Recovery of low frequency data from 10Hz geophones

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CREWES

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Outline

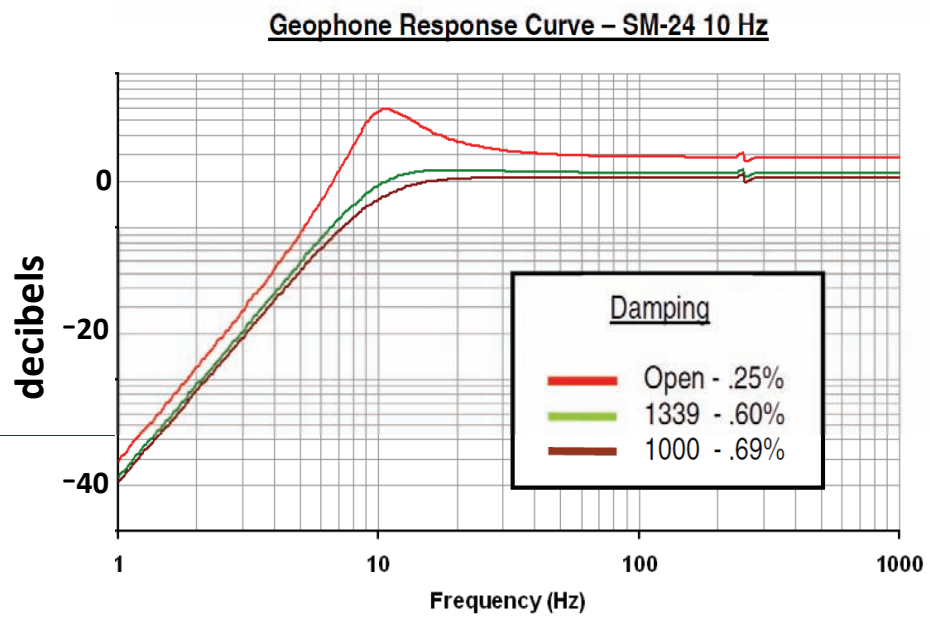
- The rationale
- The inverse filter
- Data sets
  - Blackfoot data
  - Spring Coulee data
  - Priddis data
- Conclusions

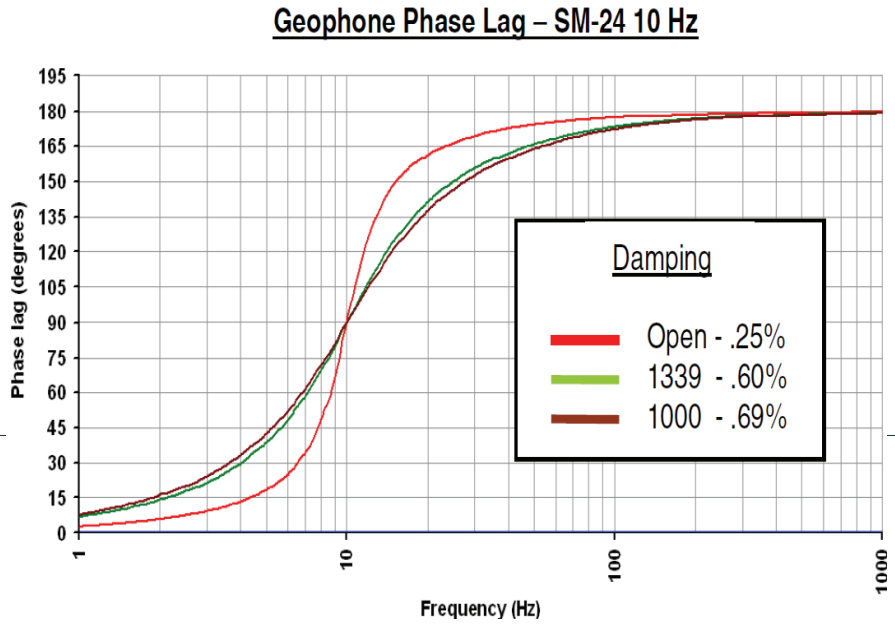
The rationale

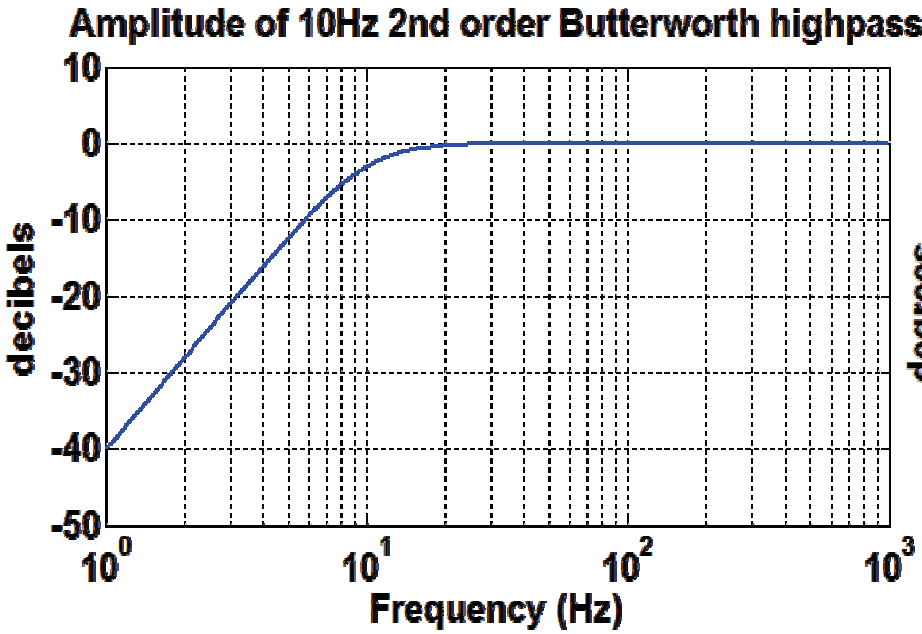
Increased low-frequency data bandwidth provides:

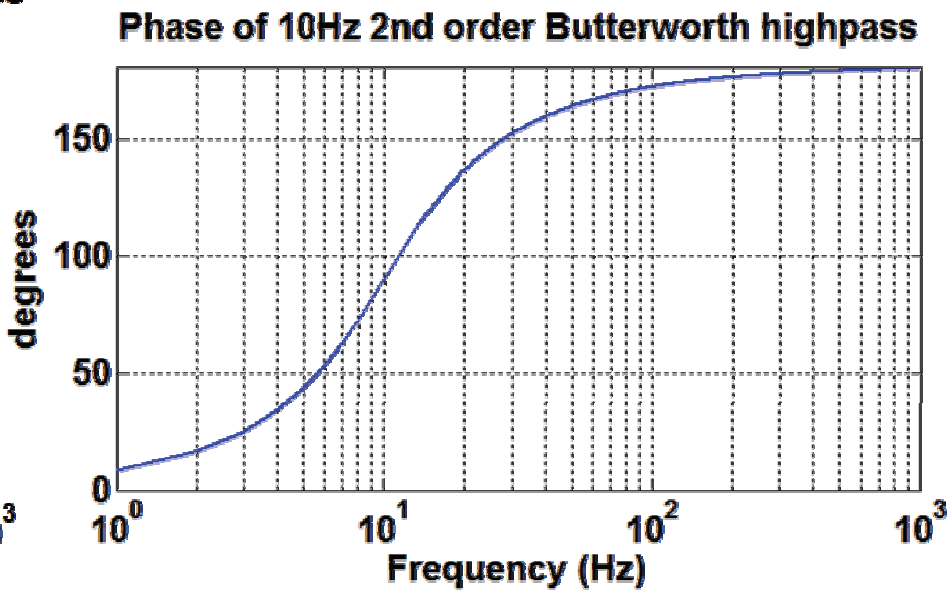
- improved velocity information
- improved inversion results
- better converted wave data
- better resolution

Geophone response









Low frequency recovery filter

If s_{10} represents the 10 Hz data, then we recover low frequencies via:

$$s_{10\_conv} = s_{10} \bullet b_{10}^{-1}$$

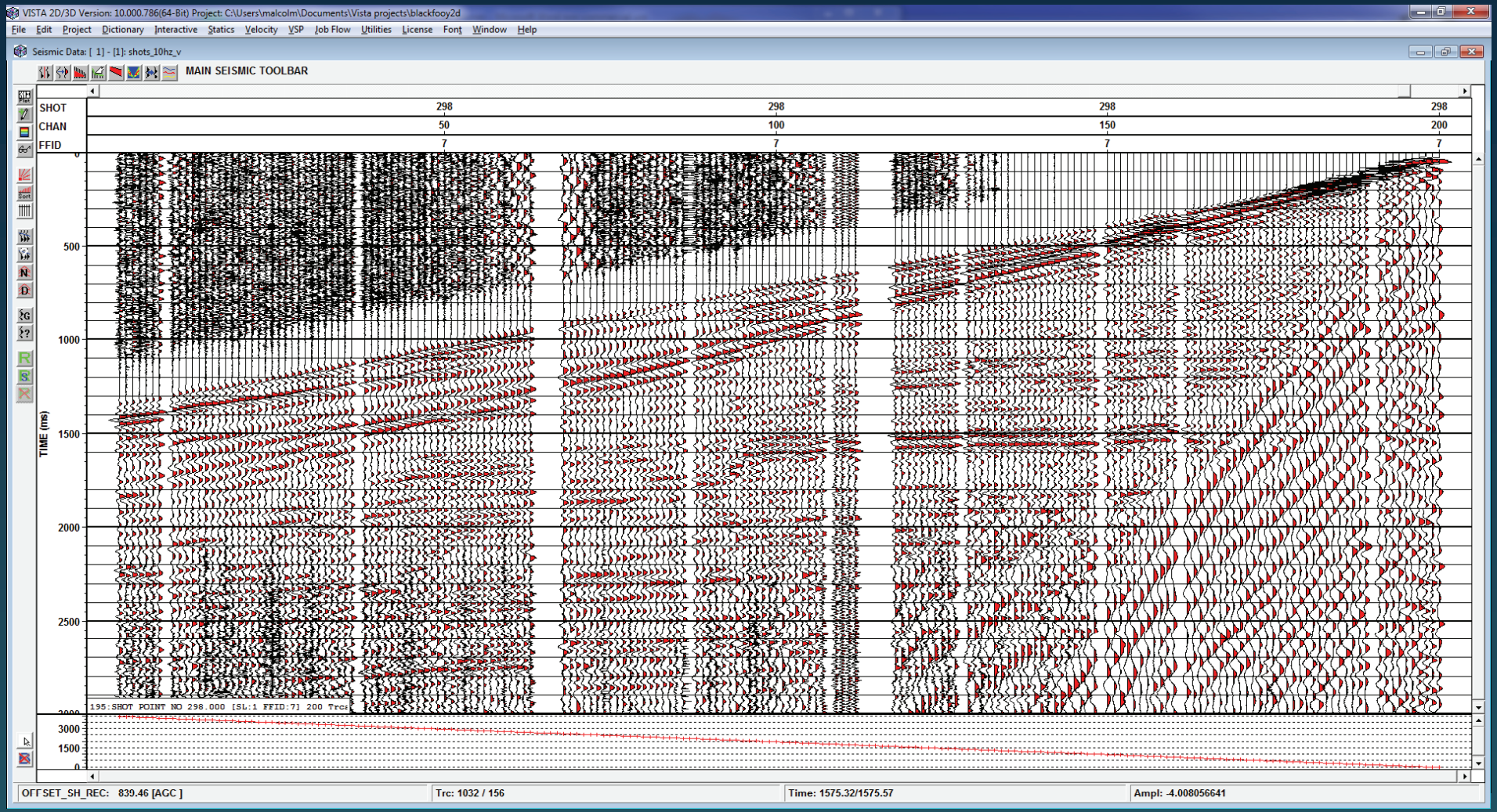
b_{10}^{-1} Is the inverse of the impulse response of a 2nd order 10Hz Butterworth high-pass filter.

Blackfoot low frequency survey

Survey parameters:

- 4Km line length
- Group interval 20m
- Receivers:
  - 10Hz 3C geophones
  - 10Hz vertical string (6 over 20m)
  - 4.5Hz 3C geophones
  - 2Hz vertical geophones
  - 2Hz horizontal geophones (60 in centre of spread)
- 6Kg dynamite @ 18m
- Recording instruments: ARAM-24; Low cut filters out
- Shot in July 1995
- See 1995 CREWES Research Report for details

Blackfoot low frequency survey



10Hz single geophone vertical component

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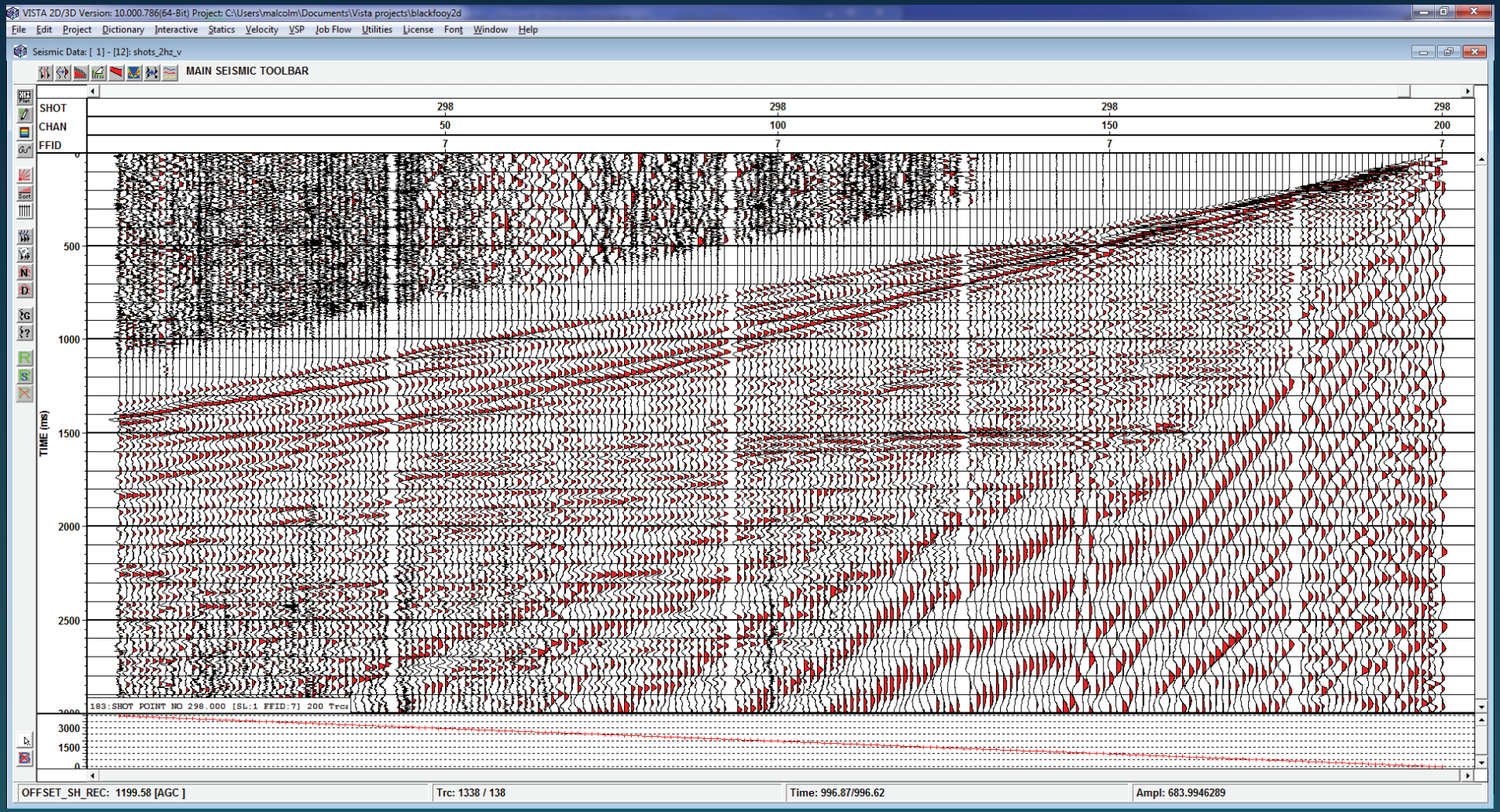
Blackfoot low frequency survey



2Hz single geophone vertical component

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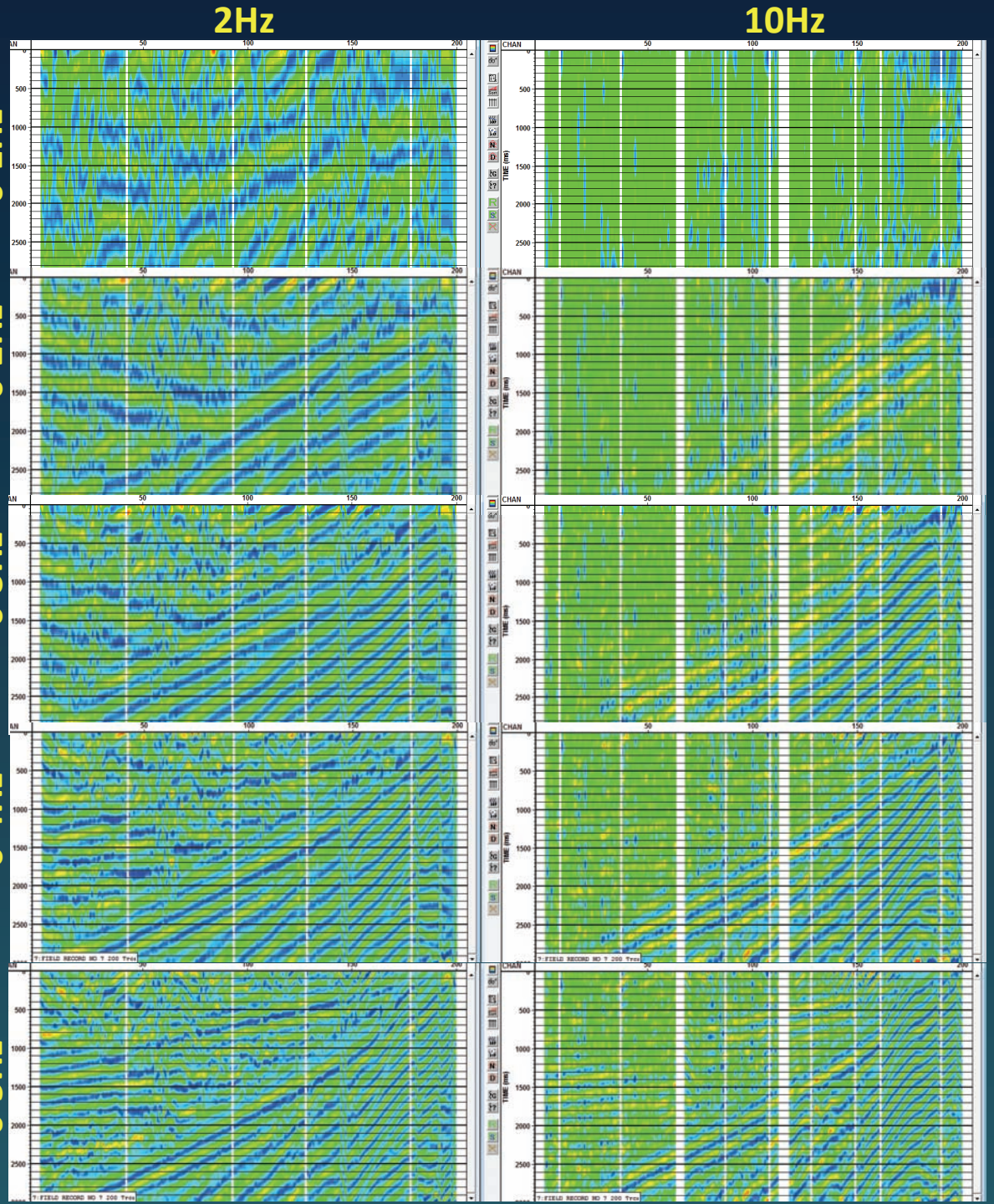
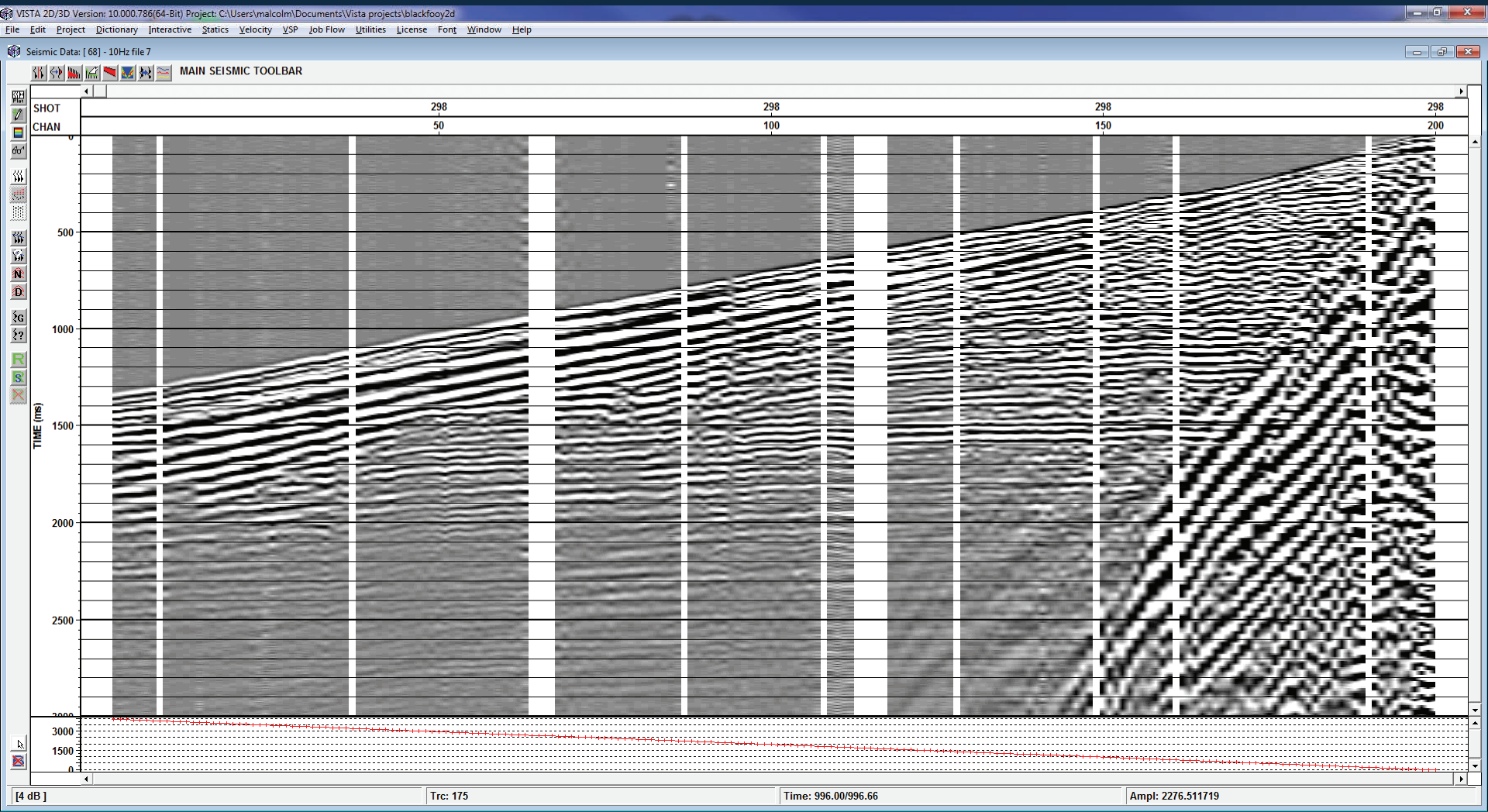


Filter panels of the 2Hz and 10Hz gathers

Blackfoot low frequency survey



10Hz shot gather

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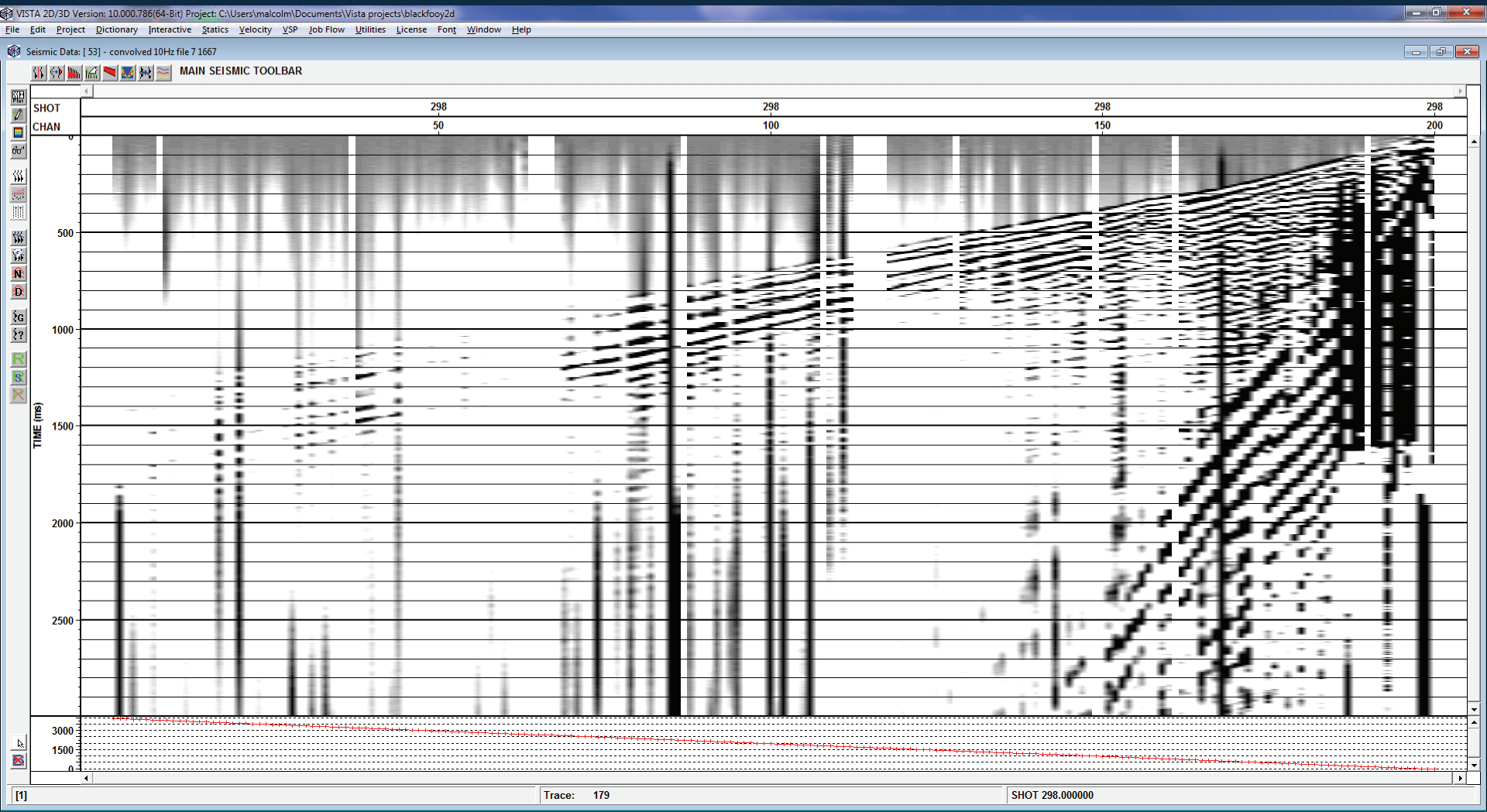
Blackfoot low frequency survey



10Hz shot gather after convolving

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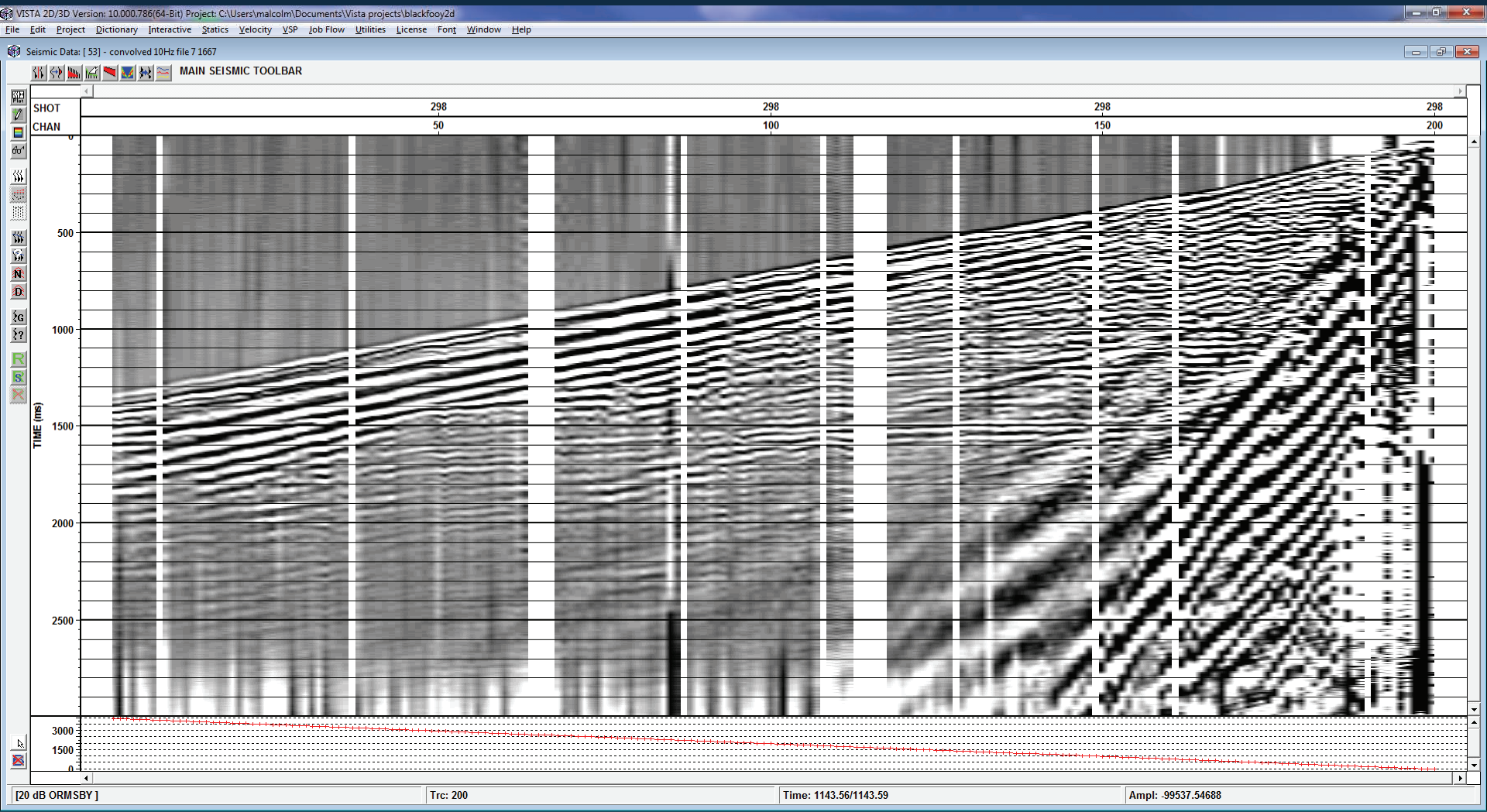
Blackfoot low frequency survey



10Hz shot convolved gather with 2Hz low cut filter

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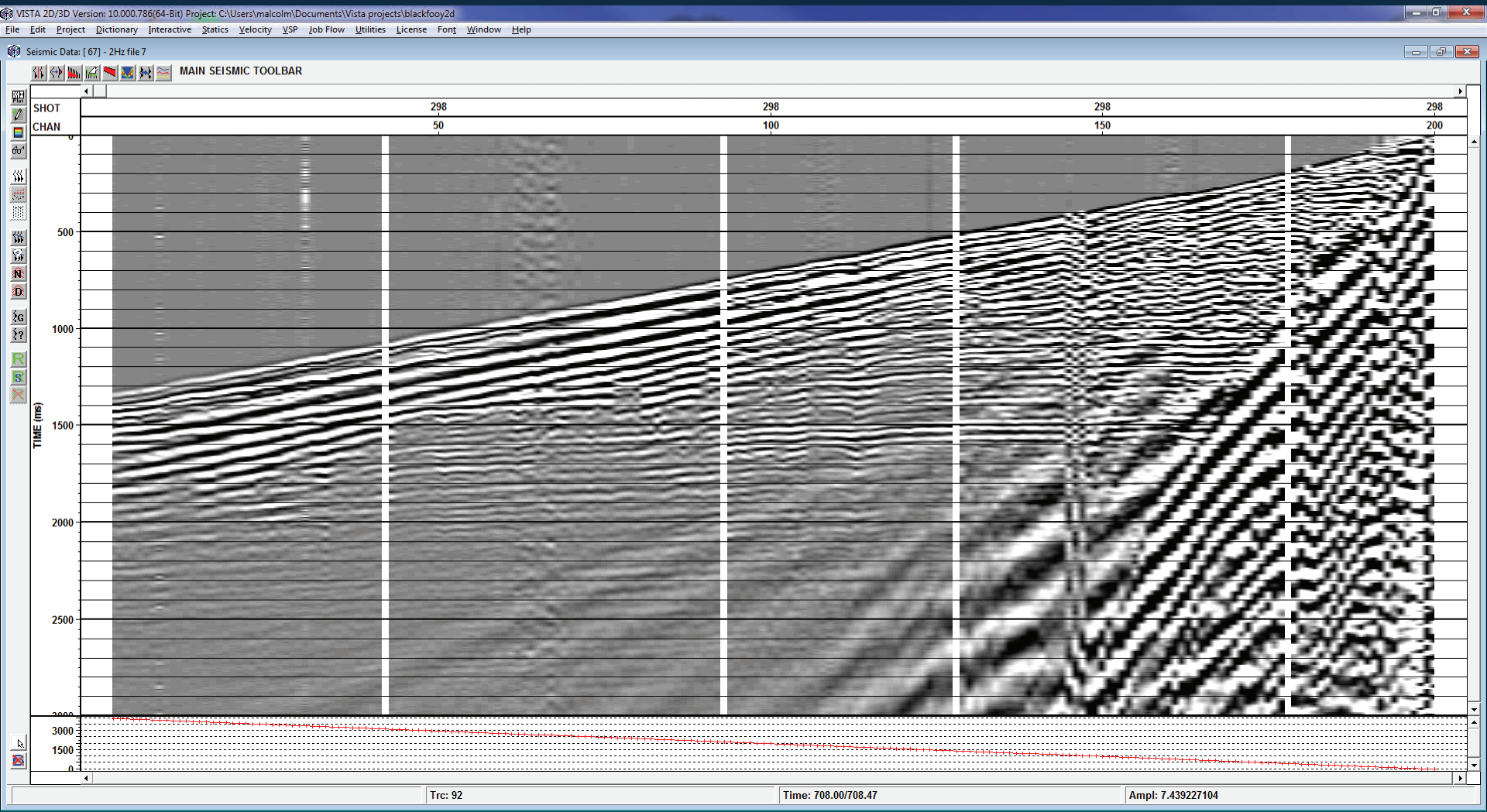
Blackfoot low frequency survey



2Hz shot gather

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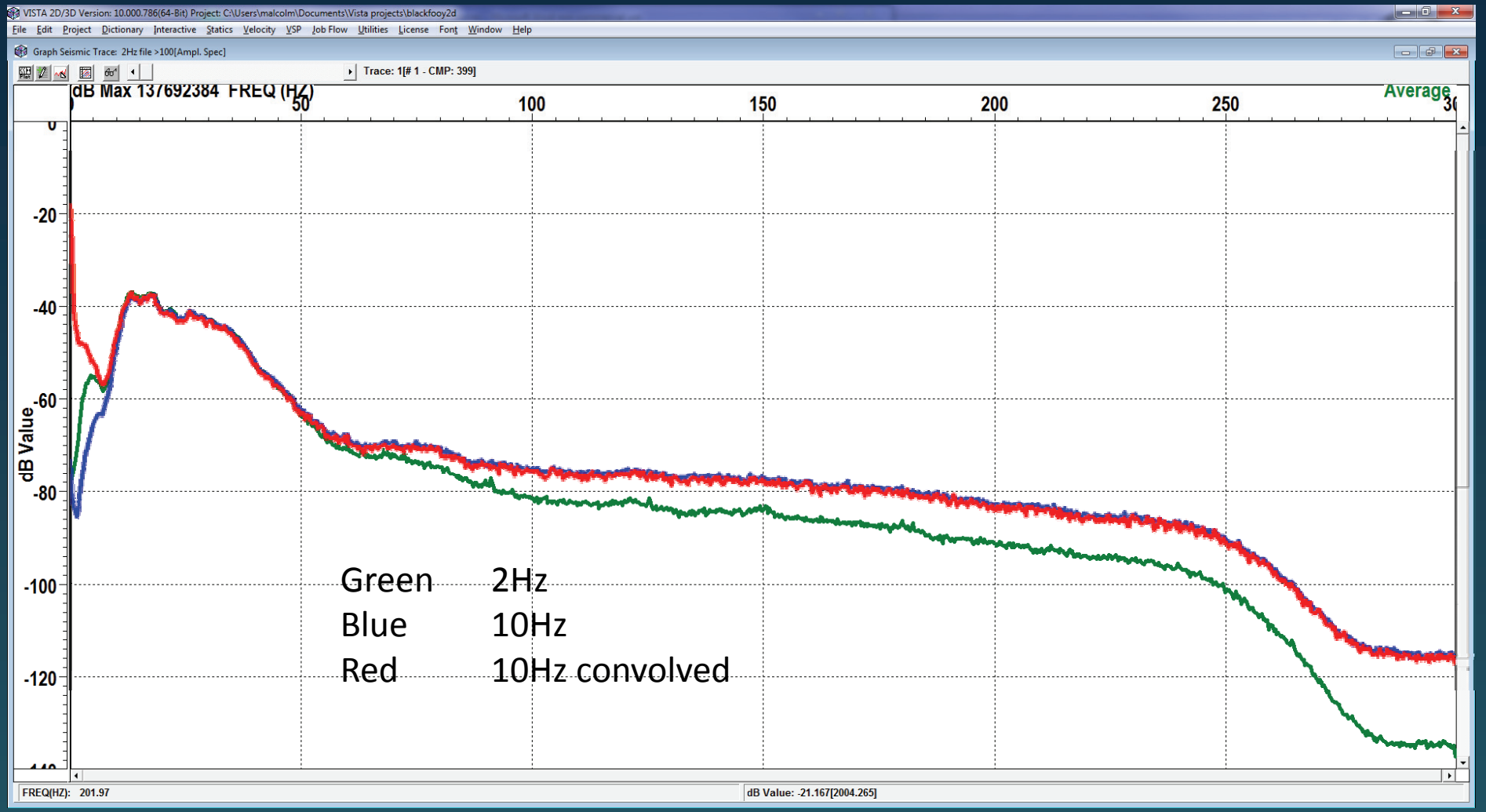
Spectra



Average amplitude spectra for the gathers for offsets >100m

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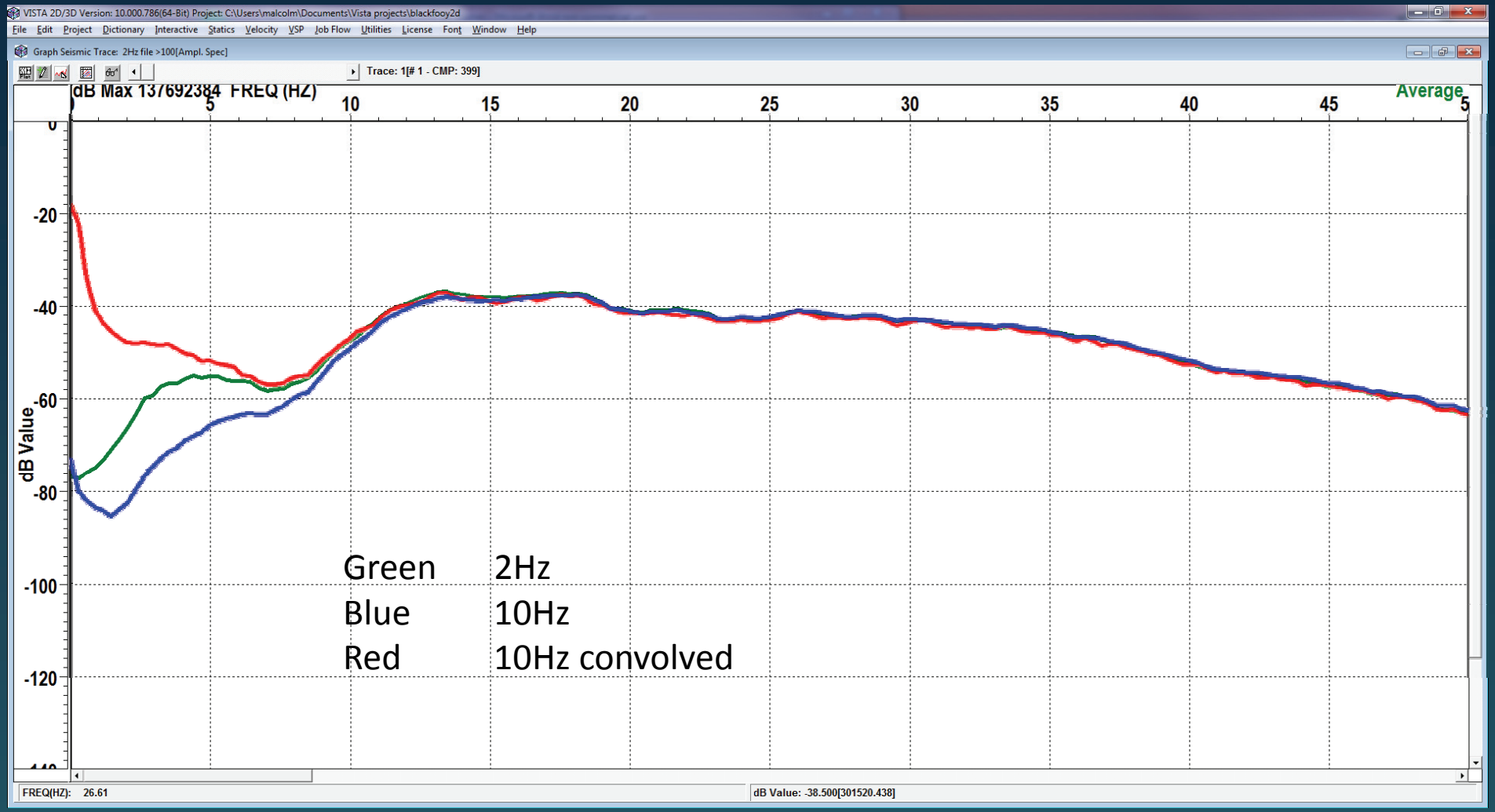
Spectra



Average amplitude spectra 0-50Hz for offsets >100m

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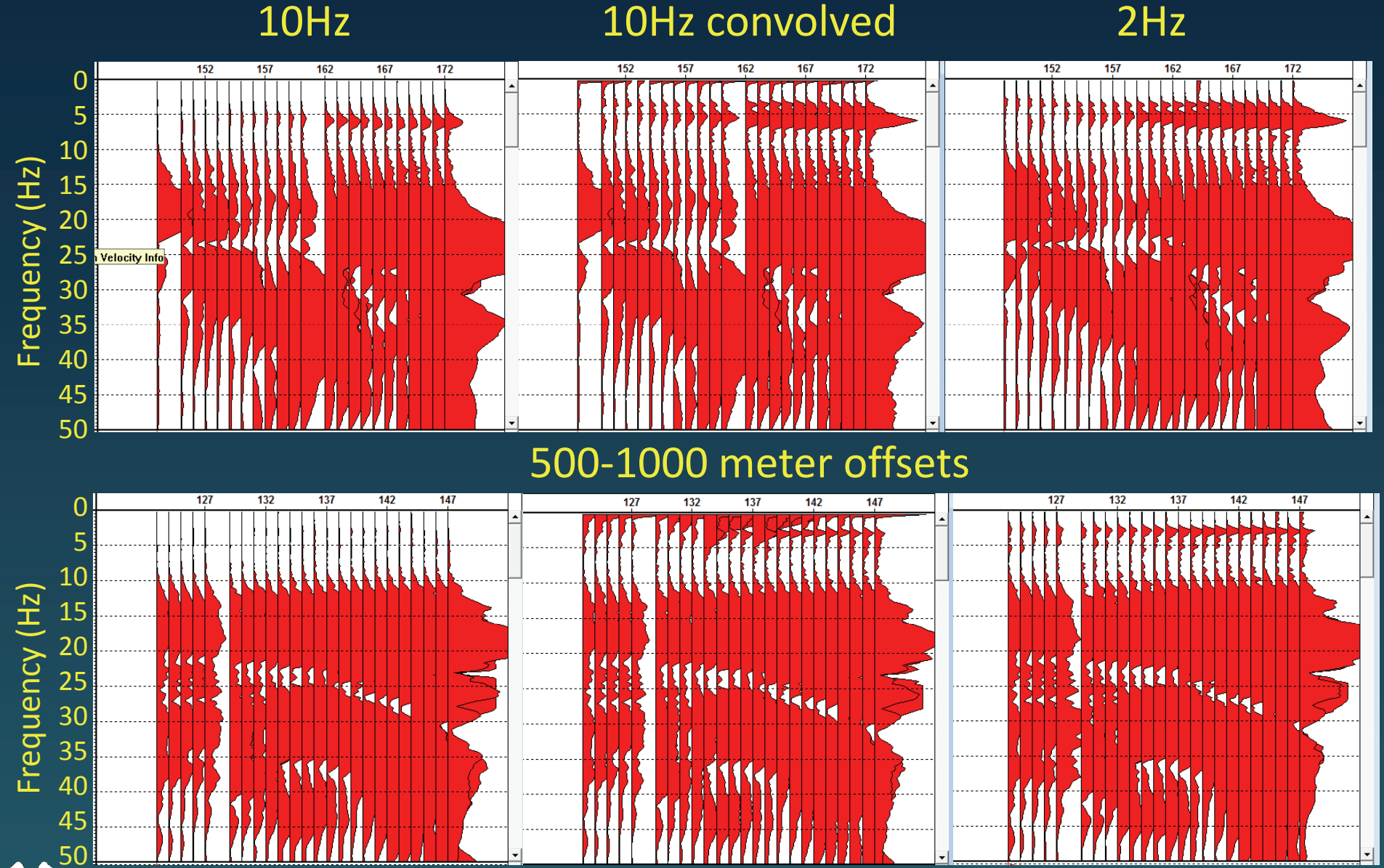
Spectrum plots



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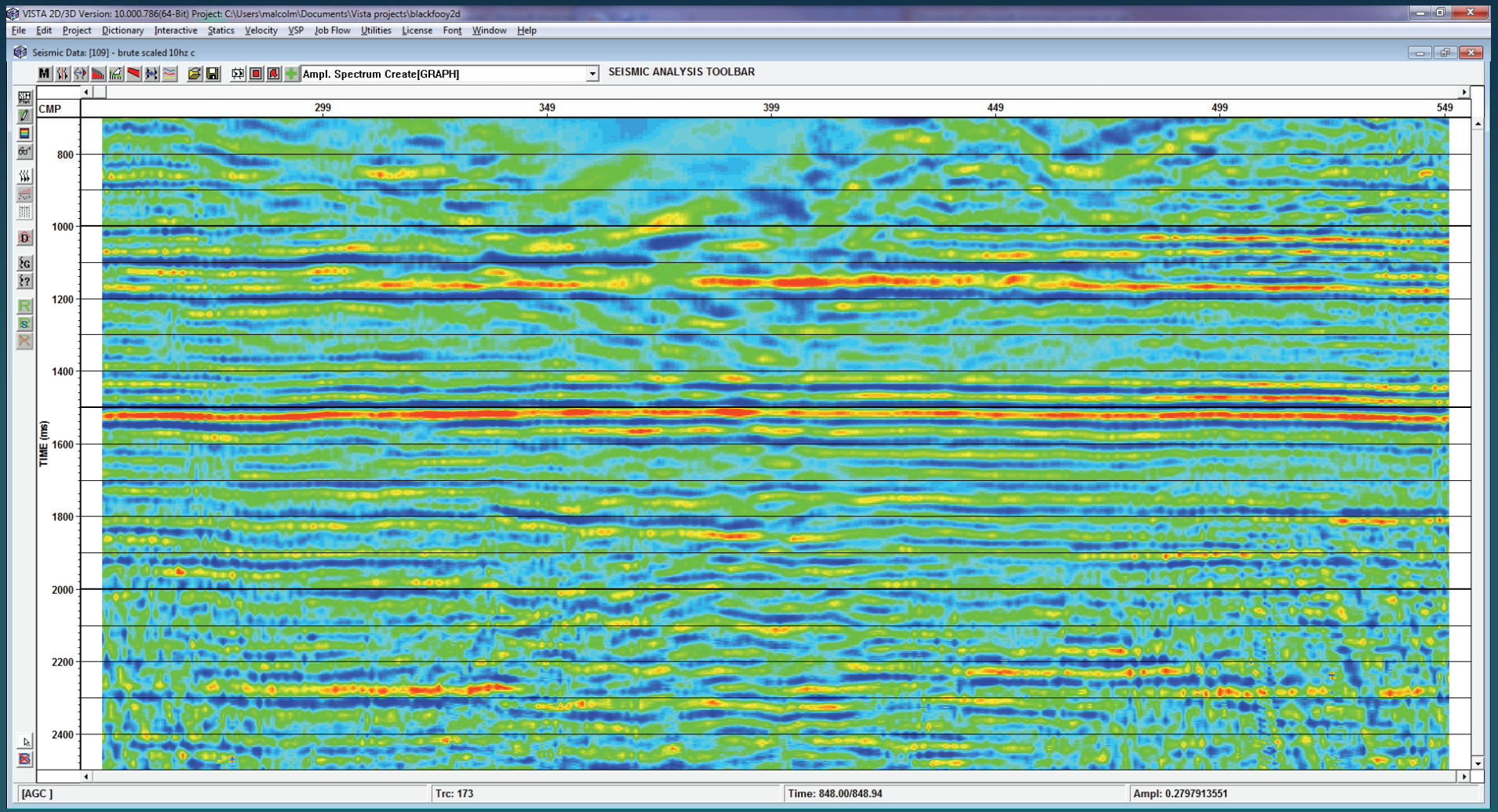
Brute stack of the 10Hz data



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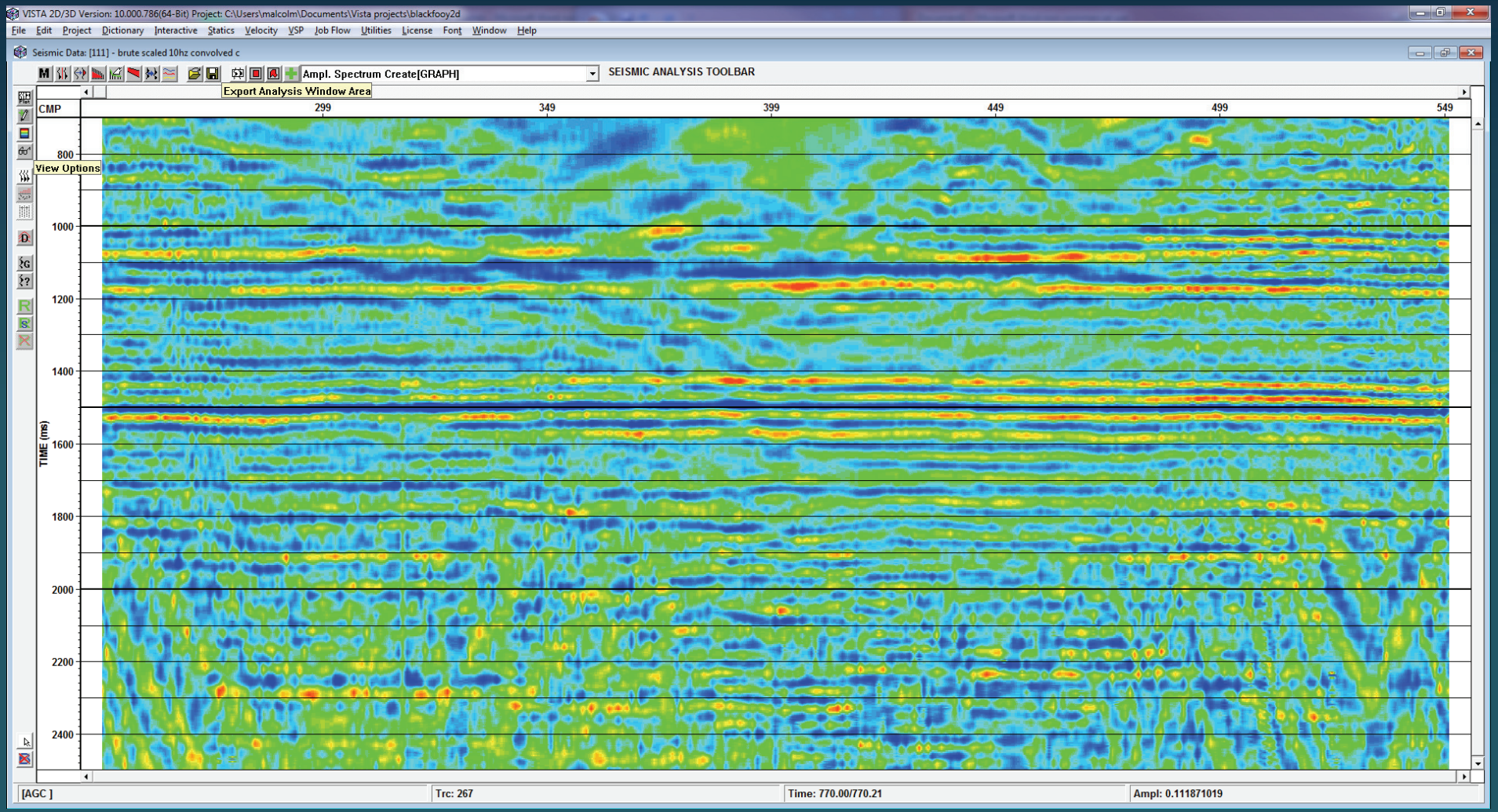
Brute stack of the 10Hz convolved data



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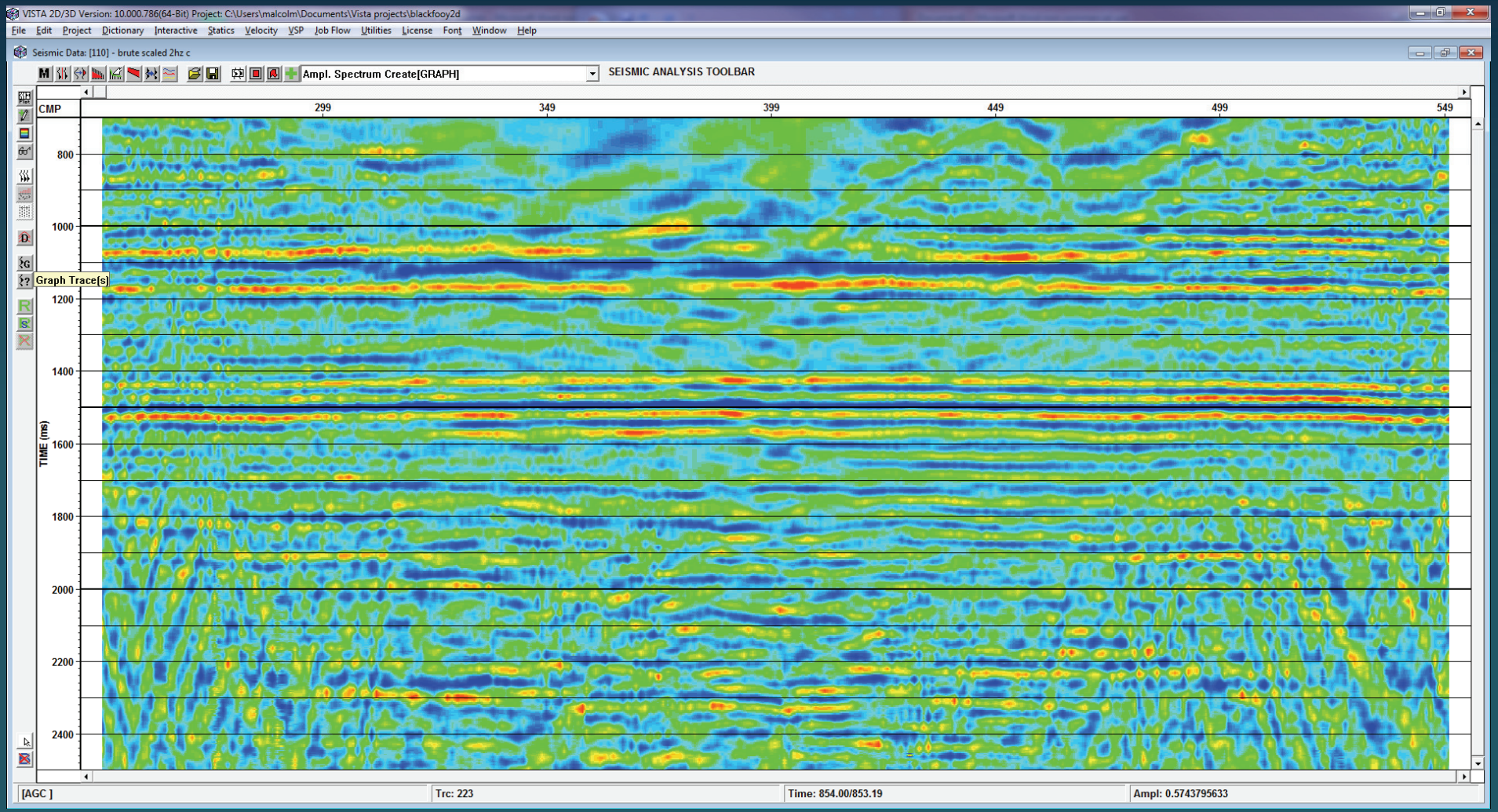
Brute stack of the 2Hz data



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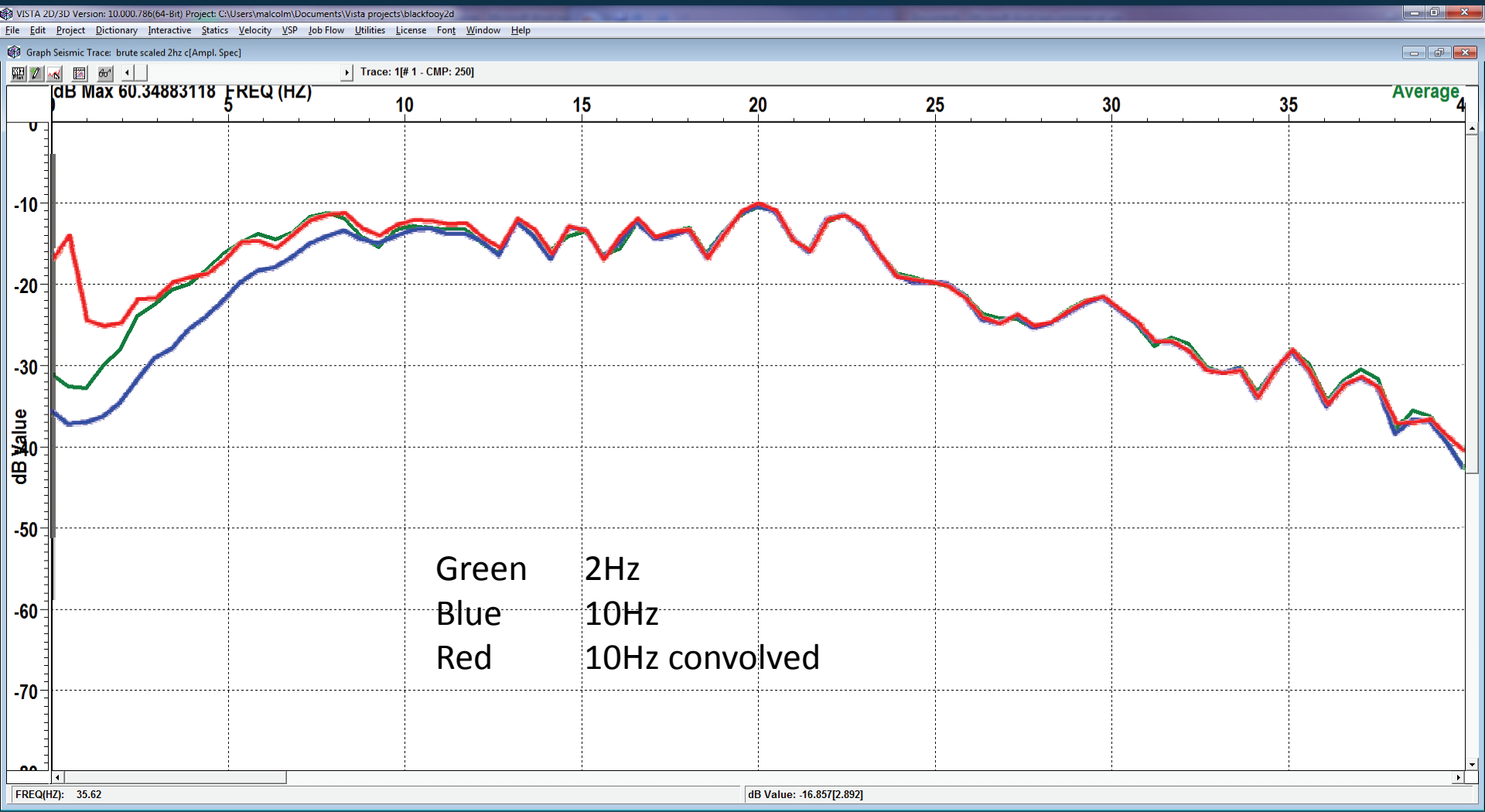
Spectra of the three brute stacks



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Thoughts on this result

This survey was designed for low frequency acquisition.

Data is being recovered down to about 2Hz (two octaves).

A low cut filter of 1 or 2Hz removes the near DC component from the convolved data.

Original processing of the data showed frequency content down to 0.5Hz in the 2Hz geophone data.

Further processing of the 10Hz convolved data is still required to fully evaluate the usable bandwidth.

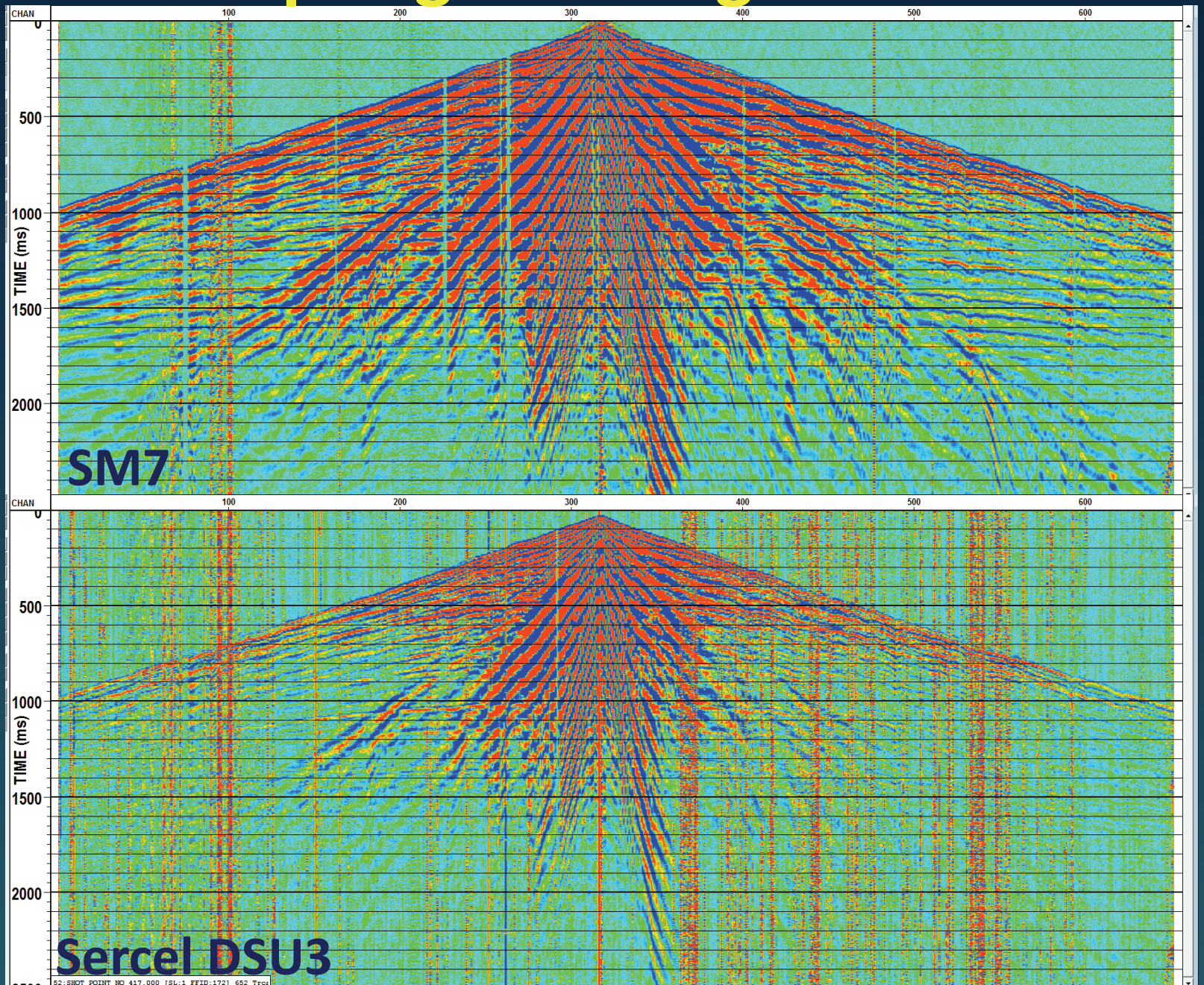
The 4.5Hz geophone data will be processed in the same way and compared to the 2Hz data.

Spring Coulee

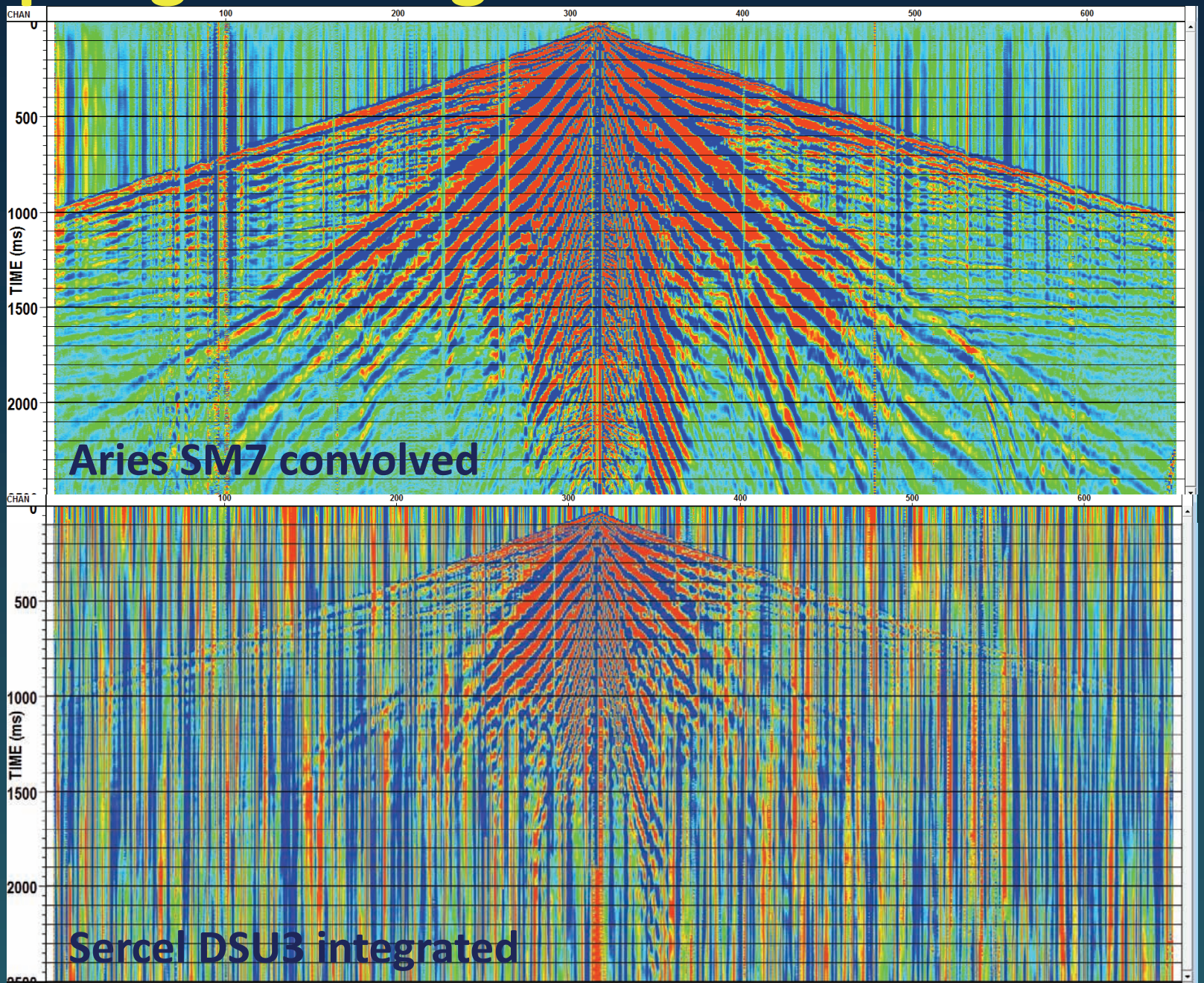
Recording parameters:

- 6.5Km total line length
- 10m group interval
- 2Kg dynamite at 18m
- Sensor SM7 geophones
- Sercel DSU3 MEMs accelerometers
- Recording instruments:
  - ARAM Aries; Low cut filters 3Hz
  - Sercel 428XL; Low cut filters out (DSU3)
- Shot in January 2008
- See 2008 CREWES Research Report for details

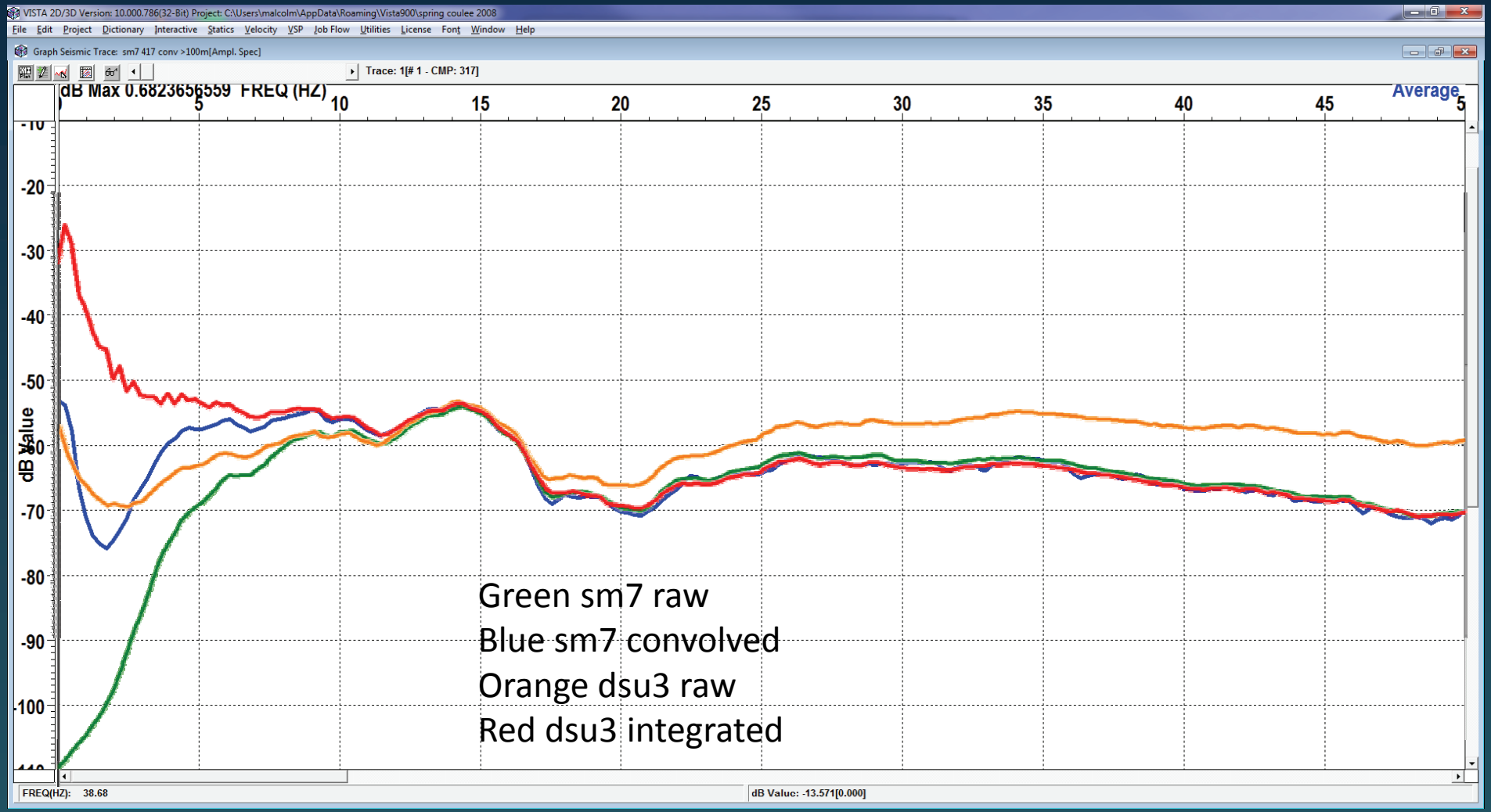
Spring Coulee gathers



Spring Coulee gathers after correction



Spring Coulee spectra



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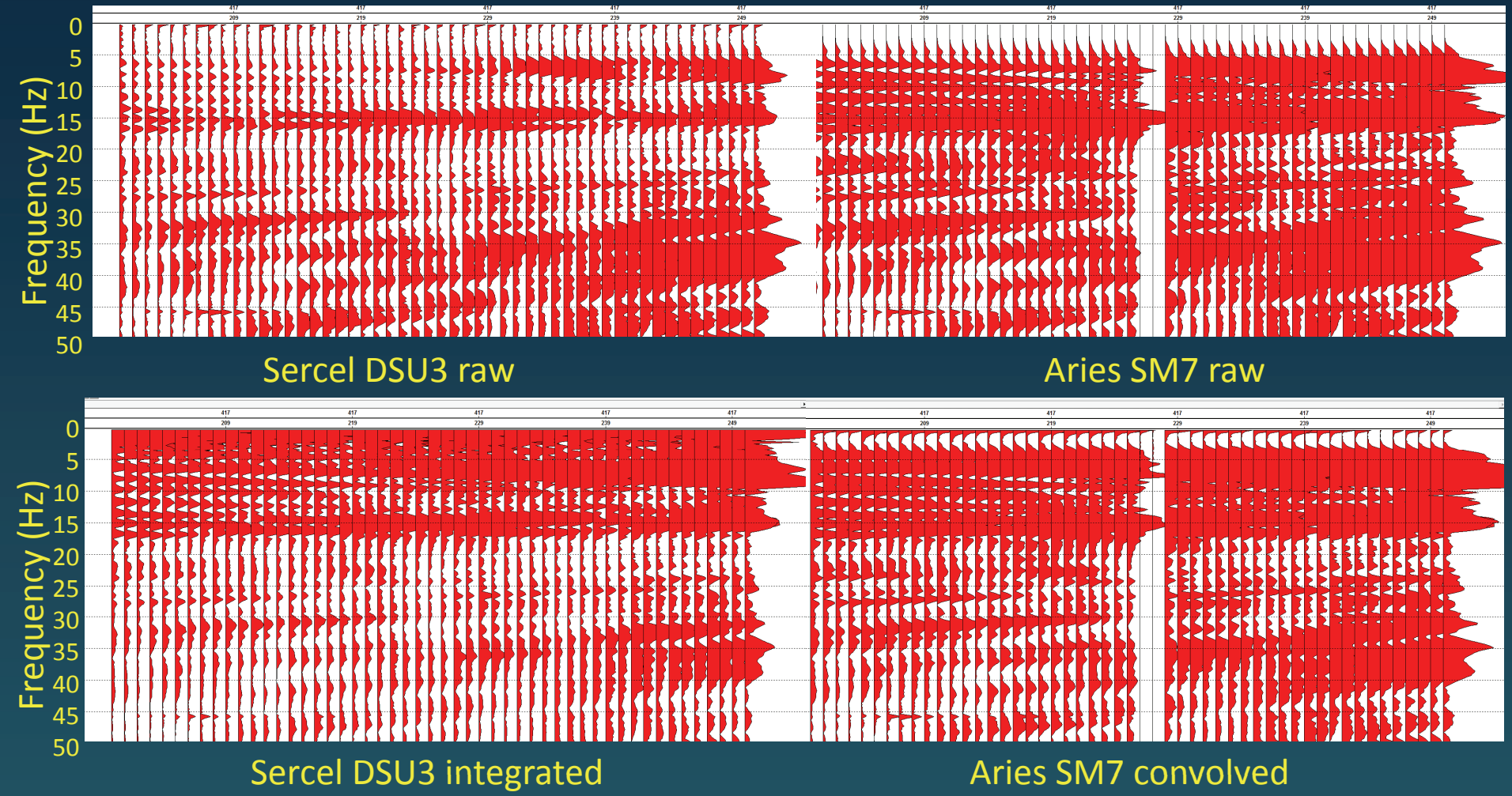
Spring Coulee



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Thoughts on this result

This survey was not designed specifically for low frequency acquisition.

The 3Hz low cut acquisition filter removes the possibility of recovering data from below this frequency.

Again, a low cut filter of 2Hz would remove the near DC component.

Priddis seismometer test

Survey parameters:

- 8 stations spaced 10m apart
- Receivers:
  - Nanometrics Trillium 240 seismometer
  - Sercel DSU3 MEMS accelerometers
  - ION Vectorseis MEMS accelerometers
  - Sensor SM24 3C geophones
- Recording instruments:
  - Aram Aries; Low cut filter 1Hz
  - ION Scorpion; Low cut filter 1.46Hz
  - Sercel 428; Low cut filter out
  - Taurus; Low cut 0.004Hz, sample rate 10msec
- Source: AWD thumper, EnviroVibe
- Shot in August 2009
- See 2009 CREWES Research Report for details

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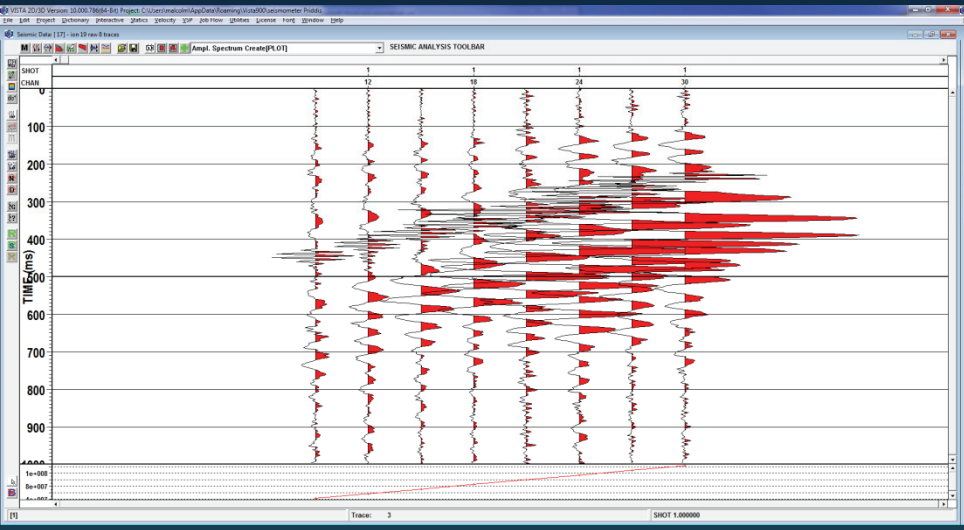
Priddis shot gathers



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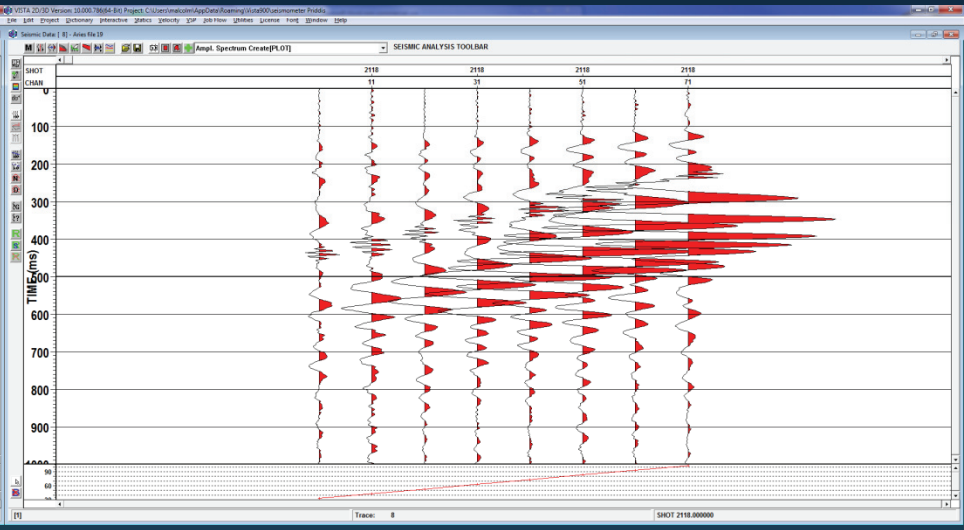
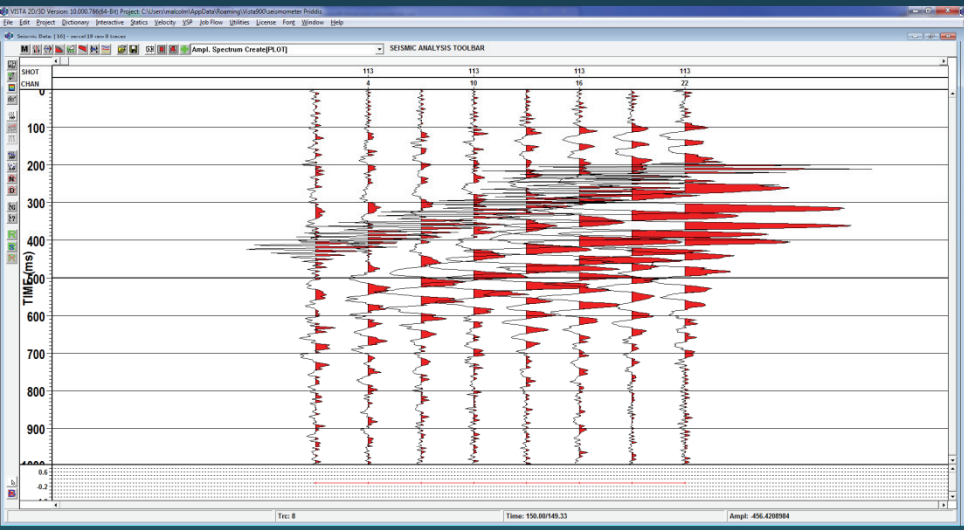
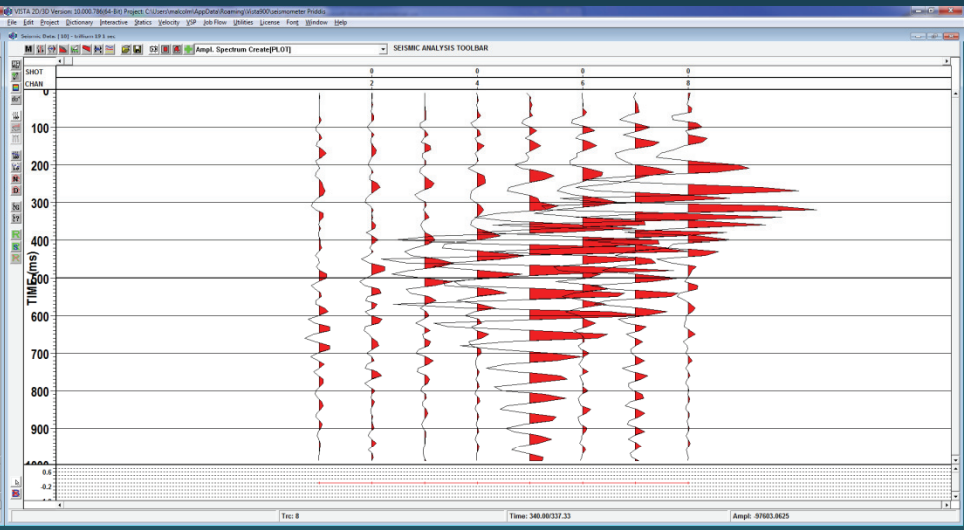


Aries SM24



Sercel DSU3



Trillium 240

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Raw data

Priddis spectra before correction

Raw data

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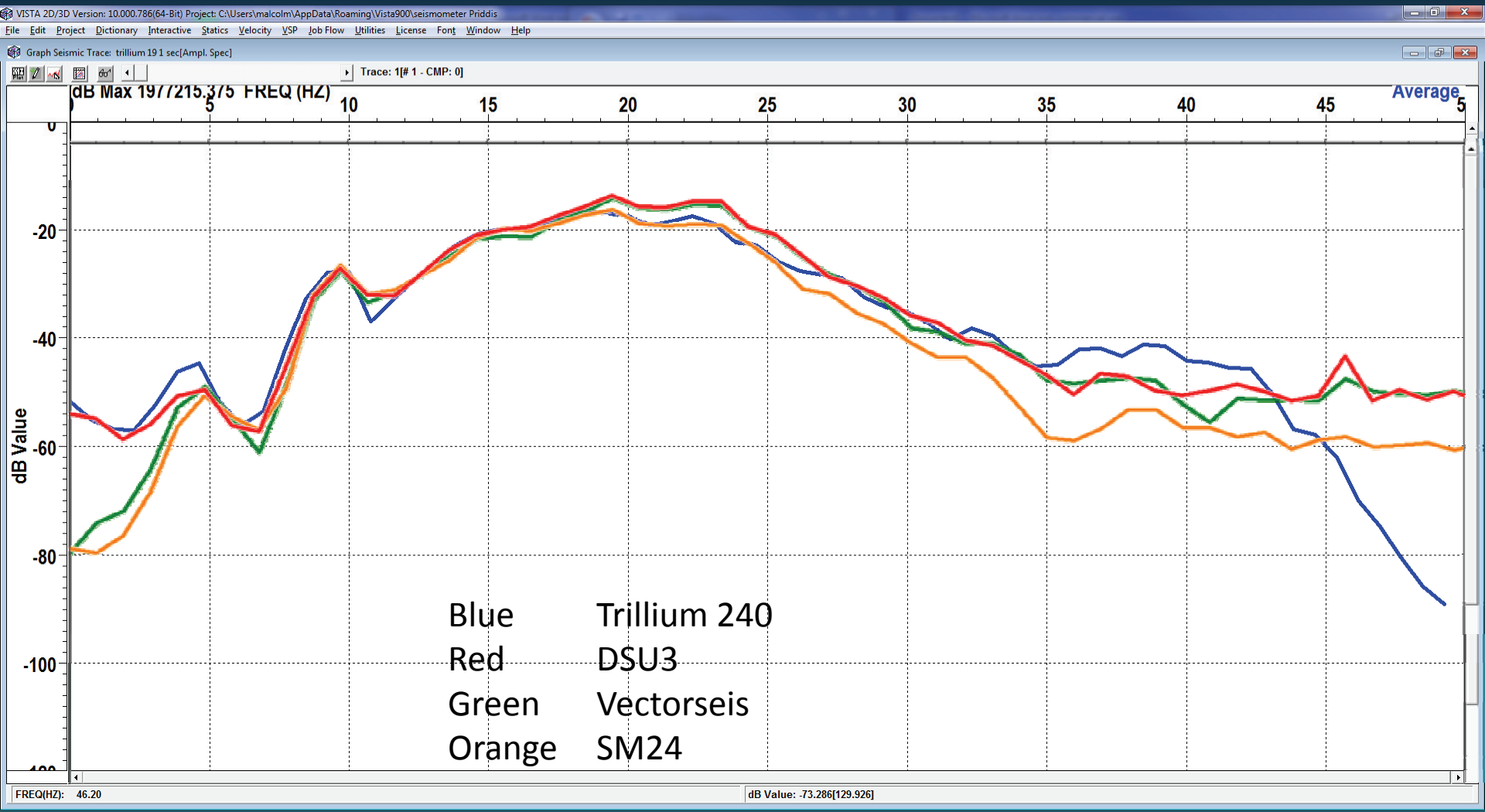
Priddis spectra (0-50Hz) before correction



Raw data

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Priddis spectra after correction

Geophone data convolved, MEMS data integrated, Seismometer data untouched

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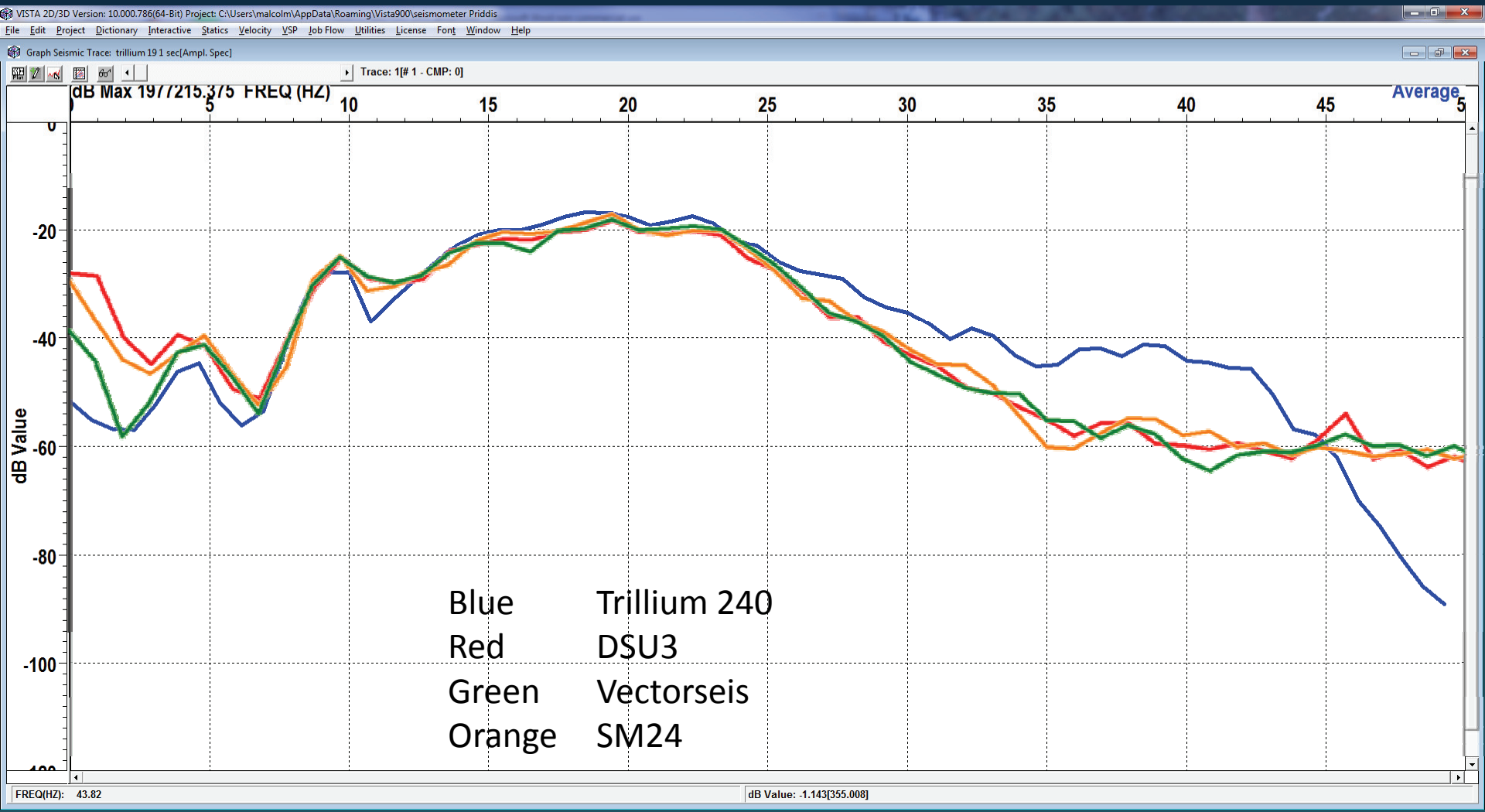
Priddis spectra (0-50Hz) after correction



Geophone data convolved, MEMS data integrated, Seismometer data untouched

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Thoughts on this result

This survey was intended to allow direct comparison between calibrated seismometers and both MEMs and geophone sensors, particularly at low frequencies.

After correction, the MEMs and geophones track fairly well above 5Hz, but below that results are inconclusive.

More analysis of this data is in the CREWES reports for 2009 and this year.

Conclusions

- The inverse filter method works.

- The method can only recover data that exists! - beware 3Hz low cut acquisition filters.

- High amplitudes near DC need to be filtered.

Proposed low frequency survey

Ideas:

- Shoot in 2011 (May?)
- Need good data area with target at useful depth
- Well control
- Compare many sensors: 2Hz, 4.5Hz, 10Hz geophones, MEMS accelerometers, seismometers
- Evaluate low frequency sources: Vibrator options, dynamite, weight drop systems
- Other thoughts?

Please express any interest right away.

Acknowledgments

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