Full-wave Seismic Analysis: Source comparisons, land streamer tests, and converted-wave processing

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CREWES Sponsors Meeting
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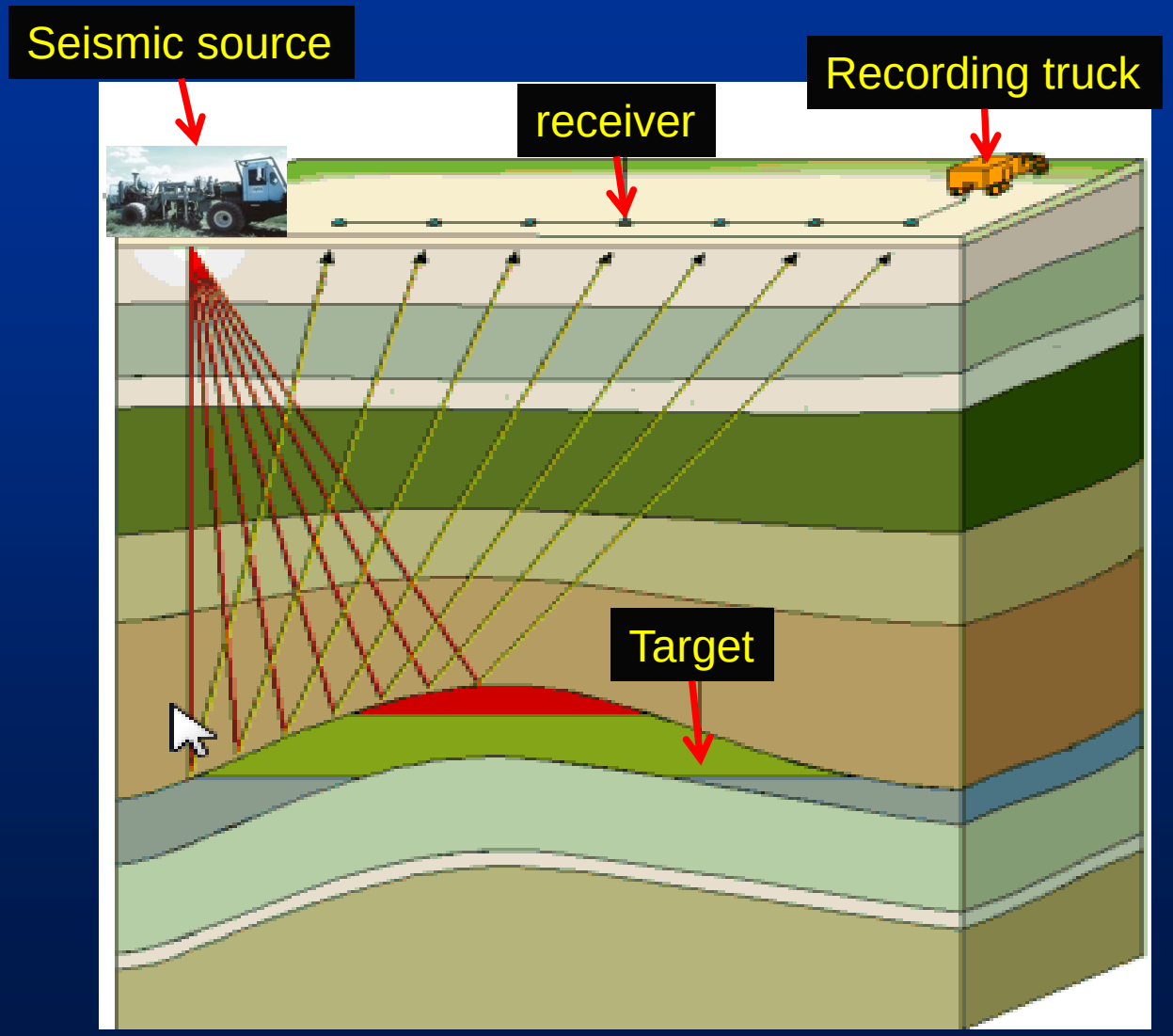
Seismic acquisition



Modified from www.bakerhughes.com

Outline

- Motivation-improvements in seismic acquisition:

  Land streamer and source comparison

- Location- two sites in Alberta, Canada
- Part I. A field comparison of 3-C land streamer versus planted geophone data
- Part II. Seismic source comparison for compressional and converted-wave generation at Spring Coulee, Alberta.
- Summary and future work

Part I:
A field comparison of 3-C land streamer versus planted geophone data

Land streamer tests

- Motivation :

  - a whole new technology to expedite land acquisition (especially 3-C)

  - compare to traditional methods

- Location – near Calgary, Canada

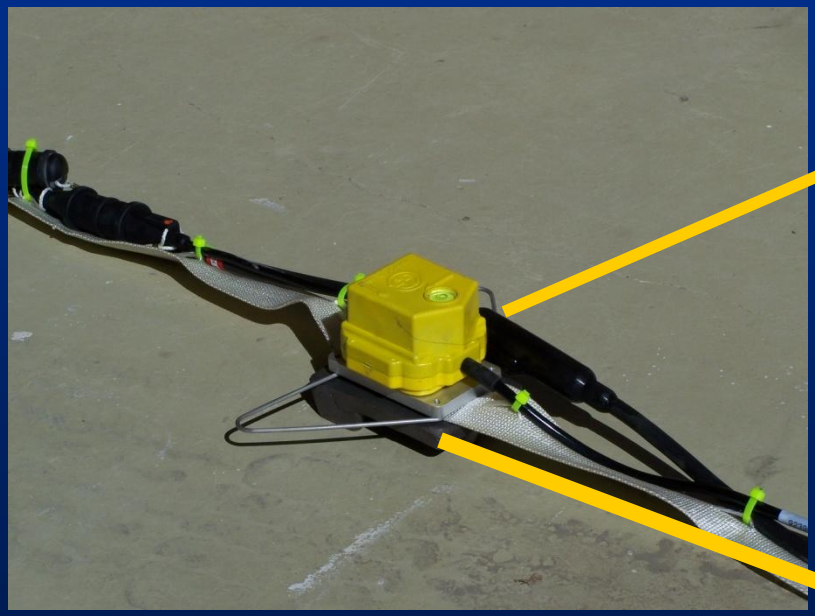
- Side-by-side experiment description-equipment, geometry

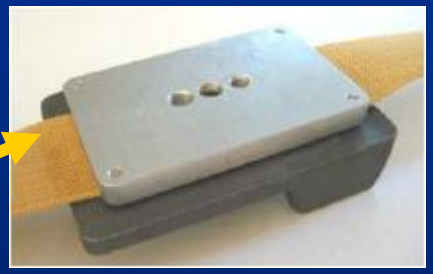
- Data examples

- Analyses undertaken to compare both systems

CREWES Land Streamer

- 3-C geophones
- Top and base metallic plates
- Anti-rotation wing
- Tow webbing





Photographs from www.geostuff.com

CREWES Land Streamer

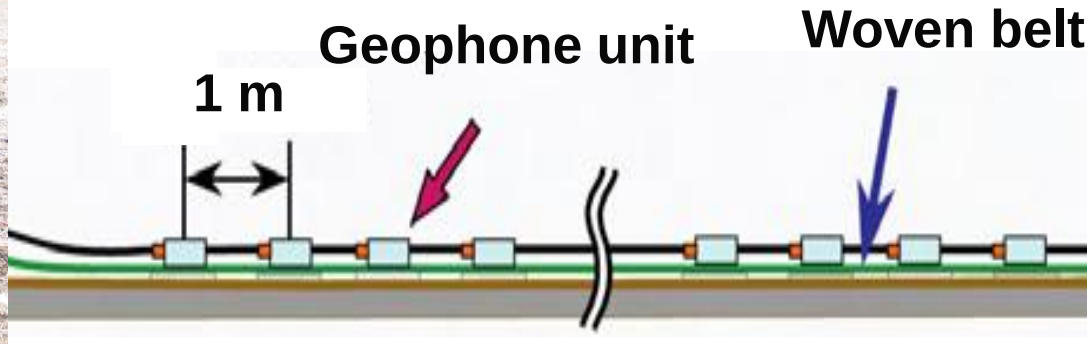
Source:
IVI-envirovibe
(18,000 lb)
10 to 250 Hz sweep,
11 s listening time
4 vertical stacks

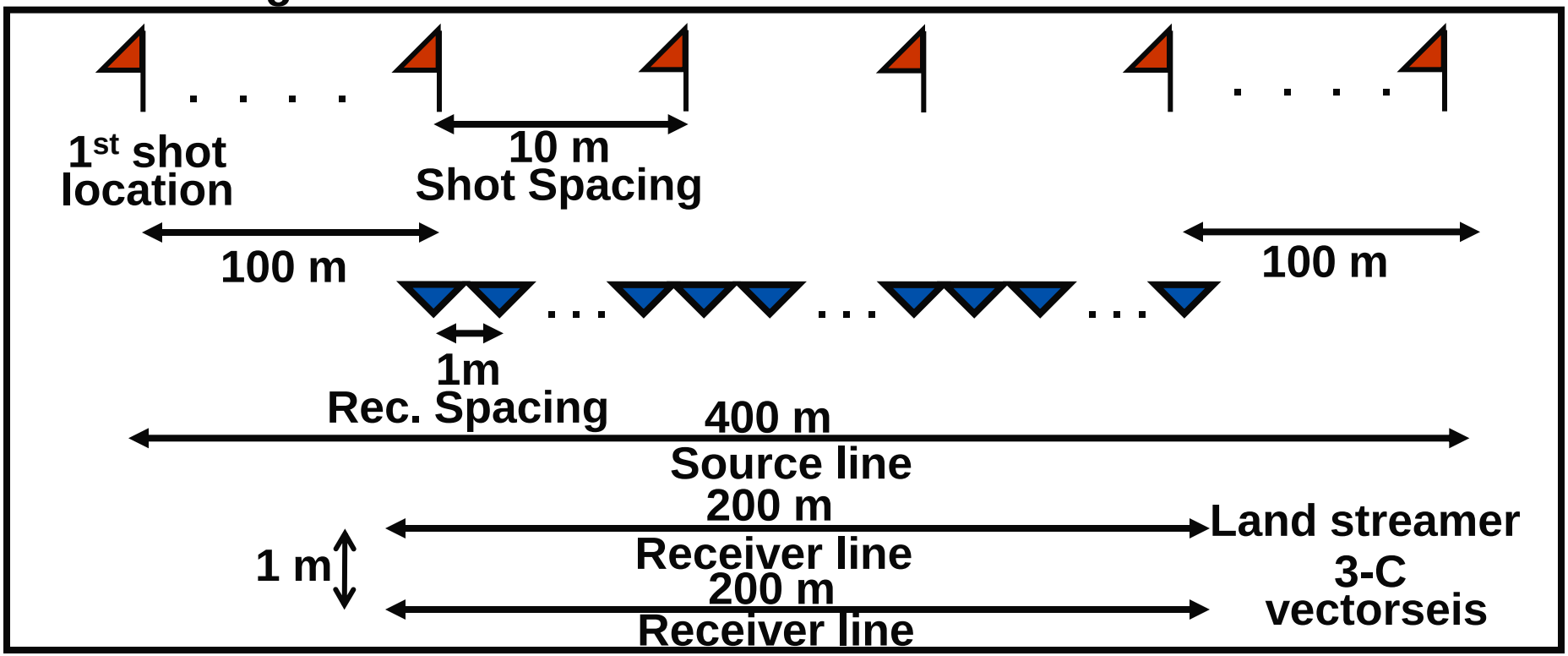
Land streamer towing device

Receiver:
10 Hz 3-C geophones

Acquisition geometry

Towing device





How do we compare the data?

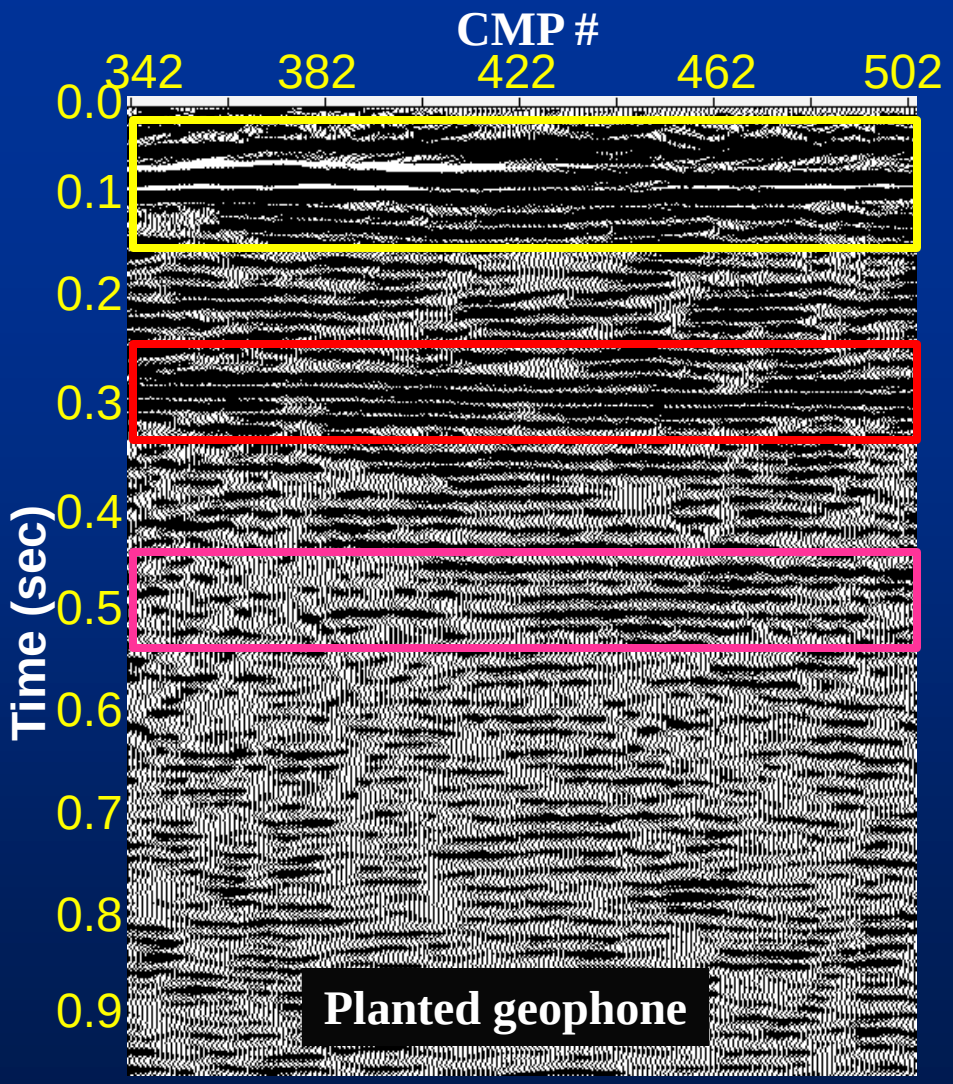
Qualitative analyses:

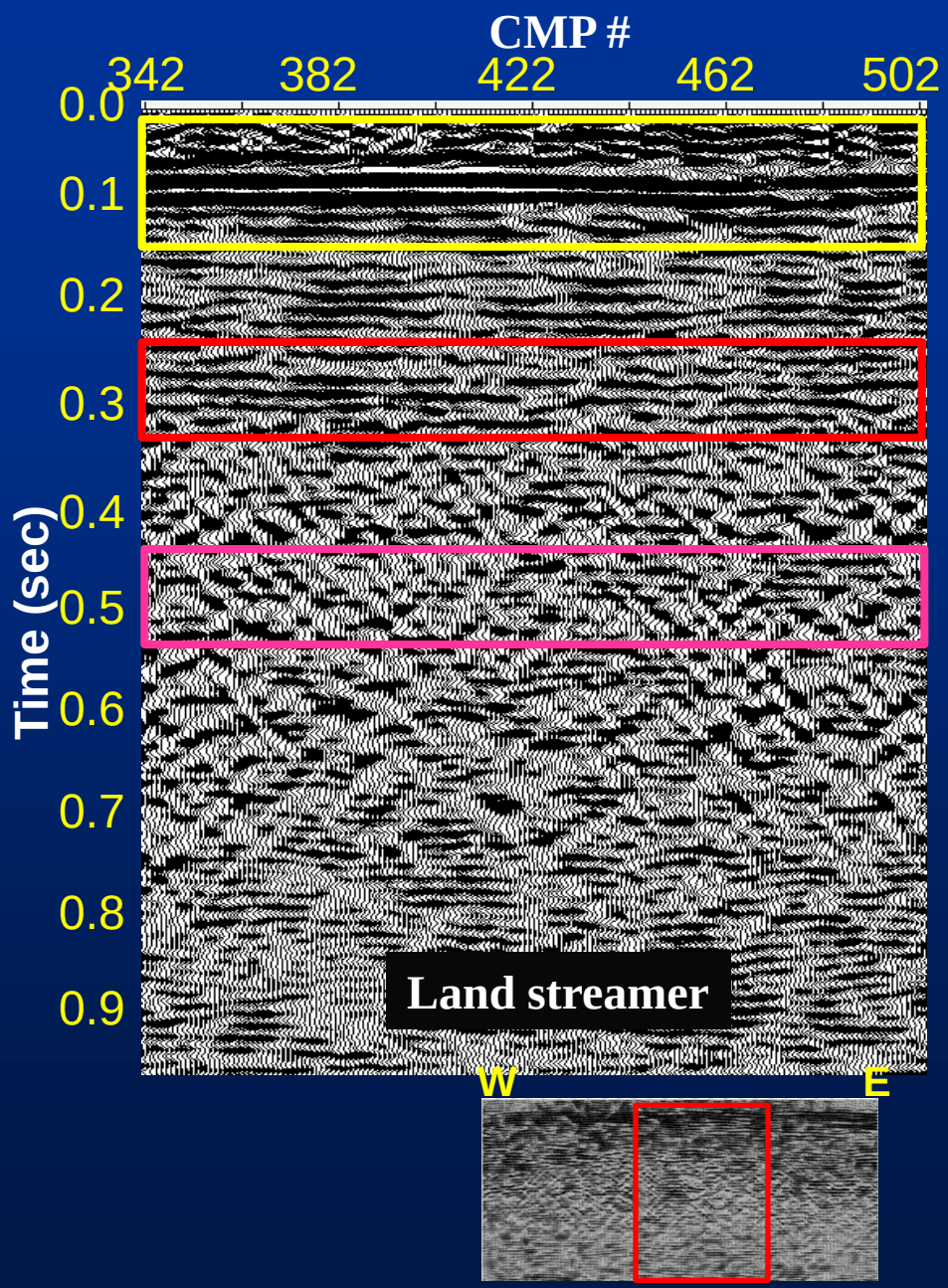
- Visual observation

Quantitative analyses:

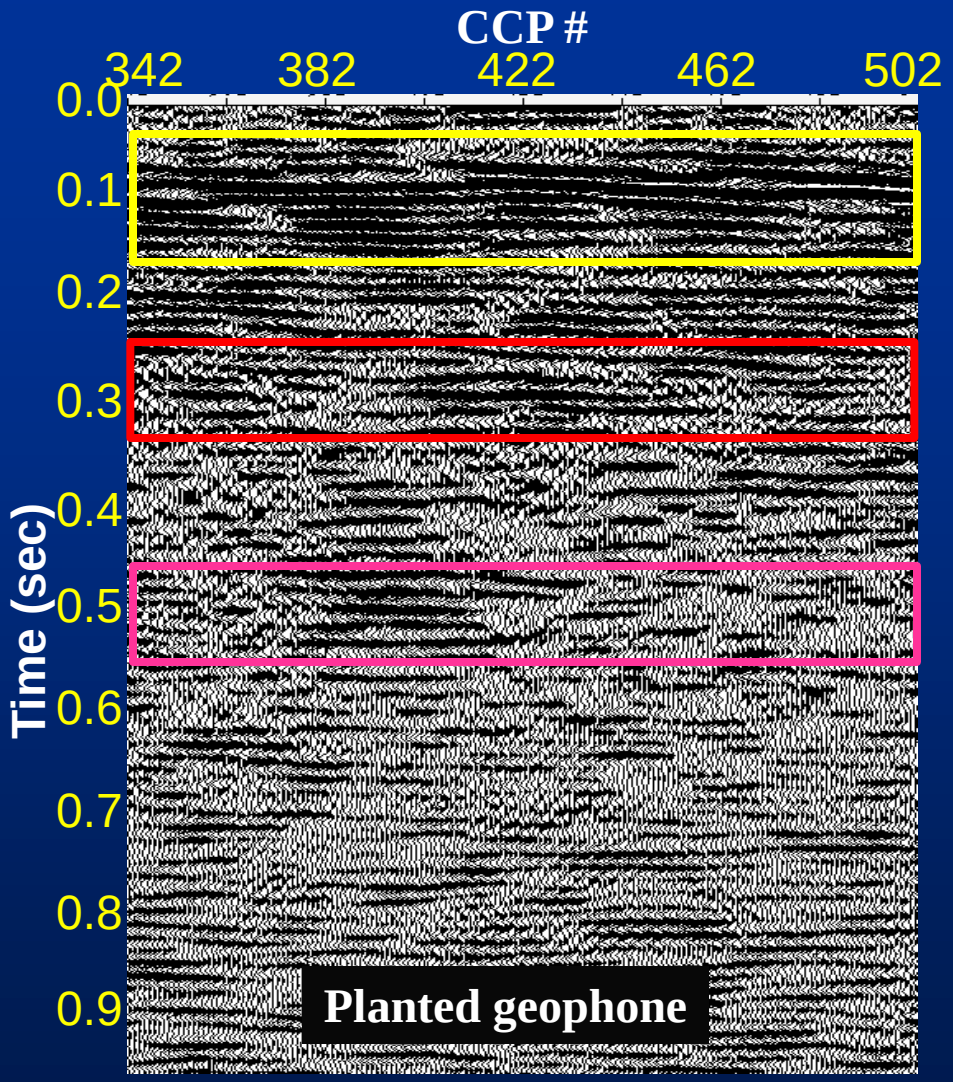
- Average amplitude analysis of raw shot gather,
- F-x Fourier analysis of stacked sections,
- Frequency analysis of receiver gathers.

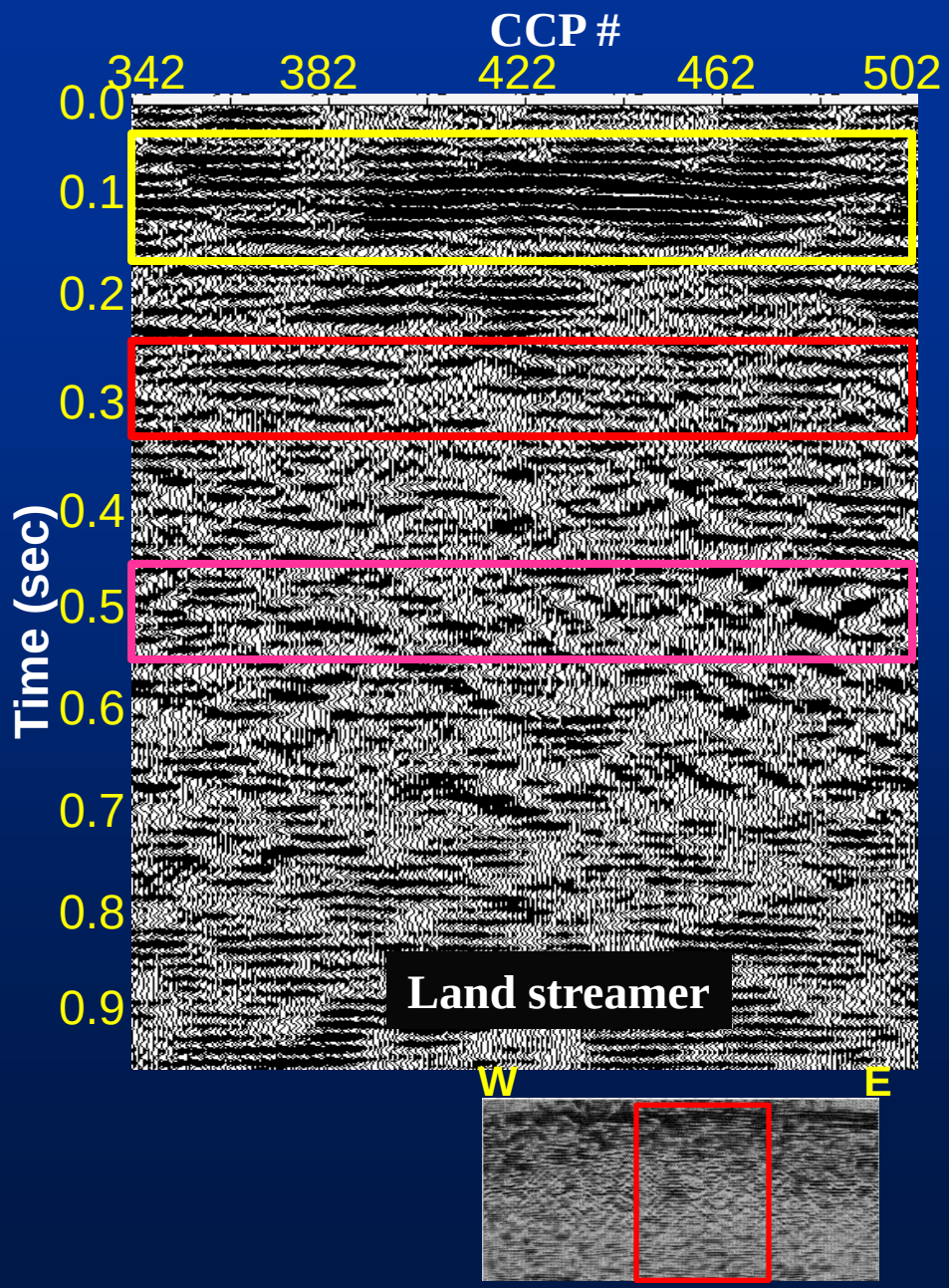
P-wave stacked sections





Converted-wave stacked sections





Spectral Analysis

Analysis of raw shot gathers and unmigrated stacked sections

1) Raw shot gathers:

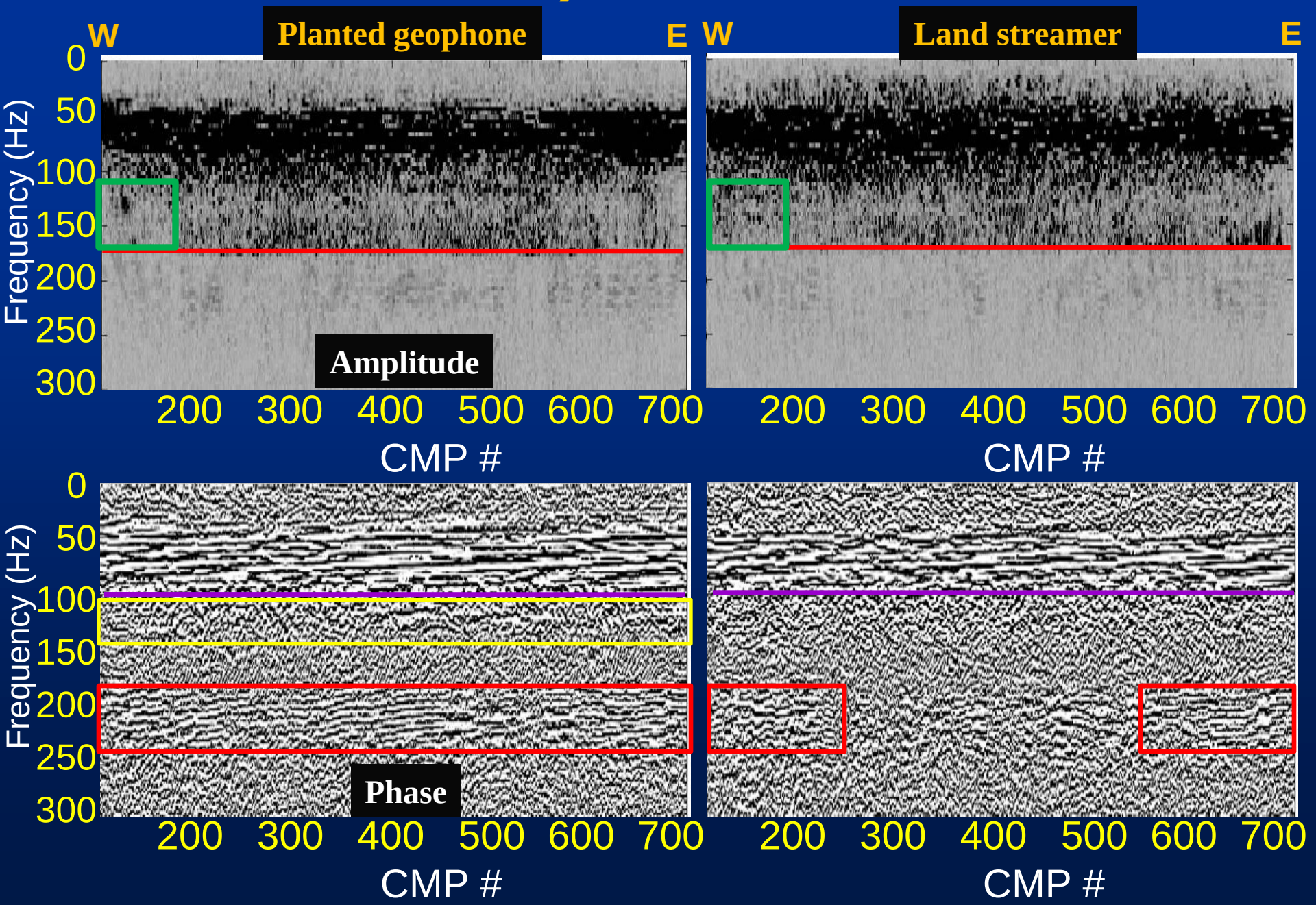
average Fourier amplitude spectra for 3 windows (data, noise and first breaks)

2) Unmigrated stacked sections:

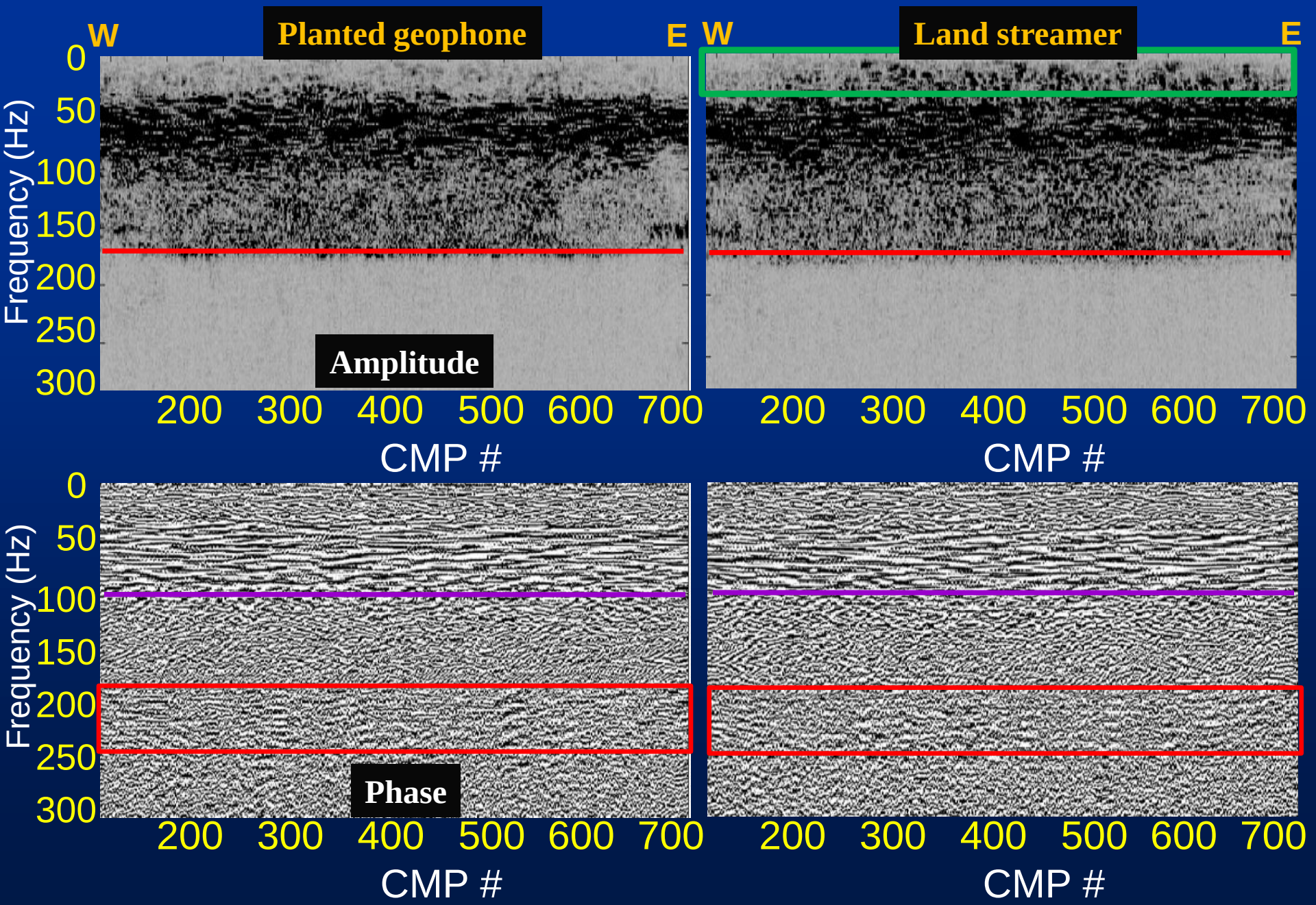
F-x Fourier analysis: amplitude and phase spectra of stacked sections

3) Frequency analysis of receiver gathers

P-wave f-x analysis



Converted-wave f-x analysis



Conclusions from Land streamer Test 2

- Vertical component datasets (planted & streamer) are similar
- Radial and transverse channels vary more
- Land streamer acquisition is viable
- Sections here image to depths of about 300m

Part II:

Seismic source comparison for compressional and converted-wave generation at Spring Coulee, Alberta

Seismic sources

Criteria for source selection:

- Penetration to the required depth,
- Bandwidth for the required resolution,
- Signal-to-noise characteristics,
- Environment,
- Availability and cost.

Dynamite

Photos taken from Cordsen et al.(2000)

Vibroseis

Photos taken from Cordsen et al.(2000)

The Spring Coulee ARAM spread

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- Recording system: ARAM Aries,
- Geophones: 652 SM7 10 Hz 3-C receivers, every 10m,
- Seismic sources-located every 30 m:

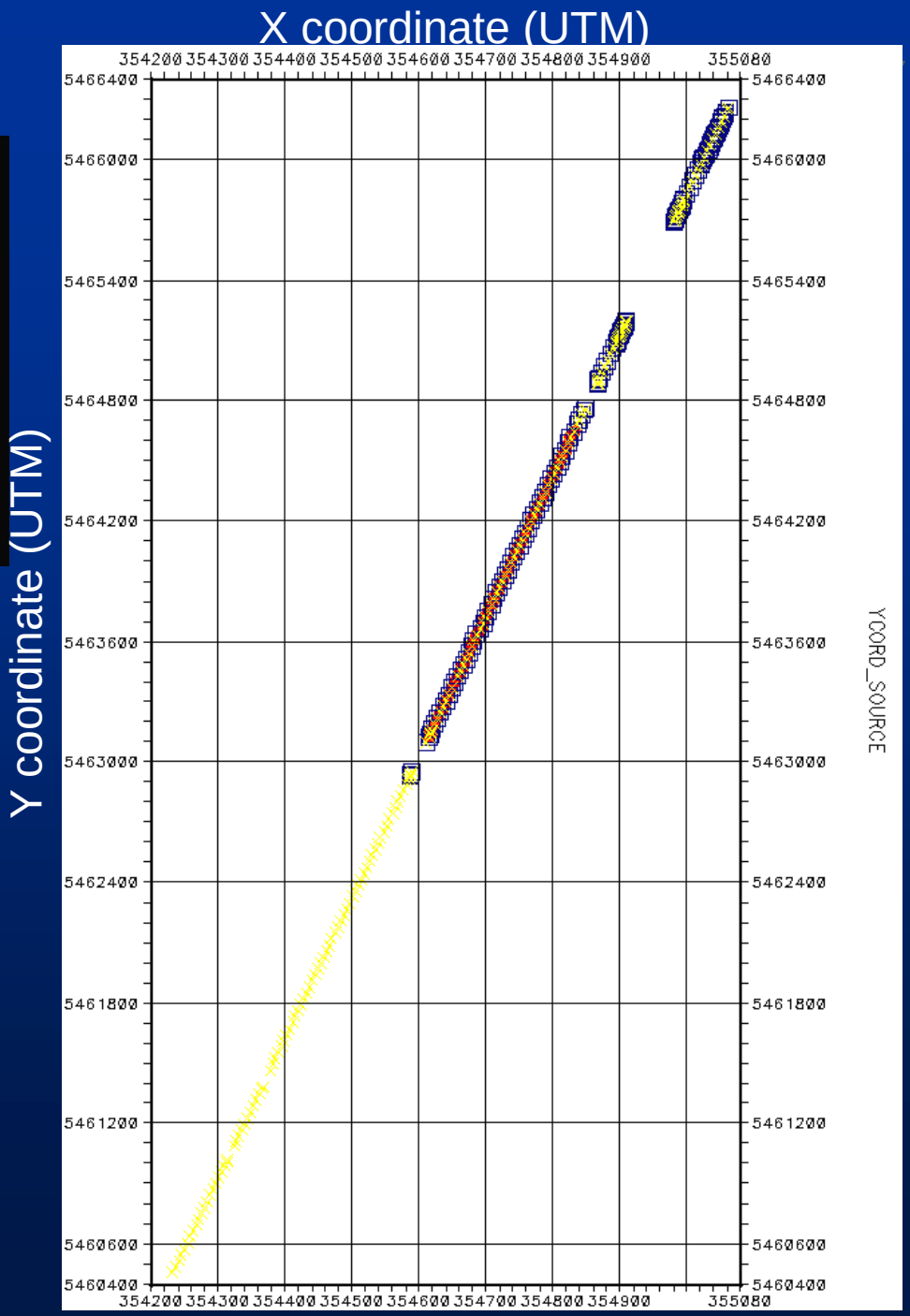
IVI Envirovibe (18,000 lb)-
stack, sweep: 10-200 Hz, listening time:11 s.

Two 48,000 lb vibroseis-196 VP, 4 times vertical stack, sweep: 4-130 Hz, listening time: 12 s.

Dynamite- 54 points at 15 m of depth, charge size: 2 kg.

Legend

- **Dynamite**
- **Mini-vibe**
- **Heavy-vibe**



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How do we compare the data?

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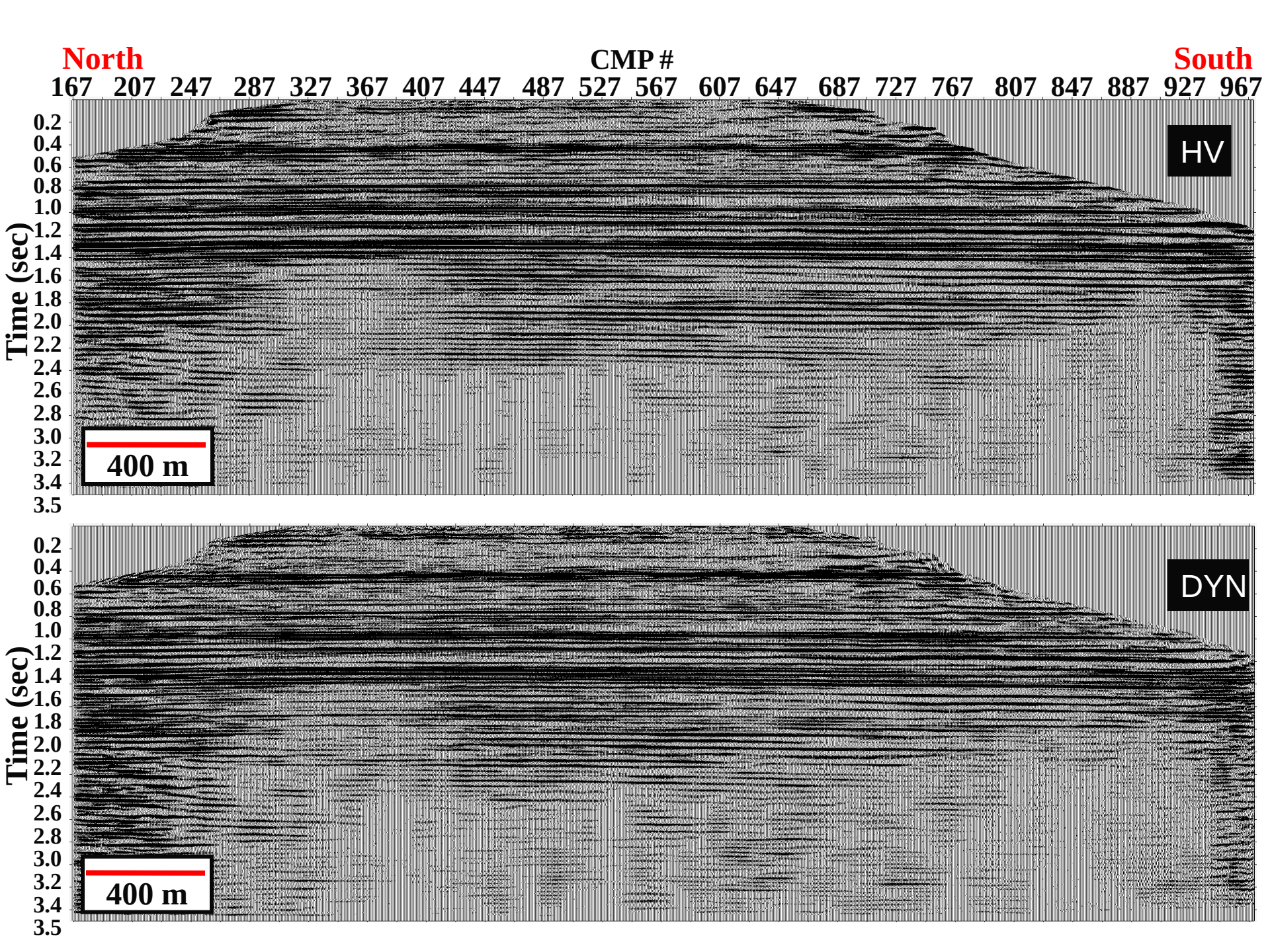
Qualitative analyses:

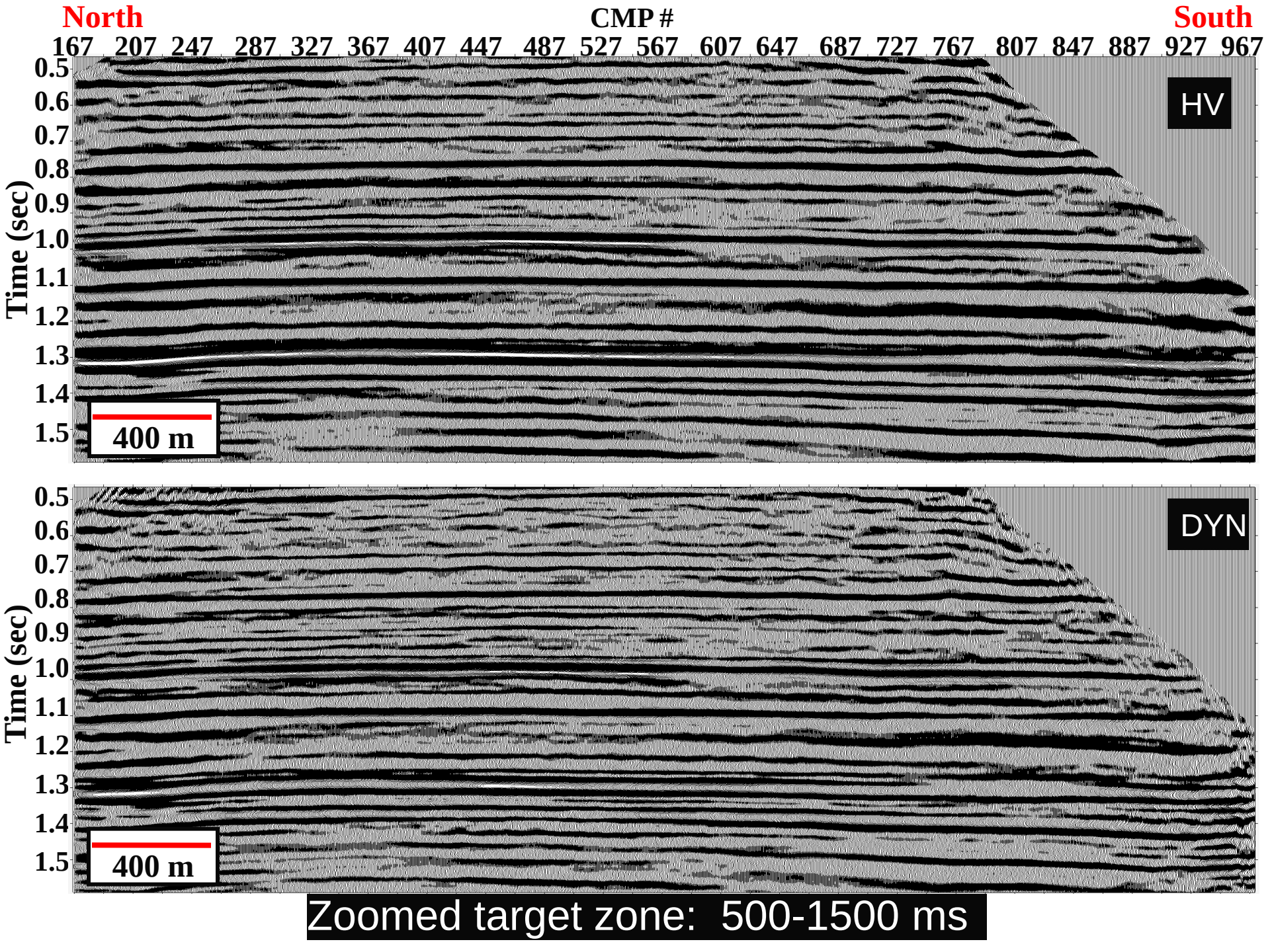
- Visual observation

Quantitative analyses:

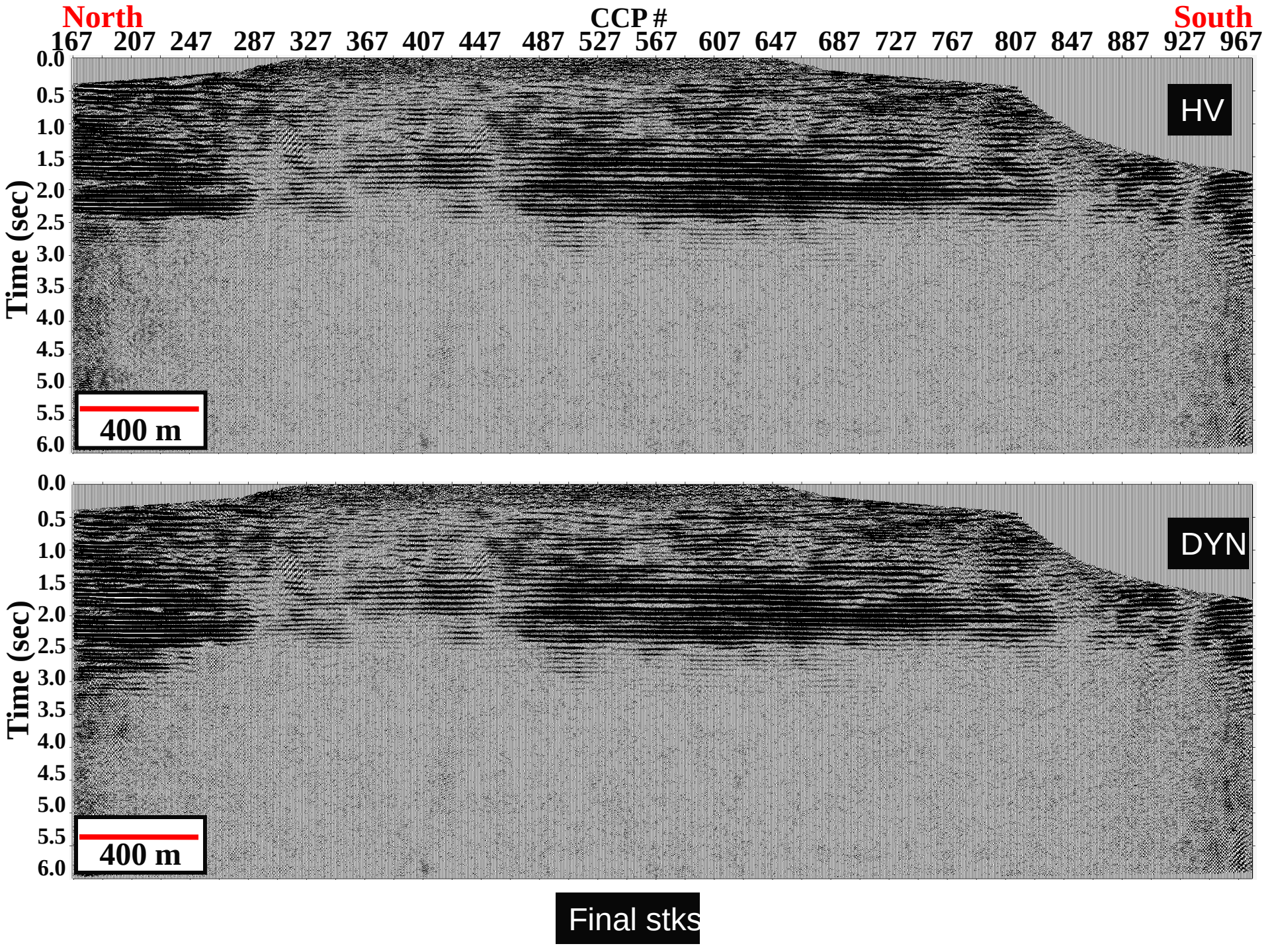
- Average amplitude analysis of raw shot gather,
- F-x Fourier analysis of stacked sections,
- Filter panels,
- Signal and noise estimation,
- Seismic resolution attributes.

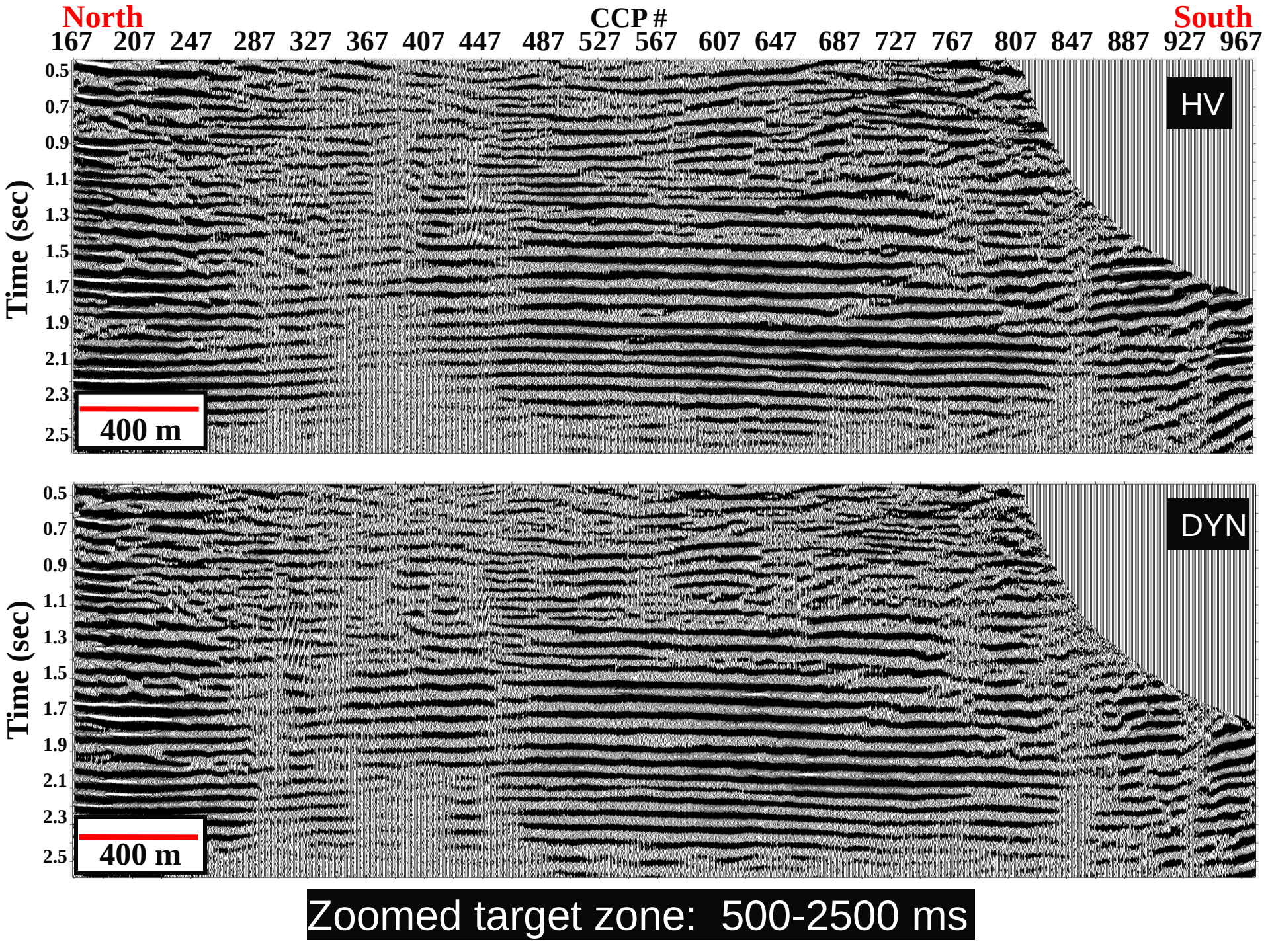
P-wave stacked sections


North
CMP #
South
167 207 247 287 327 367 407 447 487 527 567 607 647 687 727 767 807 847 887 927 967
Time (sec)
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.5
HV
400 m
Time (sec)
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.5
DYN
400 m


North
CMP #
South
167 207 247 287 327 367 407 447 487 527 567 607 647 687 727 767 807 847 887 927 967
0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5
Time (sec)
HV
400 m
DYN
400 m
Zoomed target zone: 500-1500 ms

Converted-wave stacked sections


North
CCP #
South
167 207 247 287 327 367 407 447 487 527 567 607 647 687 727 767 807 847 887 927 967
Time (sec)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
HV
400 m
DYN
400 m
Final stks


North
CCP #
South
167 207 247 287 327 367 407 447 487 527 567 607 647 687 727 767 807 847 887 927 967
Time (sec)
0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5
HV
400 m
Time (sec)
0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1 2.3 2.5
DYN
400 m
Zoomed target zone: 500-2500 ms

Spectral Analysis

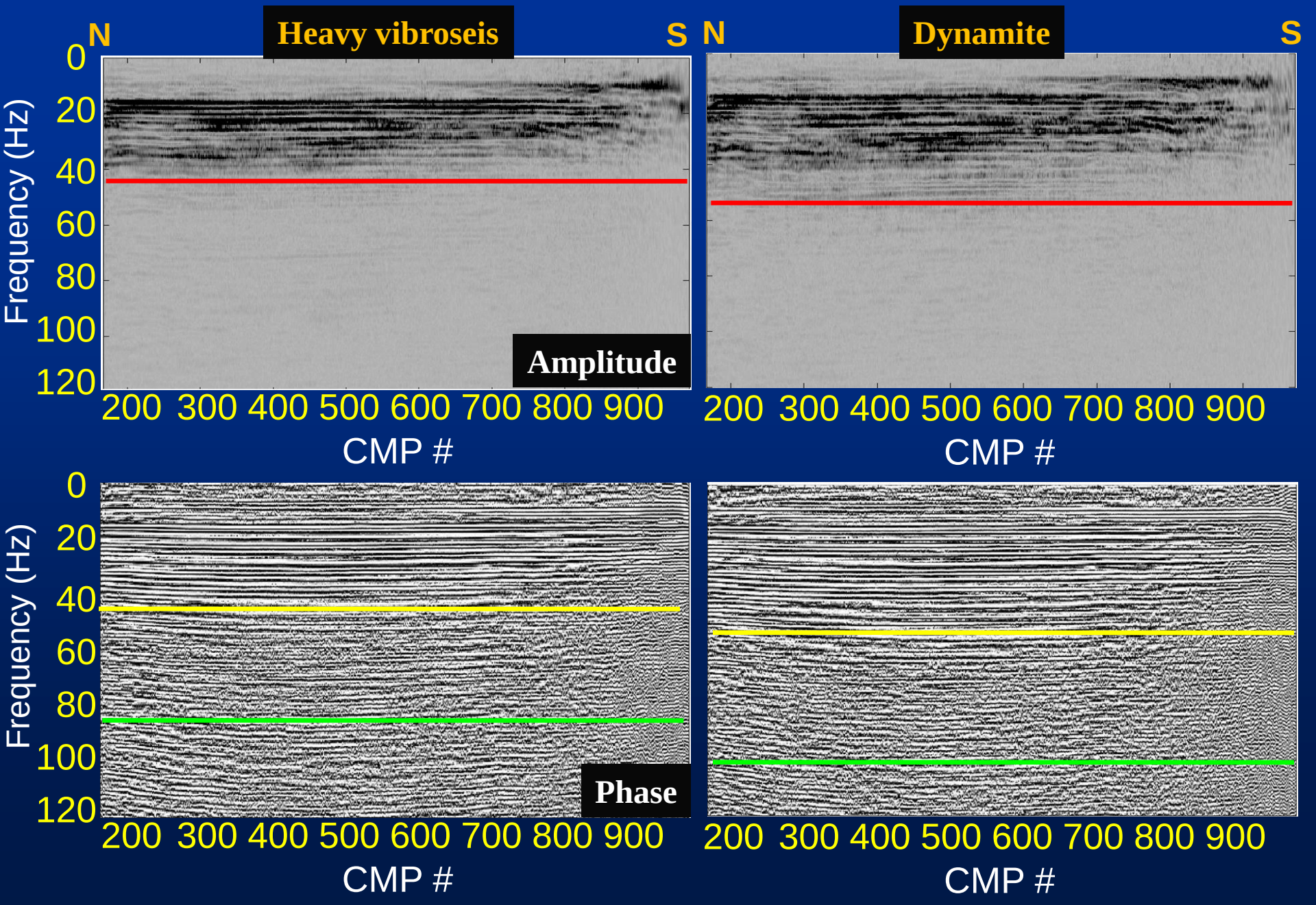
Analysis of raw shot gathers and unmigrated stacked sections

1) Raw shot gathers: average Fourier amplitude spectra for 3 windows (data, noise and first breaks)

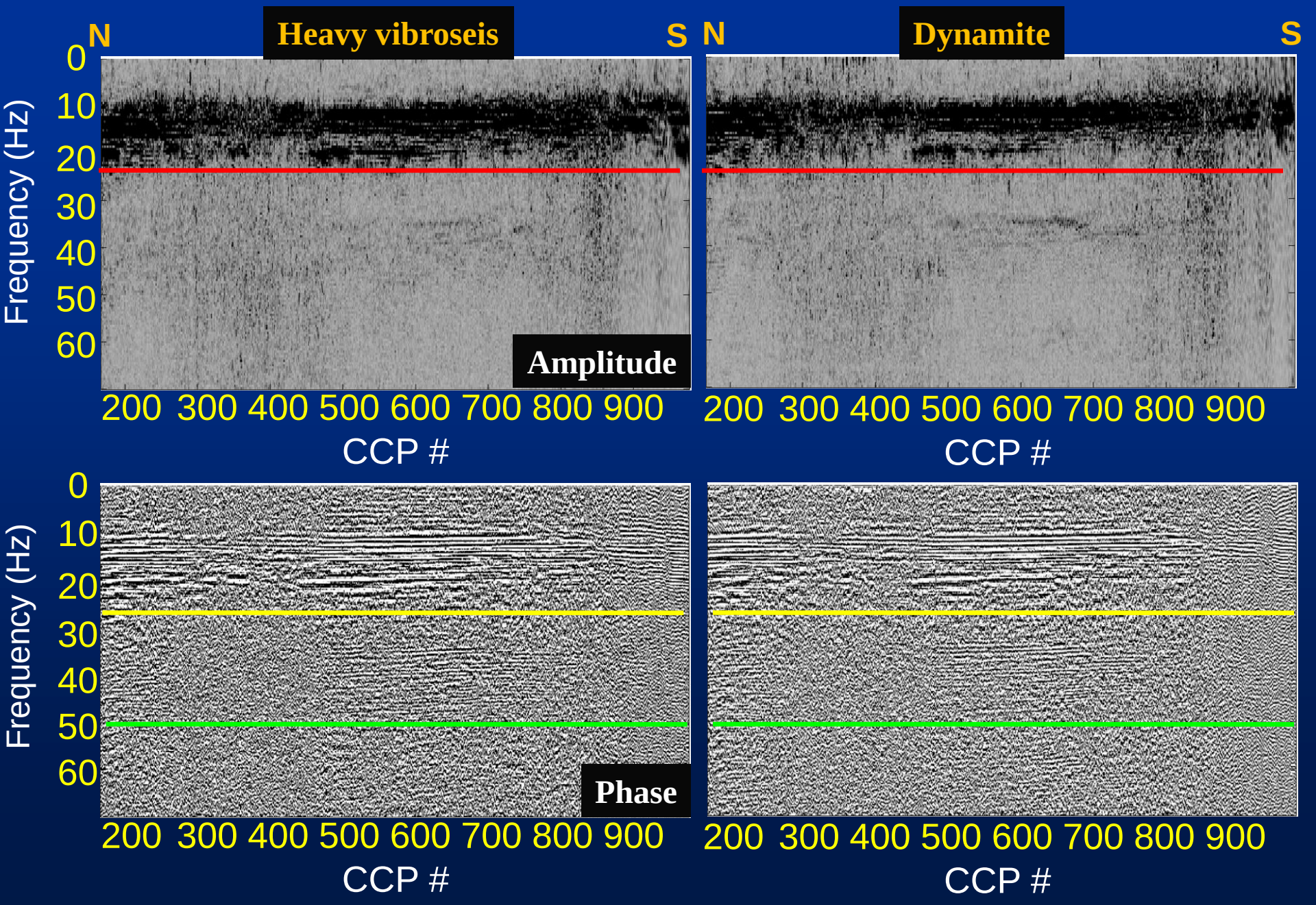
2) Unmigrated stacked sections:

- F-x Fourier analysis: amplitude and phase spectra of stacked sections,
- Realized signal band estimation (Margrave,1999)

P-wave f-x analysis



Converted-wave f-x analysis



Conclusions from Part II

- 2 seismic sources were compared: heavy vibroseis and dynamite
- P-wave: best results with dynamite
- Converted-wave: heavy vibroseis seems to perform slightly better
- Data quality- results are very similar but total cost need to be consider.

Summary and future work

- Tested the feasibility of using land streamer systems for converted-wave acquisition at Priddis
- Compared 3 seismic sources-best suited for the Spring Coulee site
- New equipment configurations and parameters
- Need more testing of source parameters
- Improvement in seismic data processing

Acknowledgements

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