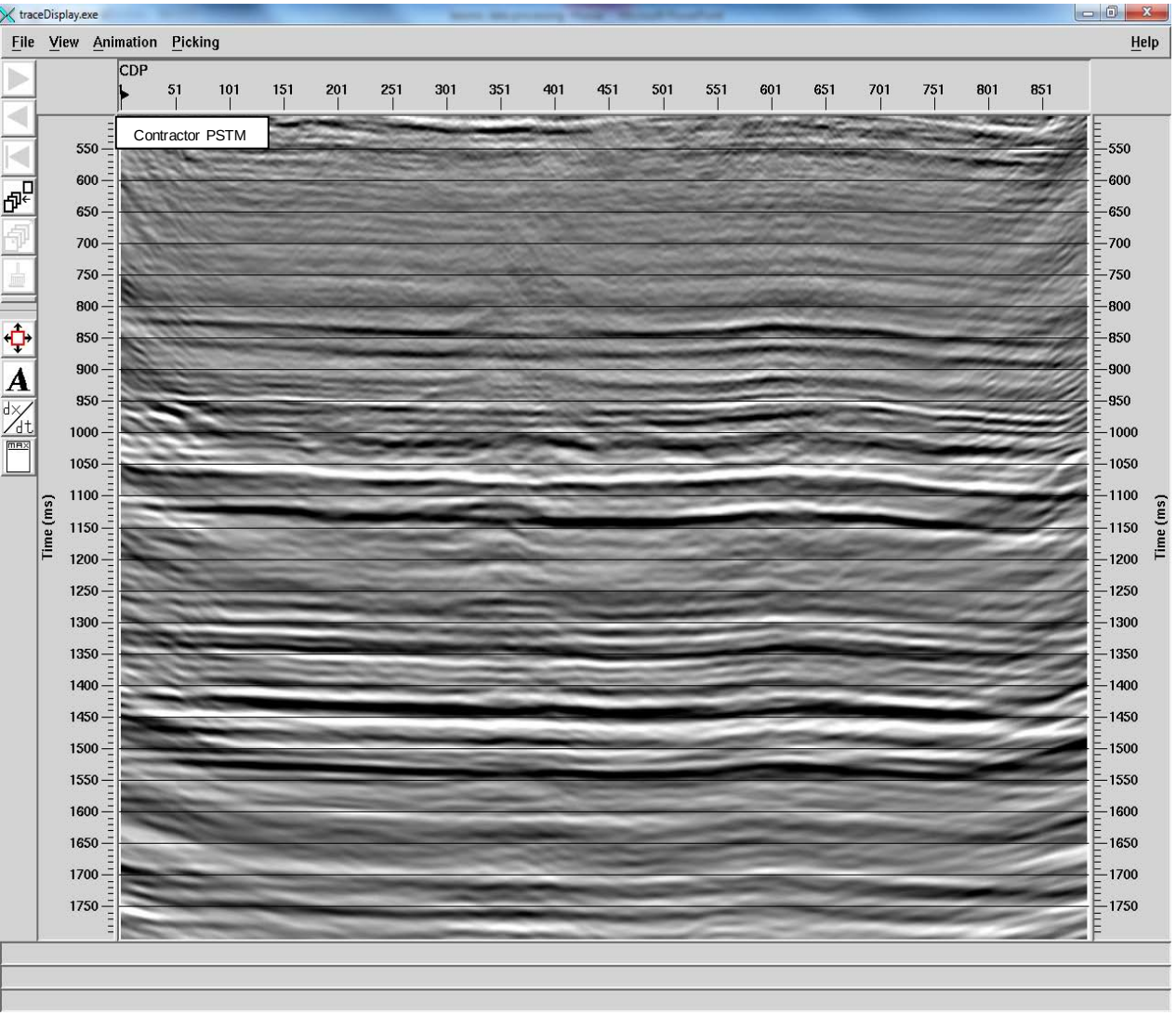
Over all, Reflections are sharpened and improved the high frequency content.
More details are now seen at reflections from 100-500ms.

CIG gather -PSTM Kirchhoff, 1750m Aperture

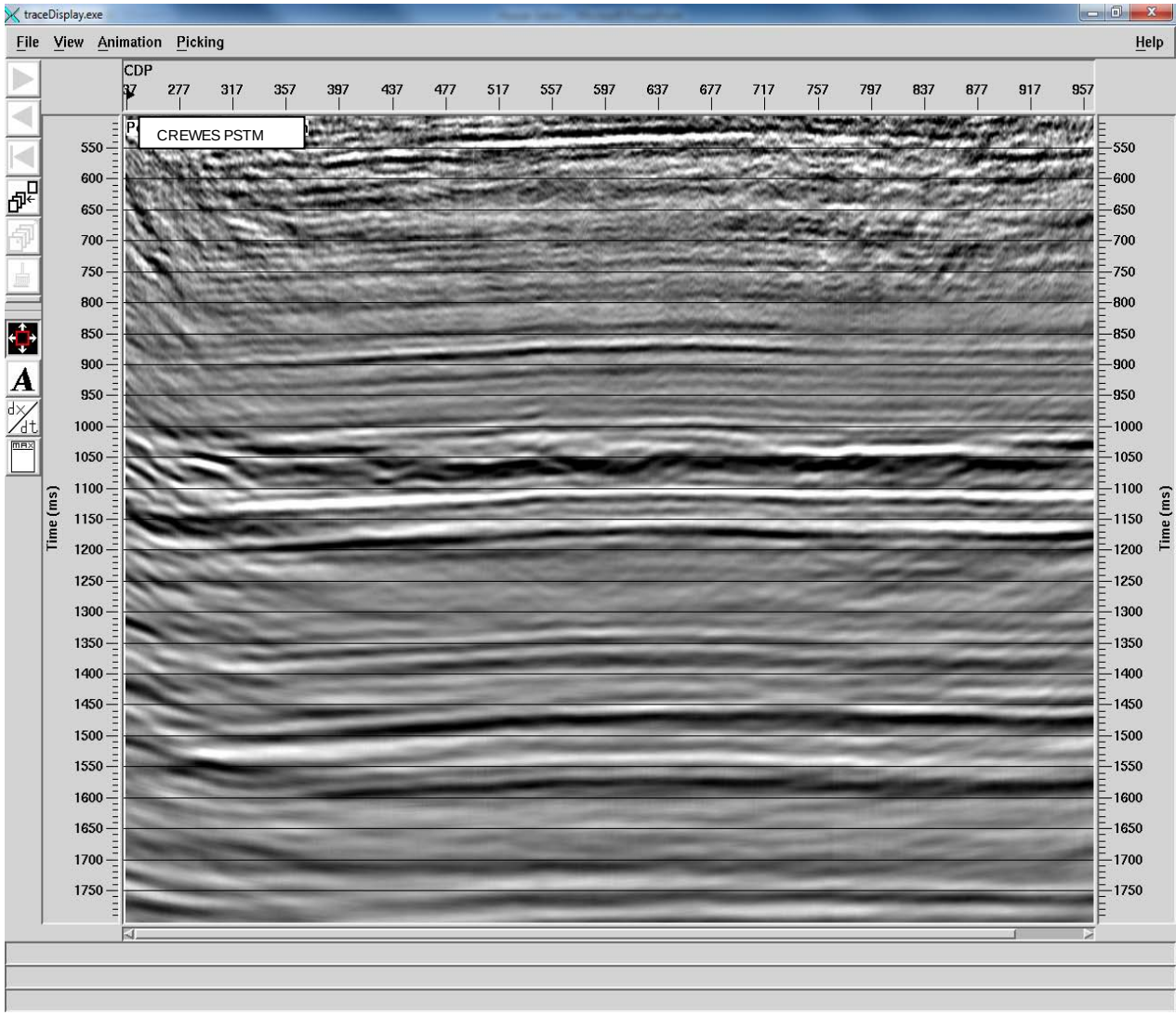


Weak reflection signals at the near offset of CIG gather.

PSTM-KIRCHHOFF: CONTRACTOR



PSTM-KIRCHHOFF: CREWES



Contractor used a different datum & replacement velocity than us (Bulk shift is needed for comparison).
Contractor applied zero-phase decon after migration whereas we applied minimum phase decon.

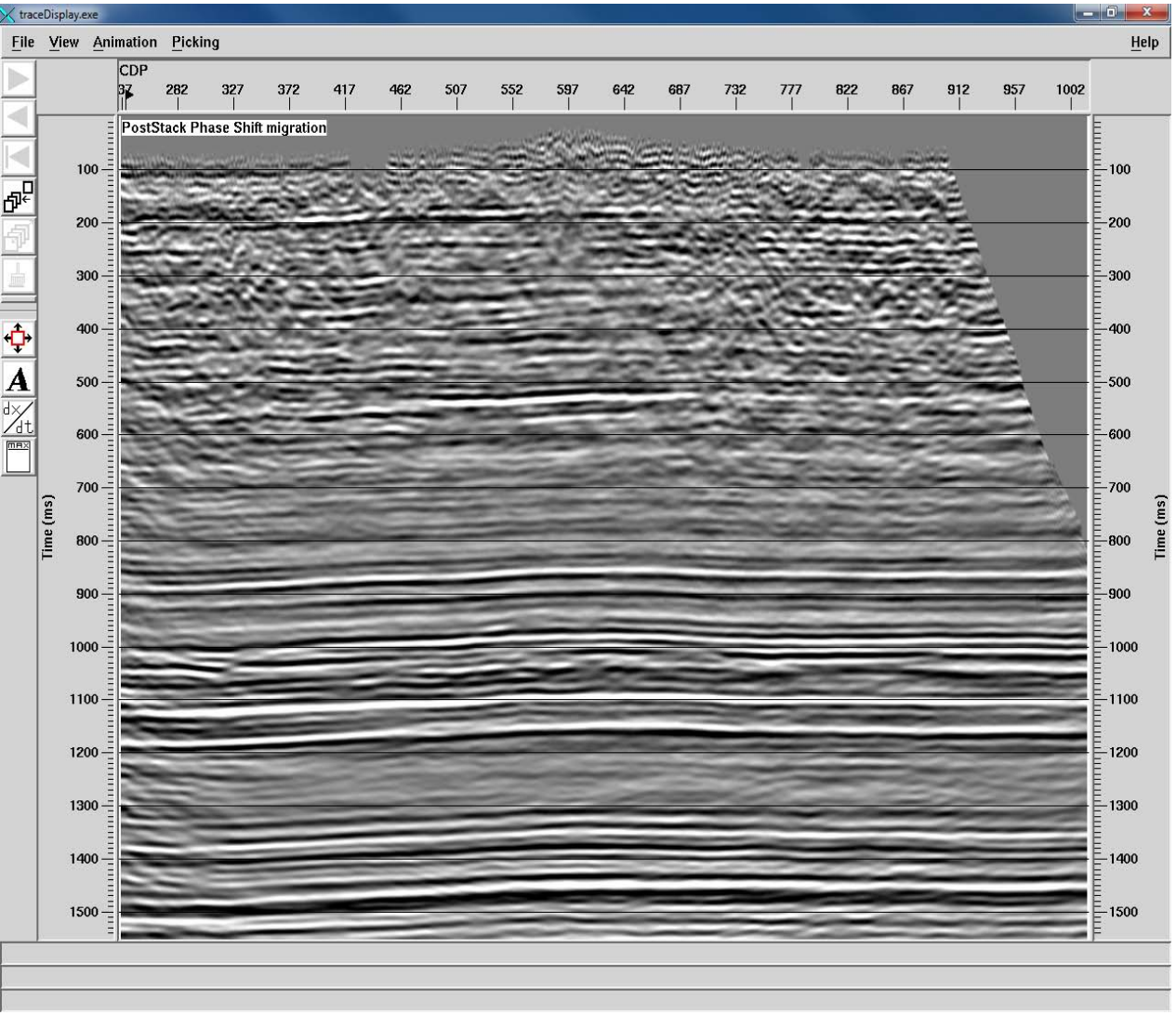
Phase-Shift : Pre- & Post– stack migration

- Stack section of Pre-stack phase shift migration used CIGs of live traces only.

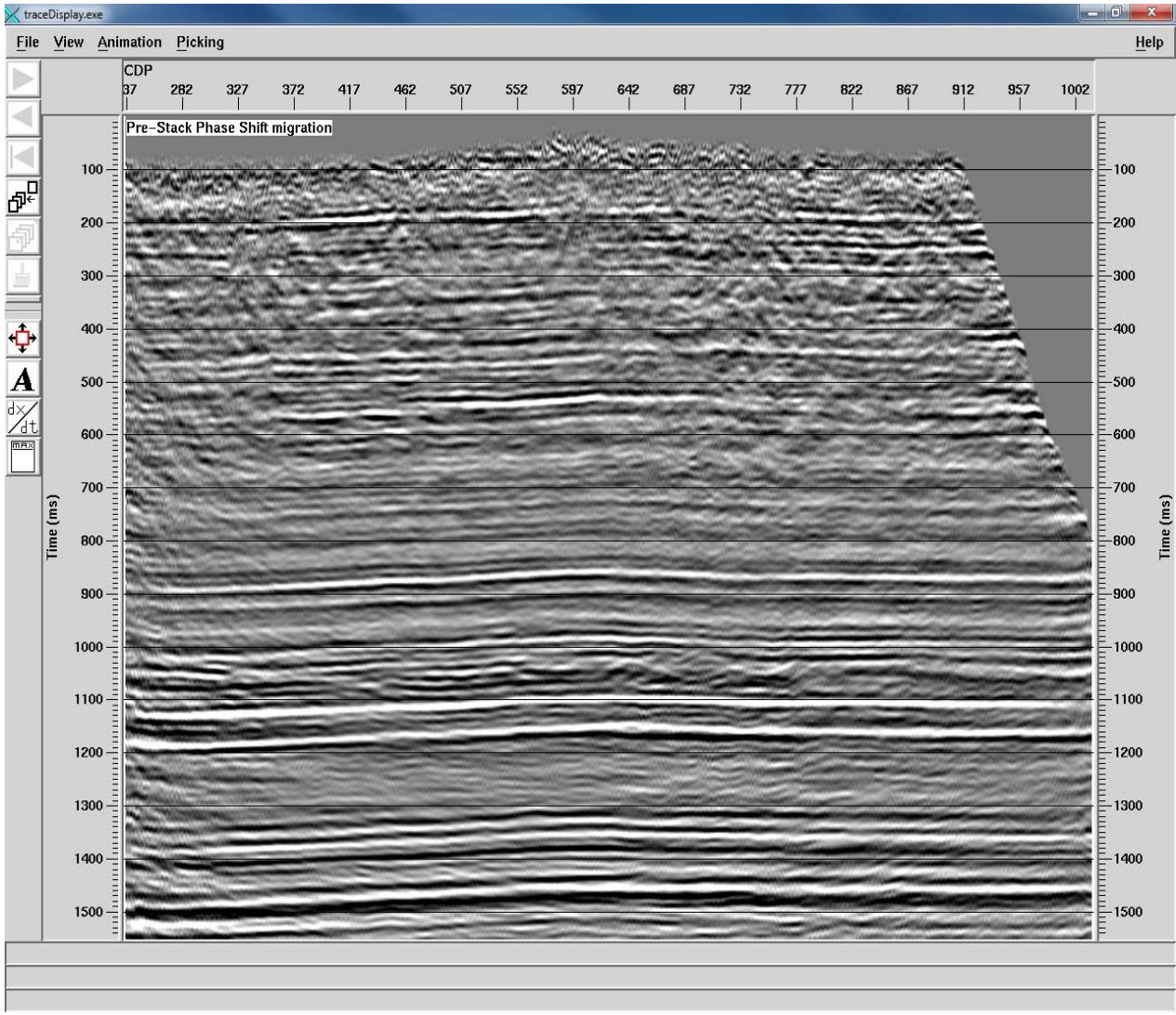
- Output CIG gathers form pre-stack phase-shift migration populate **noisy** traces for the padded traces compared to PSTM Kirchhoff.

- If we ask to re-kill dead traces inside phase-shift module, then the CIG does not populate full regular offsets for each bin for the CIG gather.

POST-STACK PHASE-SHIFT

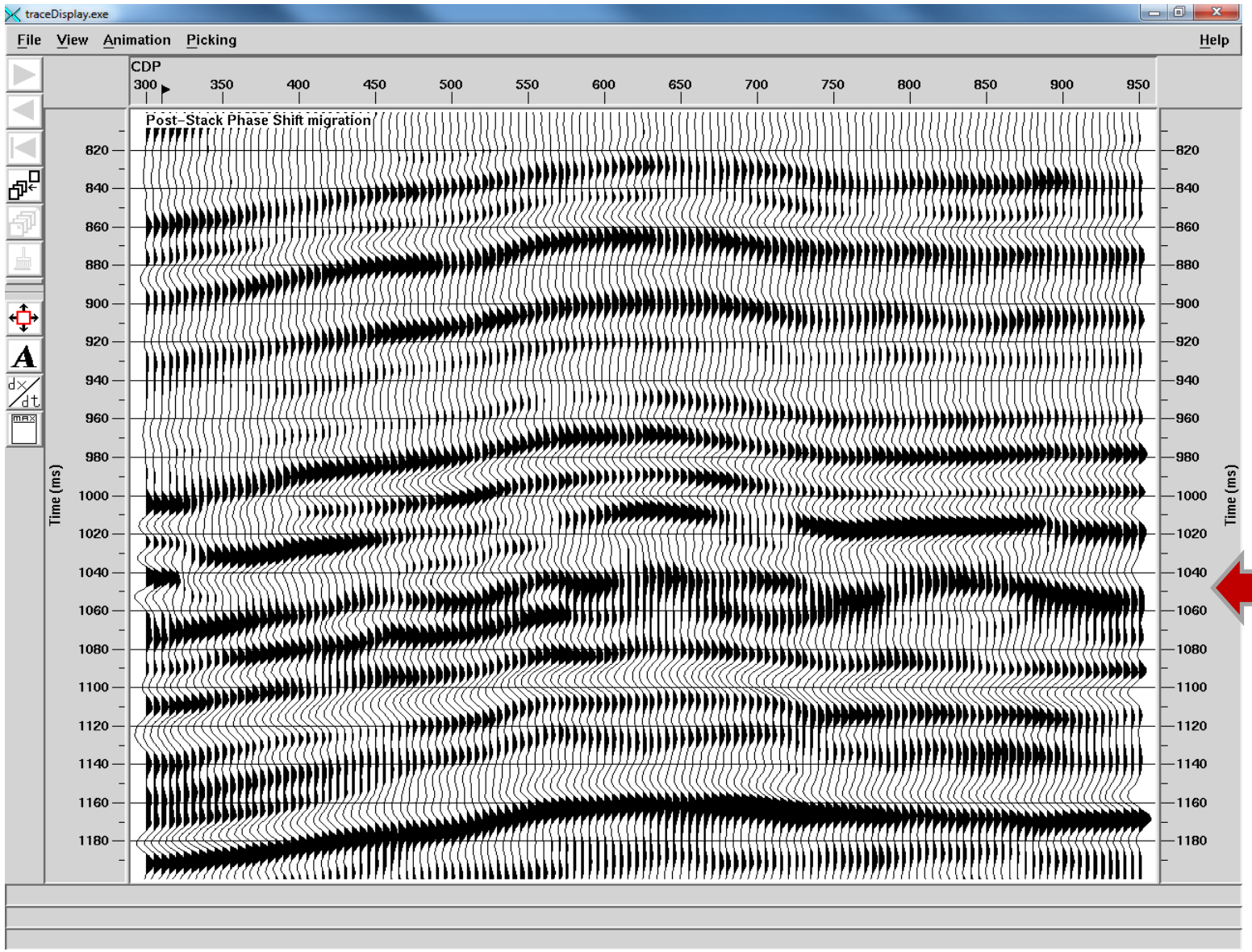


PRE-STACK PHASE-SHIFT



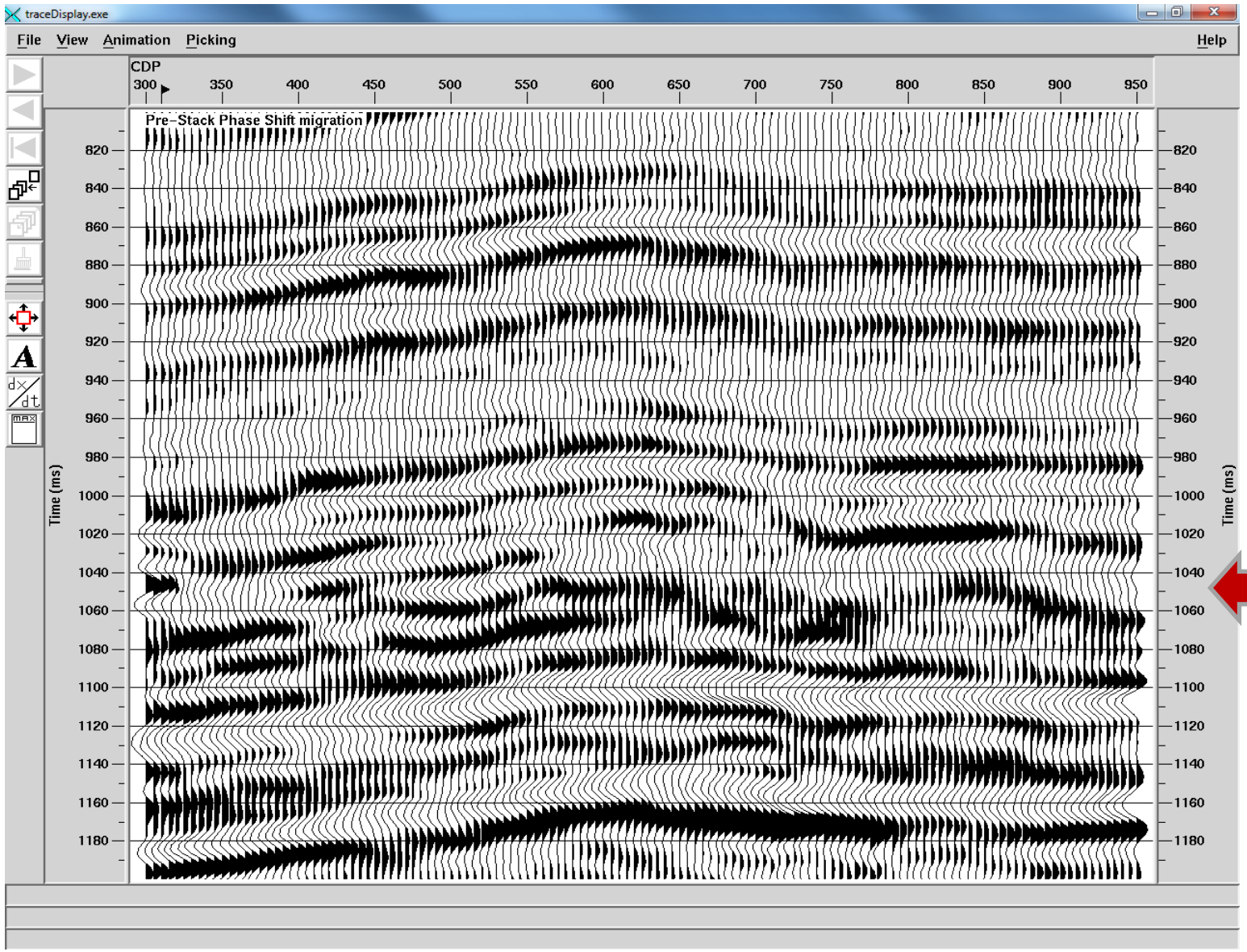
More detailed are shown and better continuity of reflectors at the top of PSTM.

Phase-shift: post-stack migration section -zoom



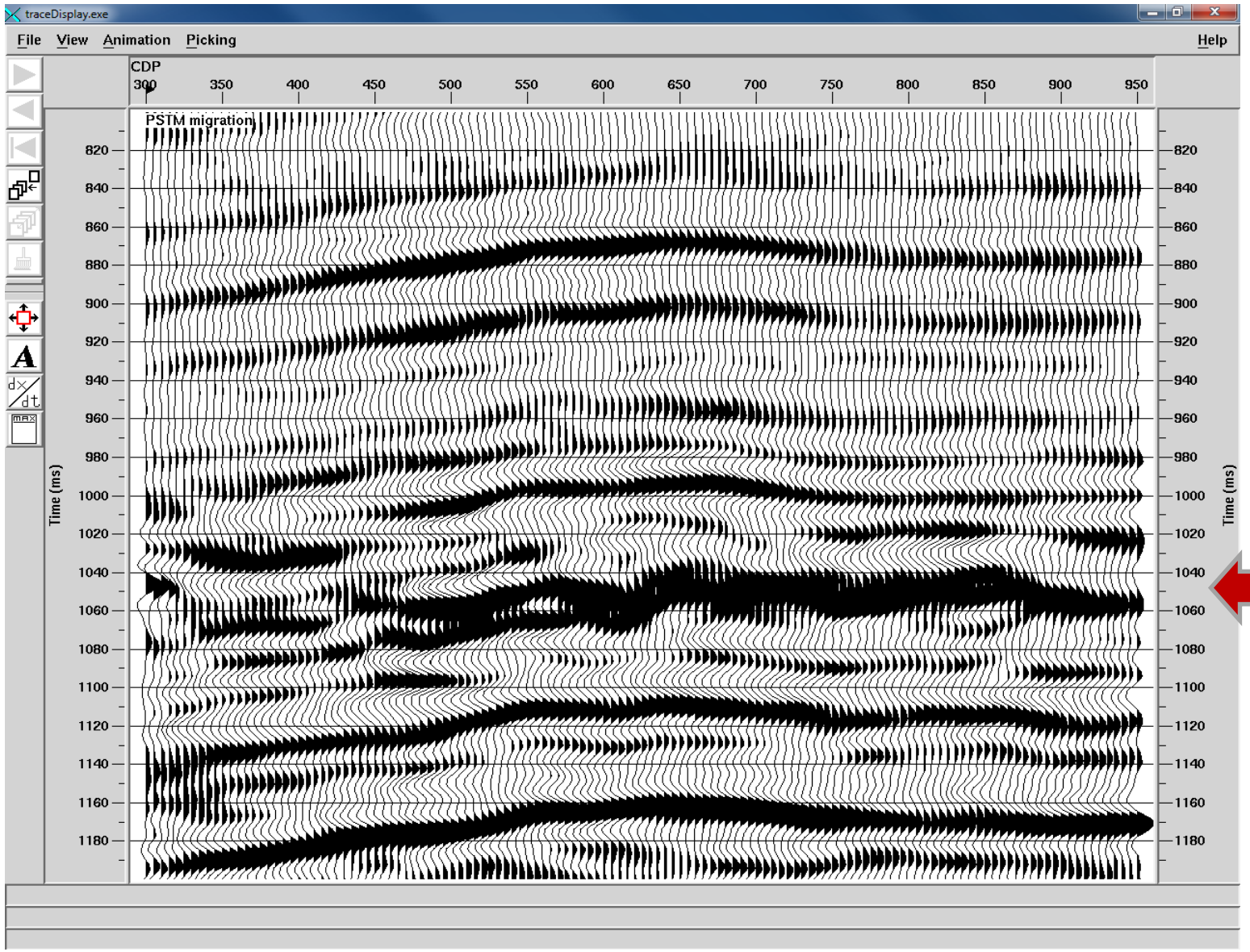
Zone of interest

Phase-shift: Pre-stack migration section -zoom



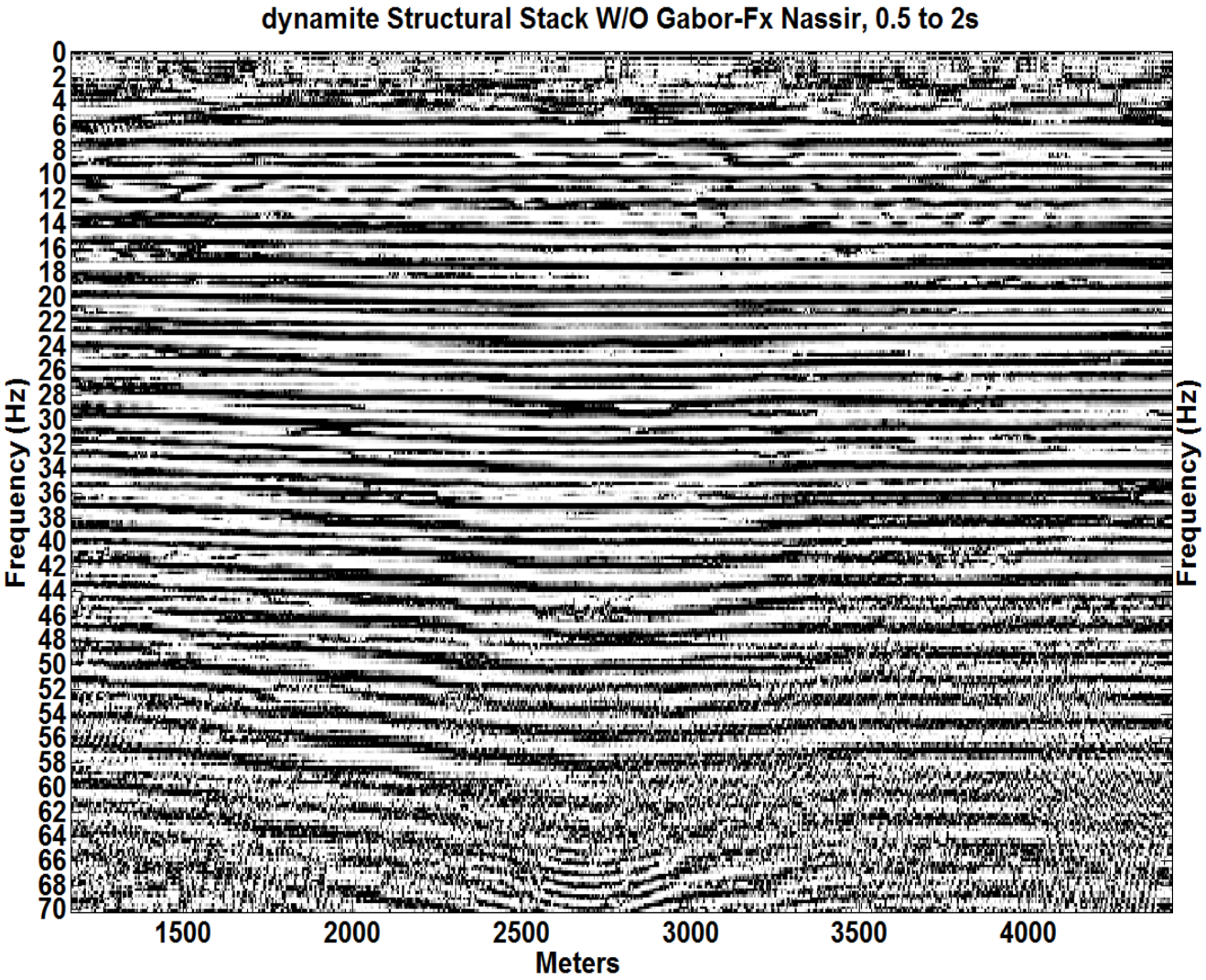
Zone of interest

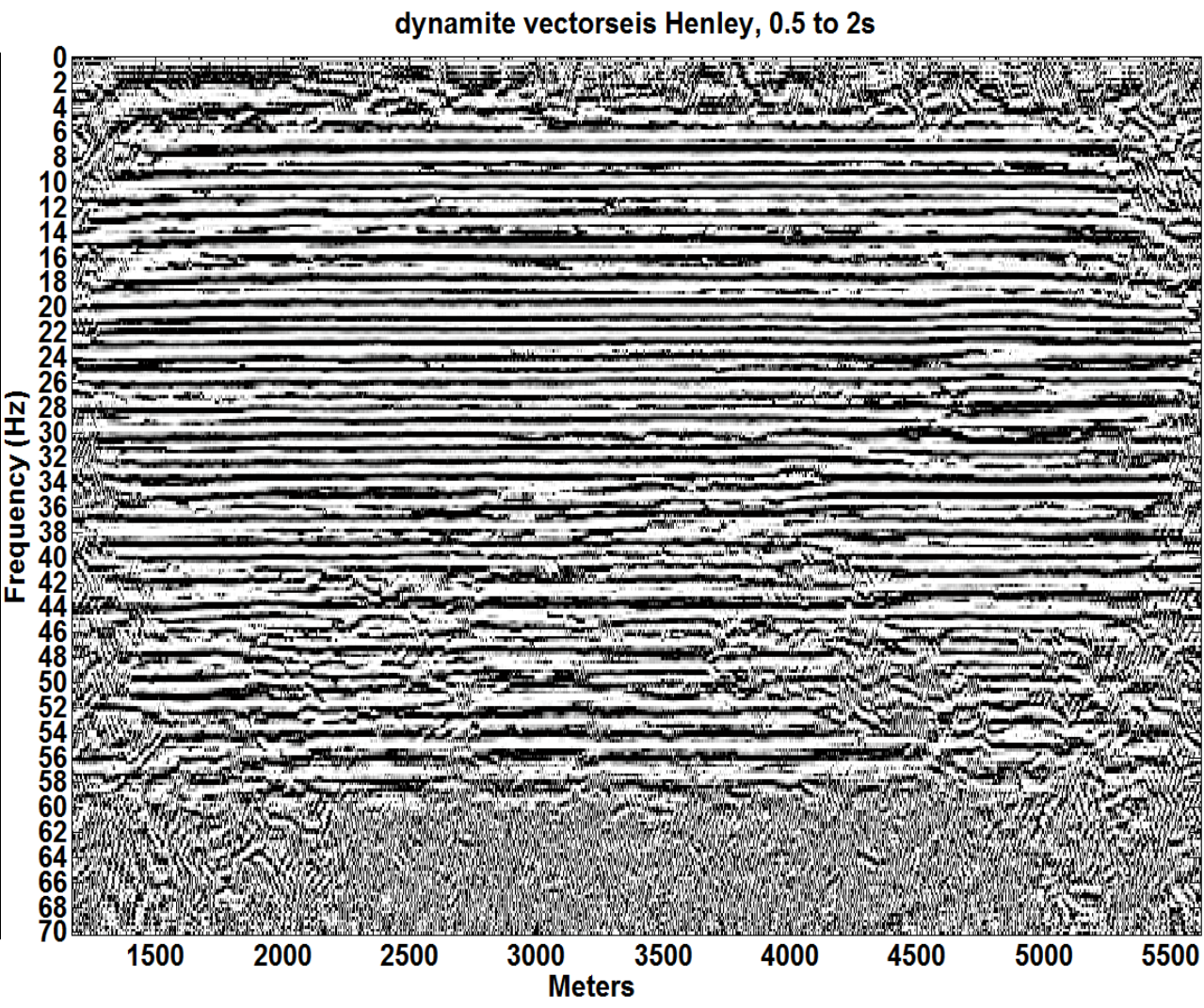
Kirchhoff: Pre-stack migration section -zoom



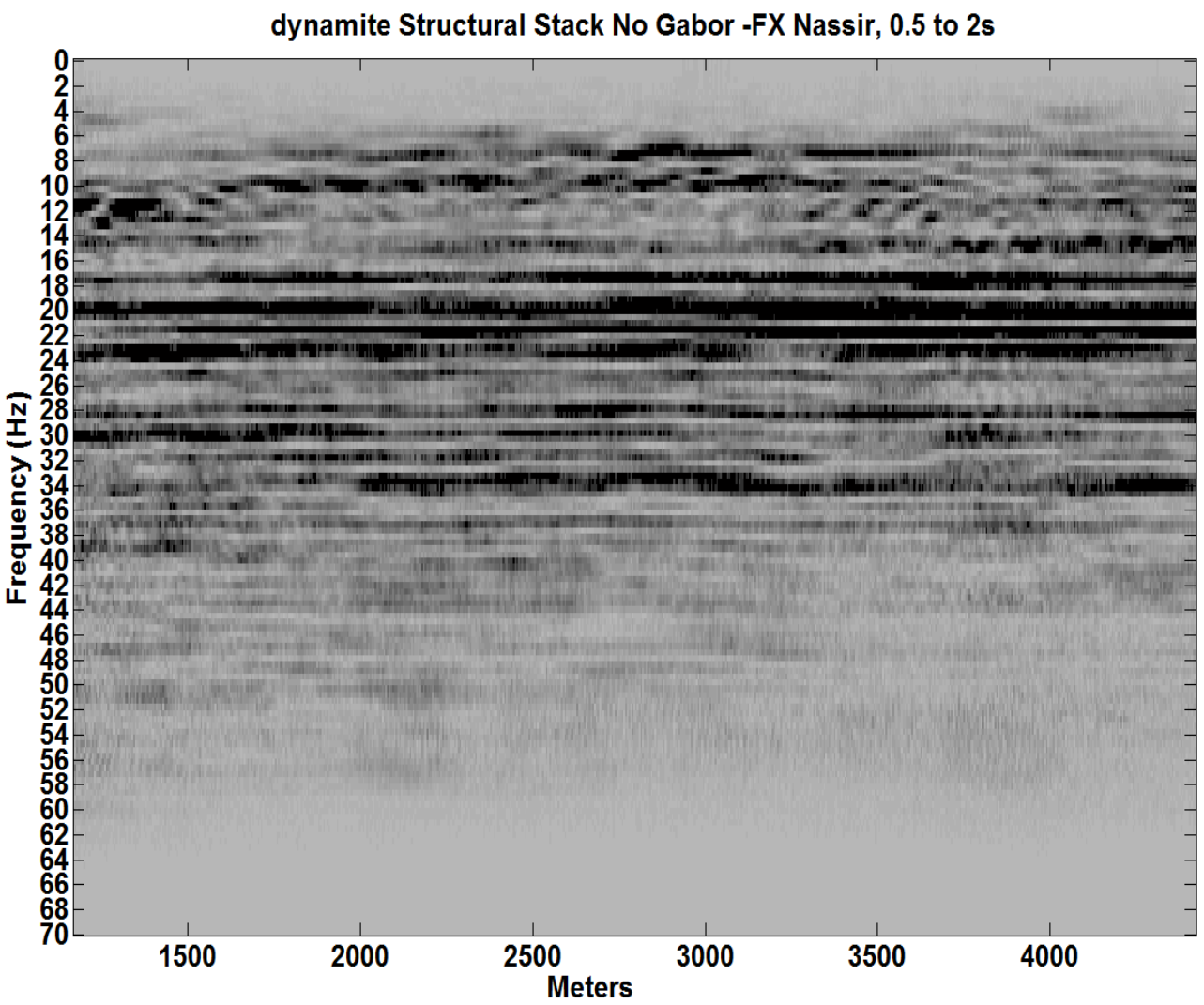
Zone of interest

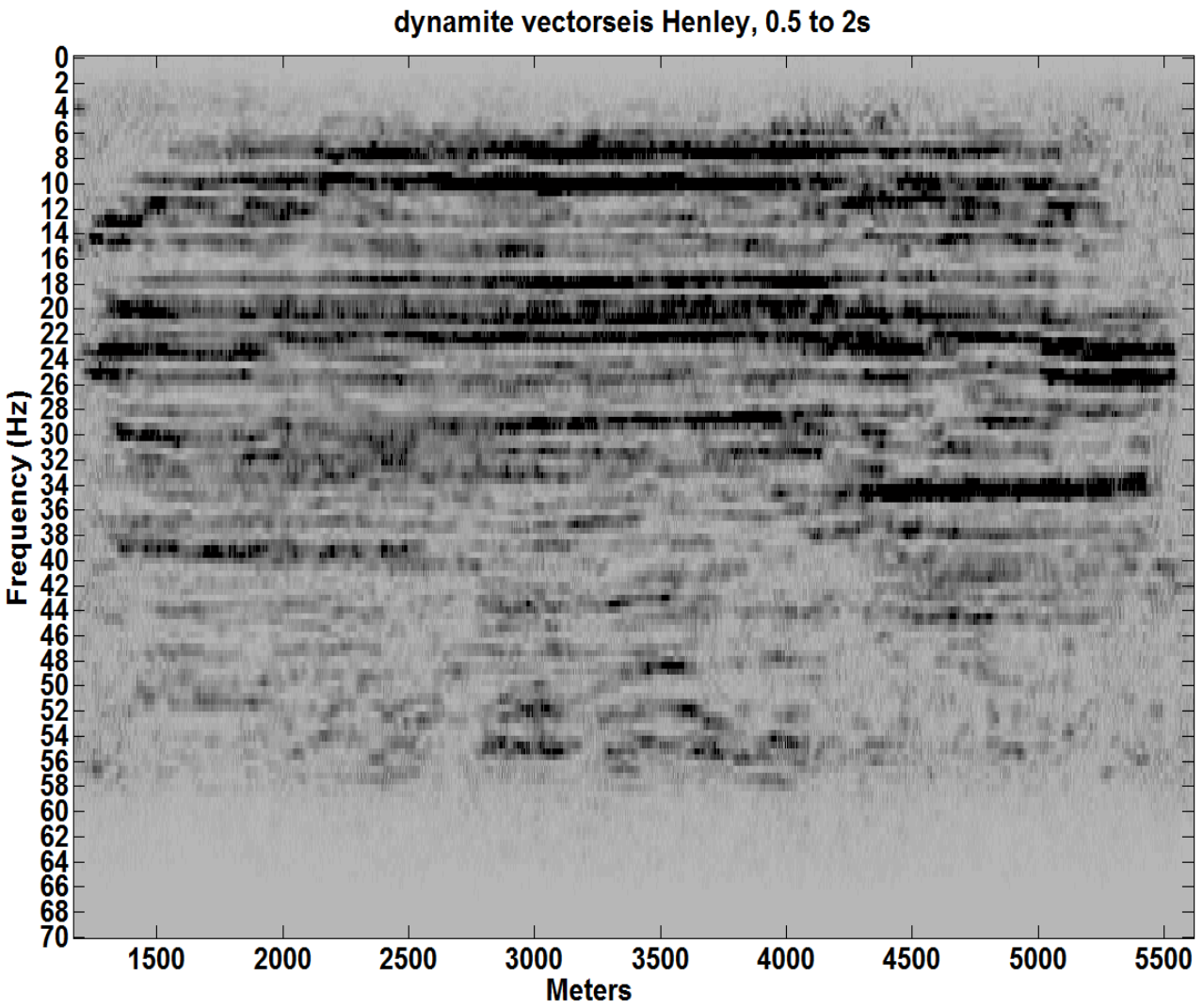
Estimation of band signal – Complex Phase





Estimation of band signal – Complex Phase





Inversion

Seismic data conditioning – Trim static and super gathers.

Offset to angle conversion - angle gather & angle stacks

Well to seismic tie and Wavelet extraction for each angle stack

AVO Analysis

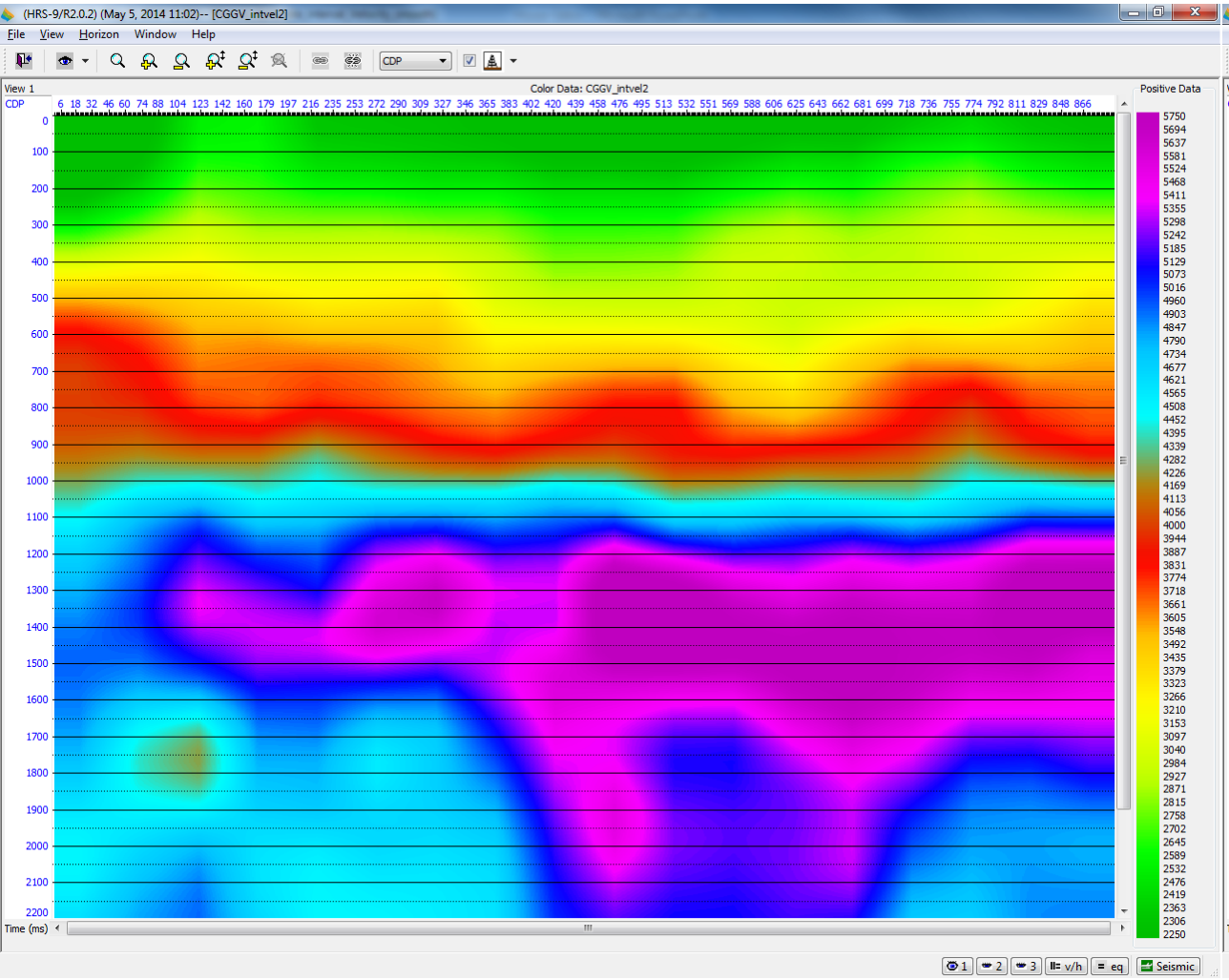
Building low frequency model

Post stack analysis and inversion

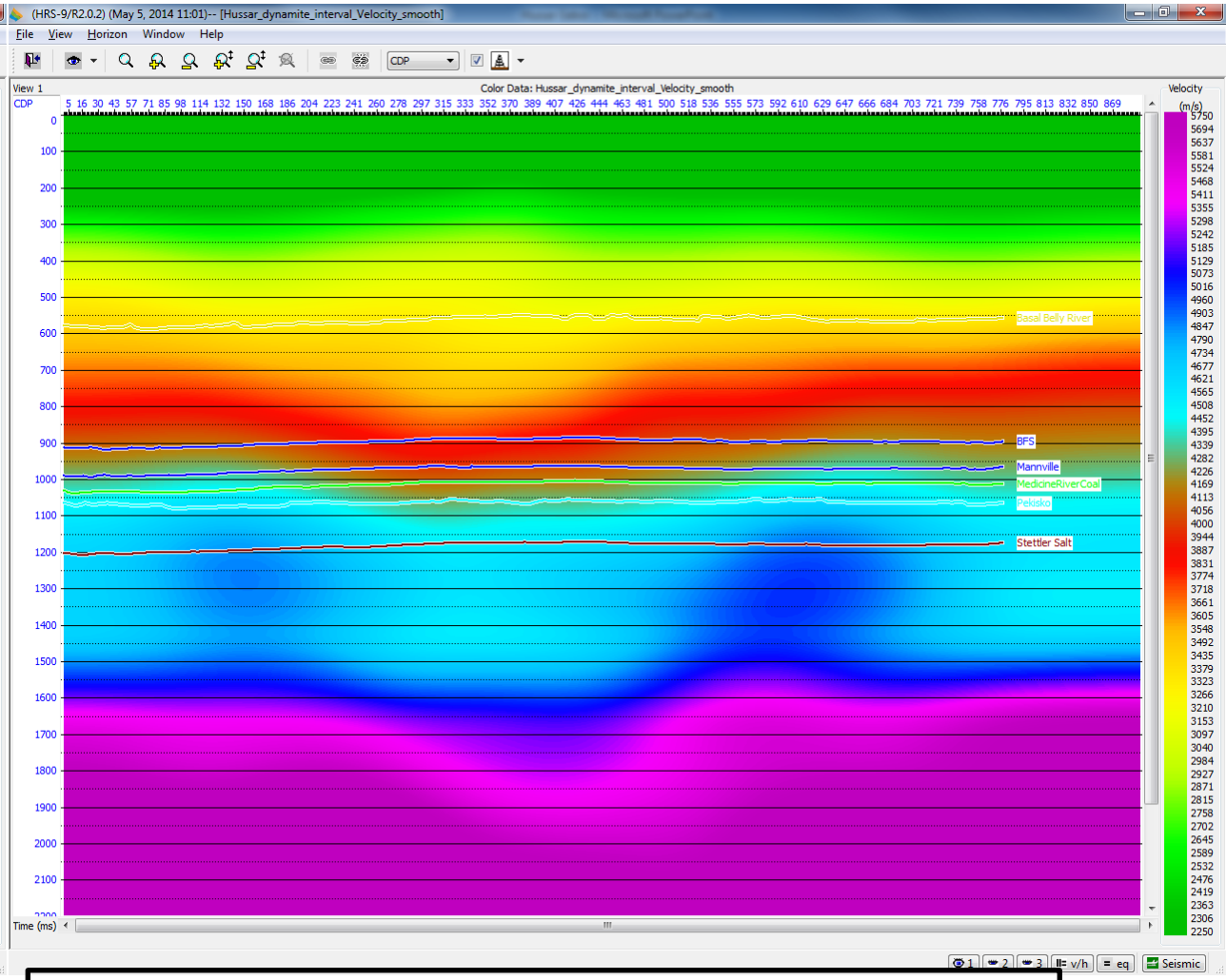
Pre-stack analysis and inversion

Interval velocity

Contractor

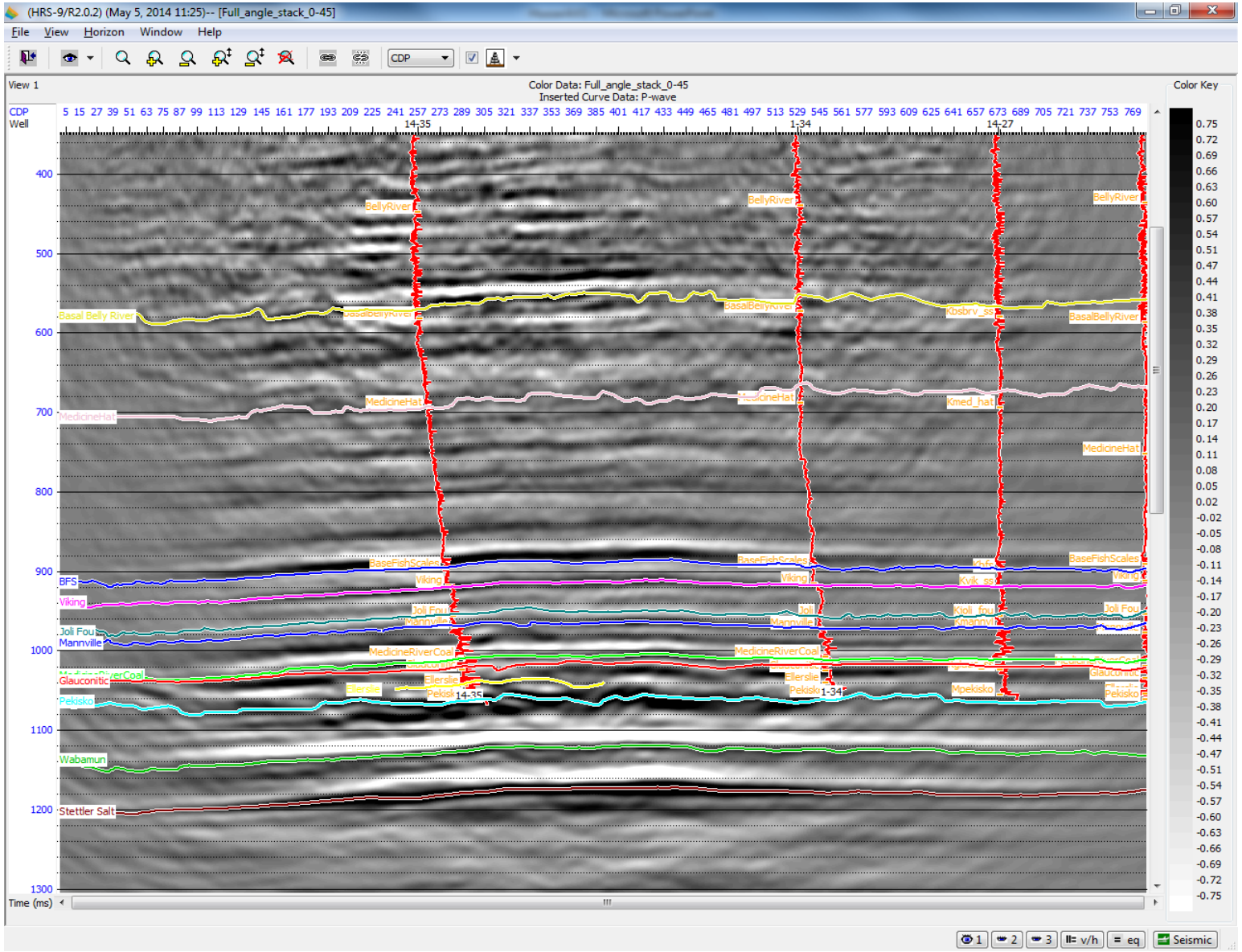


CREWES

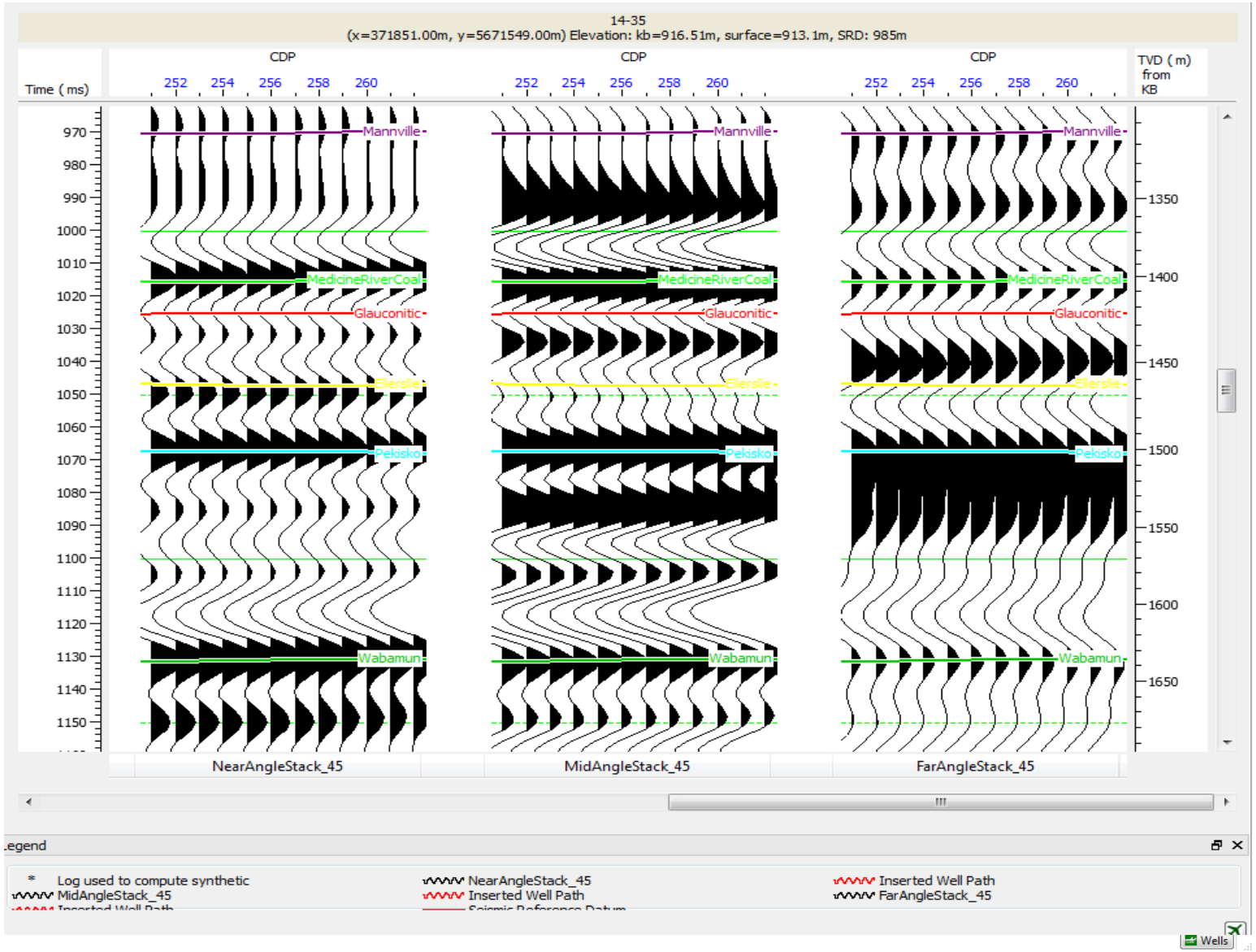


Zone of interest from 1000-1100ms.
Note the smooth and continuity of interval velocity across section compared to CGG interval velocity section

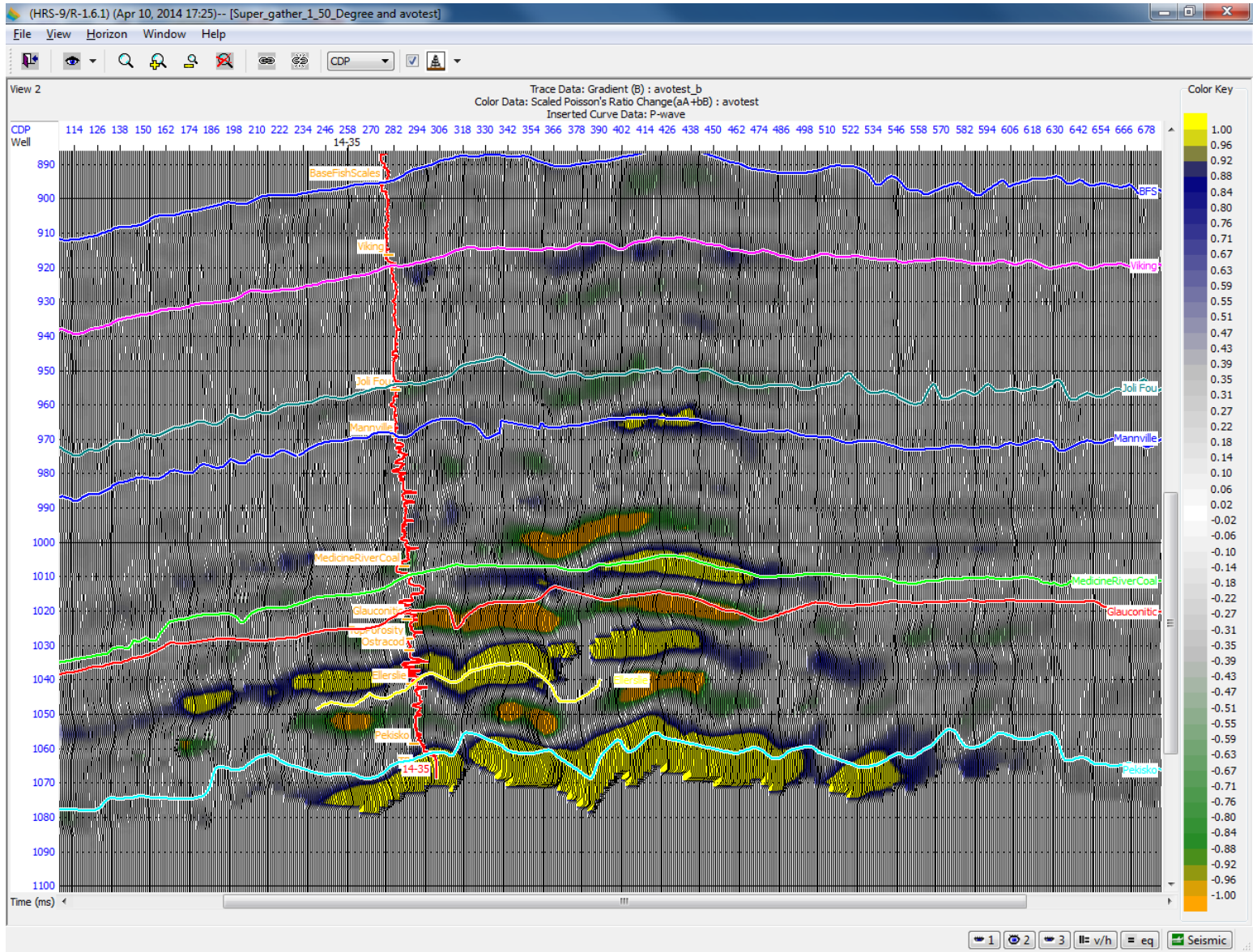
Stack (0-45 degree) section - Hussar



Angle stacks near Well: 14-35



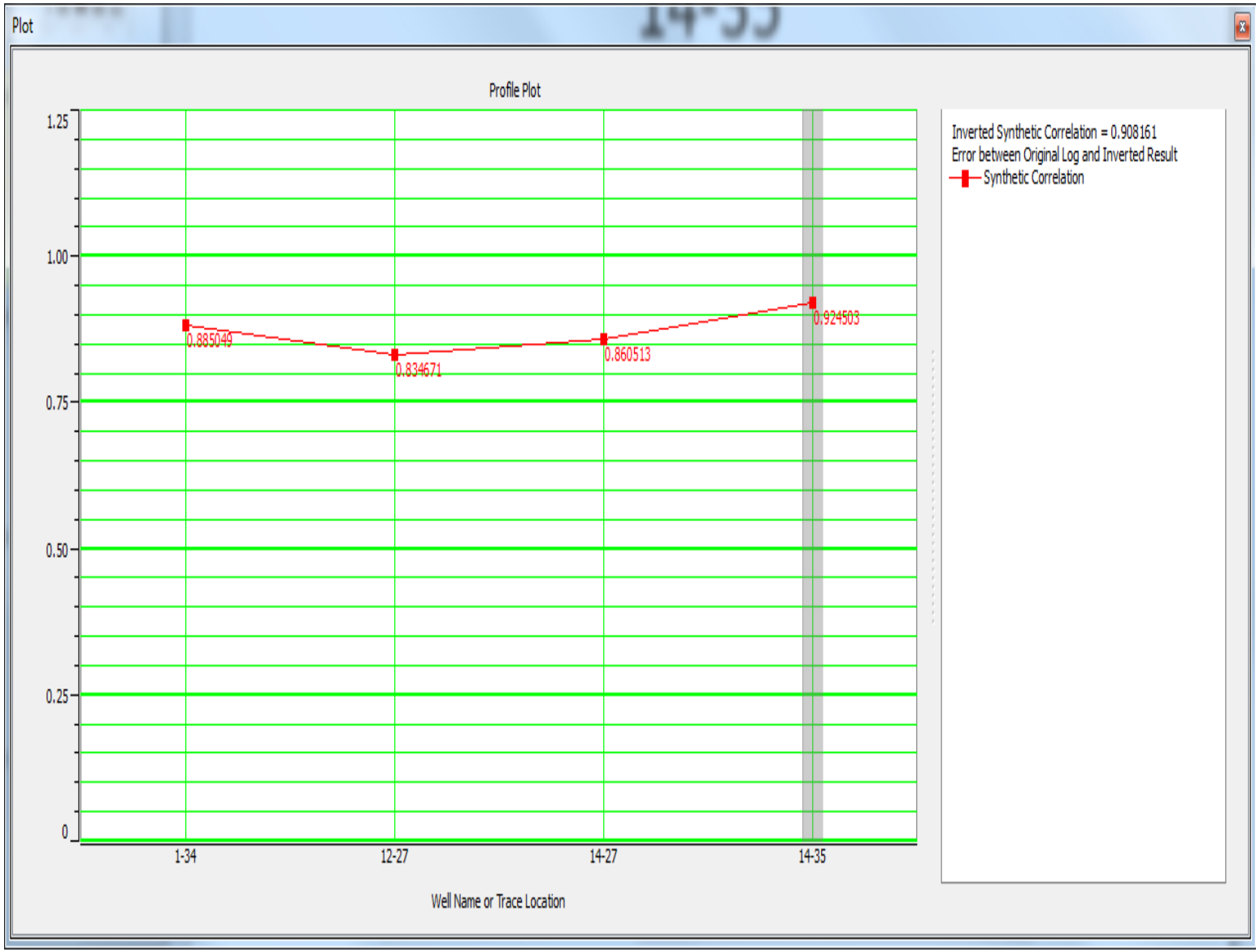
AVO Analysis- scaled pseudo Poisson ratio



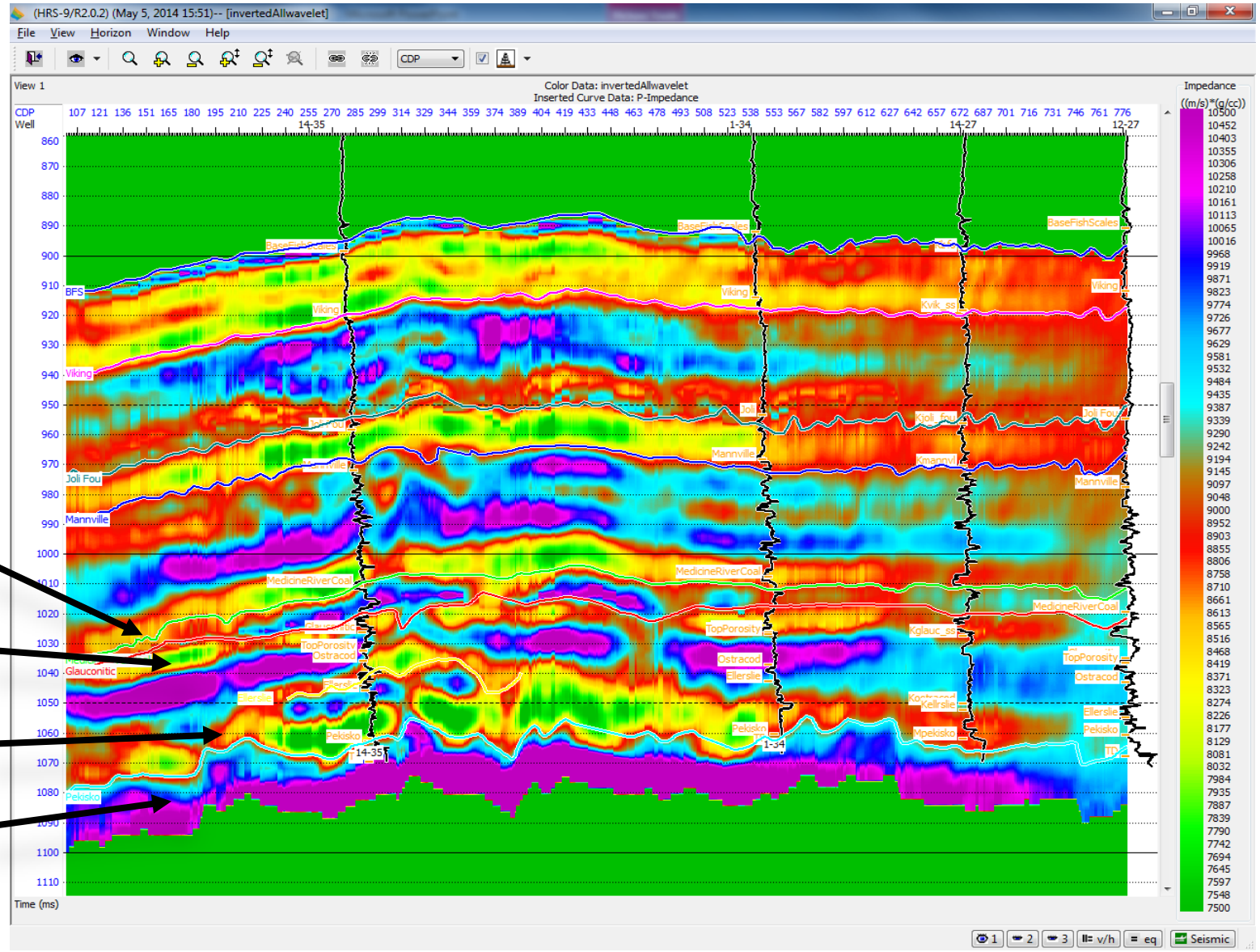
*Negative values (orange in color) shows top of sand reservoir of Glauco more clear compared to Ellerslie FM.

* Bright yellow is the base of the reservoir where shale layers manifests.

AVO Inversion Analysis- correlation profile



Post stack inversion: P-Impedance



Medicine River coal

Gluaco sand

Ellerslie

Pekisko

Zone of interests are Glauco sand channel overlain by Medicine River coal marker.

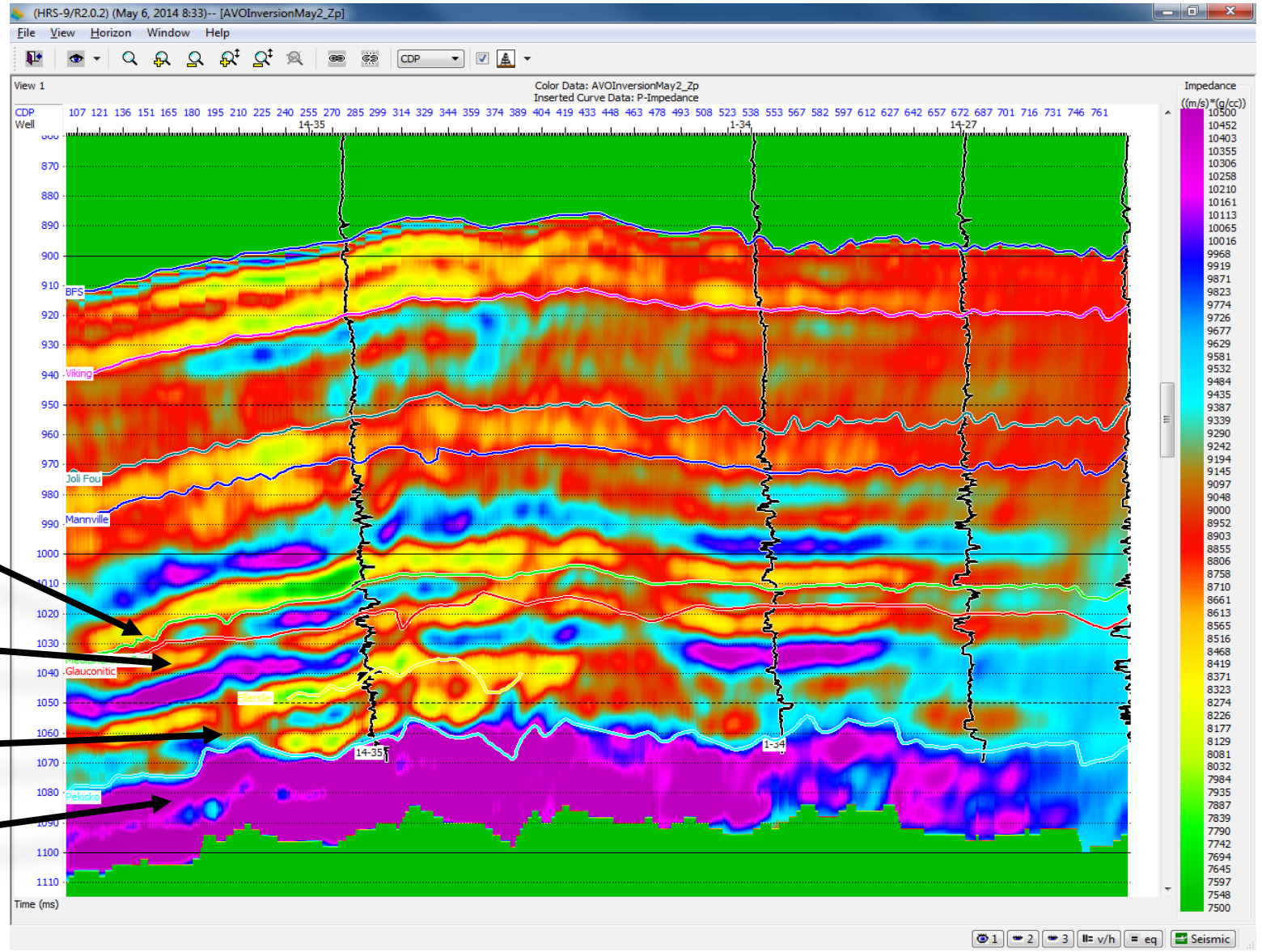
The second zone of interest is Ellersli Fm above Pekisko. From literature this oil bearing formation.

Horizon colors:
Midicne-River coal: **green**

Glauco horizon: **red**

Pekisko Horizon: **Cyan**

AVO Inversion: P-Impedance



Medicine River coal

Gluaco sand

Ellerslie

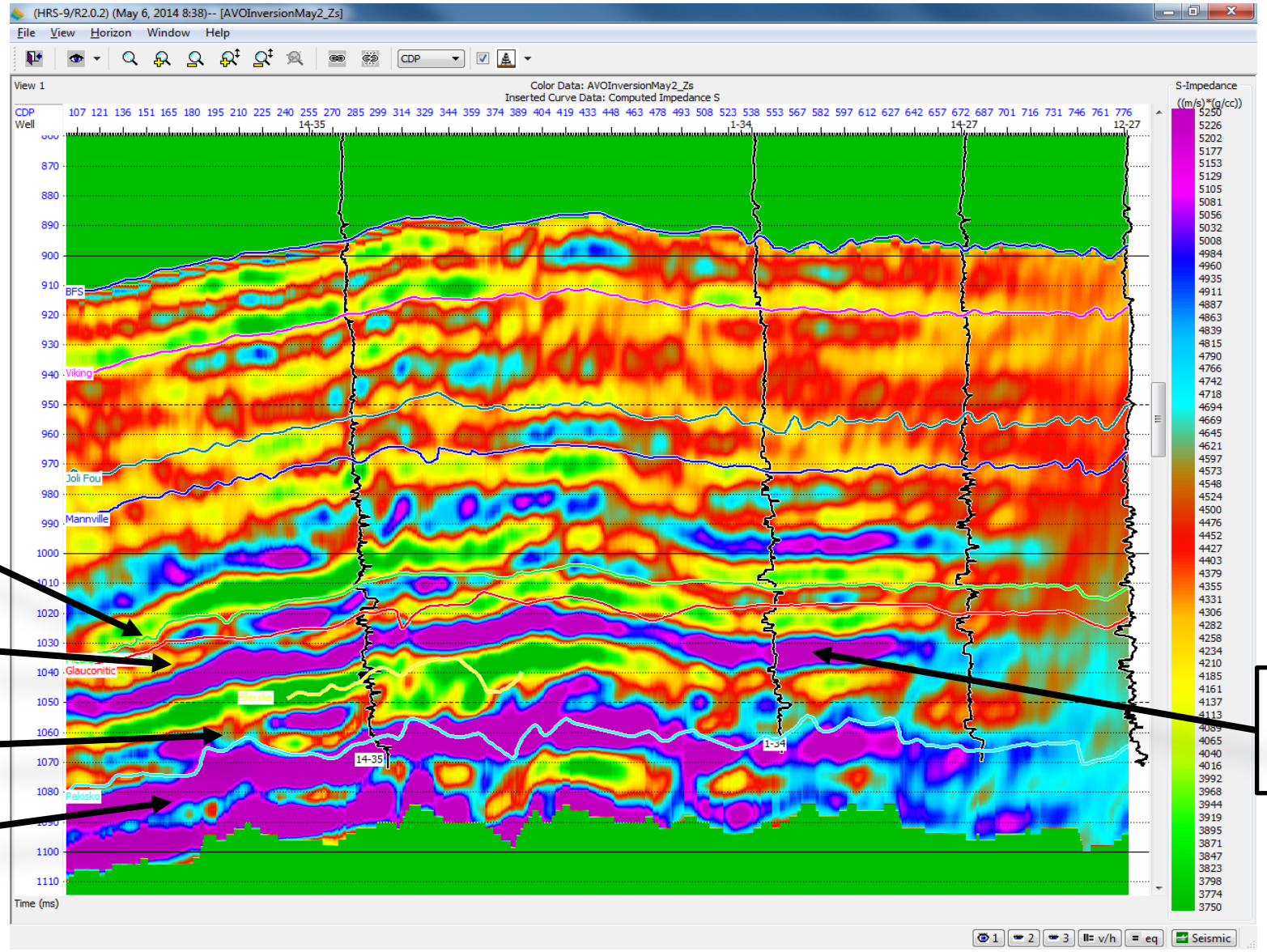
Pekisko

Horizon colors:
Medicine-River coal: **green**

Glauco horizon: **red**

Pekisko Horizon: **Cyan**

AVO Inversion: S-Impedance



Medicine River coal

Gluaco sand

Ellerslie

Pekisko

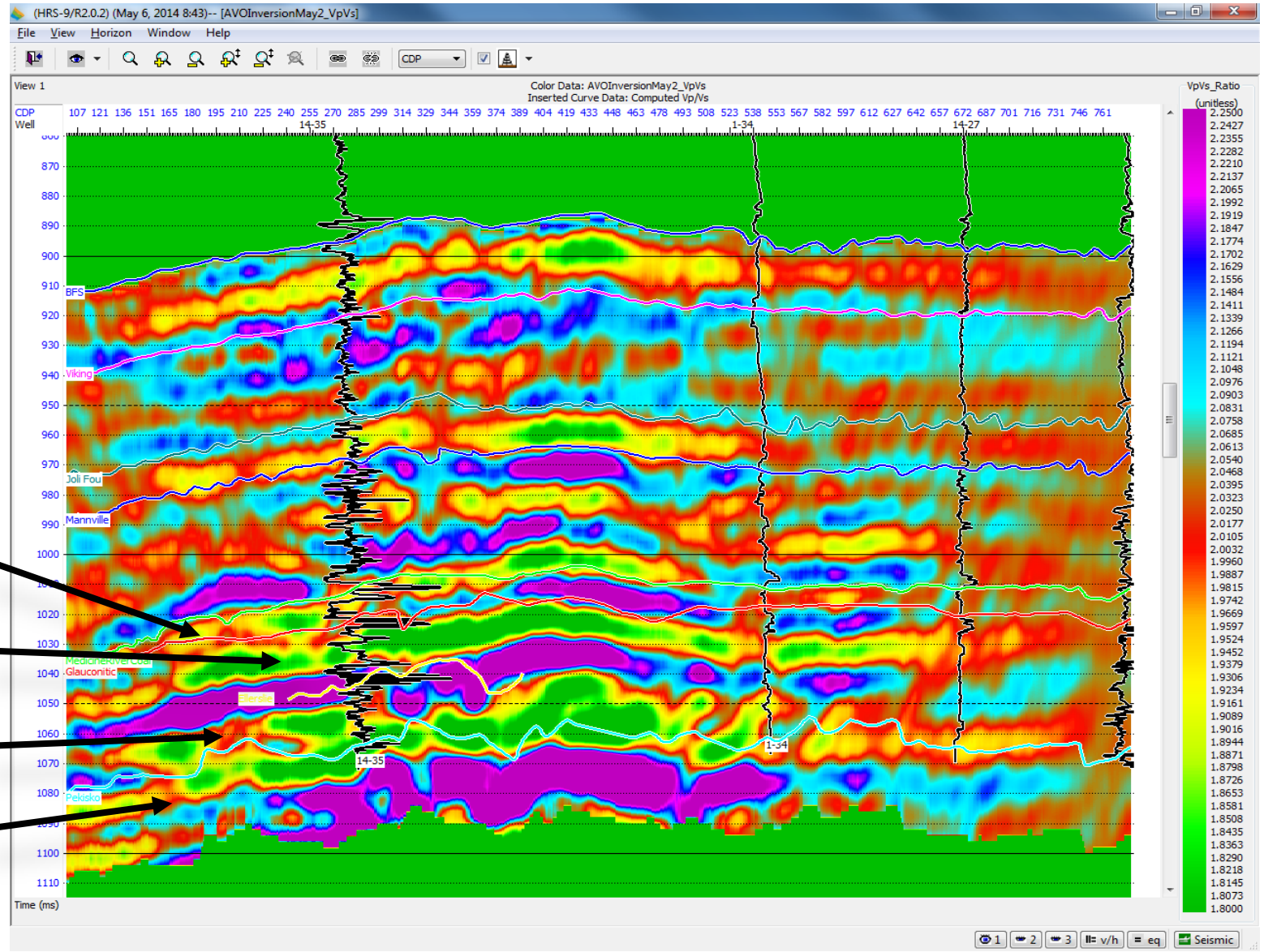
Horizon colors:
Medicine-River coal: **green**

Glauco horizon: **red**

Pekisko Horizon: **Cyan**

Hard shale top of Ellerslie is clearly showing

AVO Inversion: Vp/Vs



Medicine River coal

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Pekisko

Horizon colors:
Medicine-River coal: **green**

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Conclusions

- Re-processing of 2D lines show more details at the zone of interests. Reflection signal is down to 3Hz.
- Noise attenuation by Radial dip filter successfully attenuate ground roll and pump jack noise.
- Maximum offset of CIG gathers is good to approximately 3440m compared to 1980m of CGG processing.
- PSTM migration focuses reflected energy, collapses diffraction and improve image section.
- Elastic rock sections delineate lateral extensions of Glauconitic and Ellerslie prospects. All impedance and elastic sections were inverted to 3Hz as low frequency cutoff (1-3Hz).

Further work

- Improve pre-stack imaging using PSPI. Will use CREWES PSPI code for Hussar data.
  - To gain more reflection signals from 100-500ms that we were seeing in phase-shift migration and were missing from Kirchhoff migrations.
  - Investigate the CIG gather to see if reflection and S/N would be improved at near offset by using wave equation migration (PSPI).
  - Enhance lateral extension at the east side of inverted sections at Medicine Rive coal and Glauco formations for better correlation with the dipole sonic well 12-27.
- Rock physics modeling and analysis work to be done pending providing further logs and other info from Husky.

Acknowledgments

- CREWES sponsors, staff and students
- Husky Energy