CREWES

UNIVERSITY OF CALGARY

# Comparison of MEMS accelerometers and geophones at Spring Coulee, Alberta

Michael Hons and Rob Stewart

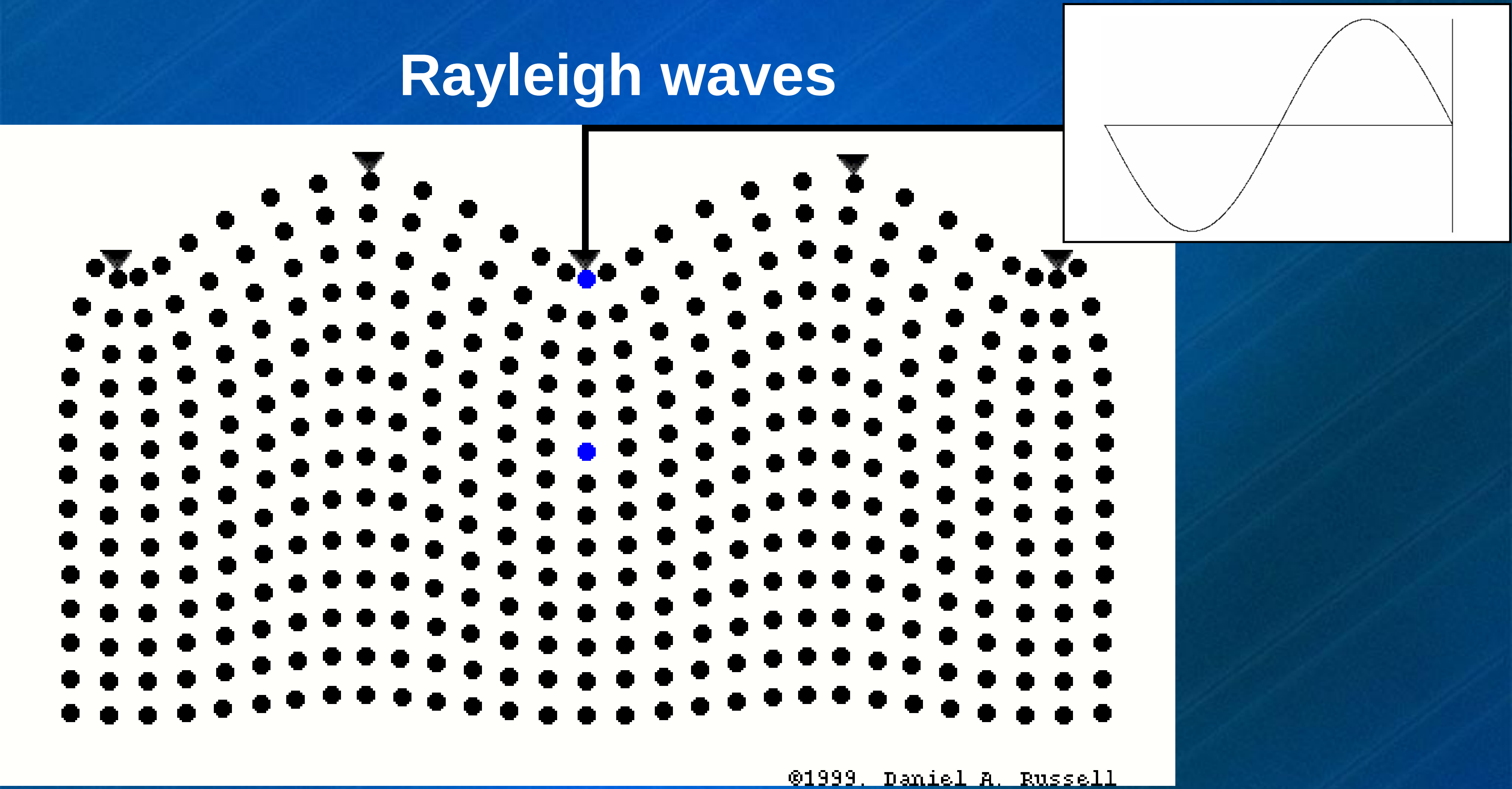
CREWES Sponsors Meeting 2008
Canmore, Alberta

# Outline

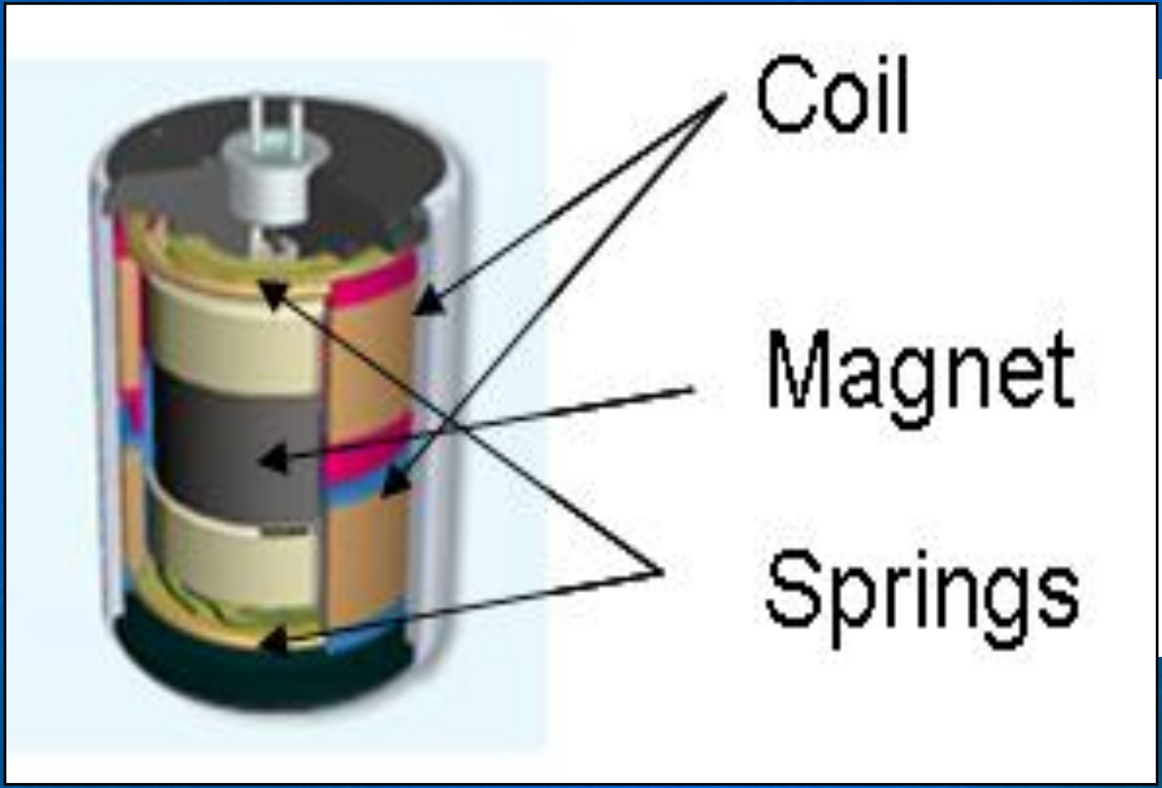
- Data correction
- Field Data
- Comparisons
  - Corrected data
  - Crosscorrelation
  - Noise window comparison
  - Trace coherence
- Conclusions

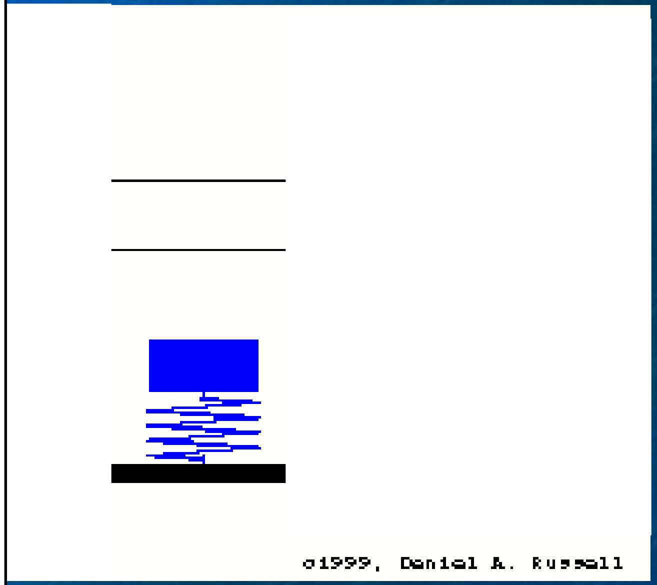
# Motion sensing

## Rayleigh waves

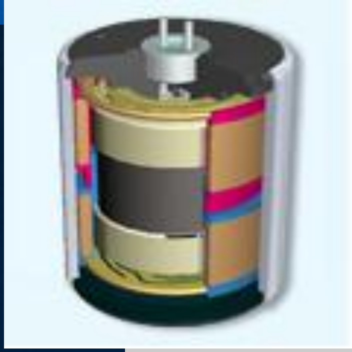


# Geophones

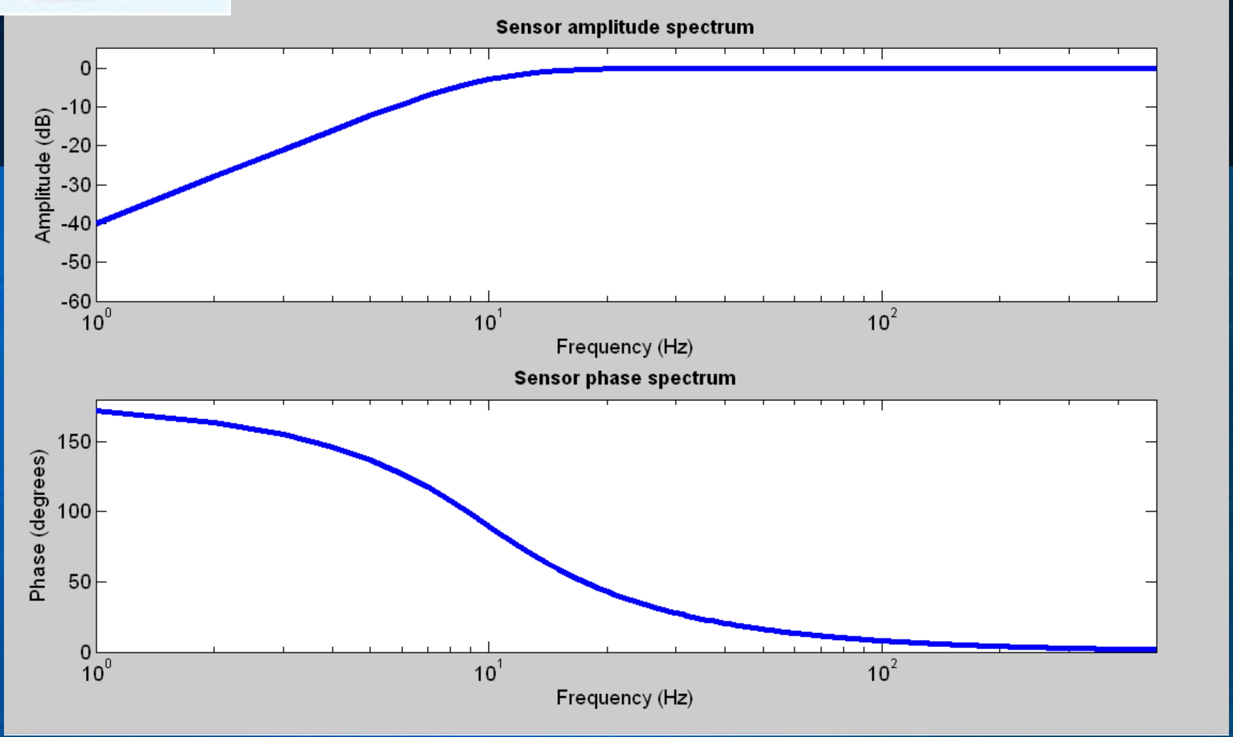


# Geophone response



$$\frac{\partial X}{\partial t} = \frac{-\omega^2}{-\omega^2 + 2i\lambda\omega\omega_0 + \omega_0^2}\frac{\partial U}{\partial t}$$



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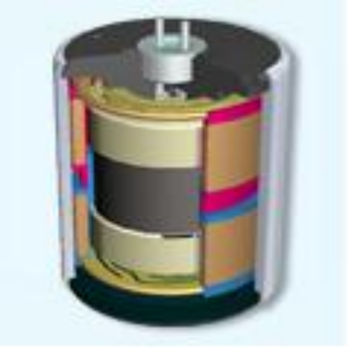
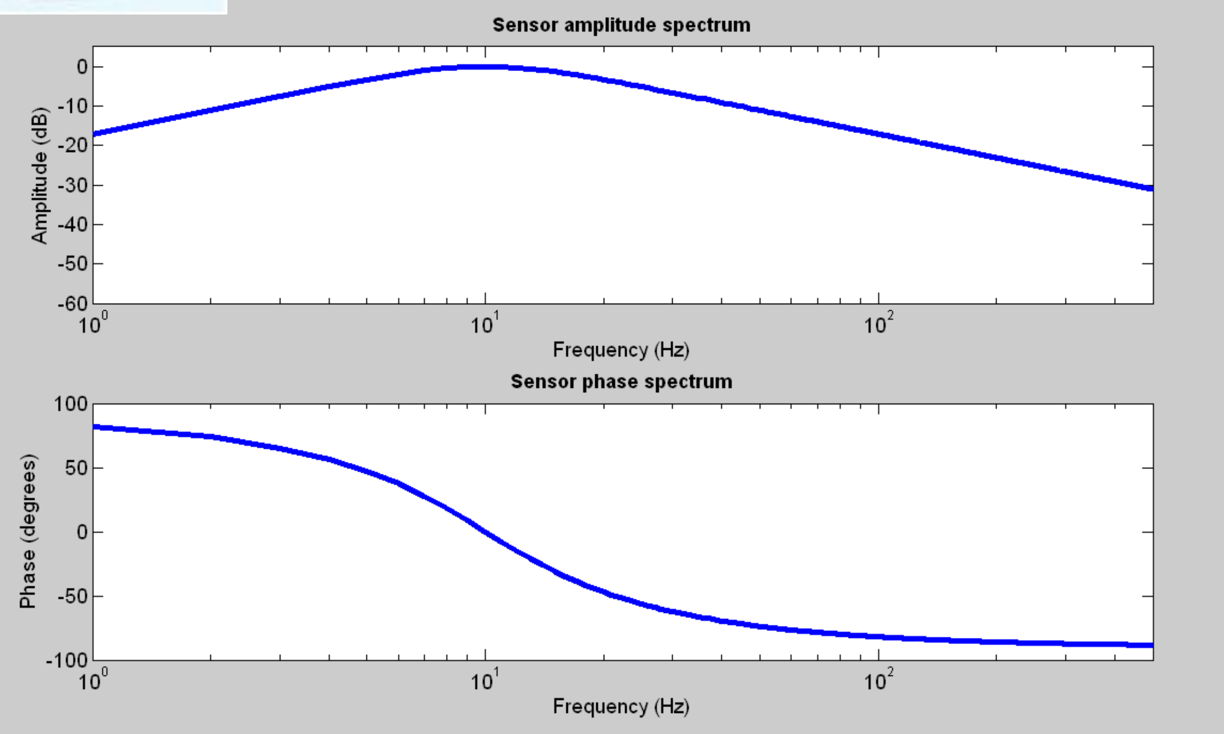
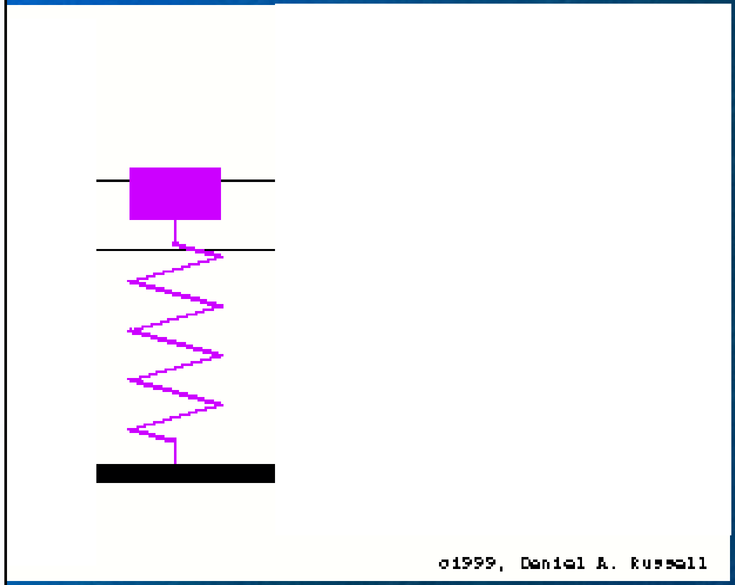


$$\frac{\partial X}{\partial t} = \frac{i\omega}{-\omega^2 + 2i\lambda\omega\omega_0 + \omega_0^2} \frac{\partial^2 U}{\partial t^2}$$

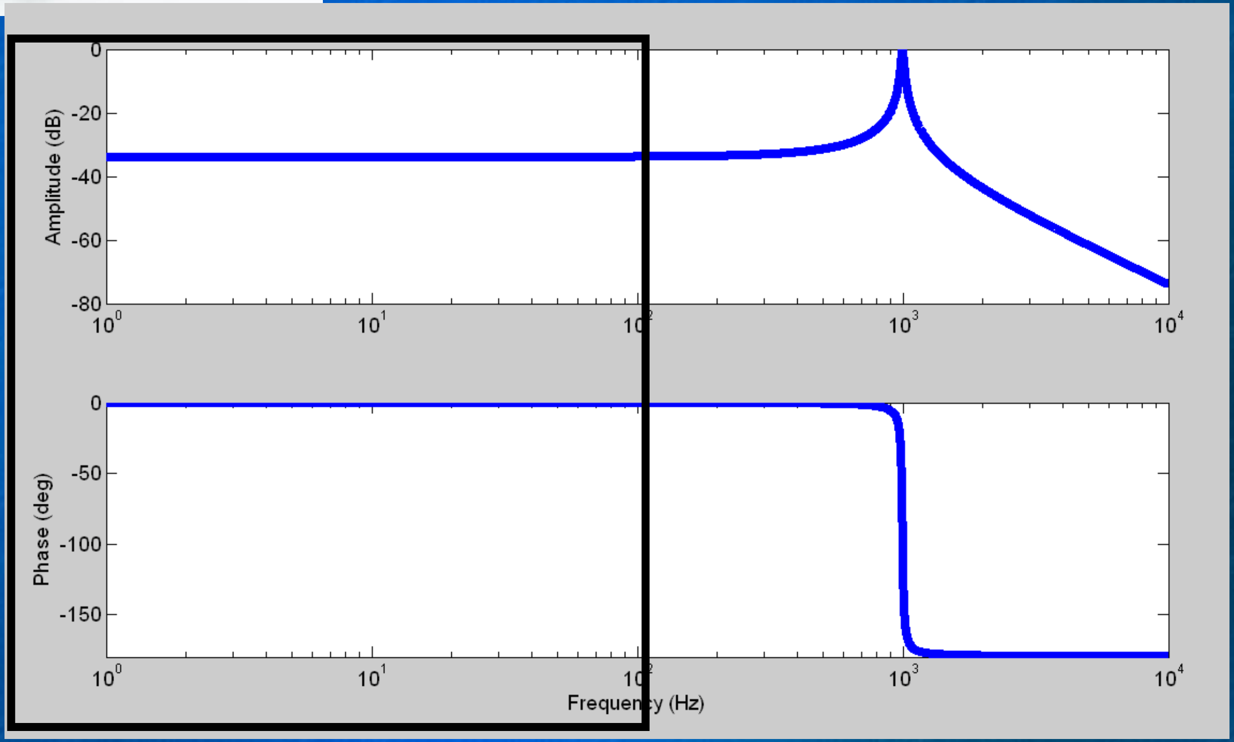


# MEMS accelerometer

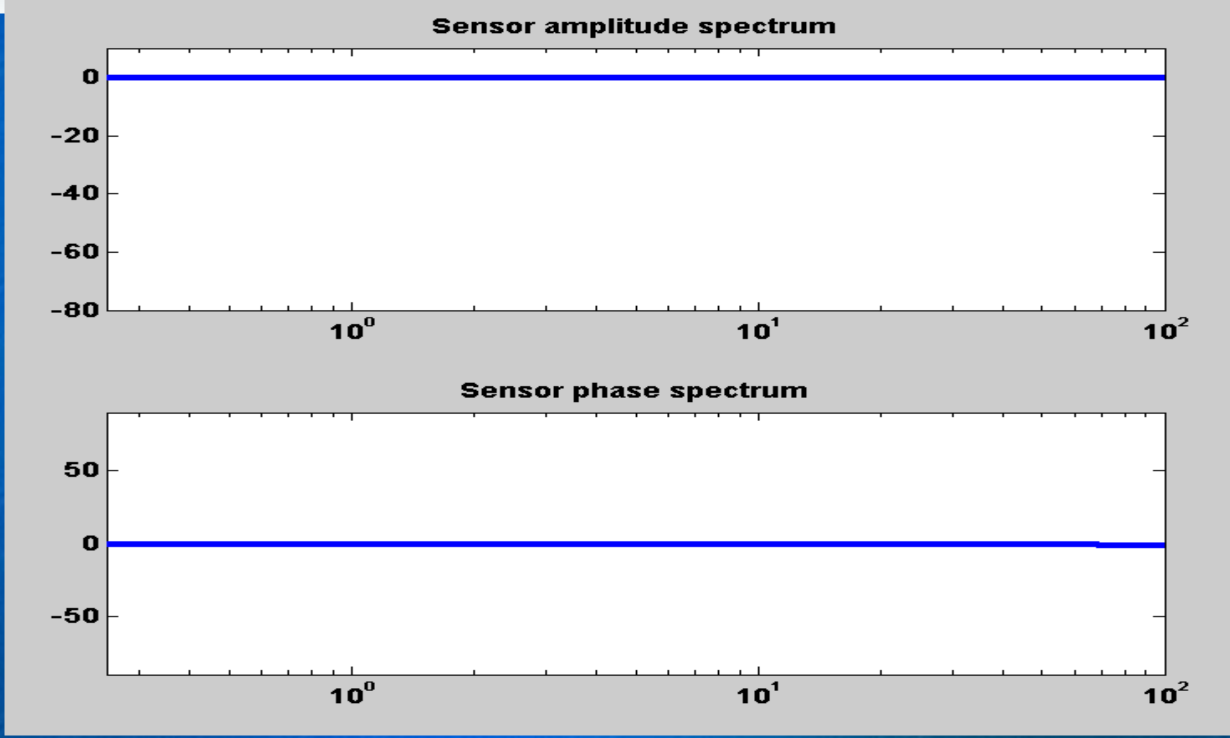
# MEMS accelerometer

$$X = \frac{1}{-\omega^2 + 2i\lambda\omega_0\omega + \omega_0^2}\frac{\partial^2 U}{\partial t^2}$$



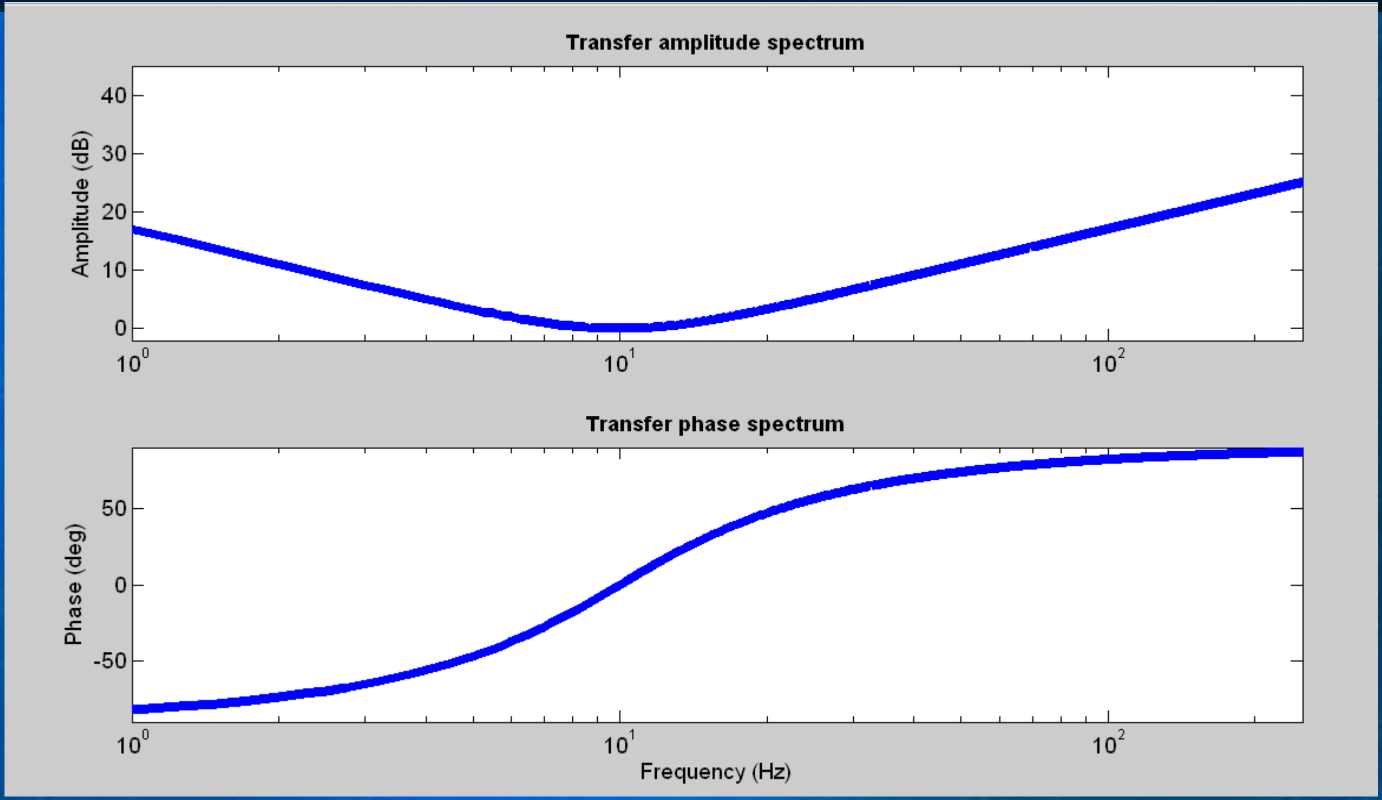
# MEMS accelerometer

$$X = \frac{1}{\omega_0^2} \frac{\partial^2 U}{\partial t^2}$$



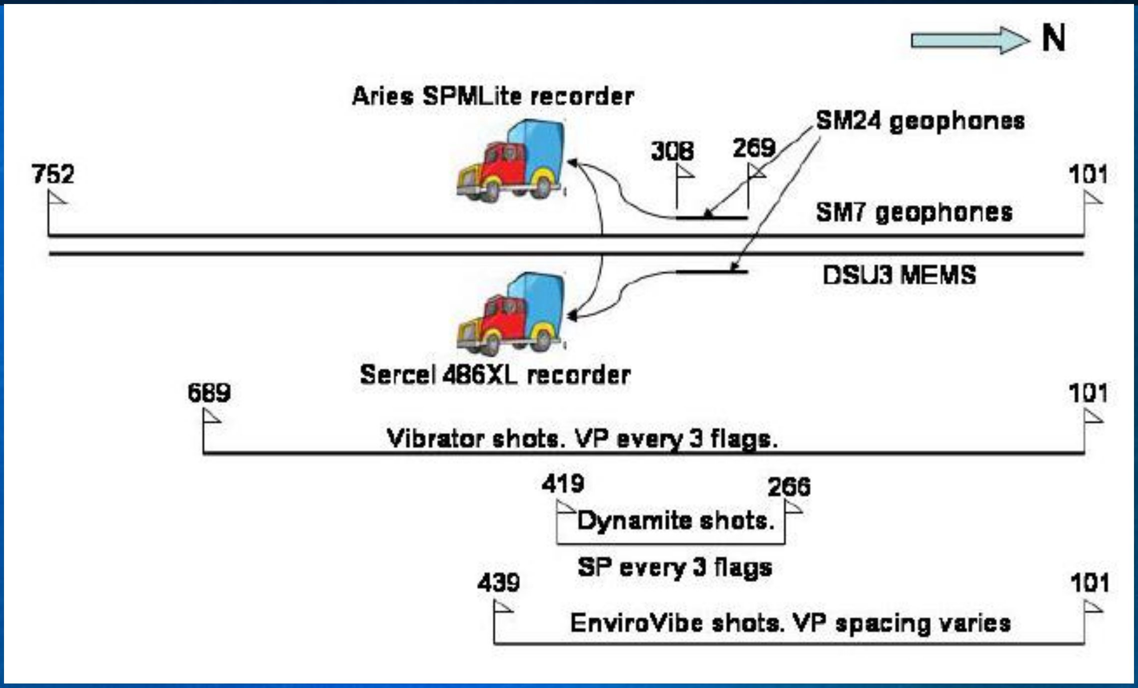
# Geophone/Accelerometer transfer

$$\frac{\partial^2 U}{\partial t^2} = \frac{2\lambda\omega\omega_0 + i(\omega_0^2 - \omega^2)}{\omega} \frac{V_G}{S_G}$$



# Field Data

- 54 dynamite shots, 40 receivers
- All receivers through Sercel system
- Receivers every 10 m, shots every 30 m
- Maximum offset: 1500 m



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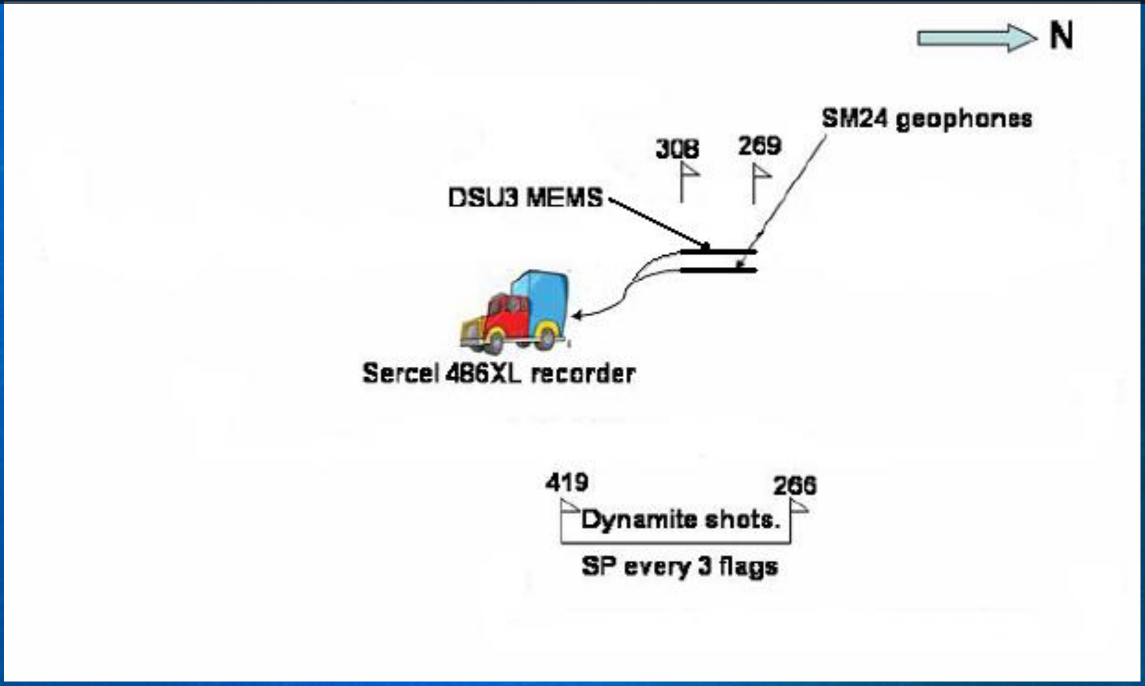
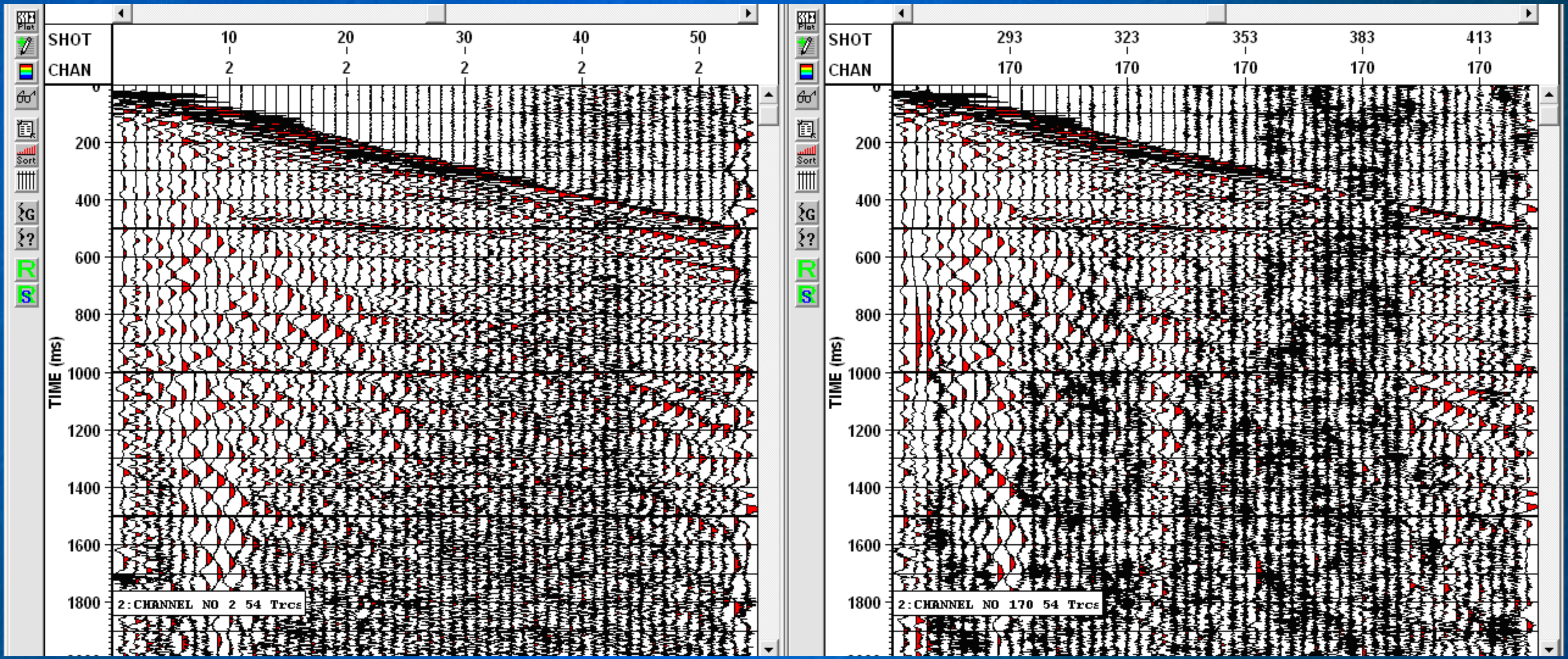


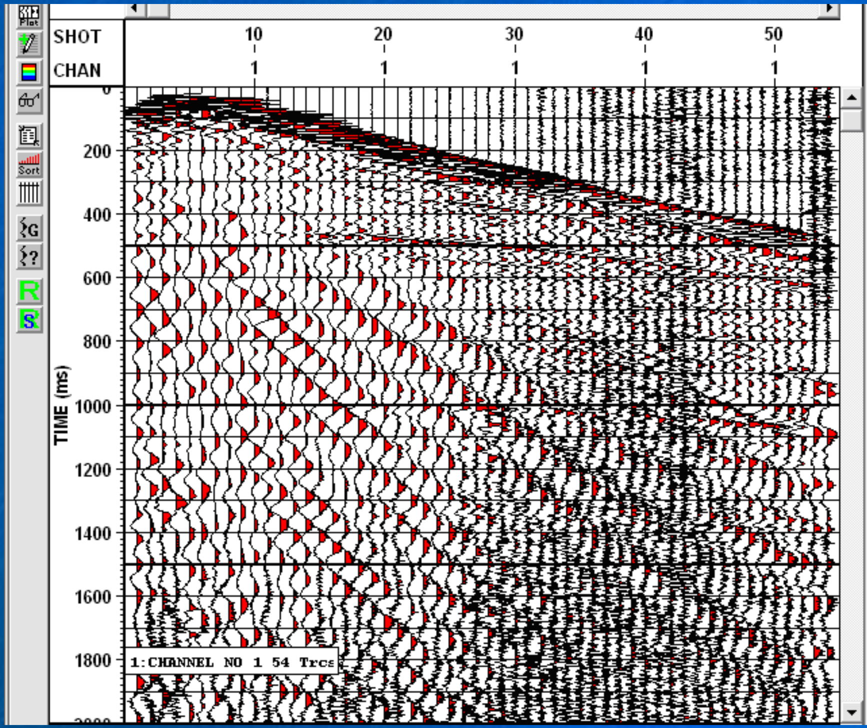
# Acceleration receiver gathers

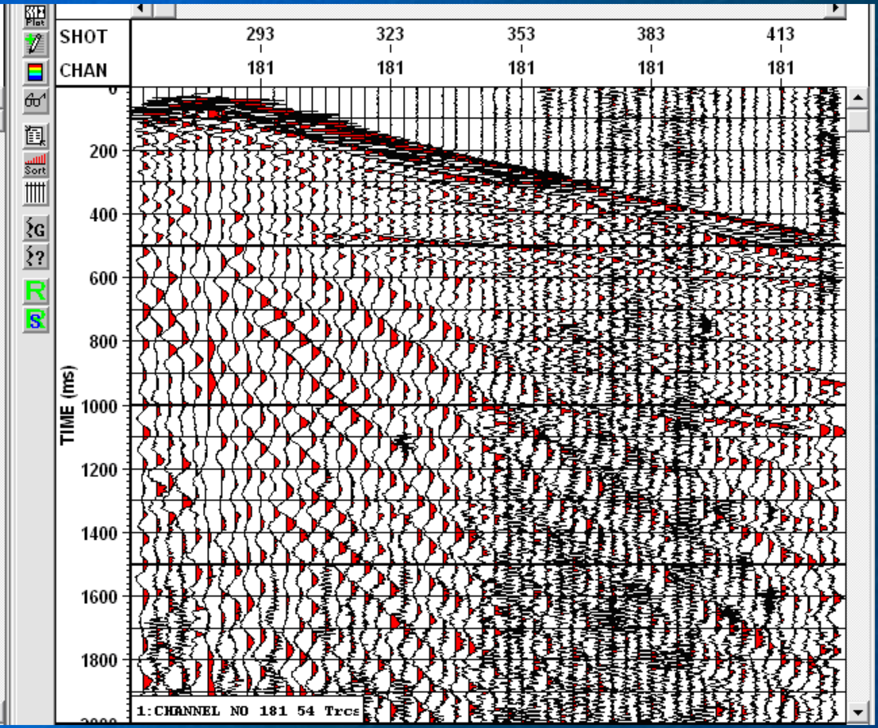
- Acceleration domain, vertical component
- Coupling problems at some stations



# Acceleration receiver gathers

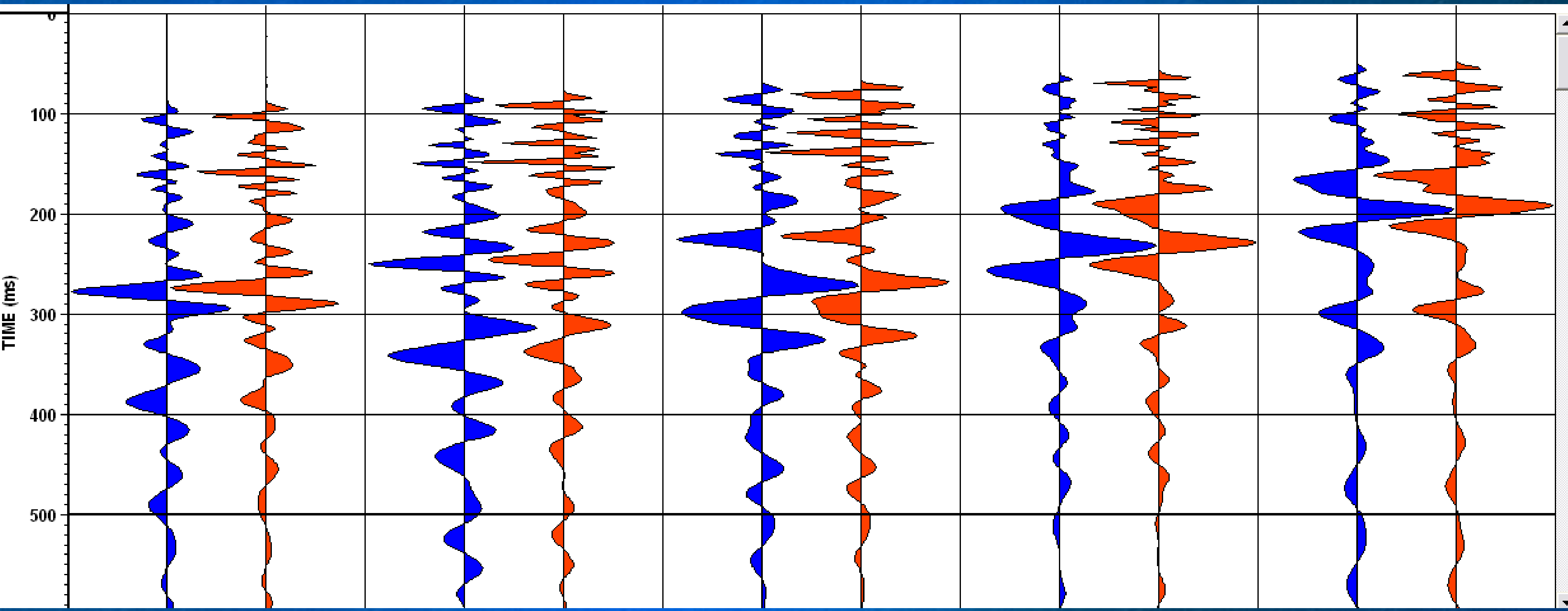
- Not everywhere
- Reflections very similar



# Acceleration traces

- Visually, very similar



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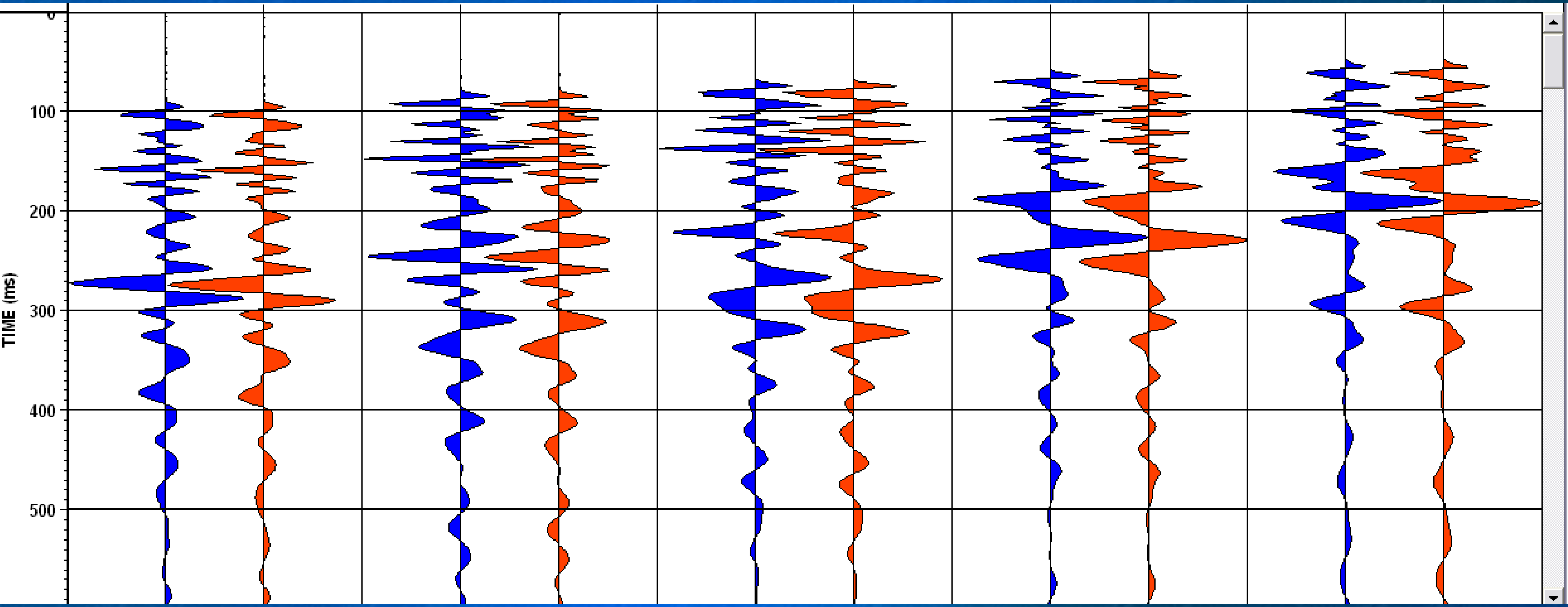
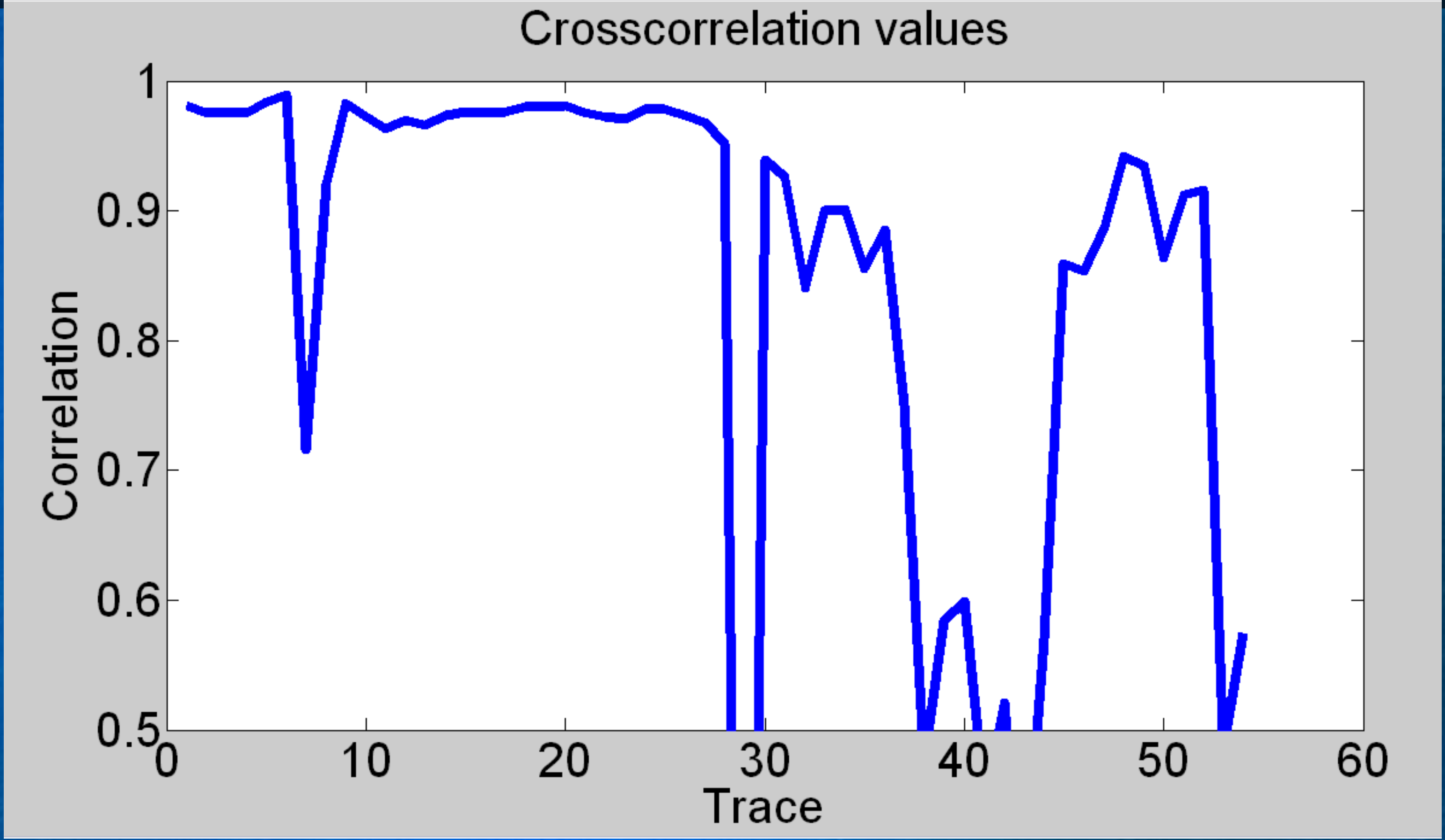


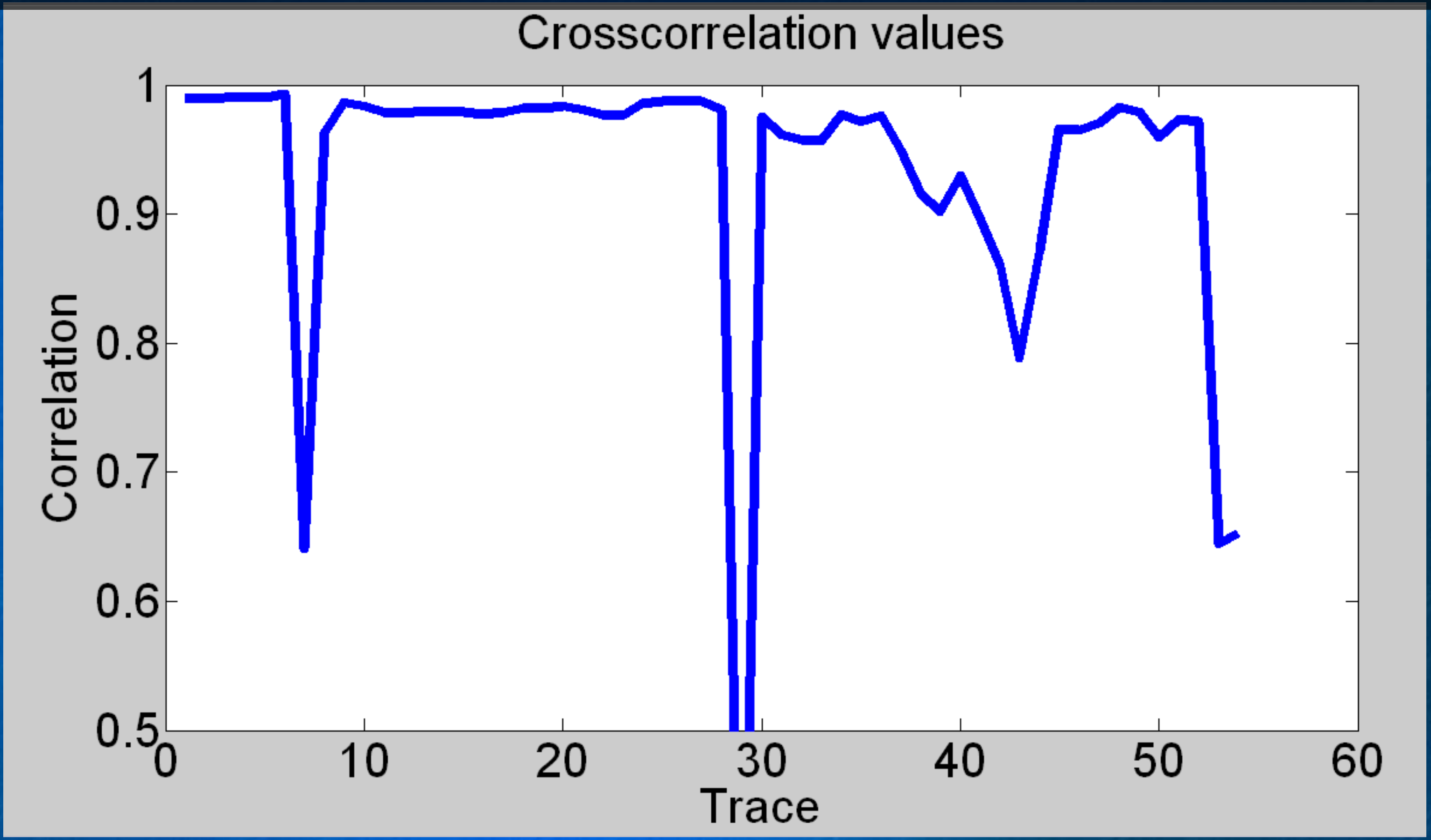
# Crosscorrelations

- 3 Hz lowcut



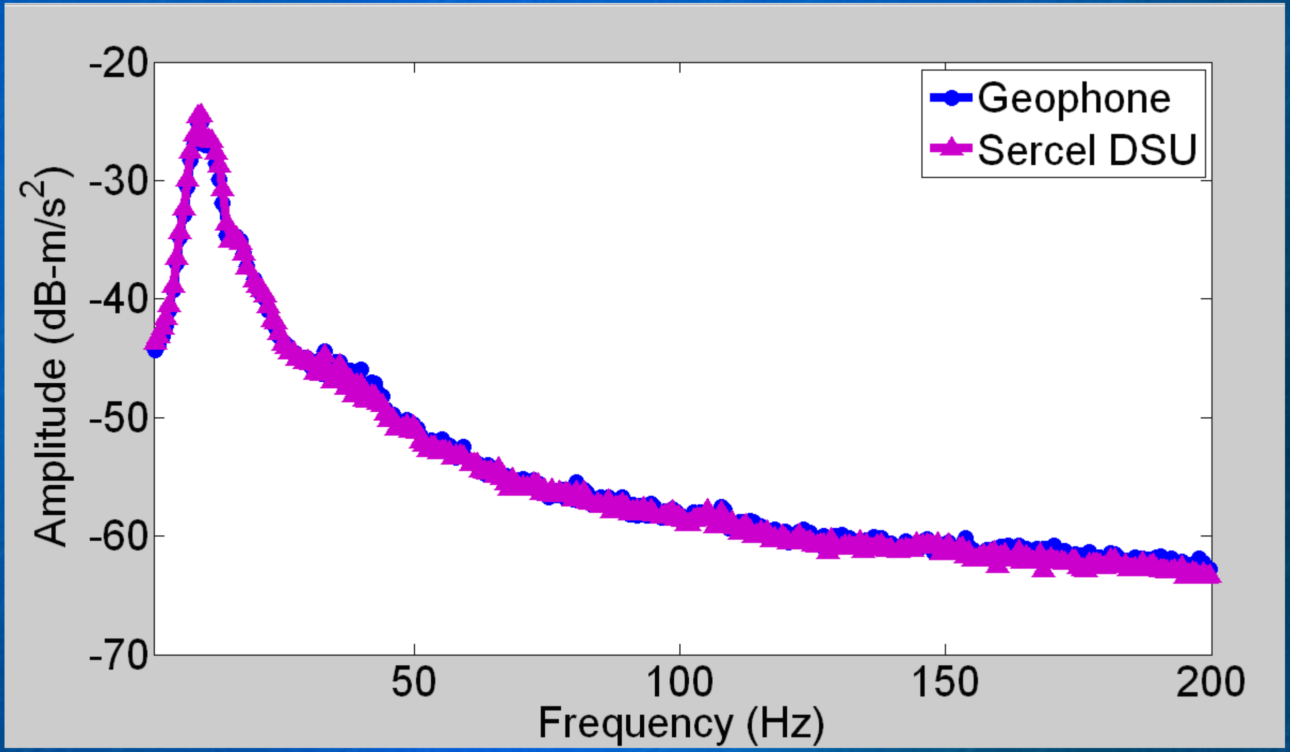
# Crosscorrelations

- 3 Hz lowcut + 60 Hz highcut



# Amplitude spectra

- Very similar at well-planted stations
- Similar overall, larger low-f in DSUs



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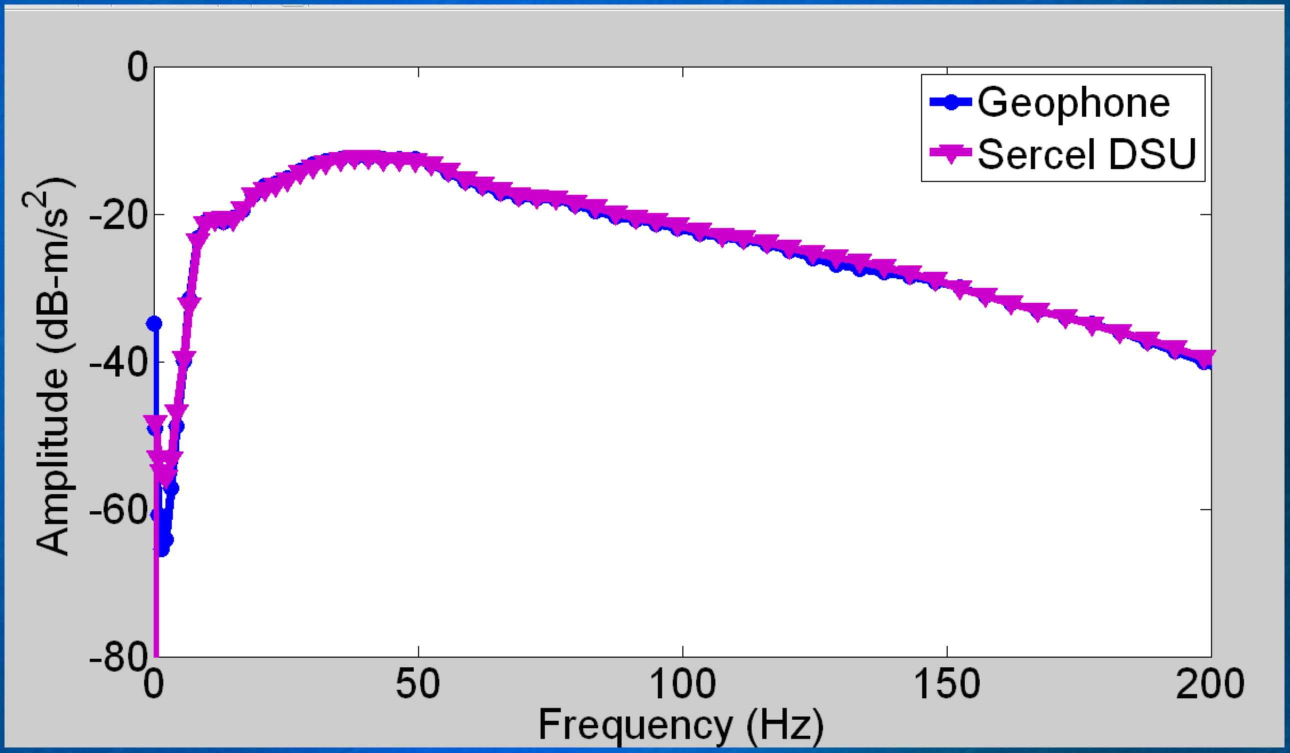

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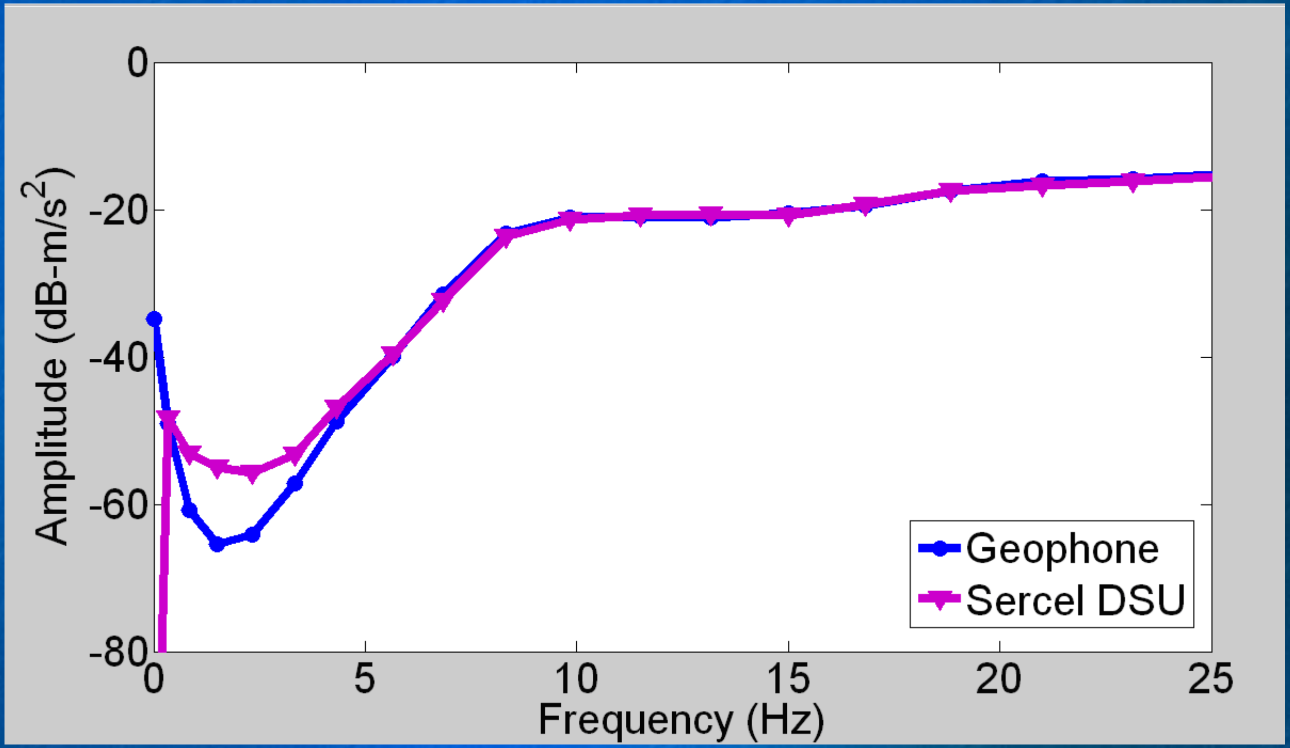
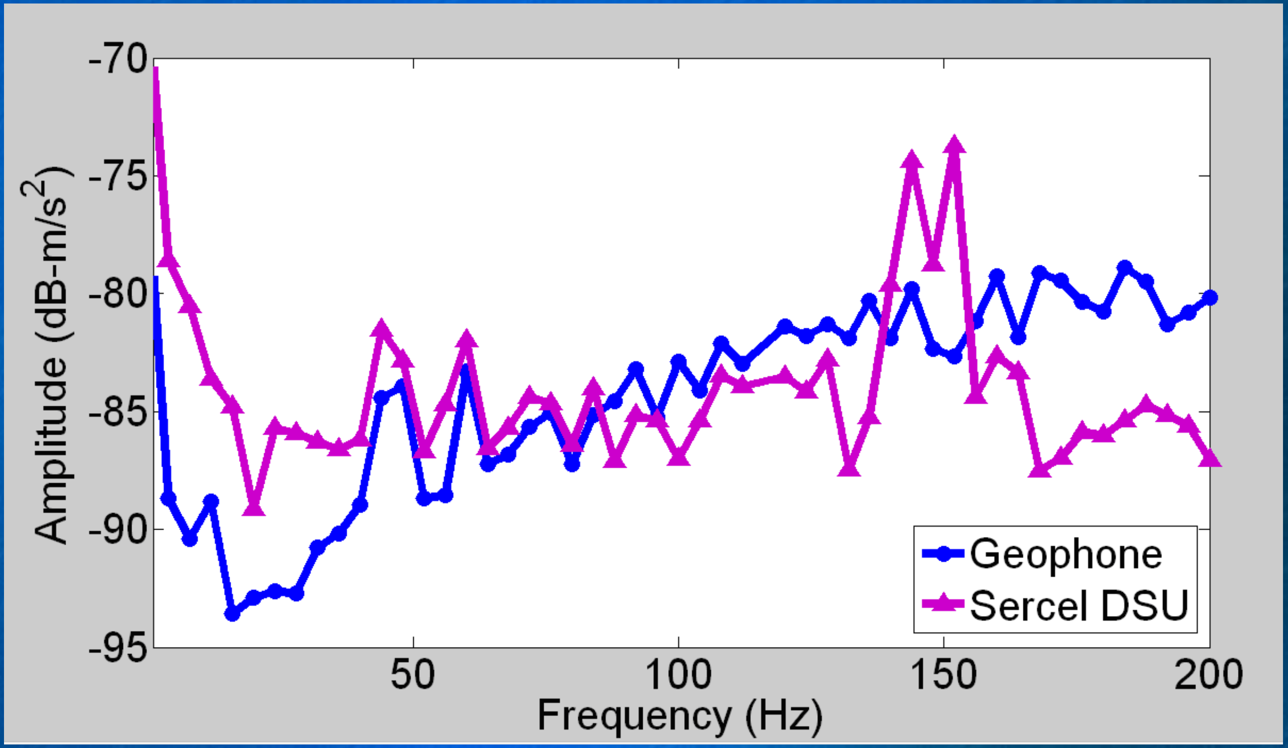


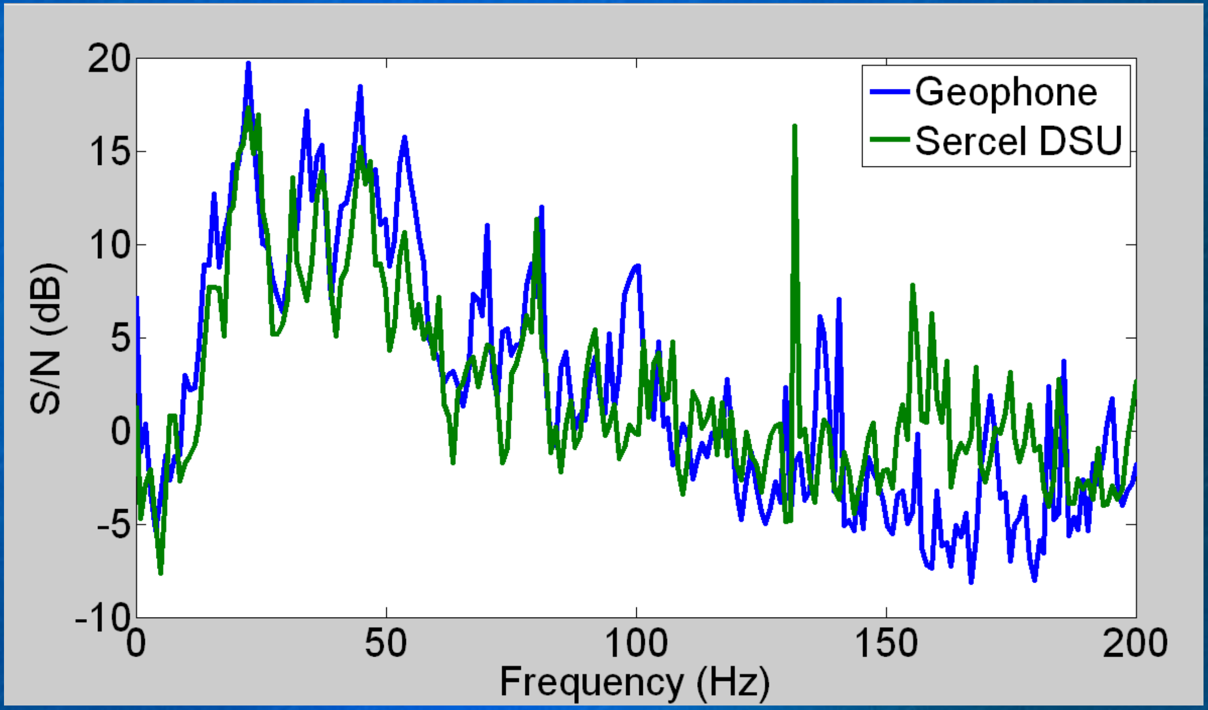
# Noise-only spectra

- Before first break arrivals
- Cross-over around 70-80 Hz



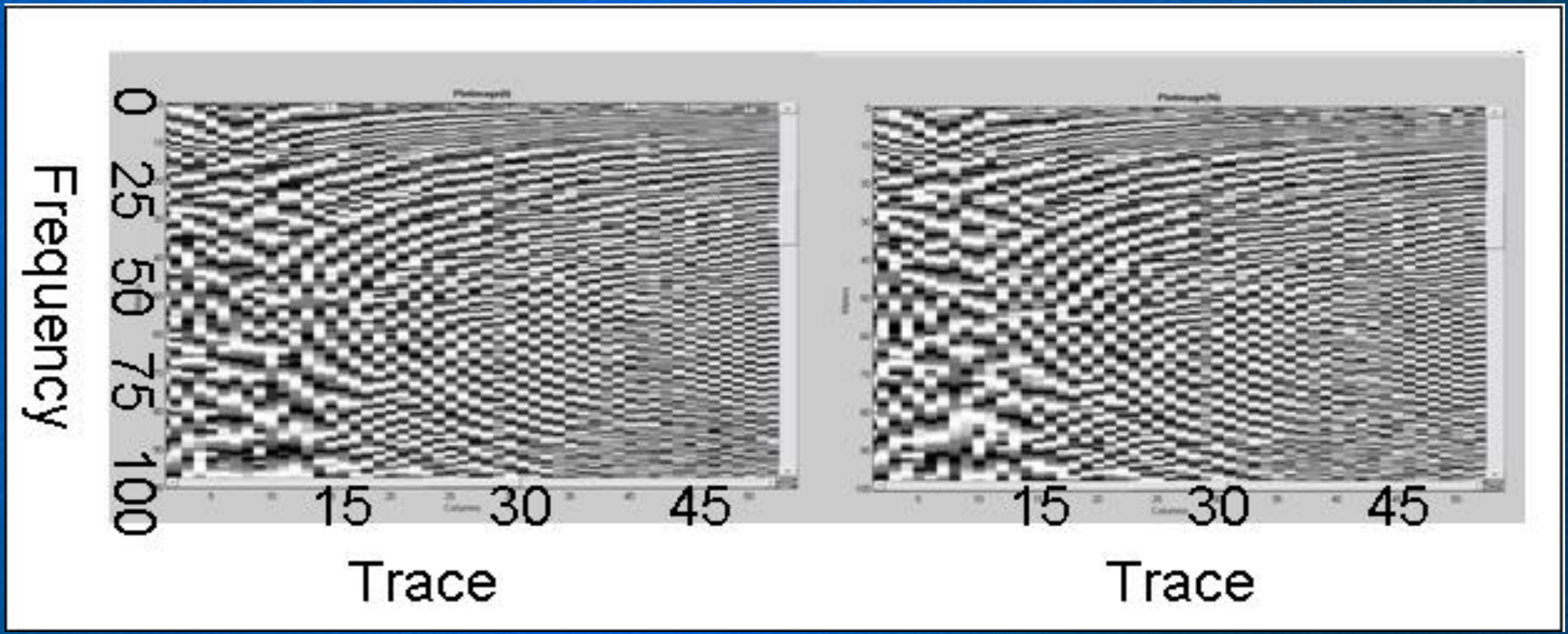
# Far-offset SNR

- From traces with >450 ms noise record
- Spectrum from reflection window divided by spectrum from noise window



# F-X coherency plot

- No major differences evident
- Geophone more coherent at low-f?



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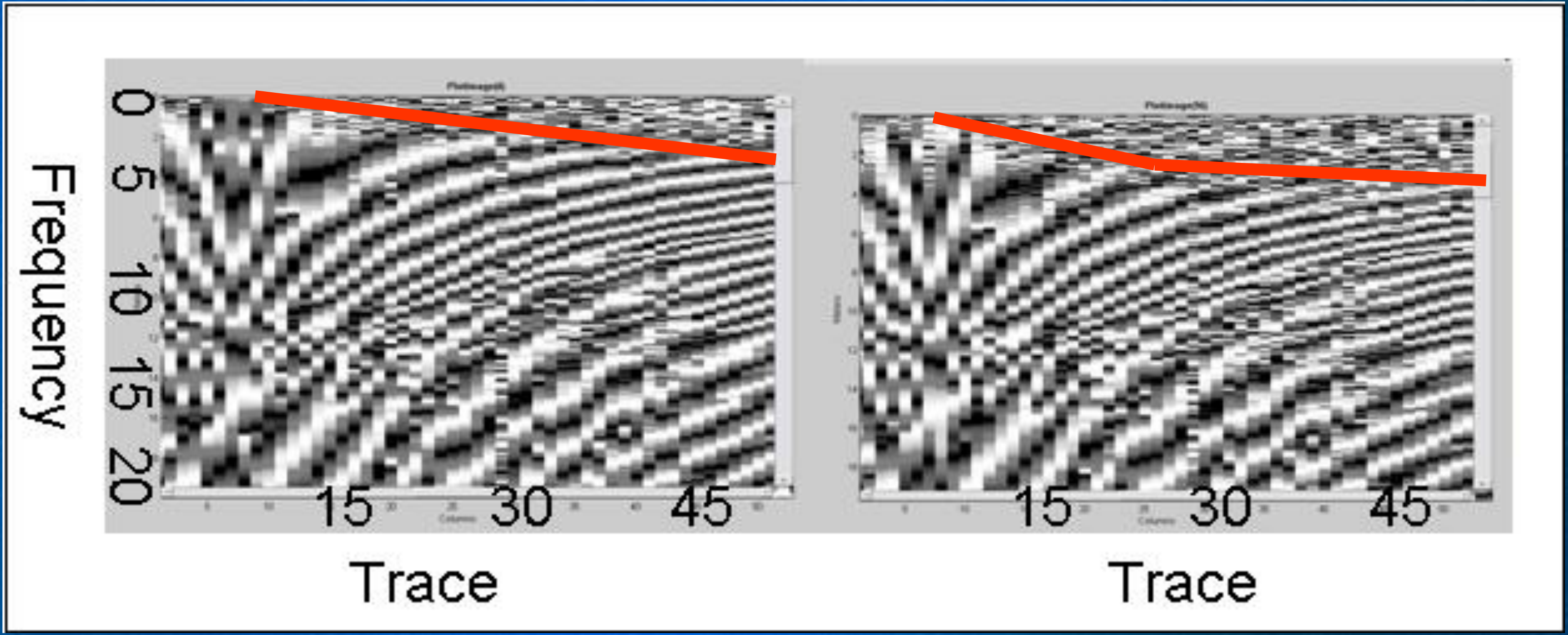
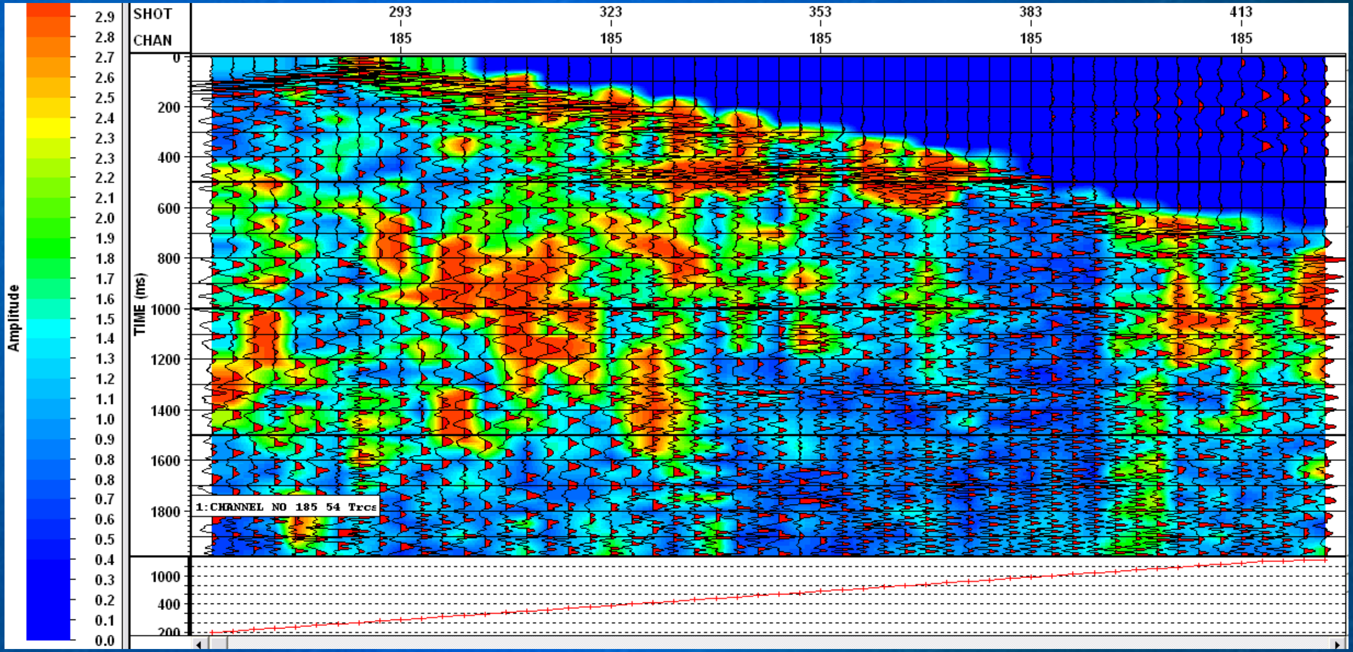


# S/N estimate

- Window 6 traces wide, 500 ms long
- Value plotted at centre of window
- DSU advantage near, geophone advantage far



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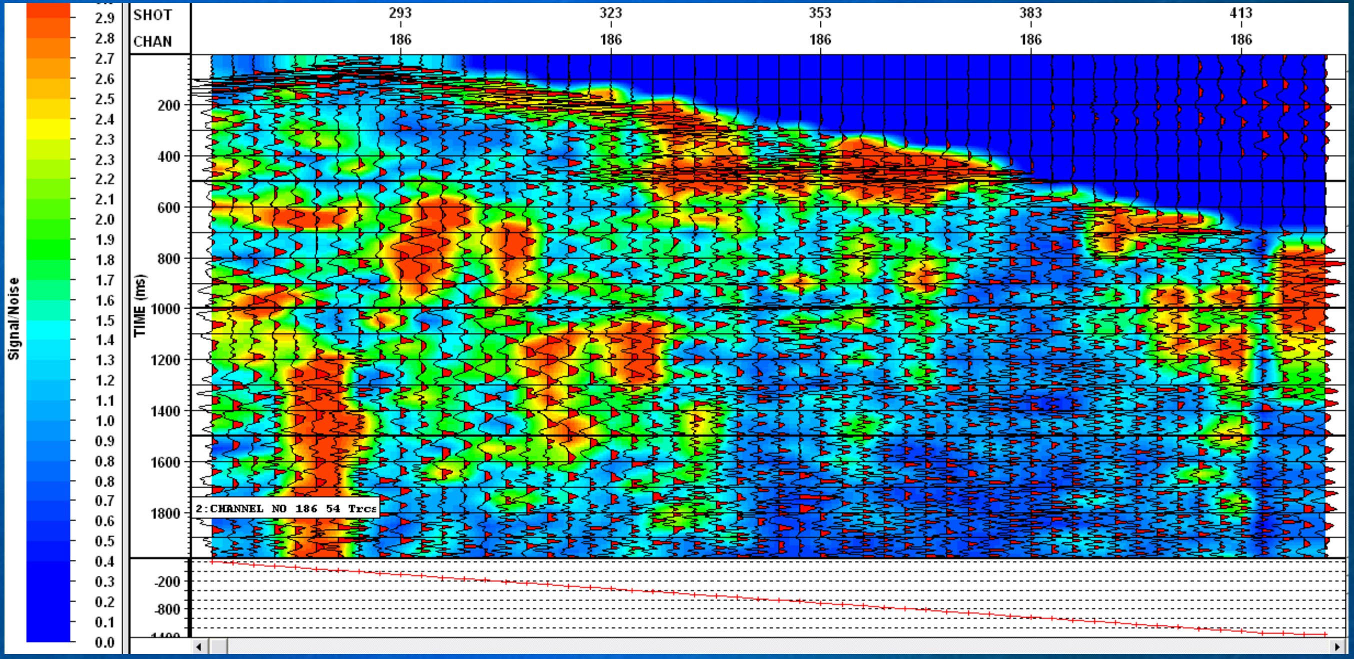
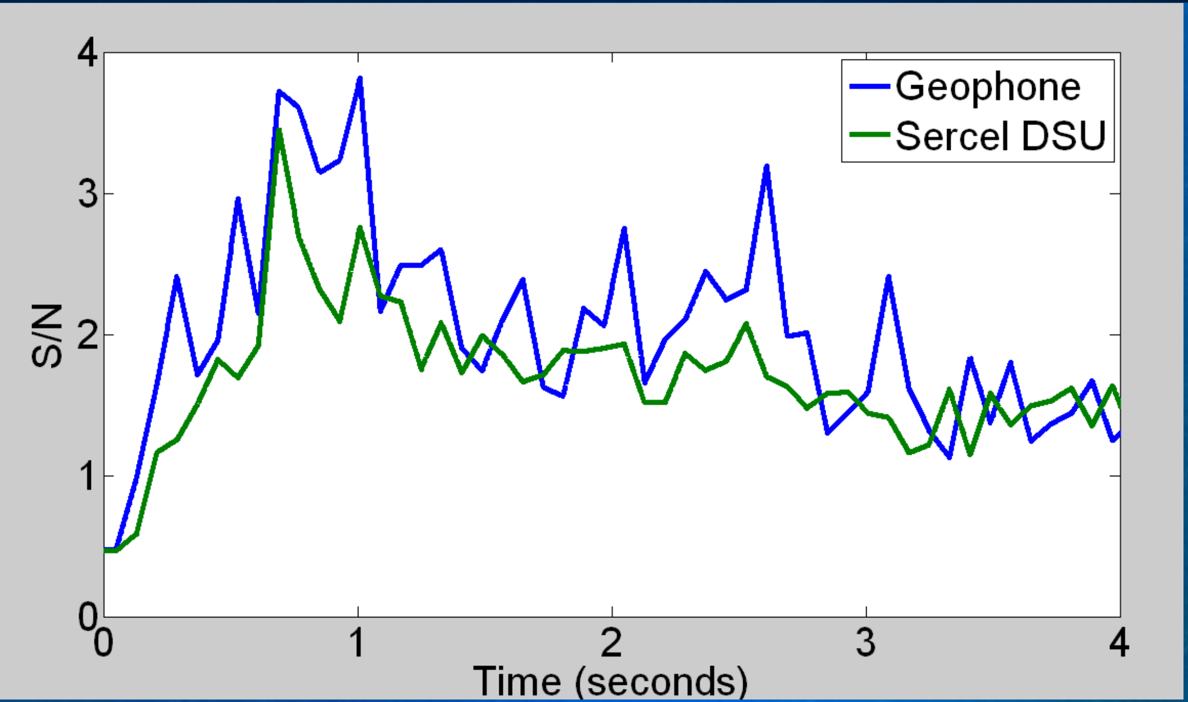


# Time/frequency analysis

- Geophones more coherent at low-f
- Fairly even over dominant frequencies
- Higher S/N at high-f in DSU, 1-2.5 sec




•5-20 Hz

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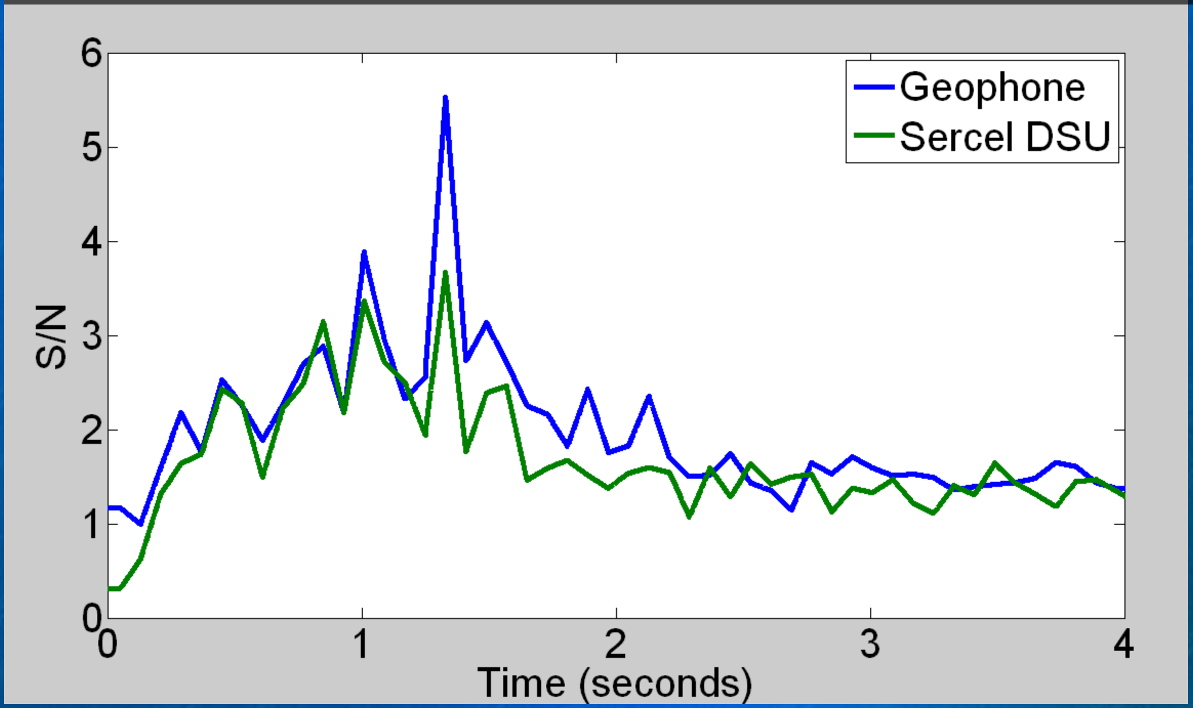


•20-35 Hz

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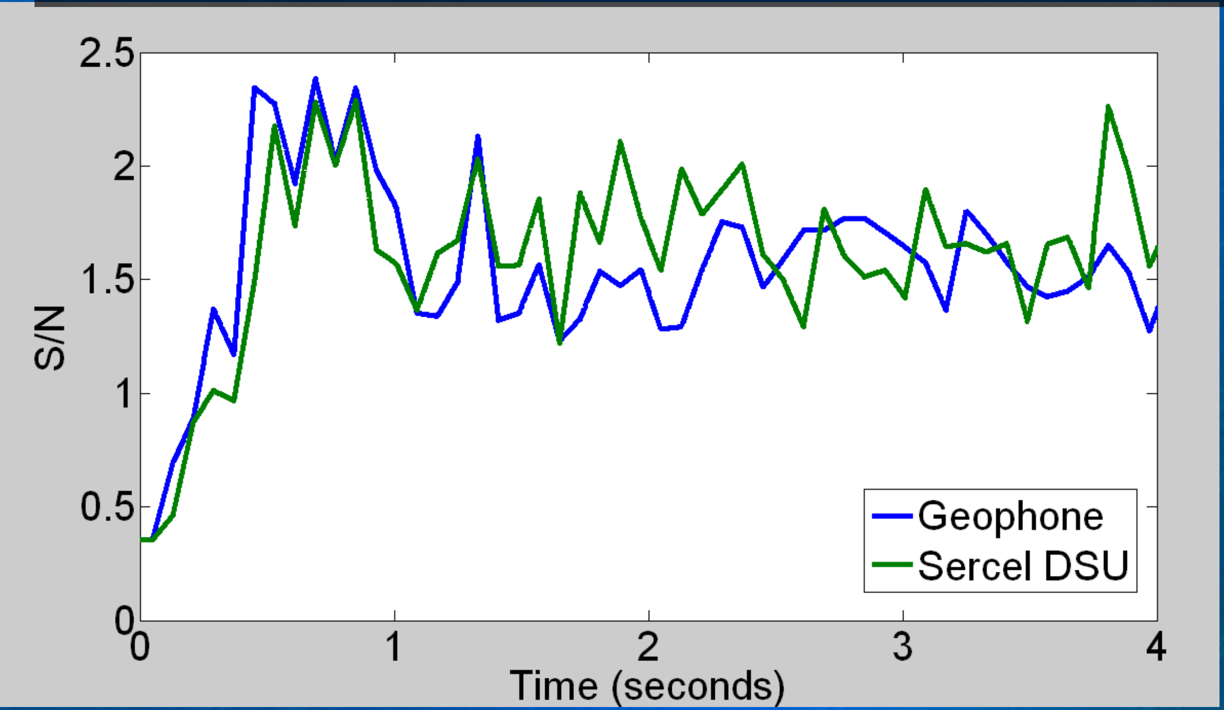


•50-65 Hz

# Conclusions

- Some coupling problems evident for DSUs
- Where well-coupled, data is similar
- Where reliable noise record available, cross-over exists ~70-80 Hz
  - Similar crossover in S/N
- No evidence of better signal at very low-frequencies in vertical component
- Early suggestions:
  - geophones may be better for lower frequency far-offset or late arrivals
  - DSUs may be better for higher frequency near-offset or shallow arrivals

# Acknowledgements


- All those who contributed to the Spring Coulee experiment
- Glenn Hauer and Malcolm Bertram
- All the CREWES sponsors