Open access seismic data with scripts for processing with open software

Karl Schleicher
University of Texas at Austin

Prologue

There is a big gap between functioning research prototype and a tested program. You learn a lot when you start processing field data. In industry, processing groups can help. They provided data expertise including selecting a suitable dataset, previous results, detailed parameters, partially processed data for input, and an eye to evaluate our new results. This paper starts to build a data library for testing open source seismic software.

Overview

Goals

Current Progress

Conclusions

Future Direction

Long Term Goals

- Build an open-access seismic library with scripts for open software processing
- The library can be used by others to recreate my processing.
- The scripts provide detailed processing sequences and parameters that can be used with or without modification.
- Accelerate testing and validation of new seismic algorithms.

Long Term Goals (continued)

- Multiple datasets suitable for testing different research efforts (2d, 3d, land, marine, noise, multiples, sampling, field data, synthetic data, etc).
- Evaluate the relative strengths of open-access seismic software.
- Improve open-access seismic software.
- Make Madagascar the “go to” place for seismic test data.

Previous open seismic processing

- Provide instruction for basic unix, user environments, basic processing, and advanced SU scripting.
  - Demos directory in SU distribution
  - Seismic Data Processing with Seismic Un*x, Forel, Benz, and Pennington
  - Geophysical Image processing with Seismic Unix, Stockwell
- This effort's focus:
  - basic processing scripts for full processing sequence: load, trace header creation, velocity filter, velocity analysis, moveout, and stack.
  - Field data access

Current Progress

Dataset	copied	SU processing	Madagascar	In svn	description
Alaska 31-81 2d Land	y	y	partial	y	Easy statics Ground roll spikes
Alaska 635-79 2d Land	y				Hard statics
Alaska 51S-75 2d Land	y				Intermediate statics
Nankai 2d Marine	y	y	partial		deep water
Taiwan 2d Marine	y	started			strong random noise
Usp 2d Land	partial		Partial		
Teapot dome 3d land	y				
Opunake 3d marine					

Processing NPRA Line 31-81

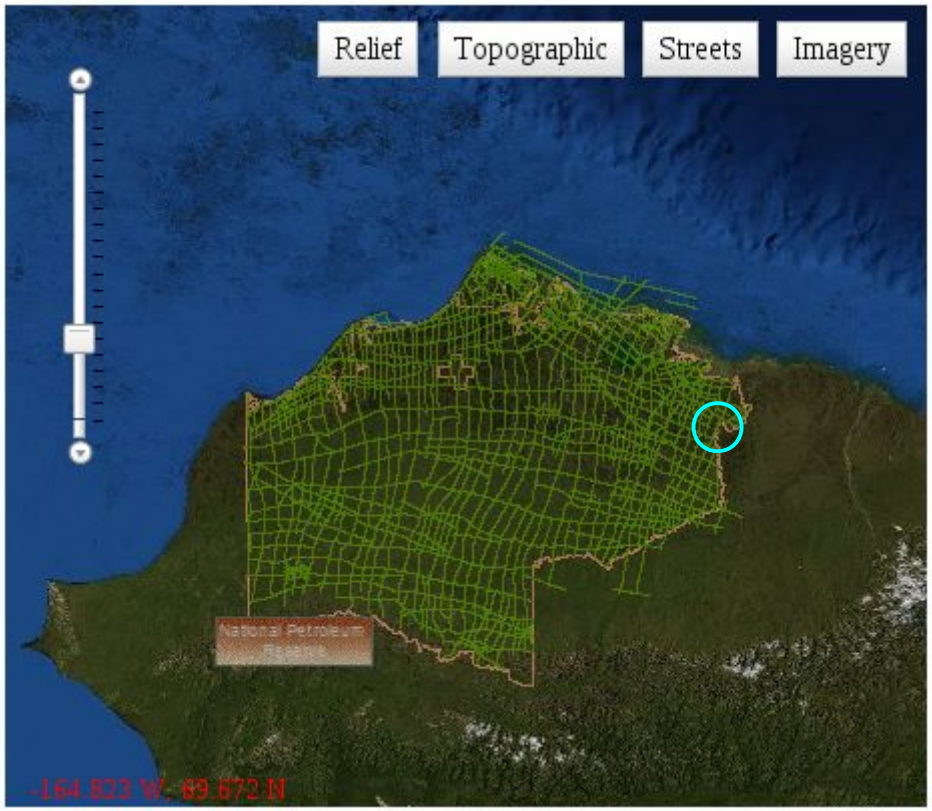
- Background information about the data
- Data Loading and initial data QC
- Shot record velocity filter
- Shot record edit, mute, cdp sort
- Velocity interpretation
- Stack
- Comparison of the SU and 1981 processing

NPRA Background

- Naval Petroleum Reserve Number 4 created by President Harding in 1929. Renamed National Petroleum Reserve in 1976. GSI collected and processed data between 1974 and 1981. Data is internet available.

Line 31-81 Background

- Line 31-81 selected because it was short line from last year data was collected. Approximate location is marked.
- Data is 96 trace, 12 fold, dynamite. 440 ft shot interval, 110 ft receiver interval.
- Previous processing included spherical divergence correction, velocity filtering, designature, agc, velocity estimation, nmo, residual statics, diversity stack, time variant filter, and agc.



Data loading and initial QC

- Segyread converted the data from SEGY to SU format.
- Surange showed only fldr and tracf in the input trace headers.
- Suximage helped identify the first 10 record to be test data. There is good signal. There is ground roll.
- Xmovie display identifies data channels 1-96, aux channels 97-101.
- First impressions of the data:
  - Good signal. Ground roll, noisy trace segments, repeated ground roll on center traces, “spikes”, small statics.
  - Suitable for testing “land noise attenuation”.

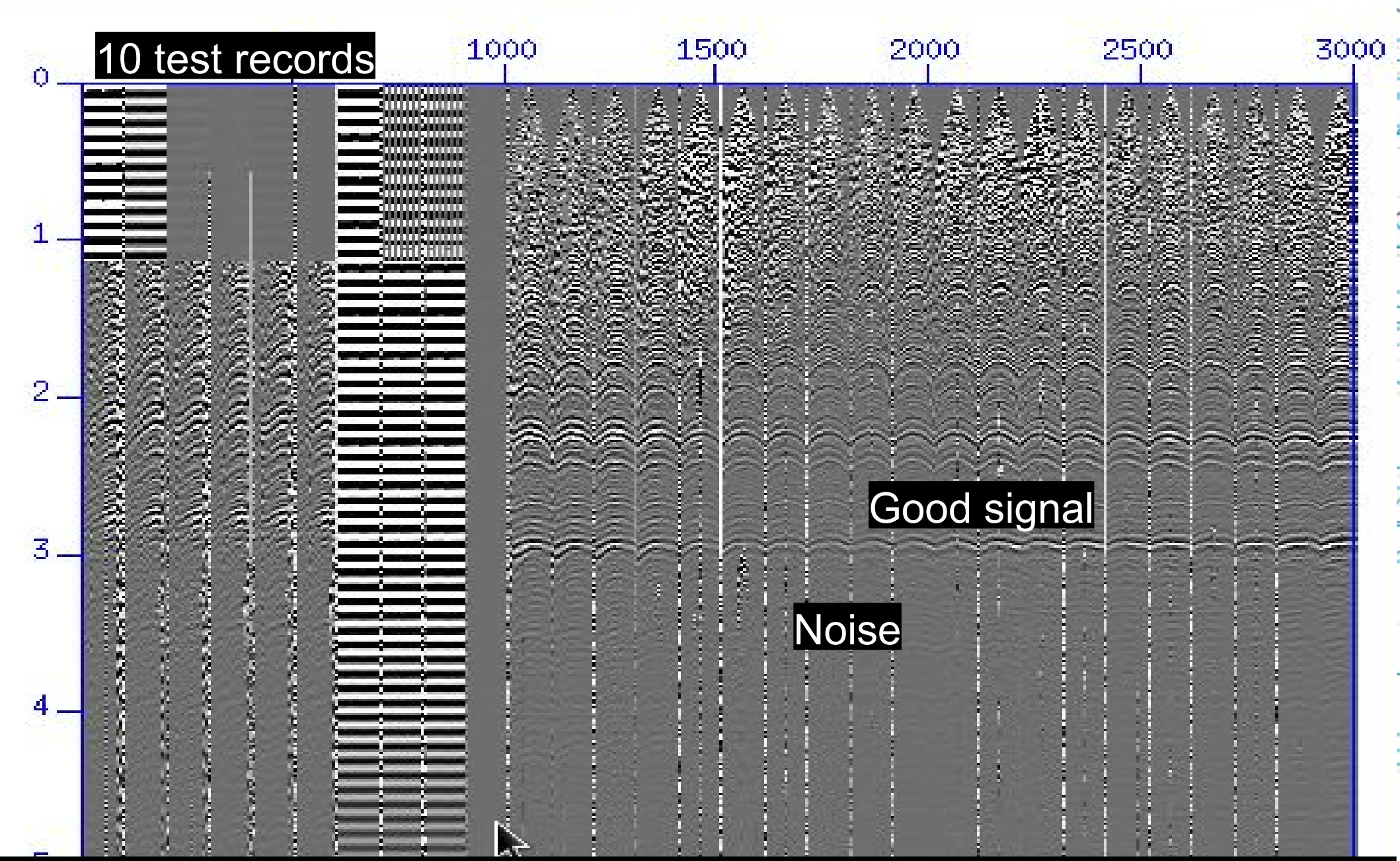
Seismic Unix (SU) processing

- Data load, header dumps, and initial qc plots
- Data observations:

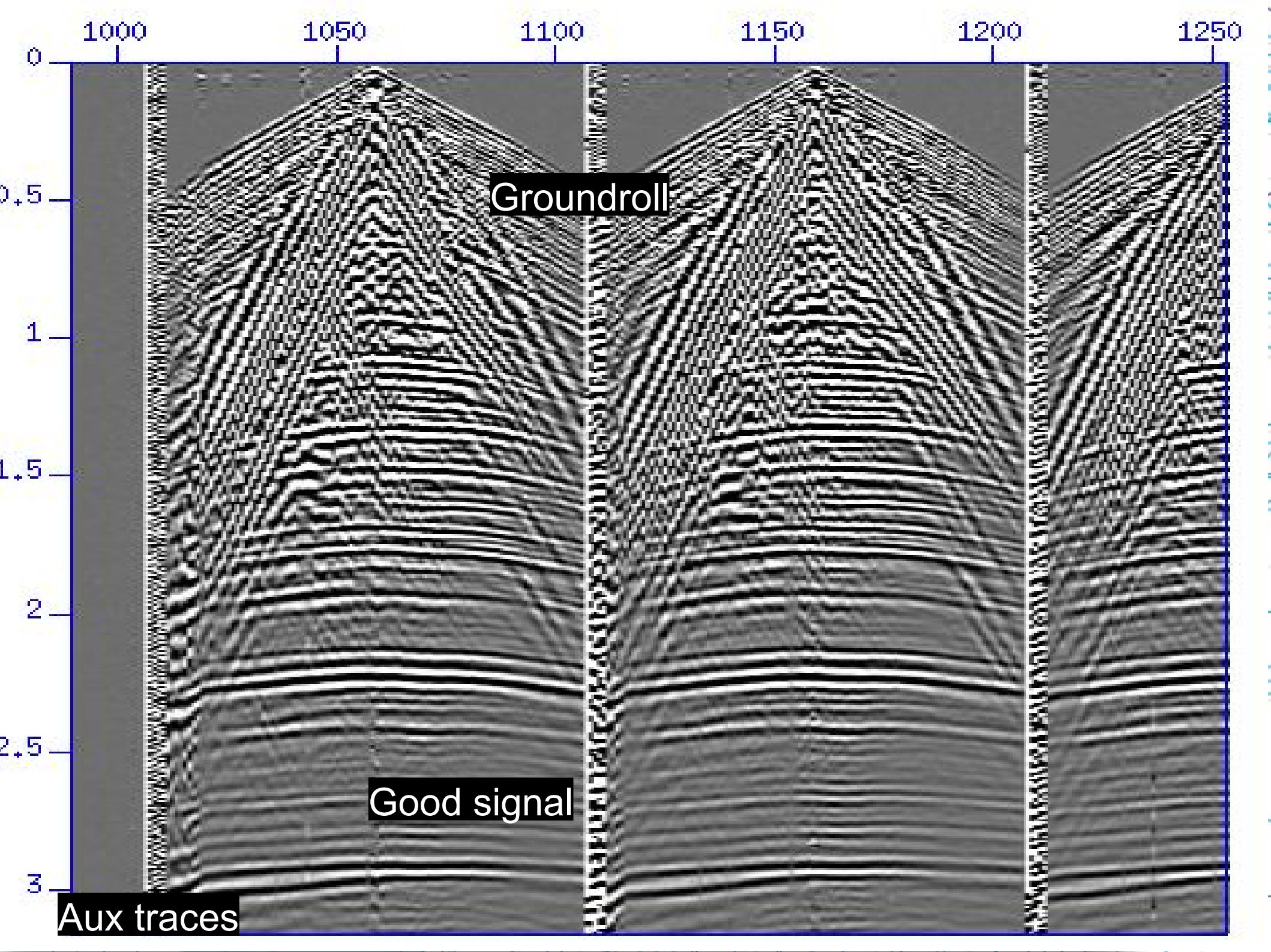
  - Ground roll, noisy traces, spikes.

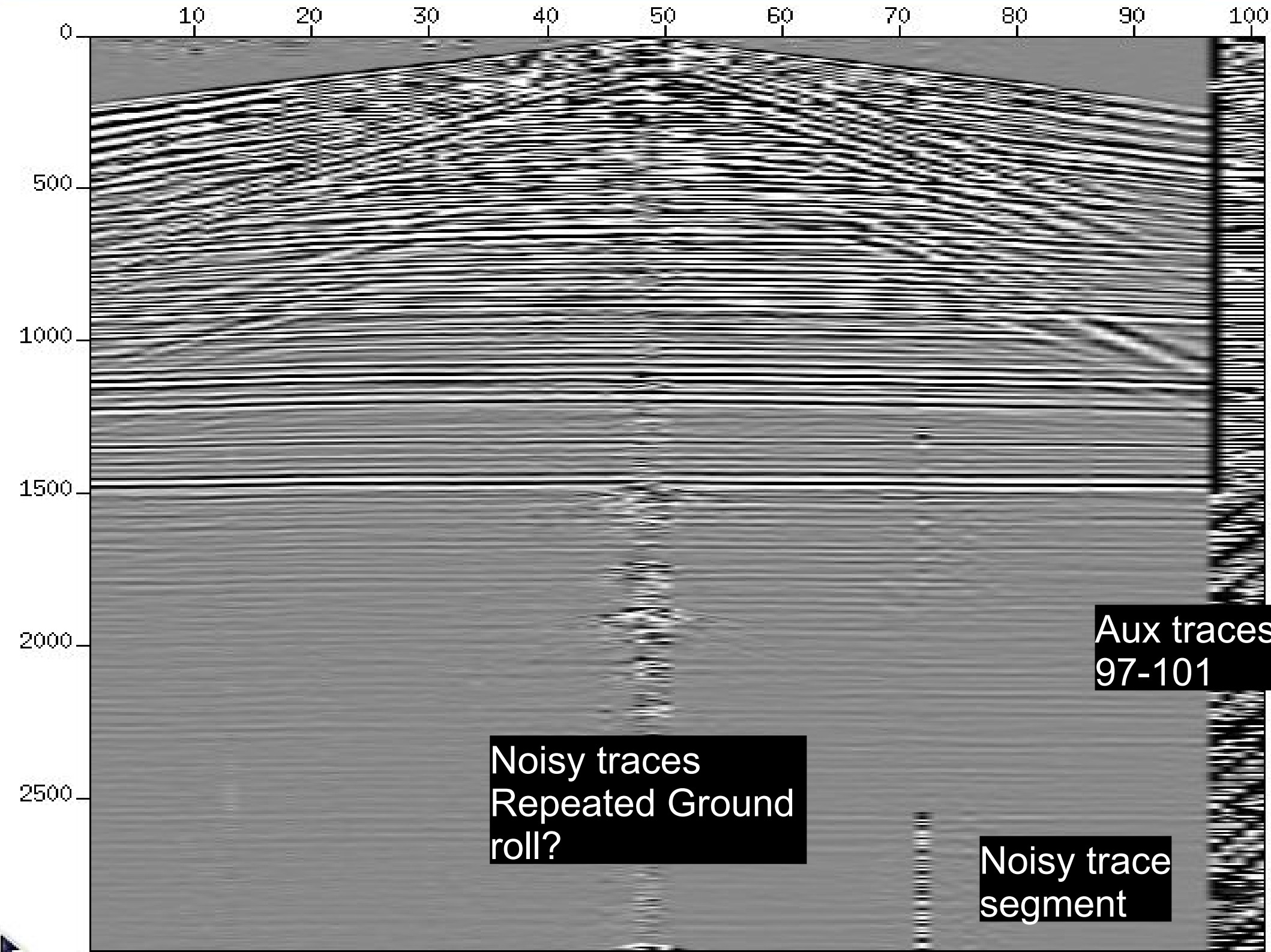
  + Good signal, small statics.

- Headers contain only flnd and tracf. Custom program to load headers
- Agc, decon, shot record velocity filter, mute, cdpgather
- Velocity analysis (a long script)
- Residual statics
- Stack (compare with previous results)
- Post stack migration



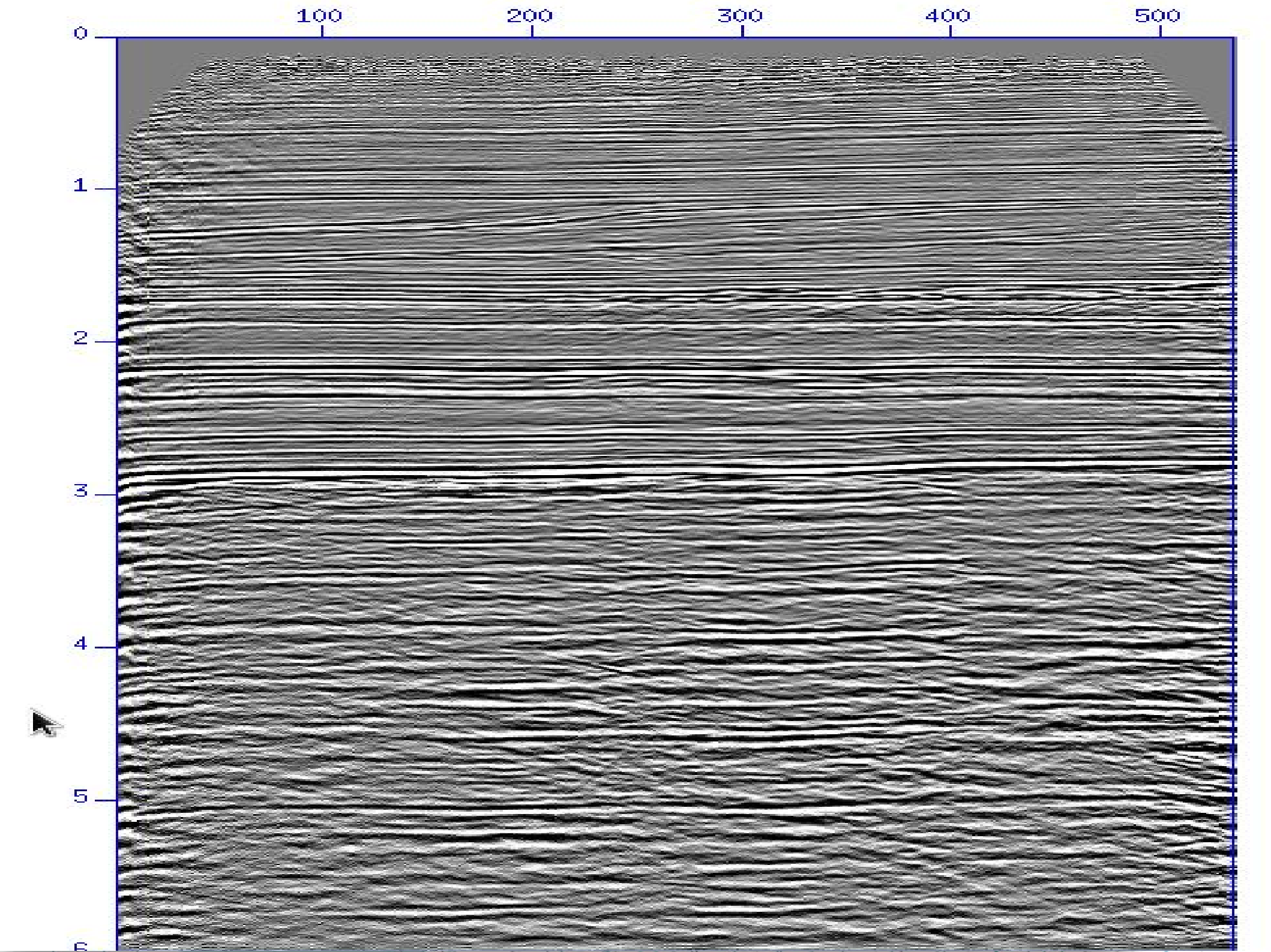
Initial view of data. Do not process first 10 records (test records). Each record has 5 aux channels. Scattered spike traces. Good signal.


1000
1050
1100
1150
1200
1250
0
0.5
1
1.5
2
2.5
3
Groundroll
Good signal
Aux traces


10
20
30
40
50
60
70
80
90
100
0
500
1000
1500
2000
2500
Aux traces
97-101
Noisy traces
Repeated Ground
roll?
Noisy trace
segment

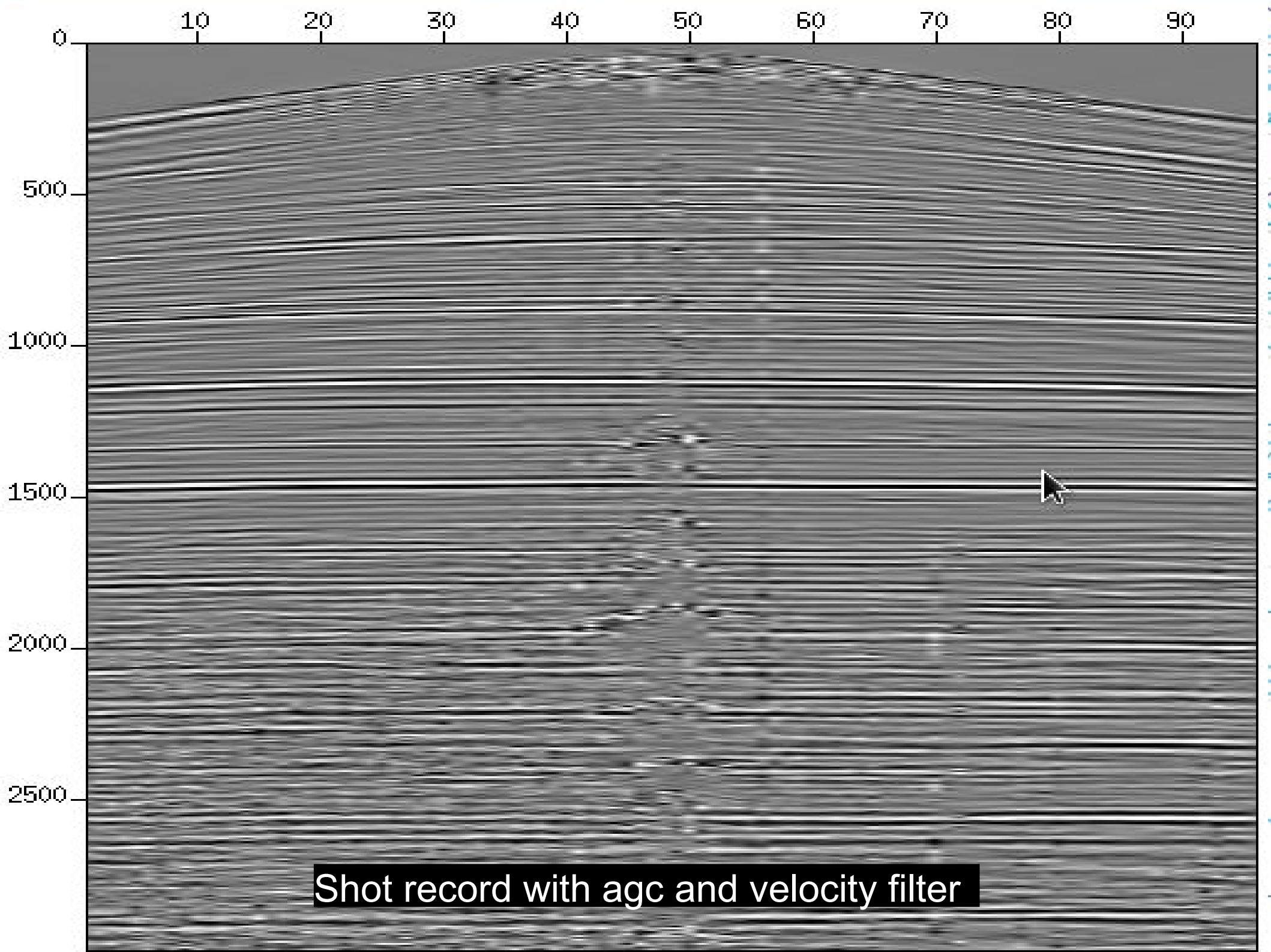
Data loading and initial QC

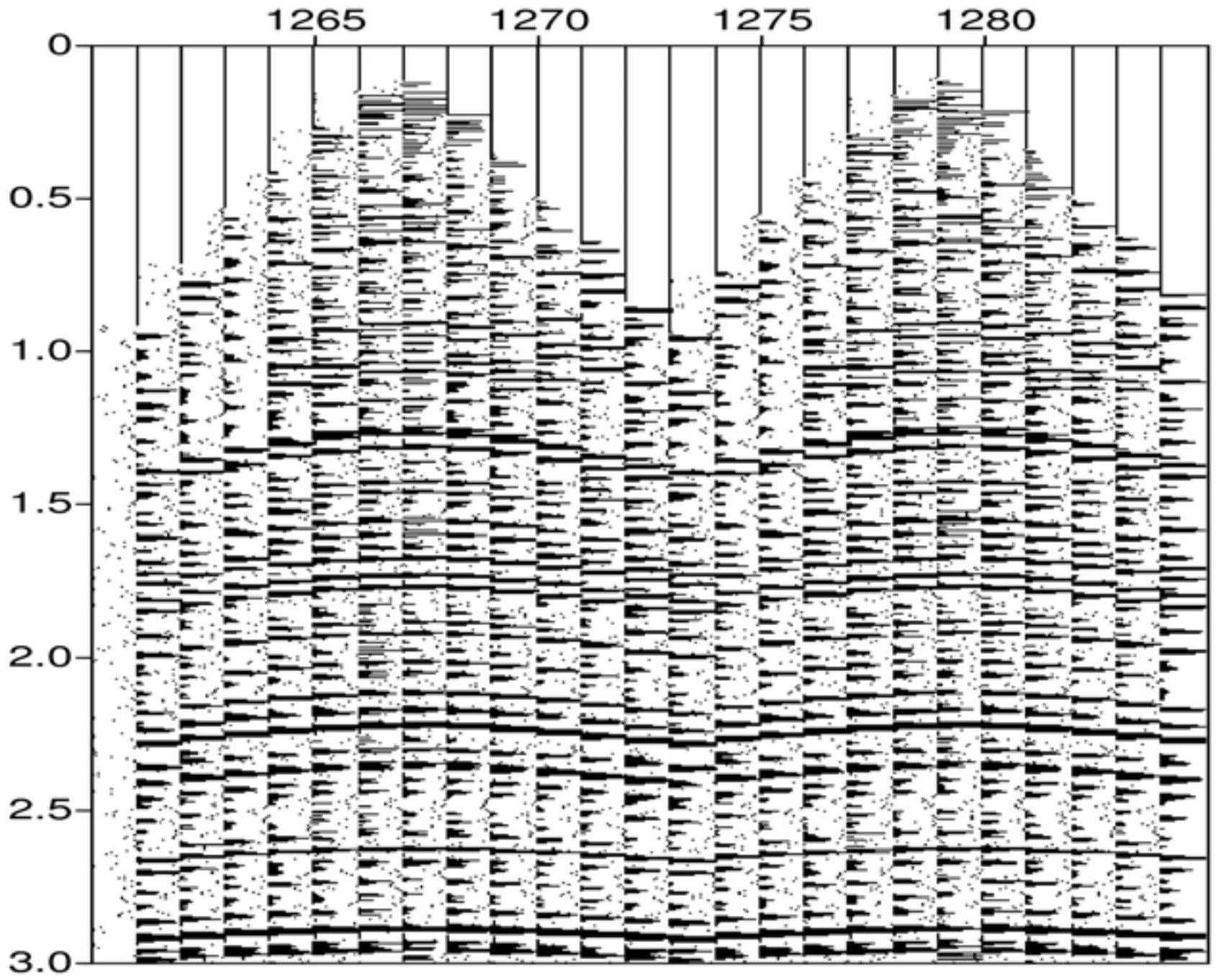
- I wrote a custom java program to load the headers. The observer log describes the (FFID,EP) relationship. The elevations are in the surveyor's log. I typed this data into two text files. I dumped the ffid, tracf headers (sugethw), assembled the data from these three textfile with a custom java program, and loaded the headers (susethw).
- Dataload program translated to python.
- Stack section from previous processing
  - loaded with straight forward segyread.
  - Surange showed a couple of headers that required update (I found many segy filed required f1, d1, f2, d2 to be zeroed).


100
200
300
400
500
0
1
2
3
4
5
6

Velocity filter, CMP gather

- I used sudipfilter to apply a shot record FK filter to remove ground roll.
- I split the positive and negative offsets and used an asymetrical dip filter (-15,5).
- I developed a looping script to separate the records and apply FK filter.
- I also applied spreading correction, mute, and ags in the same script. I looked at the results using sumovie.
- I removed a bad shot record, muted, and sorted the data to cmp. I used sumovie to view the cmp's.

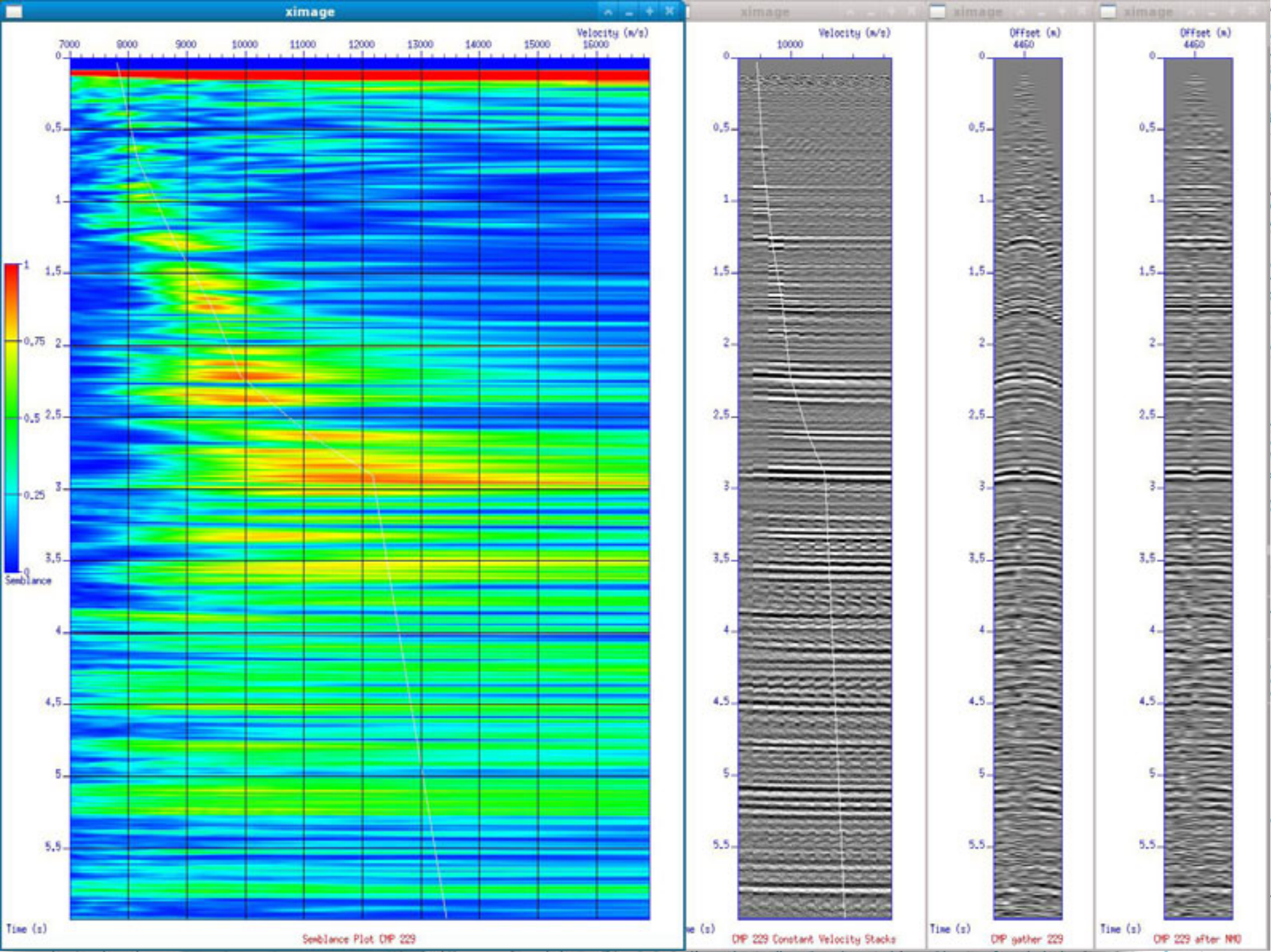

10
20
30
40
50
60
70
80
90
0
500
1000
1500
2000
2500
Shot record with agc and velocity filter

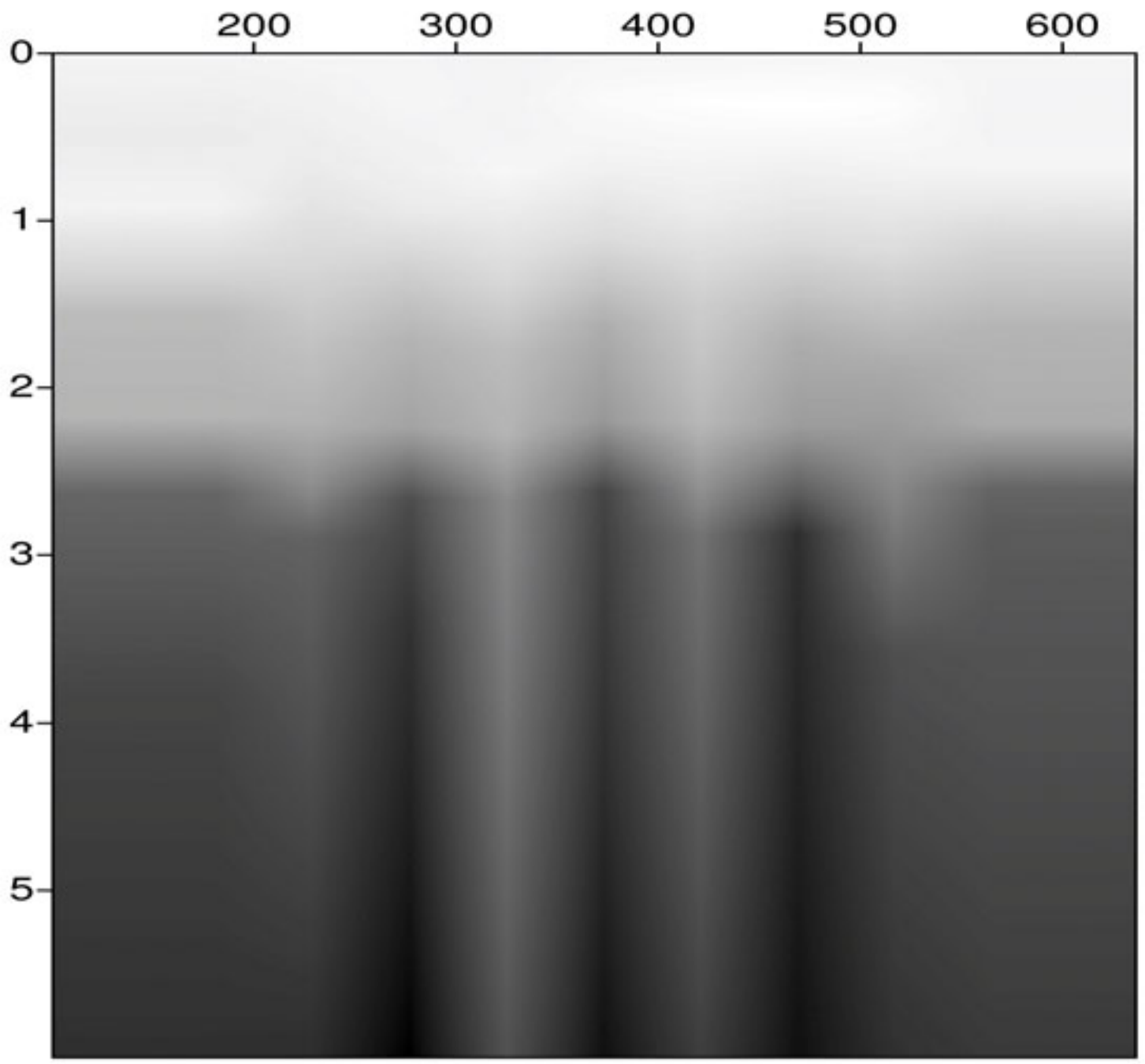


Two twelve fold cmp

Velocity Interpretation and stack

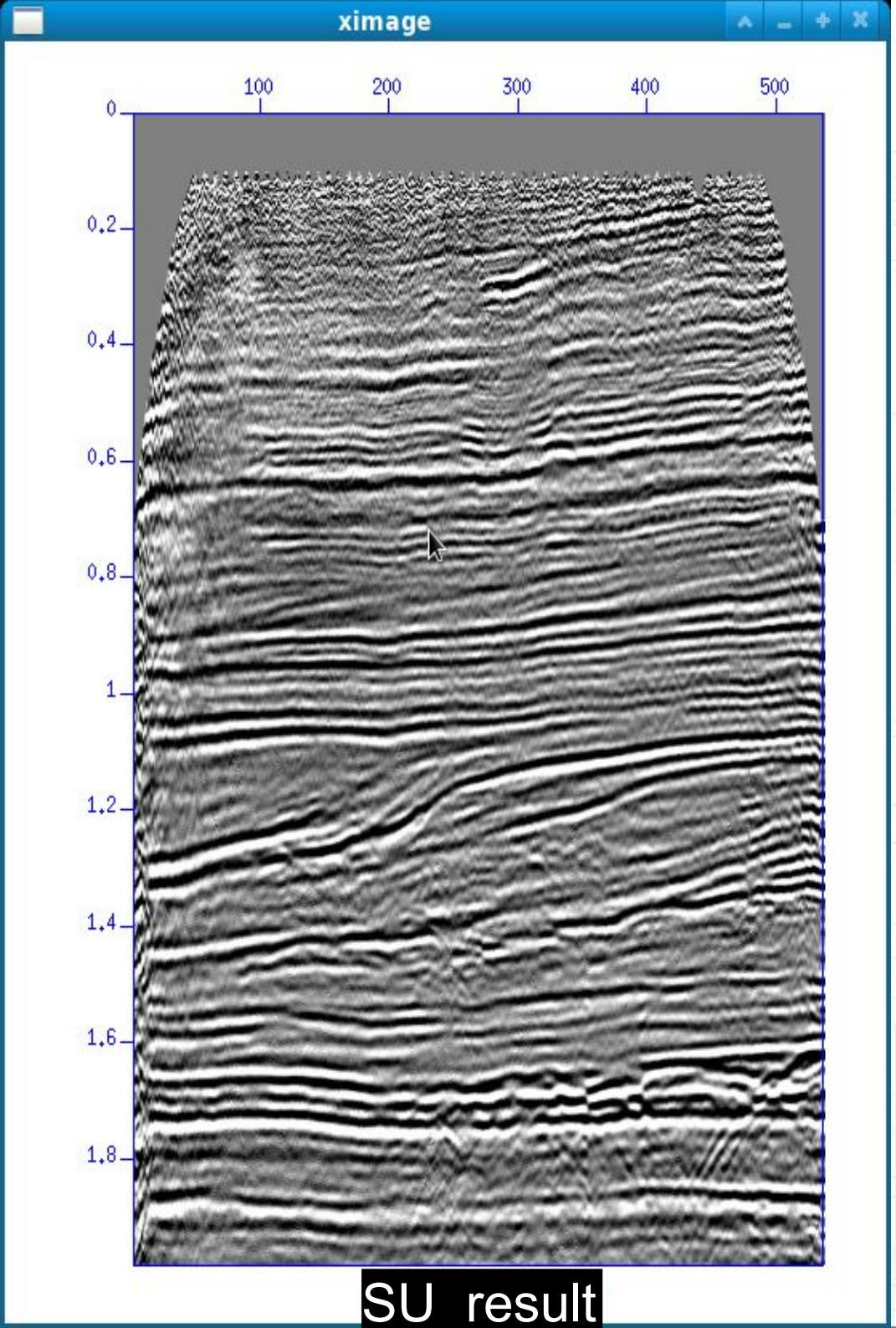
- I used a long script that combined several SU commands. This significantly improved Forel et. al. It combined the capabilities of iva.sh and velanQC.sh.
- The velocity is plotted on the semblance and the CVS plot. It can be edited on the semblance plot.
- Gather is plotted with and without NMO.
- After updating velocity the plot is recreated with the new velocity function.
- I found these upgrades were enough to provide a minimal velocity interpretation capability.


ximage
Velocity (m/s)
7000
8000
9000
10000
11000
12000
13000
14000
15000
16000
Semblance
Time (s)
Semblance Plot CMP 229
ximage
Velocity (m/s)
10000
DMP 229 Constant Velocity Stacks
ximage
Offset (m)
4460
Time (s)
CMP gather 229
ximage
Offset (m)
4460
Time (s)
CMP 229 after NMO

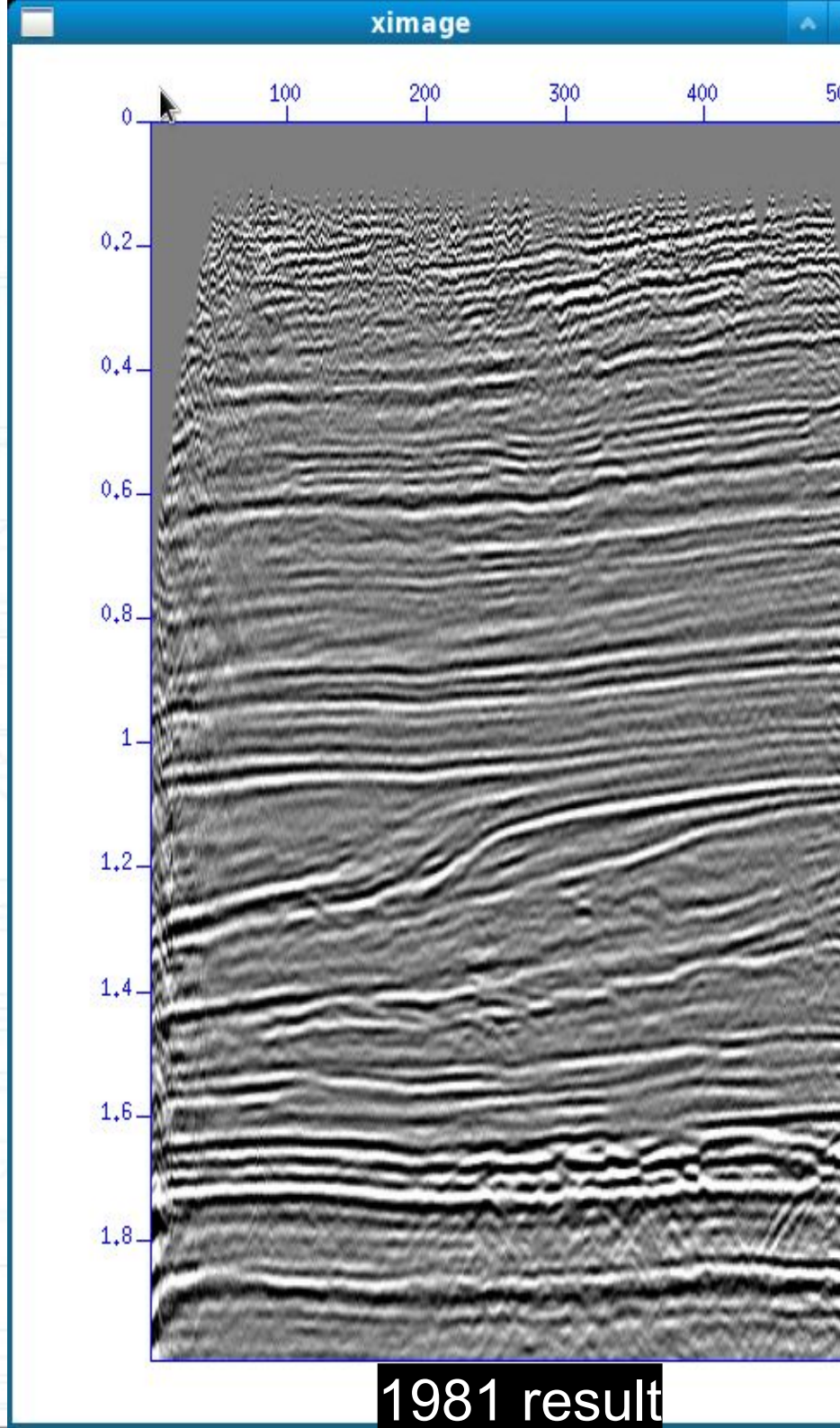

200
300
400
500
600
0
1
2
3
4
5

Stack

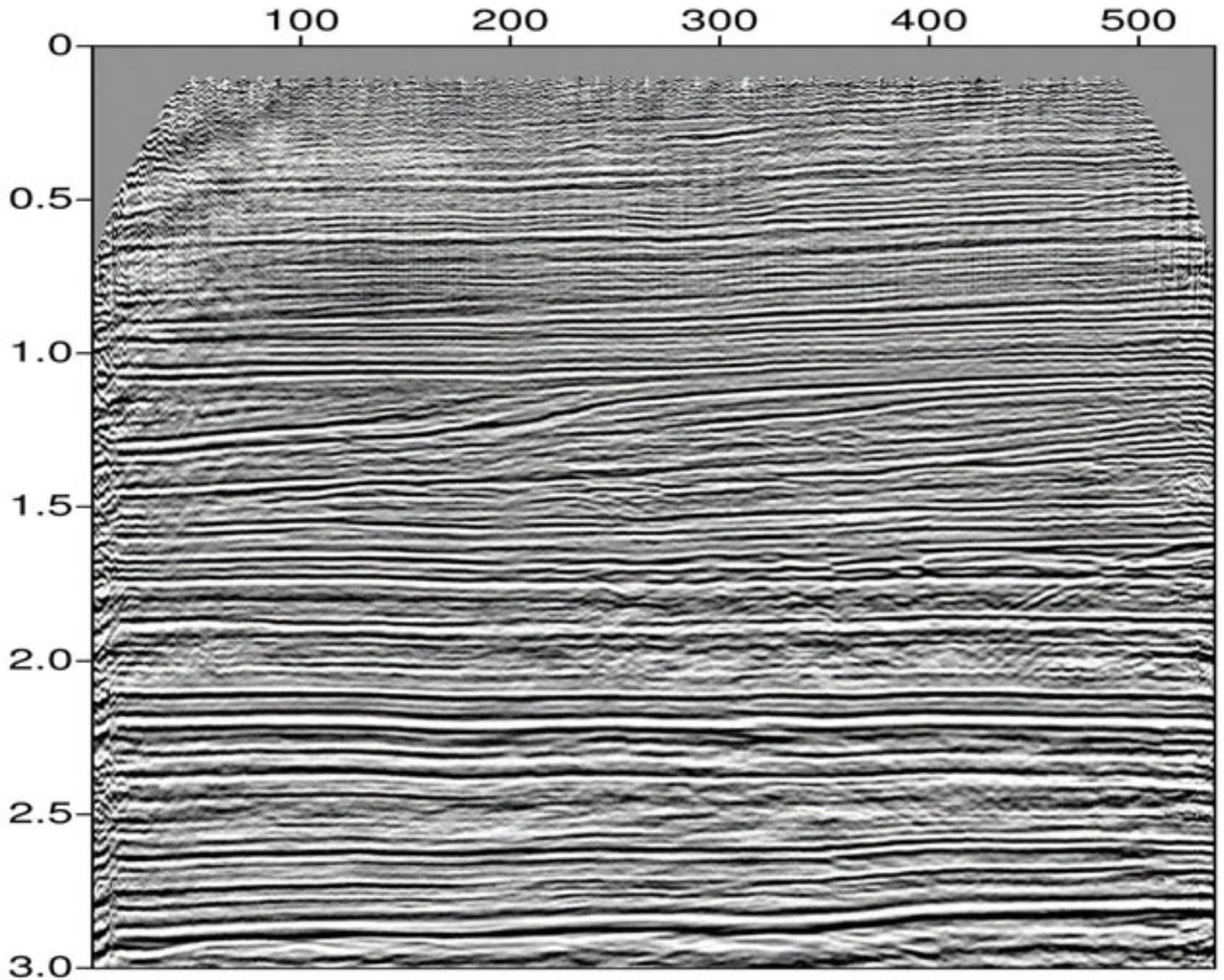
- I used the velocity field to stack the data. I applied decon in the same script.
- Differences with 1981 processing
  - GSI designature leave a different wavelet on the data than decon.
  - AGC application was different. GSI brackets velocity filter with AGC/inv AGC.
  - GSI used diversity stack
  - GSI applied residual statics



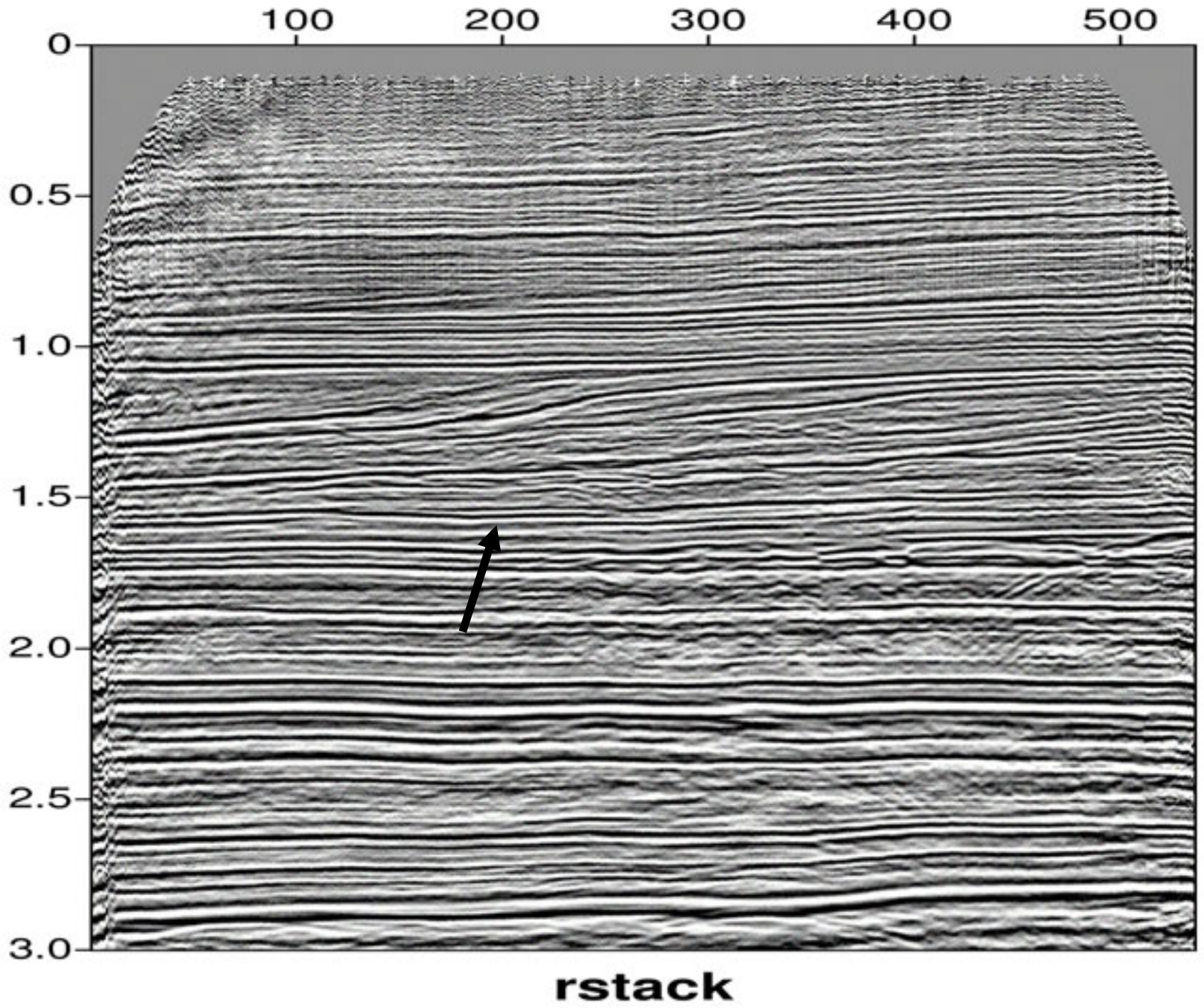
SU result

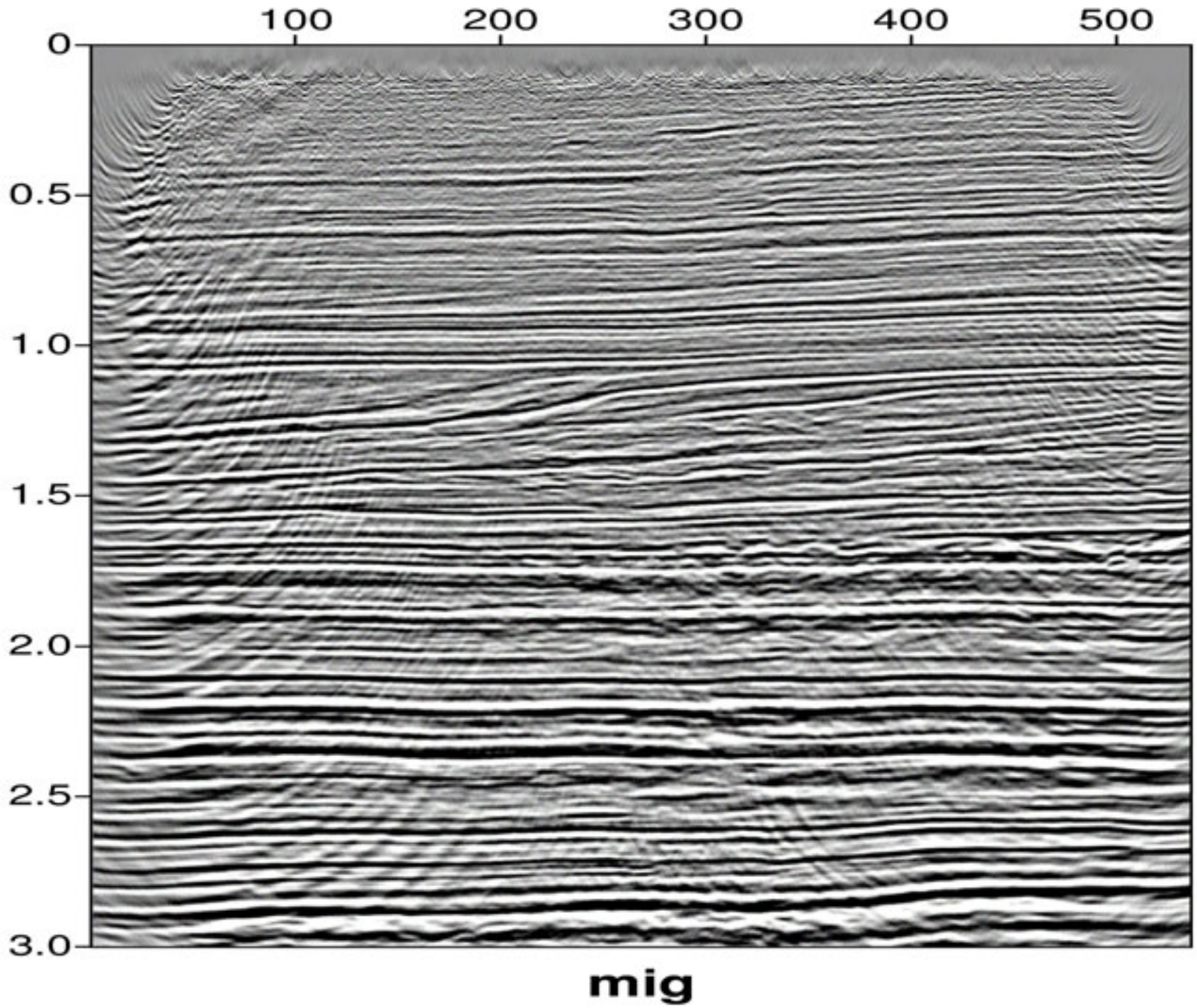


1981 result



brutestack


100
200
300
400
500
0
0.5
1.0
1.5
2.0
2.5
3.0
rstack

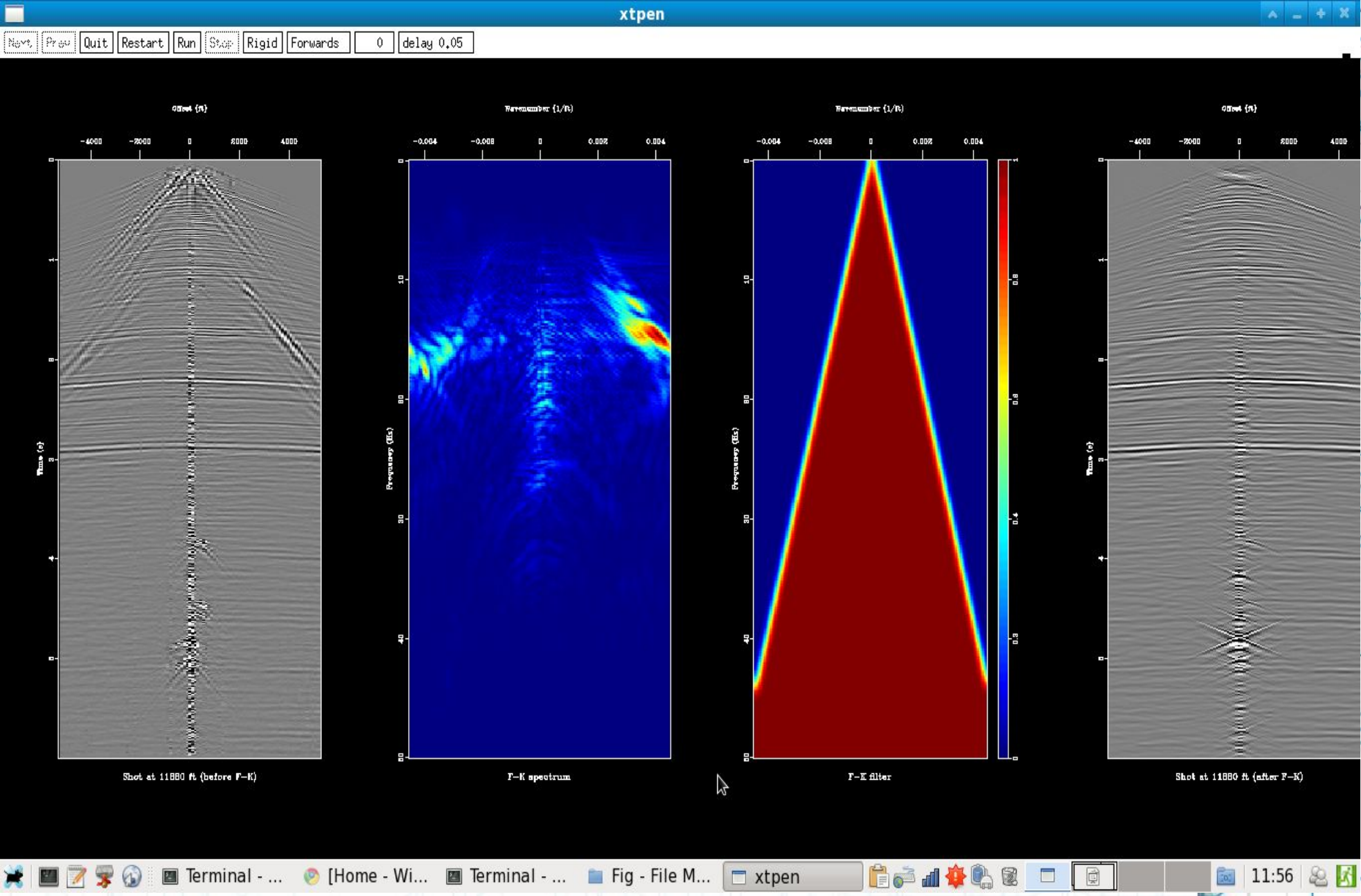

100
200
300
400
500
0
0.5
1.0
1.5
2.0
2.5
3.0
mig

Comments on SU processing

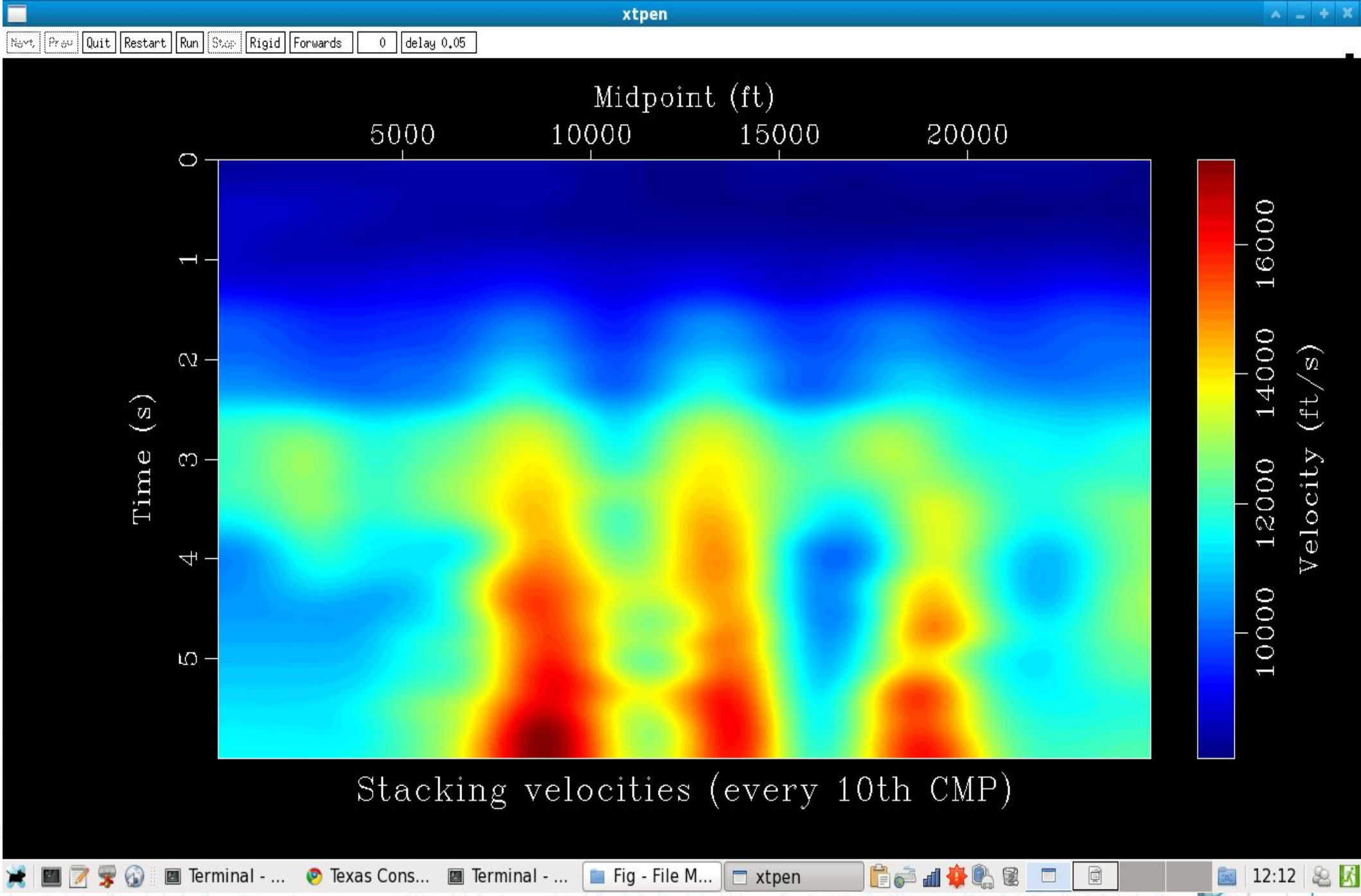
- Considering all the differences, the results are surprisingly similar.
- The 1981 result is better above 400 ms.
- SU software is hard to use:
  - Sudipfilt was not intended for prestack FK filter, so a looping script was developed.
  - The programs do not trap user errors.
  - SU's primary domain has been software prototyping.

Madagascar results

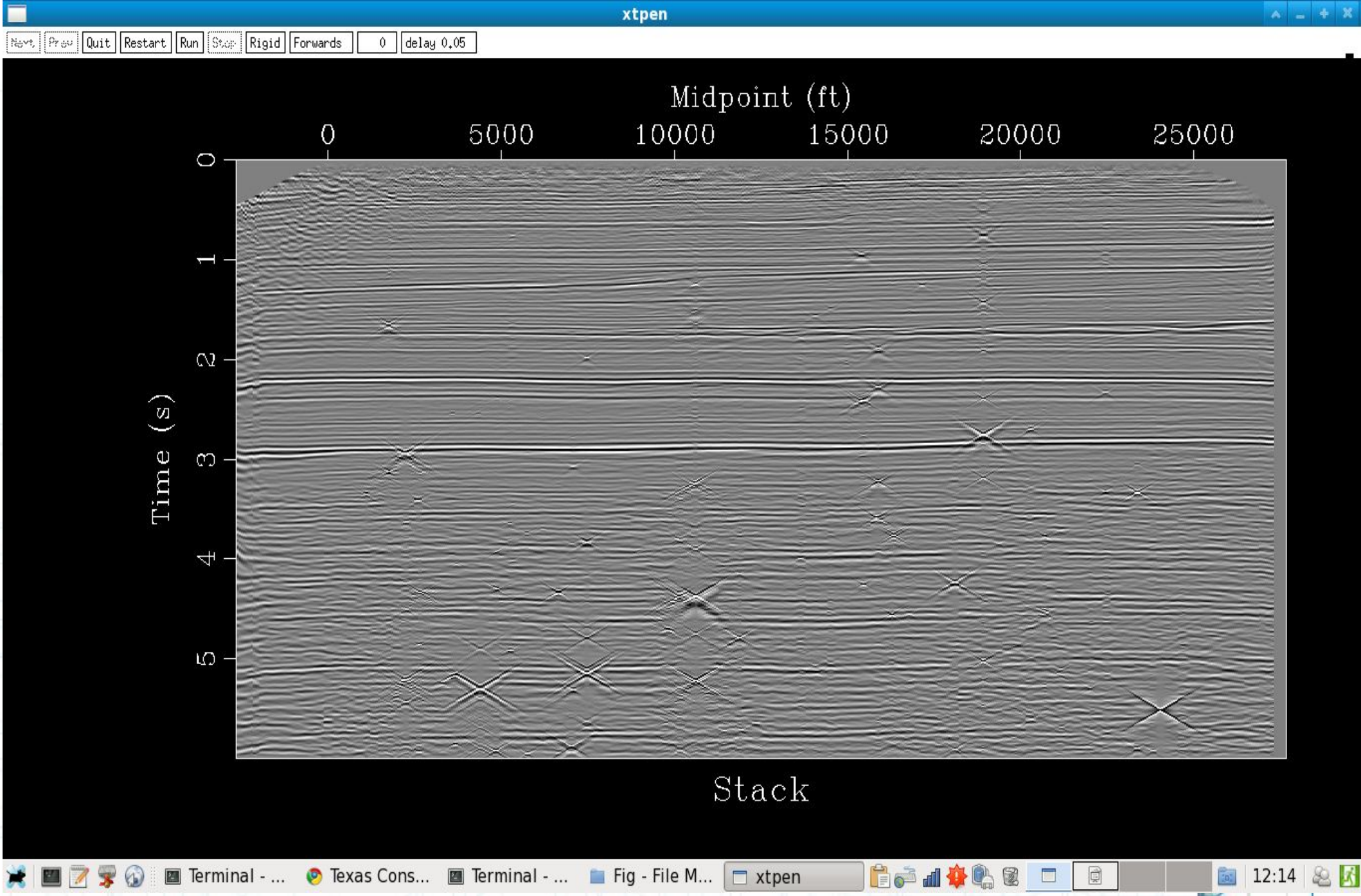
- Recently (April 29, 2011) William Burnett and Vladimir Bashkardin showed results using Madagascar on Alaska line 31-81.
- William has honors for best section. Challenge now is to match his results with a faster script.



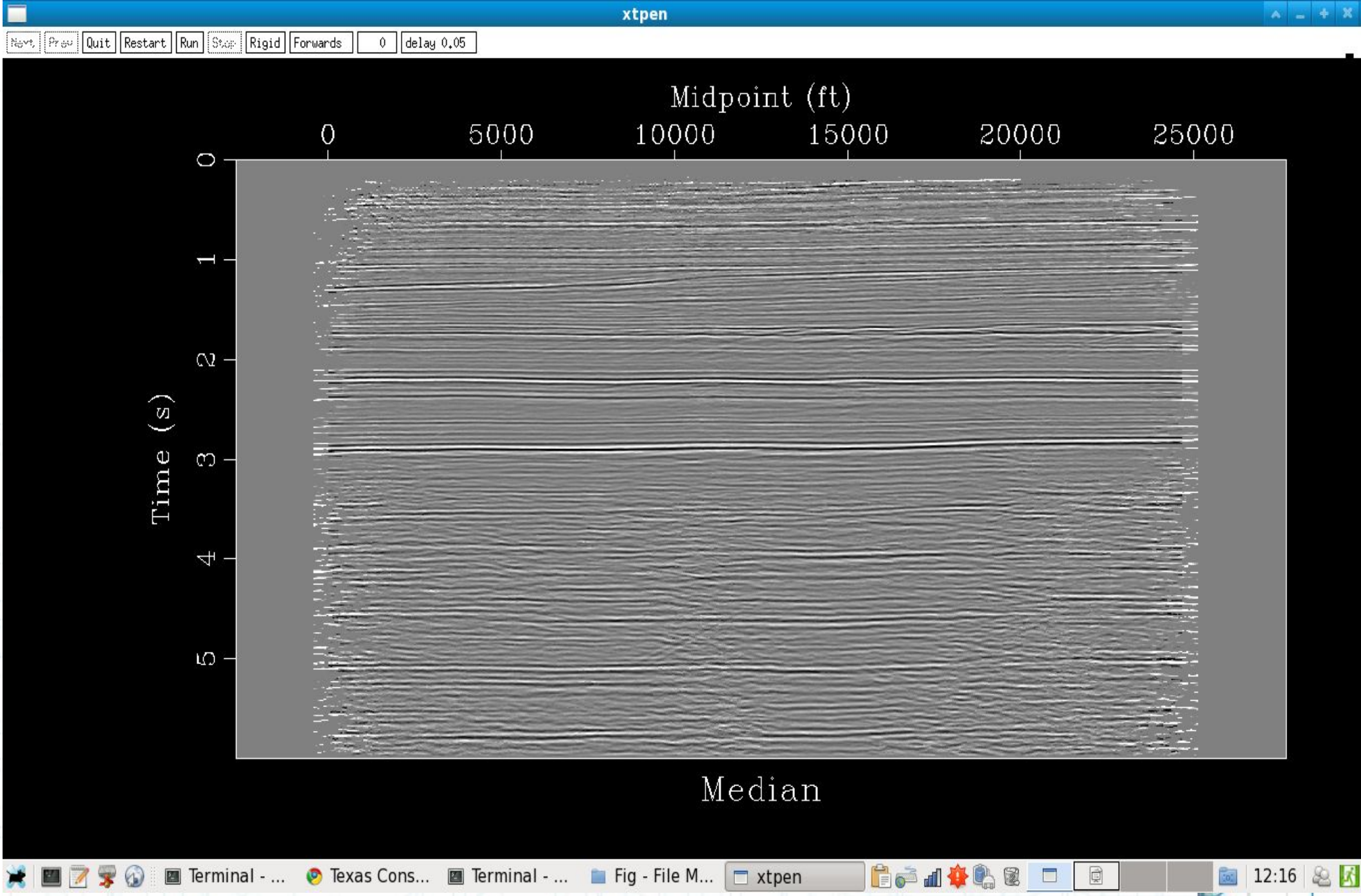
Bashkardin – fk analysis



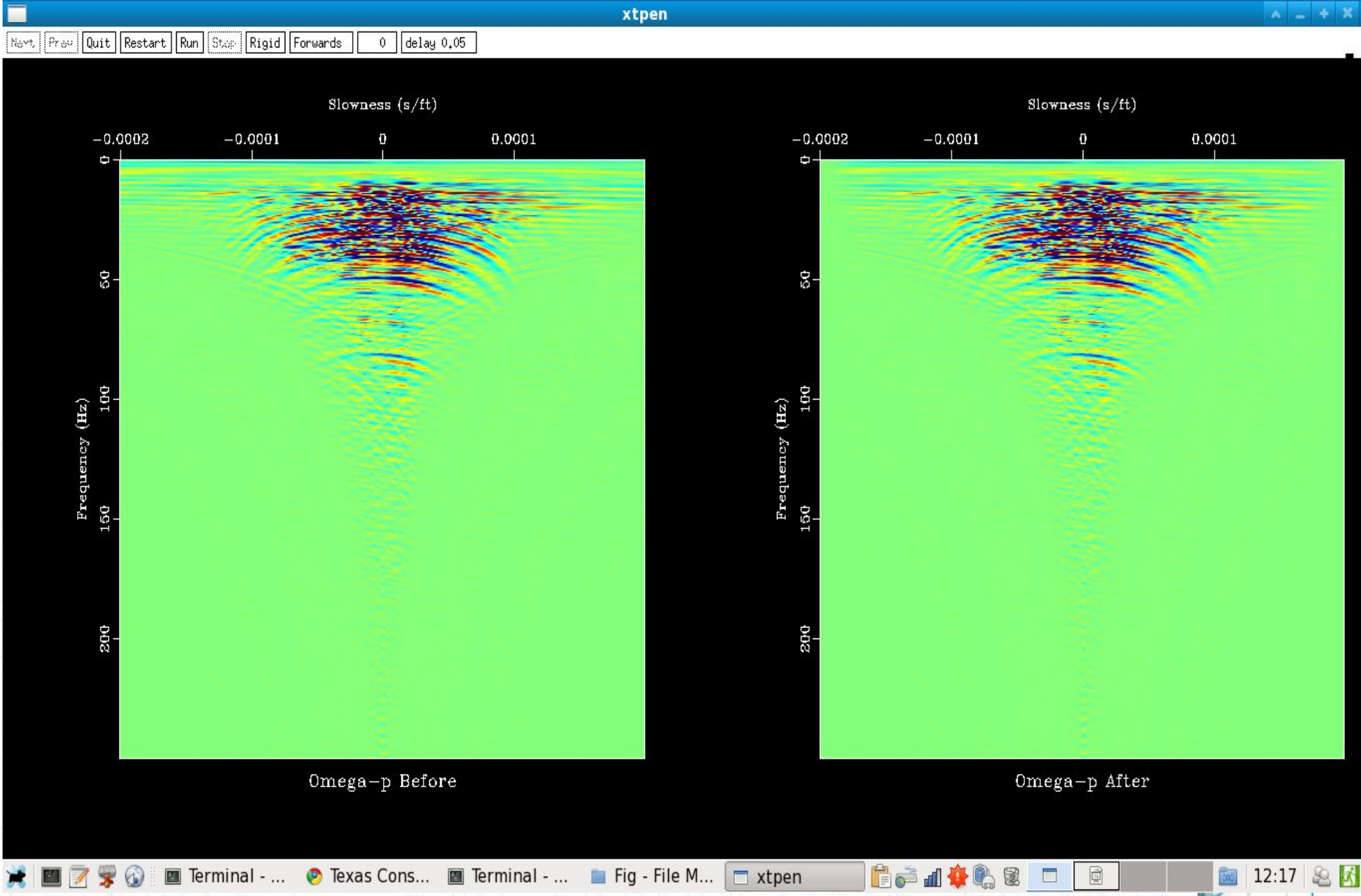
Bashkardin – automatic velocity picking show same lateral variation as manual picking



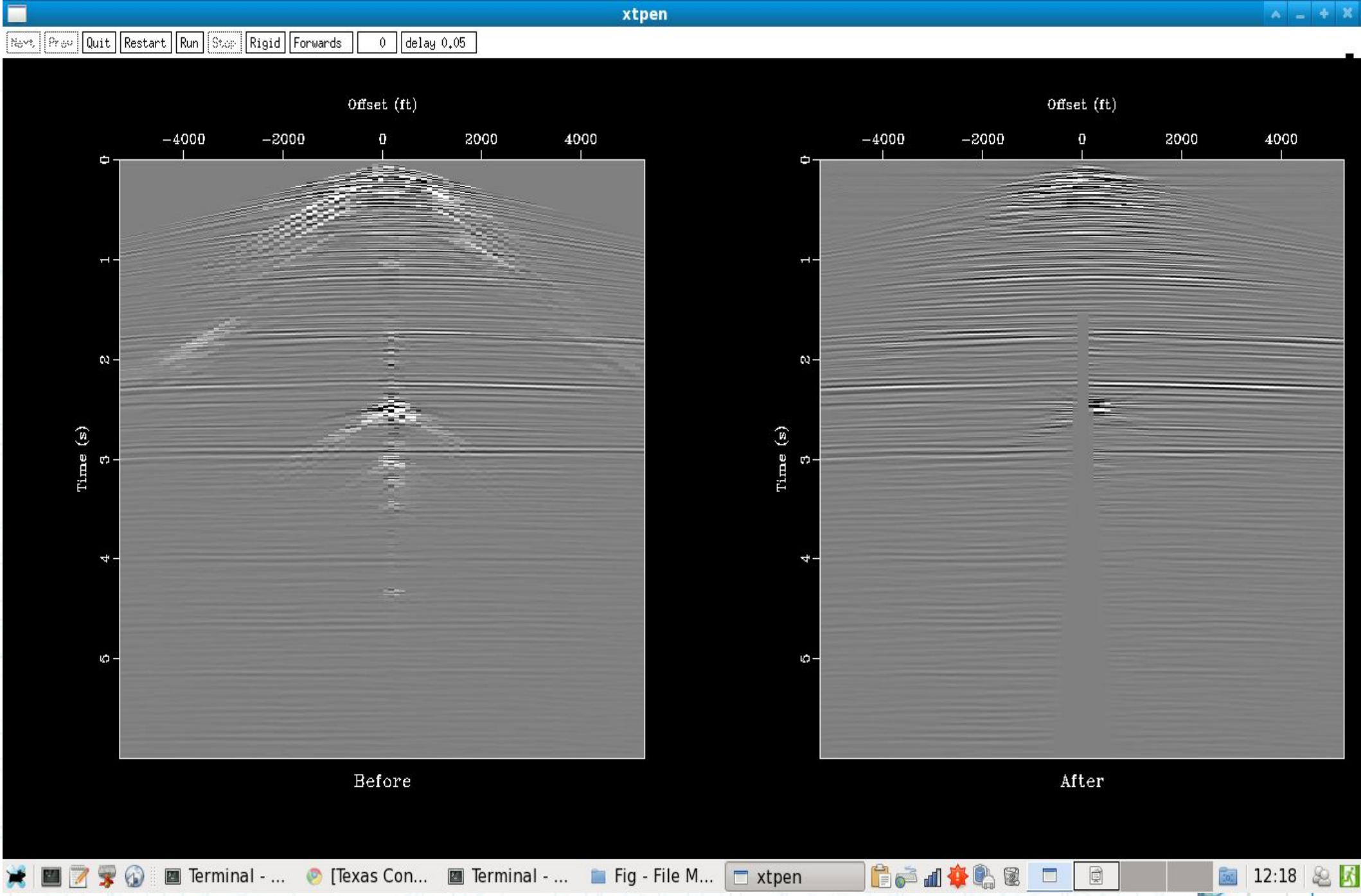
Bashkardin – stack without scaling



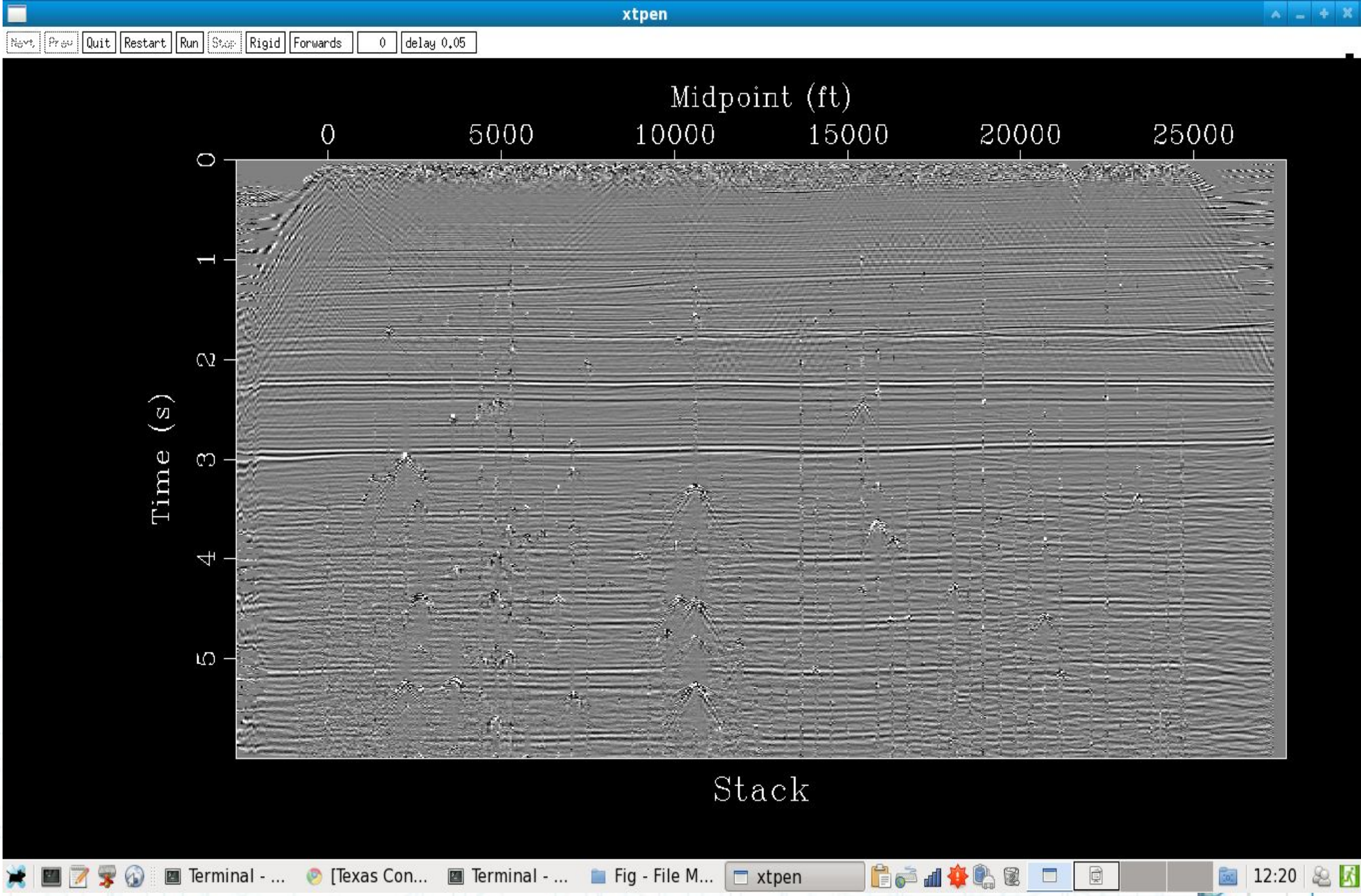
Bashkardin – Median stack



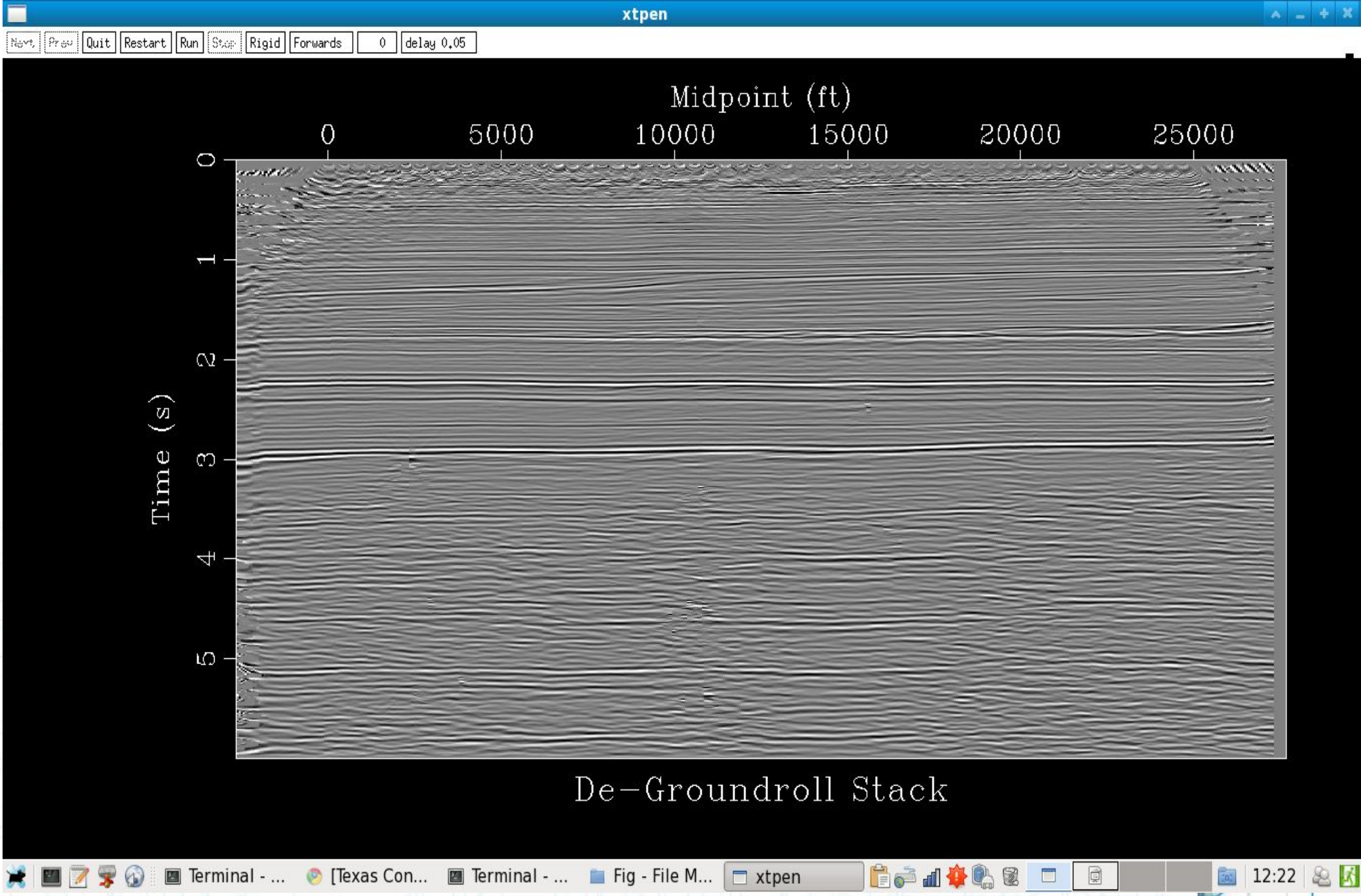
Burnett – fp analysis



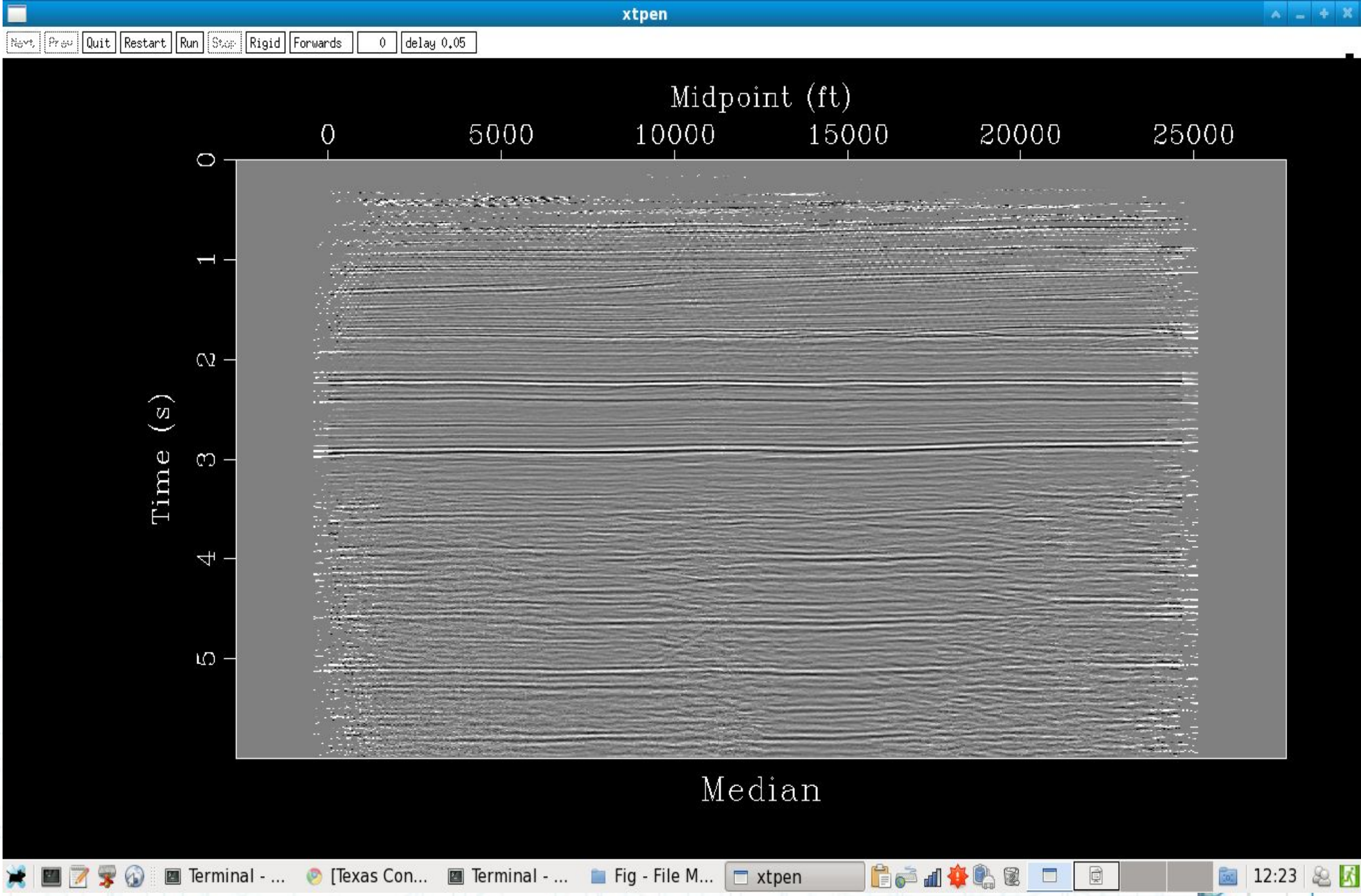
Burnett – edit and fp example



Burnett – initial stack without agc or edits



Burnett – stack with edits and fp filter



Burnett – median stack without agc, edits, or fp filter

Scripts are available

- SConstruct are in svn. $RSFSRC/book/data/alaska
- There are three directories:
  - Line31-81 the su scripts
  - bash Bashkardin's Madagascar
  - wburnett-31-81 Burnett's Madagascar
- The Sconstruct downloads the data from usgs and processes and creates displays
- Still pretty dynamic

Strengths and Weakness of Open Software

- Still early days for me, so these comments are very preliminary.
  - Basic programs (nmo, mute, edit) tend to be neglected. No one in a University receives recognition for working on these.
  - In the 1980's the universities were tops in interactive display. There has been little improvement in the packages since.
  - Hale has advocated Java and Python for a years. I think Java and Python will slowly become adopted by industry. I say slowly after observing industry adoption of c and c++. Memory problems (leaks, wild pointers) slow you down in c and c++. Java and Python solve some of these problems. JTK from Mines and Madagascar are already on board.

Strengths and Weakness of Open Software

- Madagascar
  - Steep learning curve. I am still learning basic Madagascar and struggling with tools like scons, svn, latex, and reproducible documents.
  - Seems to be improving.
- SU
  - Based on older software tools (c, make).
  - Does not seem to be improving.
  - Data is just a bunch of traces, so it is slow to extract a subset of a large dataset.
- SEPLIB, Freeusp, DDS, cpseis, javaSeis
  - I have barely scratched the surface. I did not see data viewer or velocity interpretation.

Strengths and Weakness of Open Software

- OpenDtect
  - Interpretation tool. I briefly worked on the tutorial and it appears this is an interpretation tool. I do not think it is a good tool to review your processing results.

Identified Datasets

- Alaska land line 31-81 (more lines available)
- Avenue data set from University Utah
- Land line from freeUSP “how to process tutorial” previously loaded to Madagascar
- Dragon Land3d
- Teapot Dome Land 3D
- Mobil AVO Viking Graben 2D Line 12
- Nankai 2D deep water line NT62-8 from Seismic Data processing with Seismic Un*x, Forel, et. al.
- Taiwan 2D line from Seismic Data processing with Seismic Un*x, Forel, et. al.
- Teal South from UT

Identified Datasets

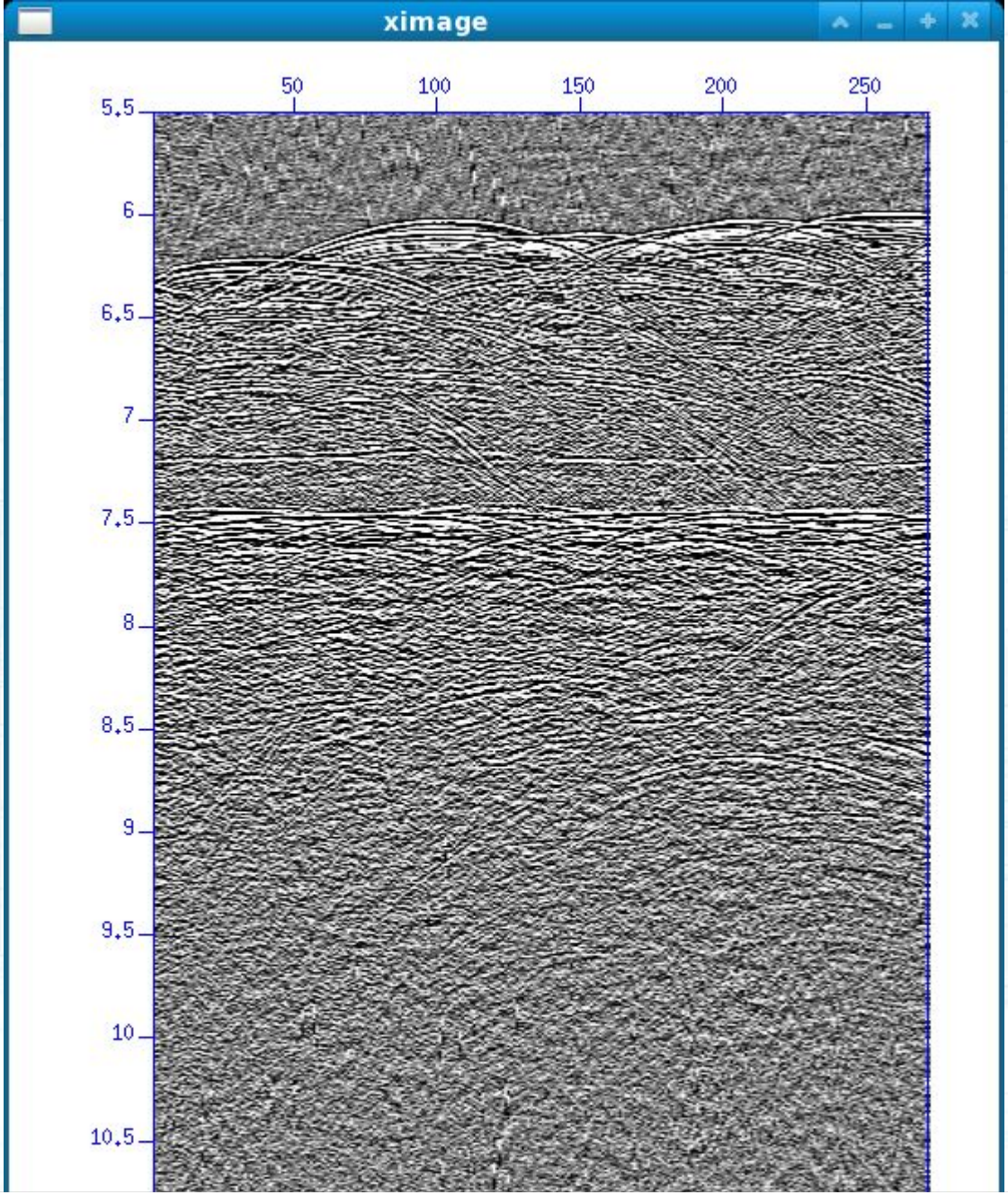
- UTIG has several data sets (mostly marine?). Need to contact DeAngelo. Stratton 3D?
- Stockwell's lab project 1-14 already ported to Madagascar.
- CSM summer camp data.
- Blake Ridge data set from USGS.
- William Burnett has one migrated line from 3D Duran Ranch project from GXT. May have restrictions.
- New Zealand Marine 3D available for media cost.
- Synthetics not main objective, but could include:
  - SEG Salt Model, SEAM, Overthrust model, various BP models (tomography salt dome,

Nankai Deep Water 2D

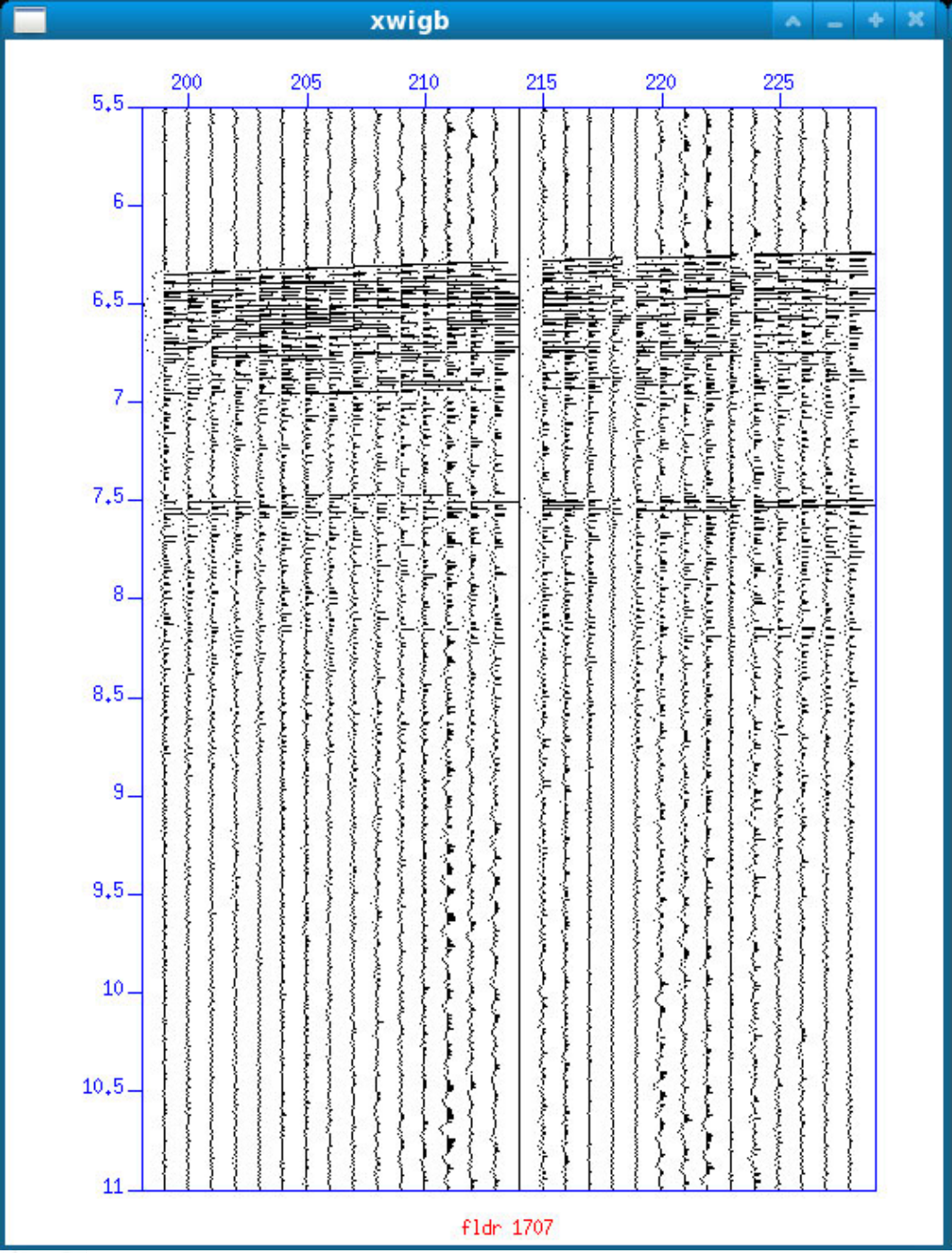
- SU processing sequence
  - Data load, header dumps, and initial qc plots
  - Tx and Fx display of selected records
  - Resample, t**2 gain, cdp gather.
  - Near trace gather display
  - Velocity analysis
  - Stack
  - Post stack migration
  - Data observations:

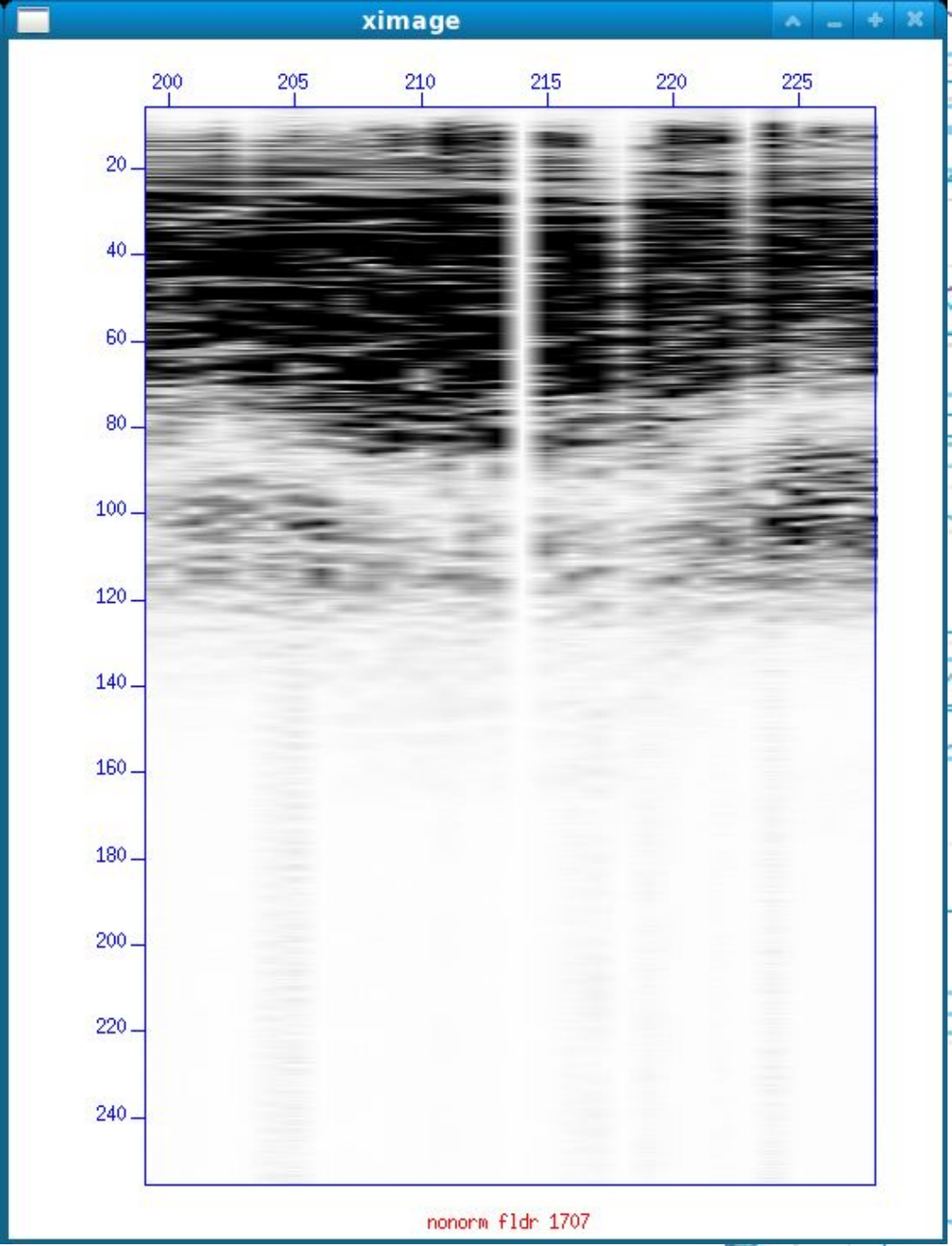
    + good signal.

    - Is velocity variation due to cable feathering?

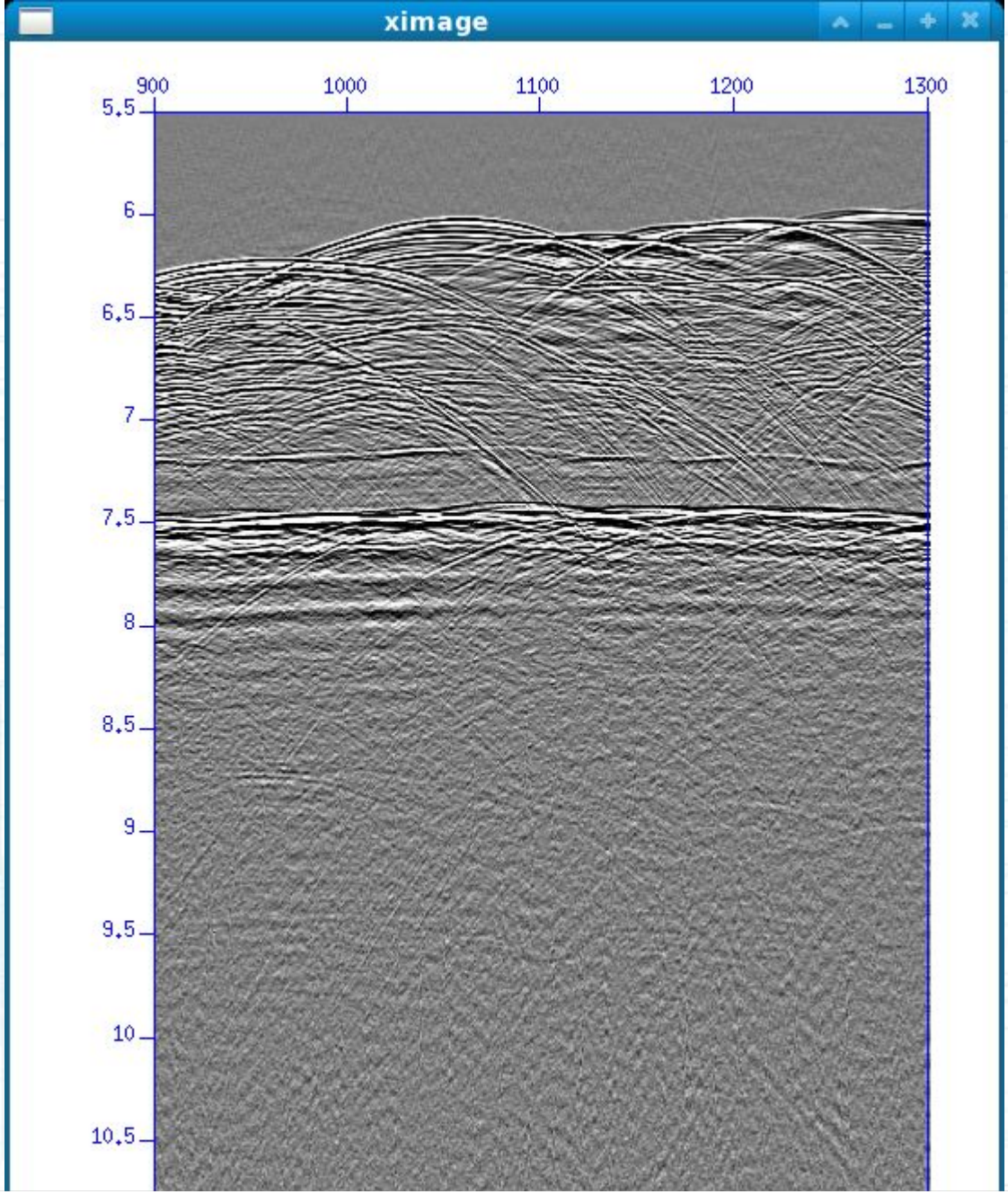


Near trace gather

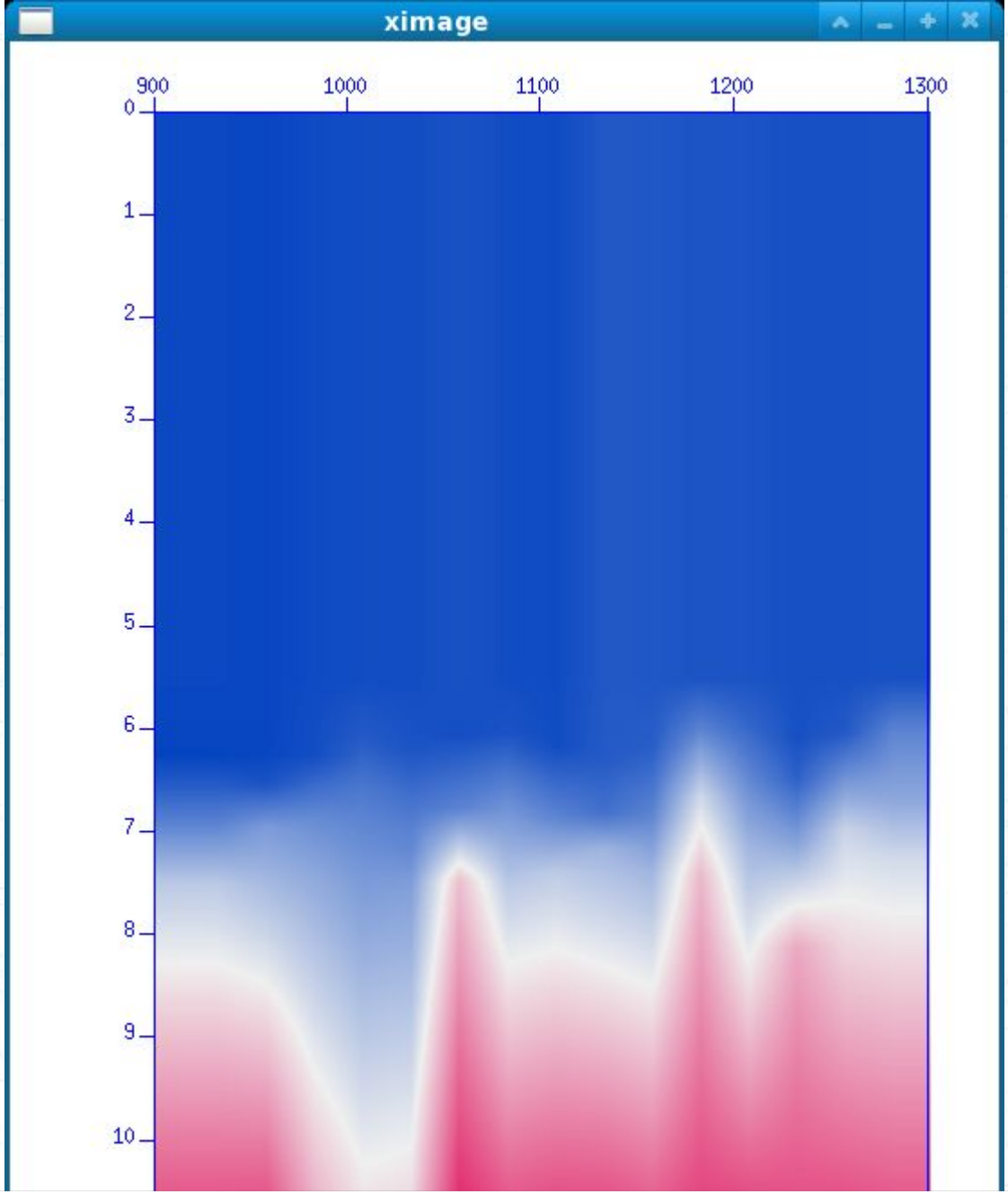




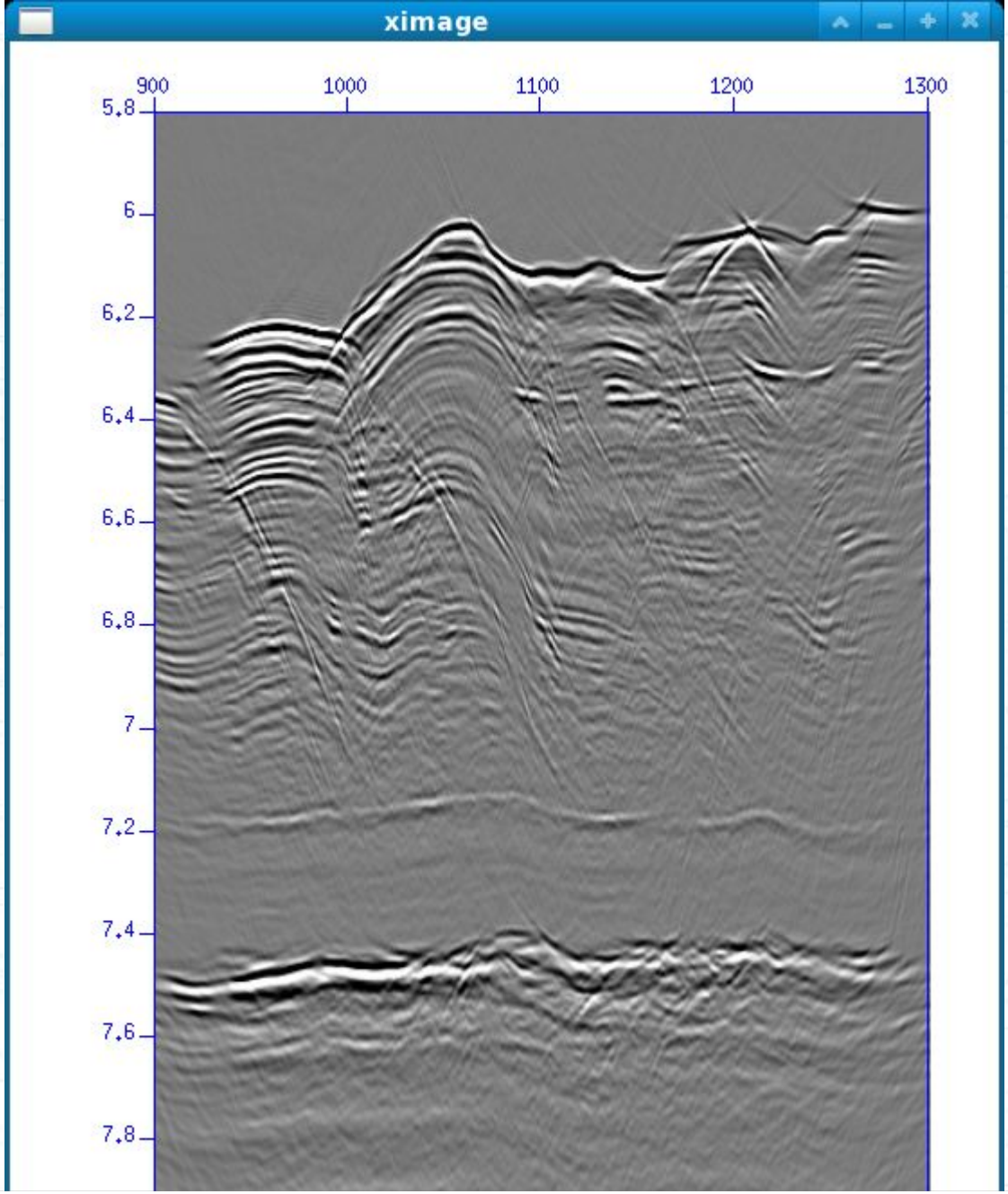
Shot 1707 TX and FX



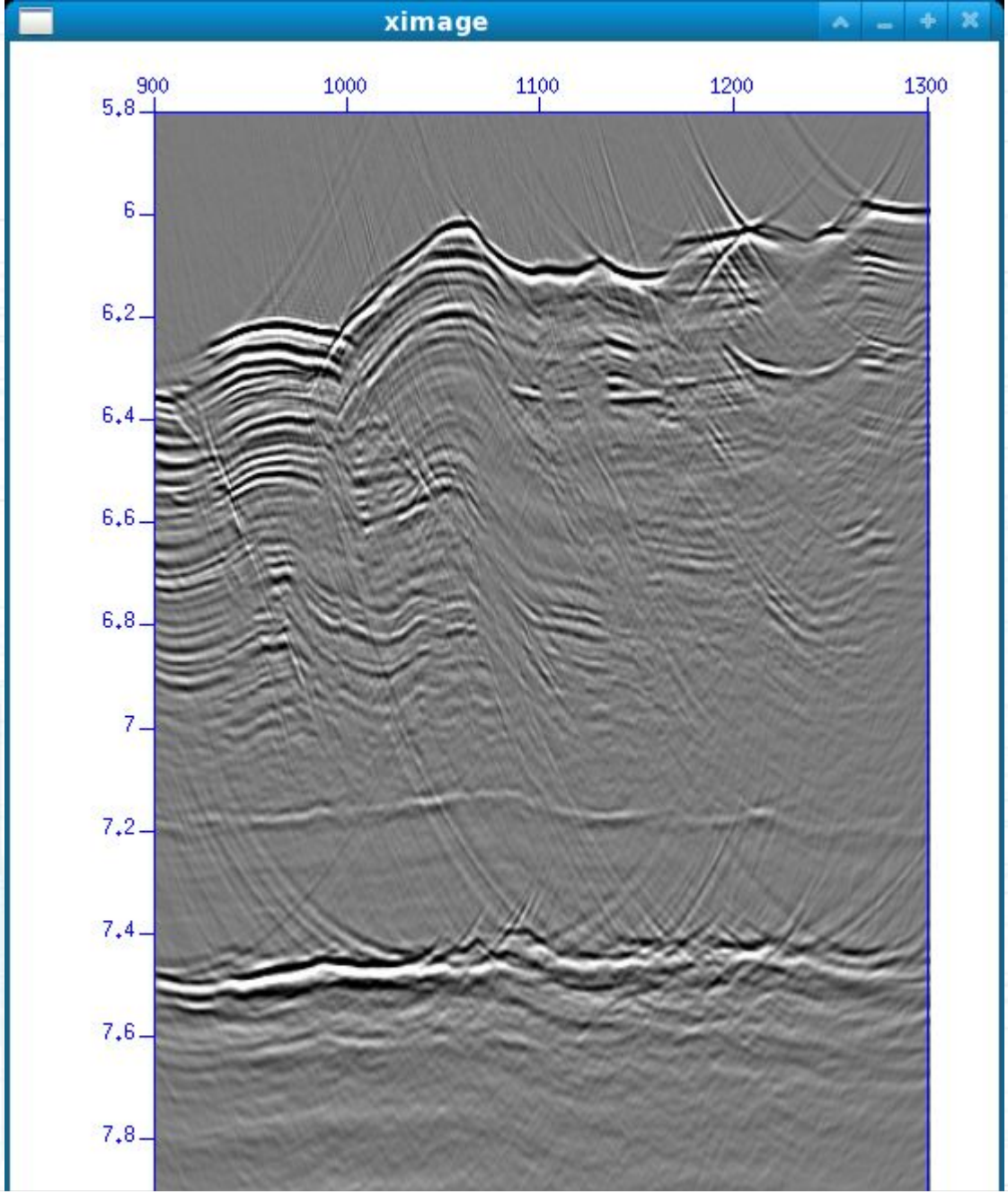
Stack



Stacking velocity



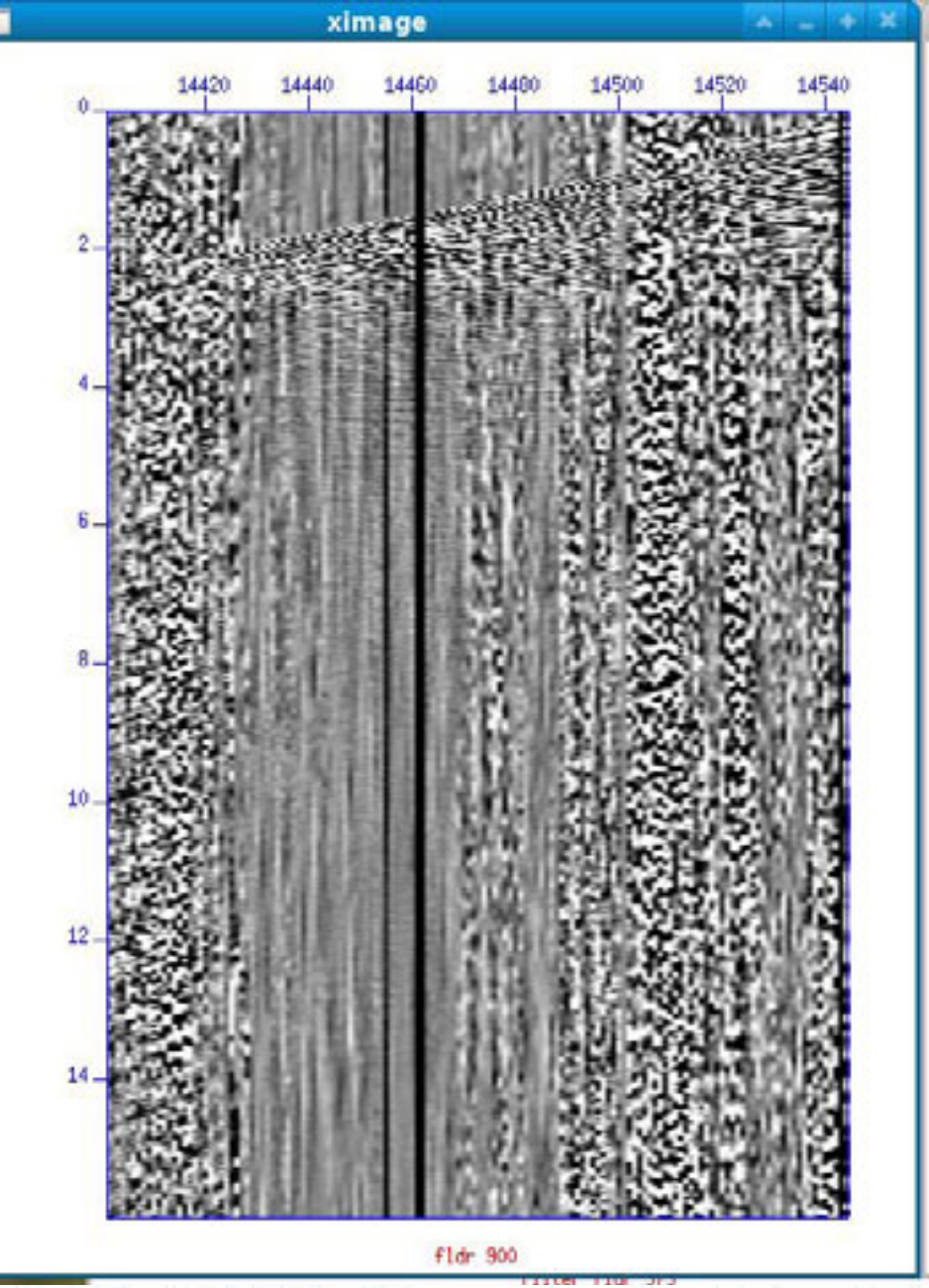
Phase shift migration

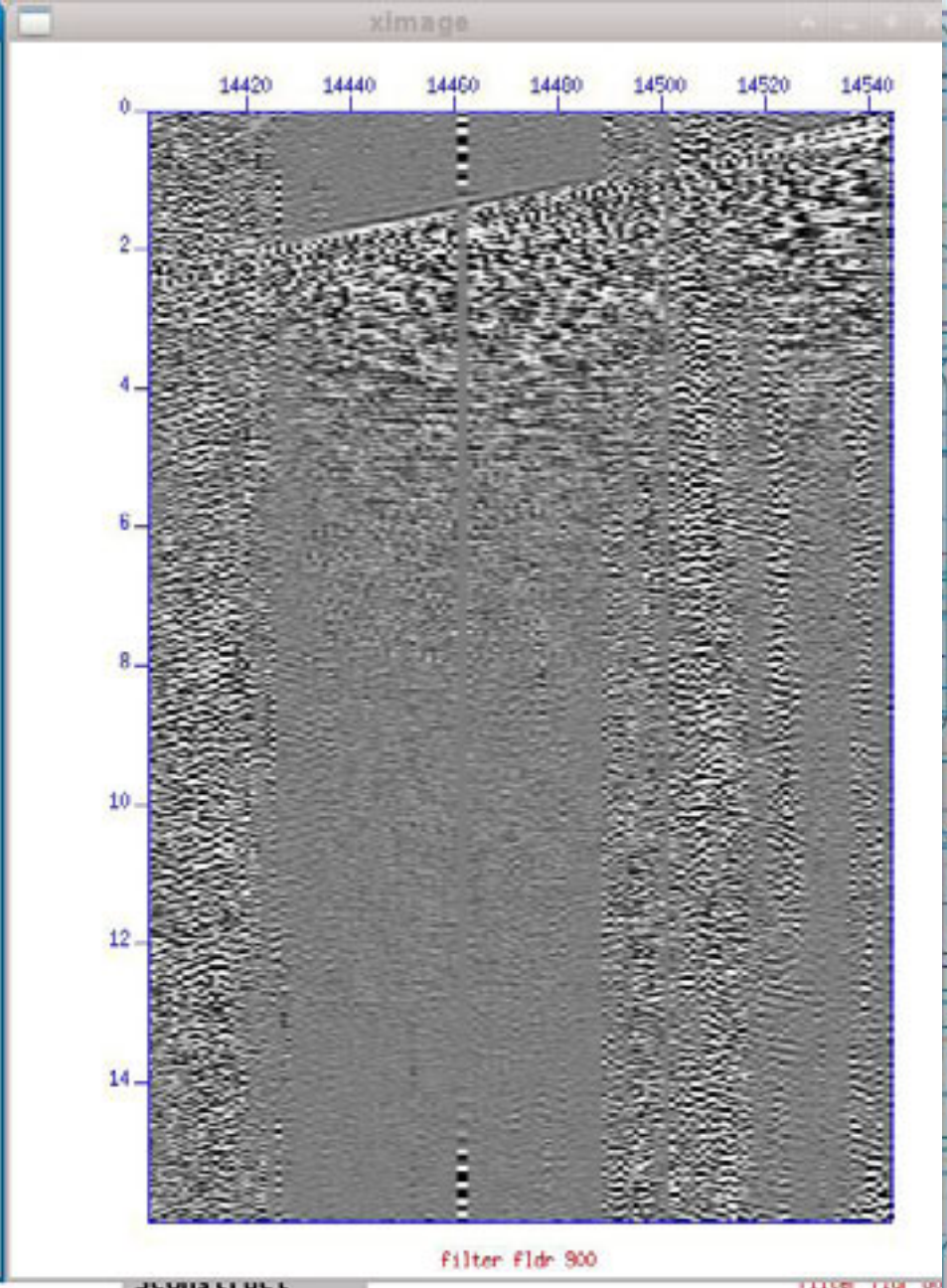


Kirchhoff migration

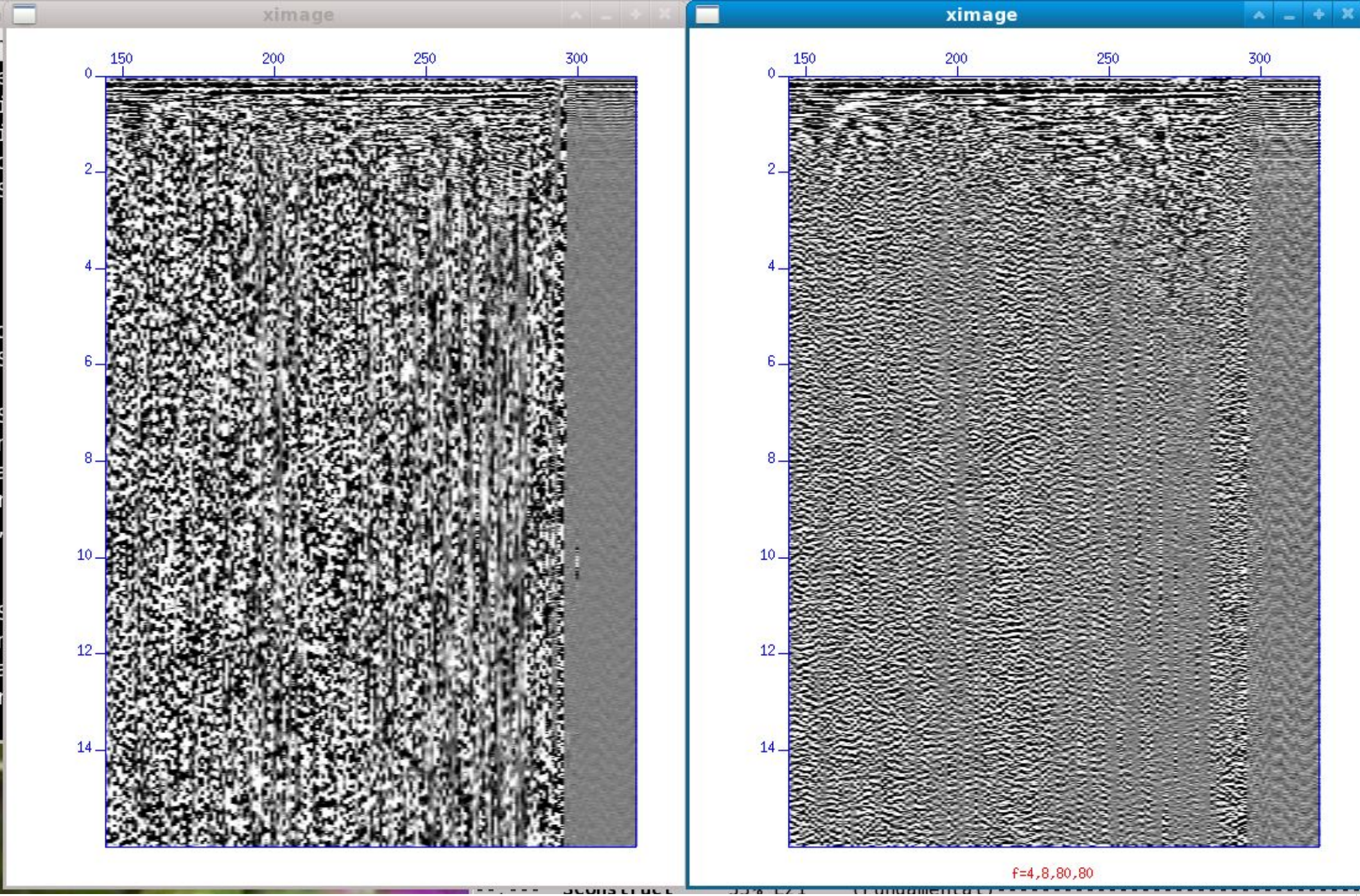
Taiwan 2D Marine

- SU processing sequence
  - Data load, header dumps, and initial qc plots
  - Shot displays before and after lc filter
  - Near trace displays before and after lc filter





Shot 900 before and after lc filter



Near trace gather (before and after lc filter)

Interactive Display Options

- I think we need better seismic visualization programs.
- Possible starting points:
  - VTK (Visualization Tool Kit)
    - Paraview
    - Visit
    - mayavi2
  - Colorado School of Mines Java Tool Kit (JTK)
  - BotoSeis

Conclusions

- Several datasets identified. Scripts started for three.
- Processing sequence is very basic. Each dataset has it's own issues (noise, statics, etc).
- The library is in the development version of Madagascar. The directory is $RSFSRC/book/data
- Alaska line 31-81 is the most mature. There are three directories in $RSFSRC/book/data/alaska
- SU is the most mature open geophysical software system. I have found it tricky to use. I think there is a bug in migkt2d.

Future Direction

- Continue to develope basic SU processing scripts
- Compare SU and Madagascar results
- Contribute program improvements to SU
- Reproducible documents describing data and scripts
- Present this paper at The PTTC Workshop - Open Software Tools for Reproducible Computational Geophysics.