Comparison of MEMS accelerometers and geophones at Spring Coulee, Alberta

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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

\[ \frac{\partial X}{\partial t} = -\omega^2 + 2i\lambda \omega \omega_0 + \omega_0^2 \frac{\partial U}{\partial t} \]
Geophone response

\[ \frac{\partial X}{\partial t} = \frac{i \omega}{-\omega^2 + 2i\lambda \omega \omega_0 + \omega_0^2} \frac{\partial^2 U}{\partial t^2} \]
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
Field Data

- 54 dynamite shots, 40 receivers
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- Maximum offset: 1500 m
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
Acceleration traces

• Visually, very similar
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
Amplitude spectra

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Amplitude spectra

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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?
F-X coherency plot

- No major differences evident
- Geophone more coherent at low-f?
S/N estimate

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

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

![Graph showing S/N vs. time with two lines, one for Geophone and another for Sercel DSU. The x-axis represents time in seconds (0-4) and the y-axis represents S/N ratio (0-6). The graph shows peaks at different times for each line, indicating variations in signal strength over time.]
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

- 50-65 Hz
Conclusions

• Some coupling problems evident for DSUs
• Where well-coupled, data is similar
• Where reliable noise record available, crossover 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