Polarization

Common-mode noise discrimination on multi-component seismic data

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Outline

- Introduction—noise discrimination principles
- Additional multi-component discrimination characteristic
- Noise modes with distinct polarization
- Common-mode technique
- Ground-roll example
- Ice flexural wave example
- Conclusions

Noise attenuation principles

- Find ***discriminating characteristics*** of noise with respect to signal
- Find a ***domain*** in which these characteristics provide the best separation
- Either ***reject*** the noise in this domain, or ***model*** the noise and ***subtract*** it in the original domain.

Some discriminating characteristics

- Frequency content
- Coherence trajectory (linear, hyperbolic)
- Point of origin
- Event timing
- Event phase

Established techniques

- F-k methods—separate noise and signal based on coherence (apparent ***velocity*** and ***frequency*** or time/space wavenumber ratio)
- RT methods—separate noise and signal based on coherence (apparent ***velocity*** and ***point of origin***)

Multi-component characteristics

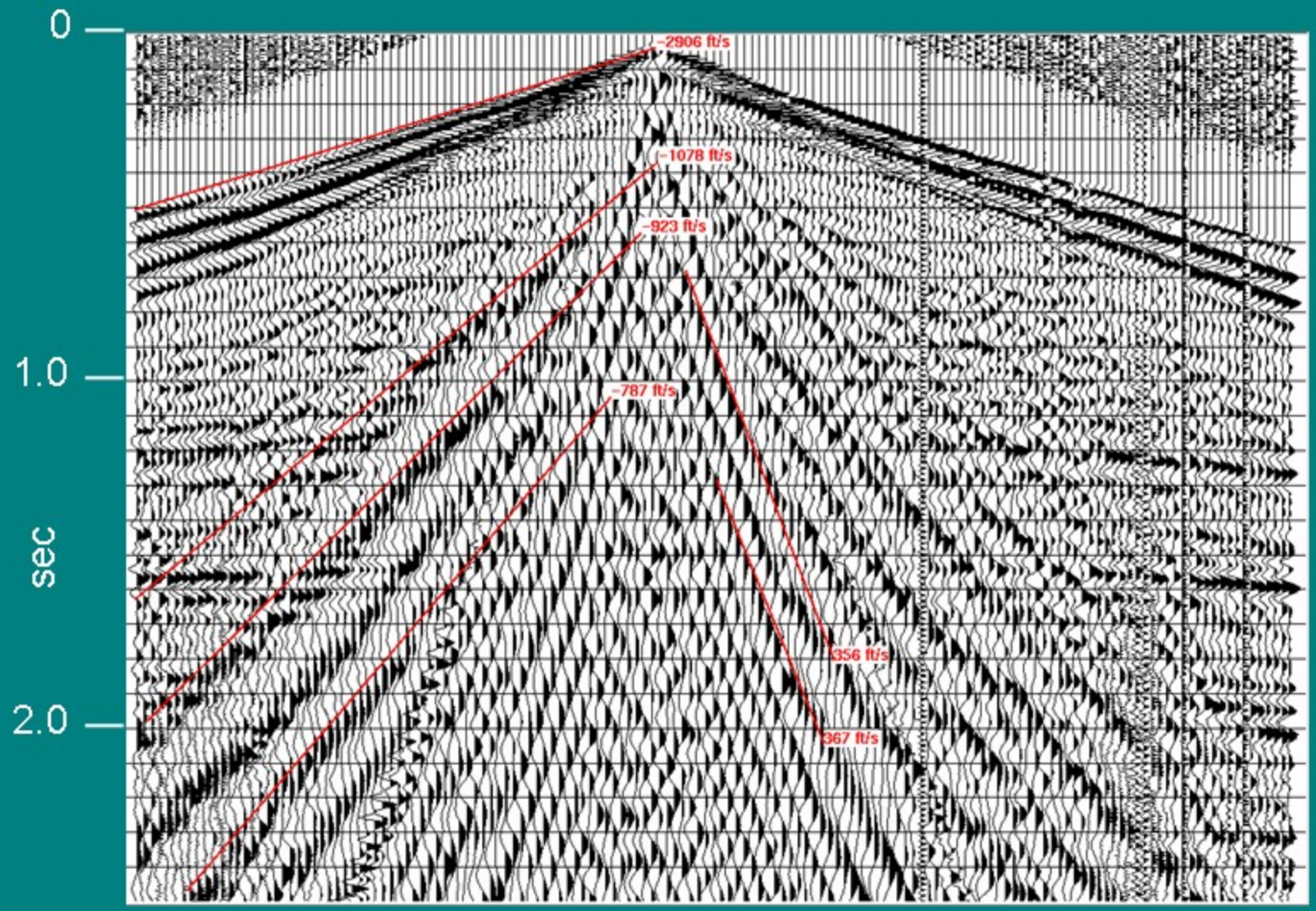
- ***Particle motion*** discrimination is unique to multi-component data
- Noise appearing on two or more components of a multi-component data set may be discriminated by particle motion ***polarization***
- Example noise modes exhibiting distinct polarization are ***ground roll*** and the ***ice flexural wave***

Common mode technique

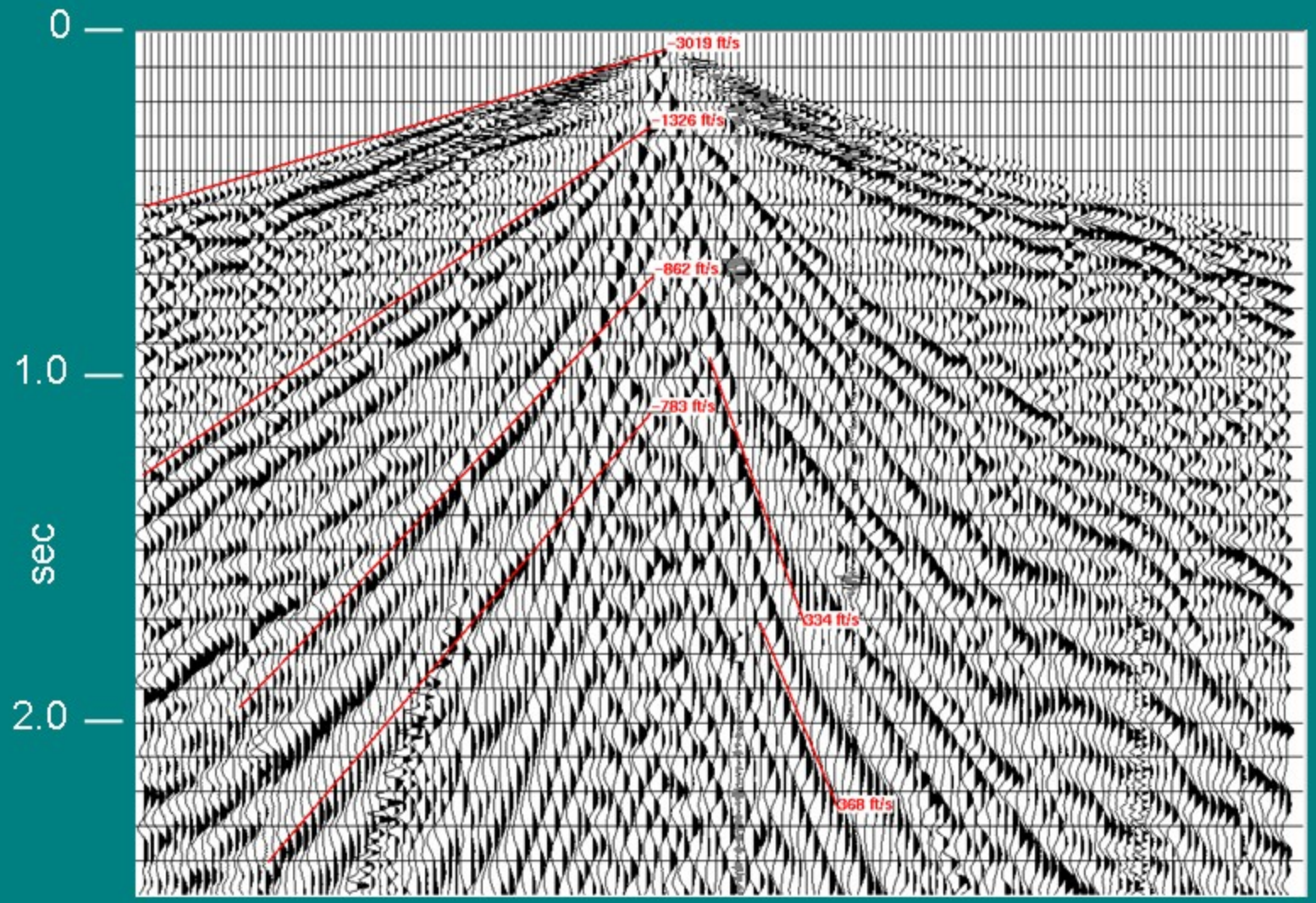
- Adjust phase and amplitude of selected noise mode on radial (and possibly transverse) components to match vertical component
- Sum all components—noise or “common mode” should be boosted, PP and PS reflections should partially cancel
- Increase discrimination by windowing noise in XT domain, or attenuating signal in RT domain

Ground roll at Blackfoot

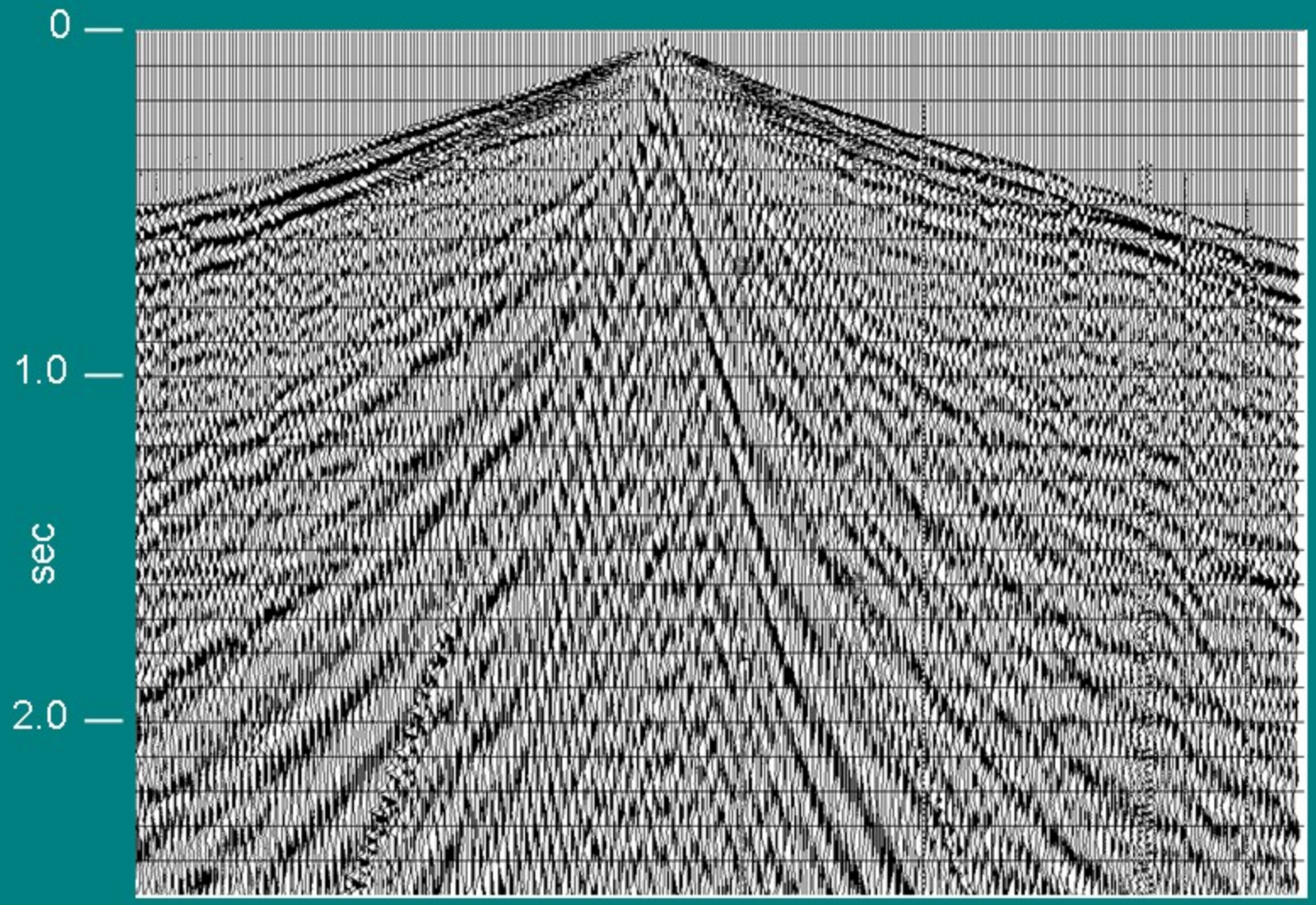
- Blackfoot 3-C 2D data exhibit moderate linear noise, including ground roll
- Ground roll is prominent on both vertical and radial (inline horizontal) component shot gathers
- Noise level varies significantly from shot to shot



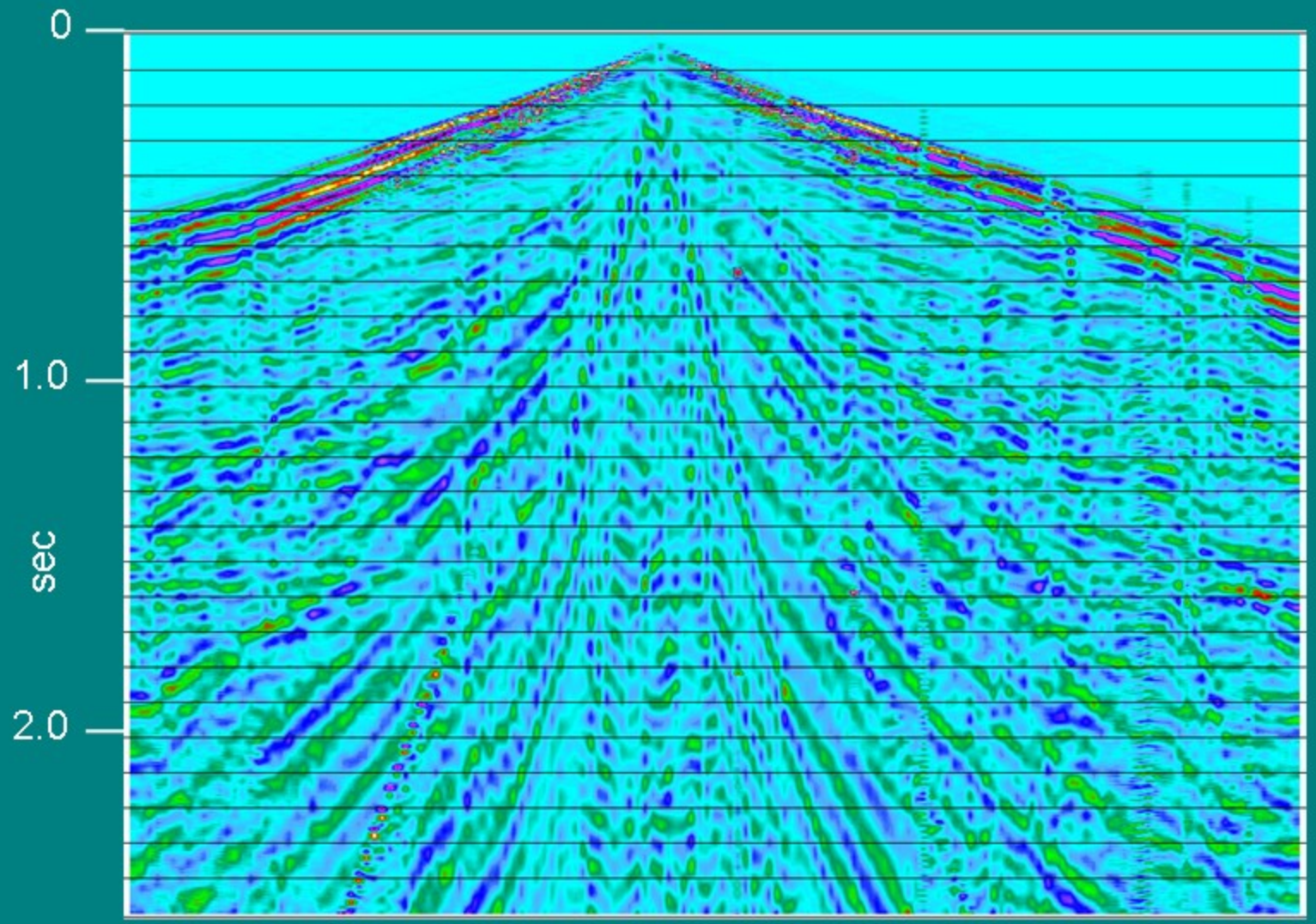
Shot 73 vertical component, miscellaneous velocities marked



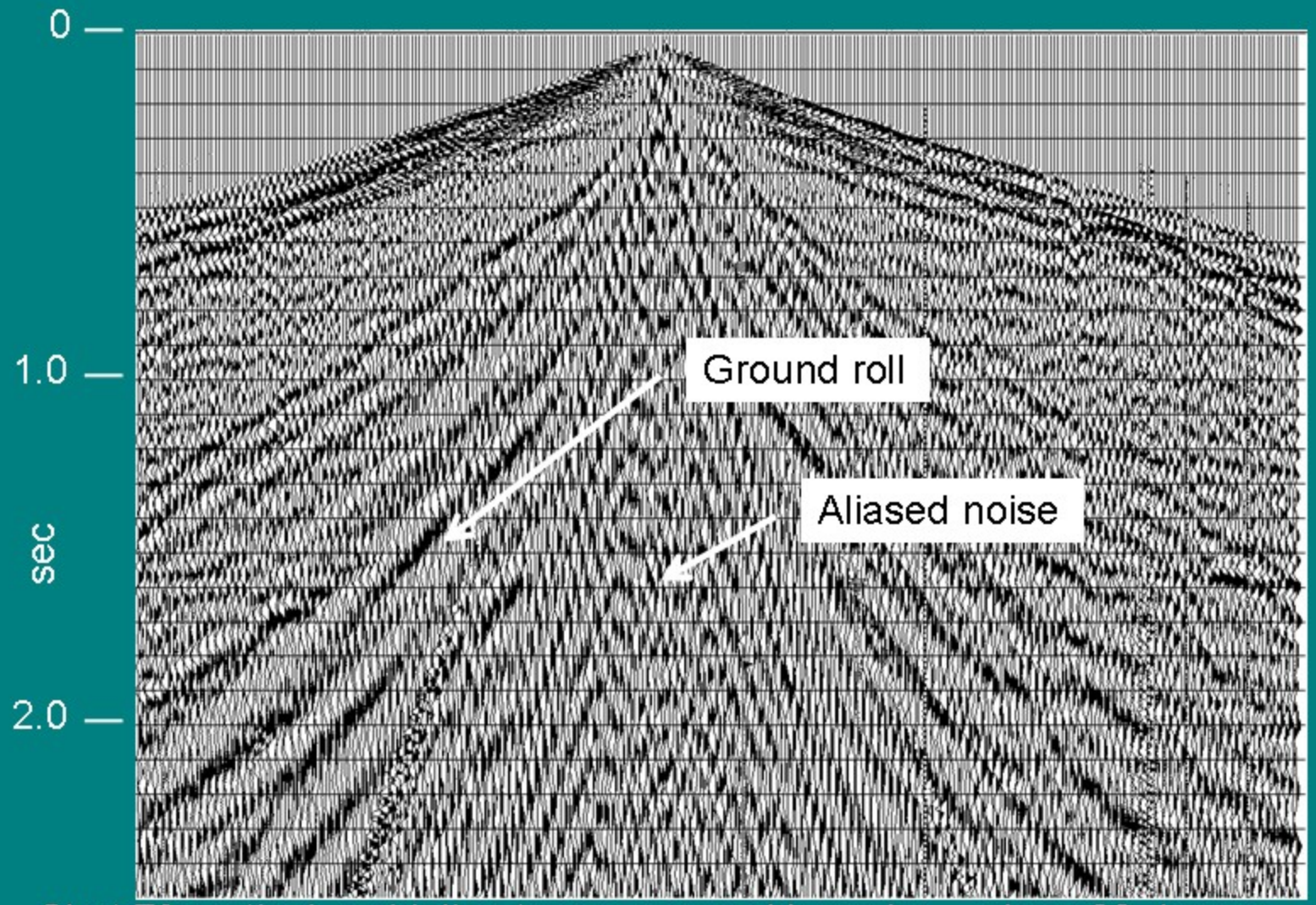
Shot 73 inline horizontal component, miscellaneous velocities marked



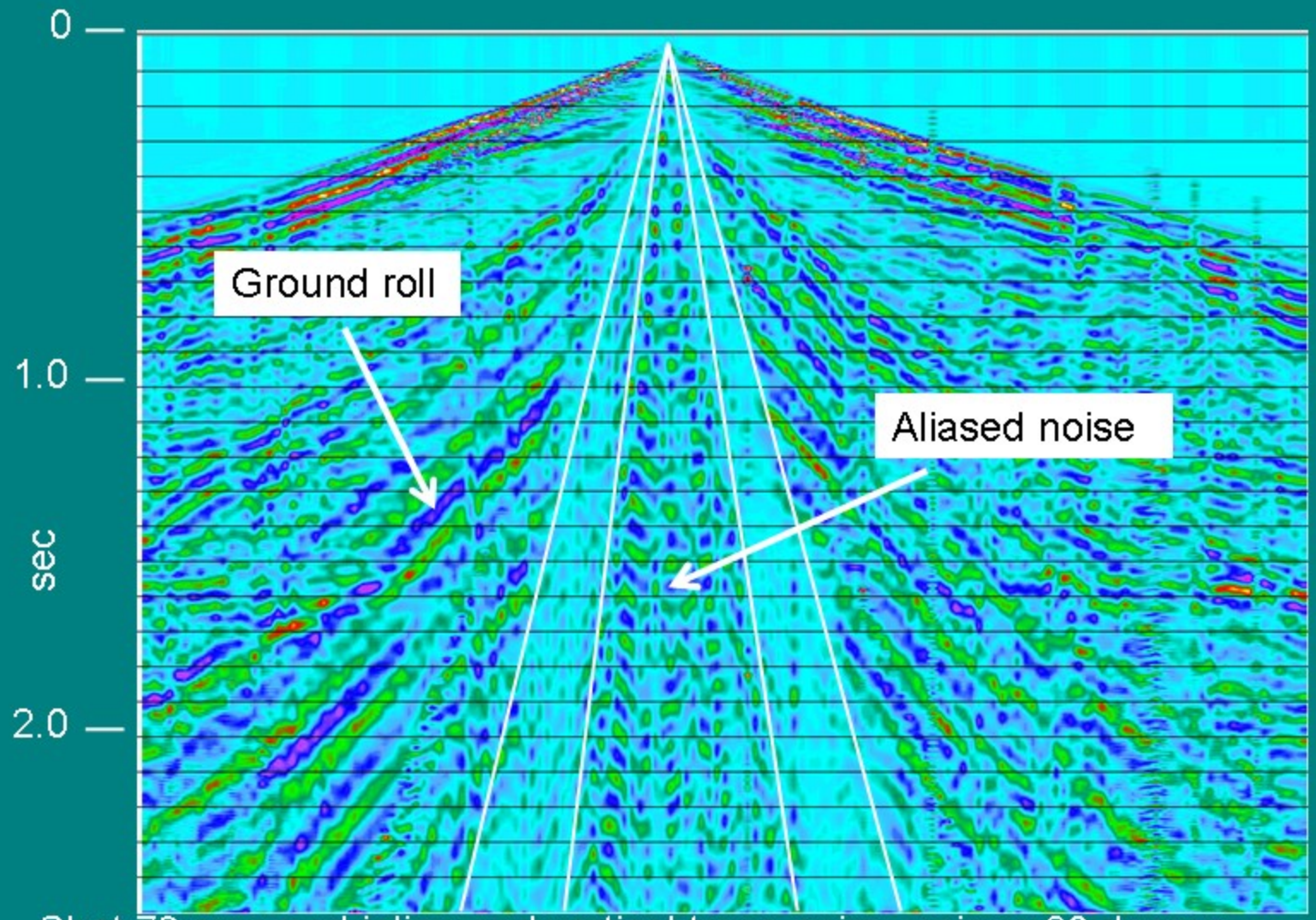
Shot 73 vertical and inline traces merged by pairs—no inline component phase adjustment—first arrivals aligned.



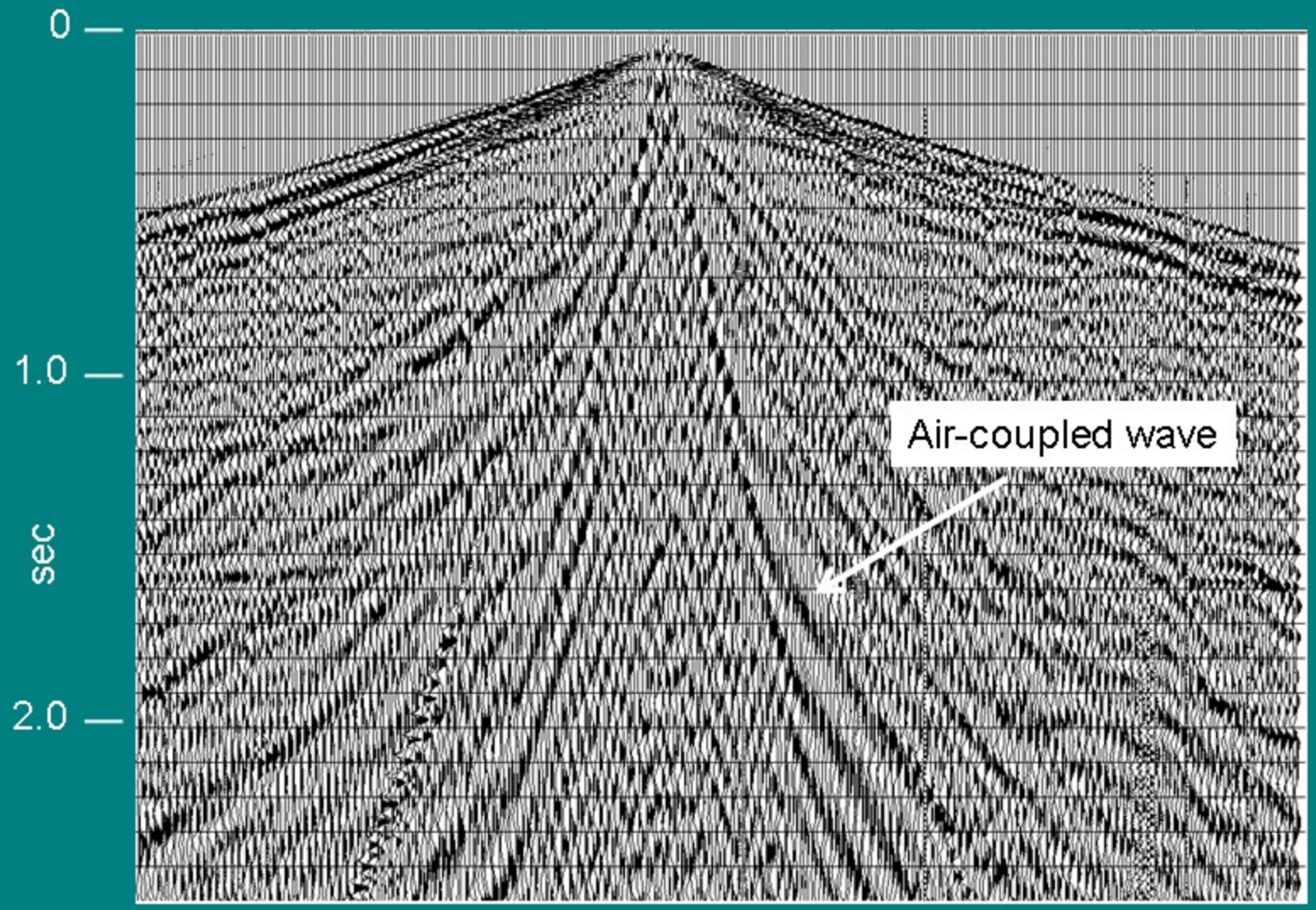
Shot 73 vertical and inline trace pairs summed—no inline component phase adjustment—first arrivals aligned



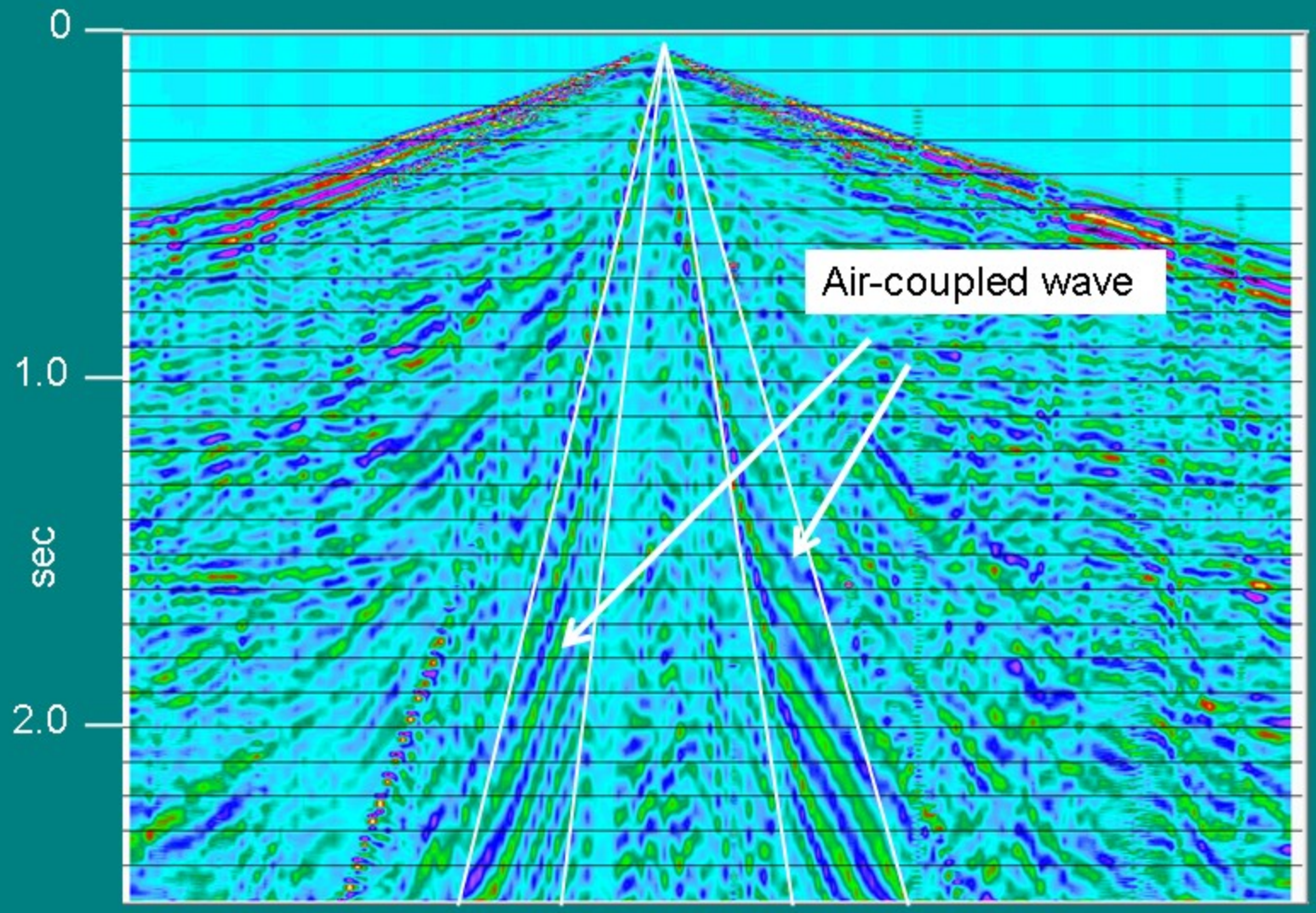
Shot 73 vertical and inline traces merged by pairs—minus 90 degree inline component phase adjustment—ground roll and some aliased noise components now aligned.



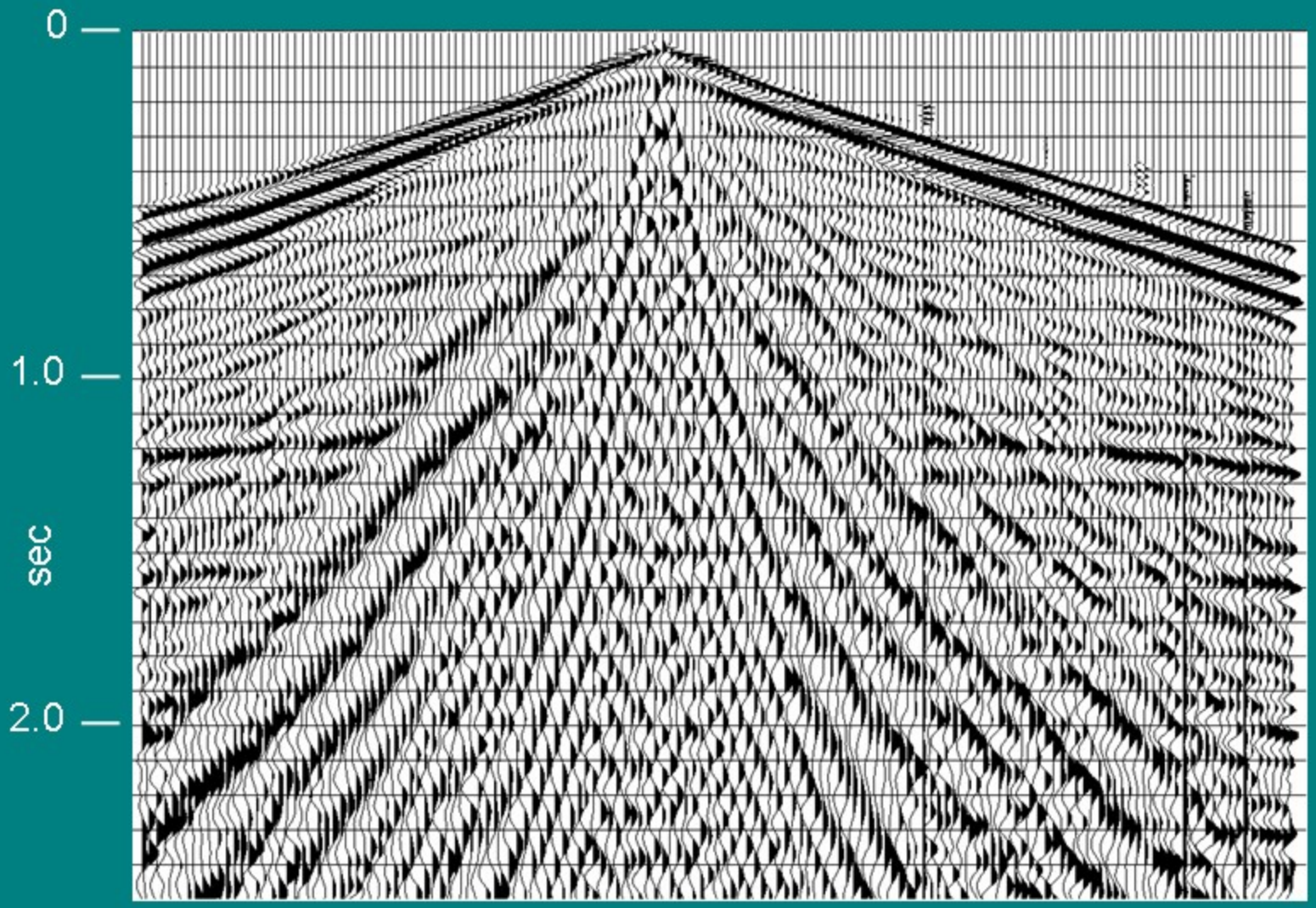
Shot 73 summed inline and vertical trace pairs—minus 90 degree inline component phase adjustment—ground roll and aliased noise now aligned.



Shot 73 vertical and inline traces merged by pairs—plus 90 degree inline component phase adjustment—air-coupled wave now aligned.



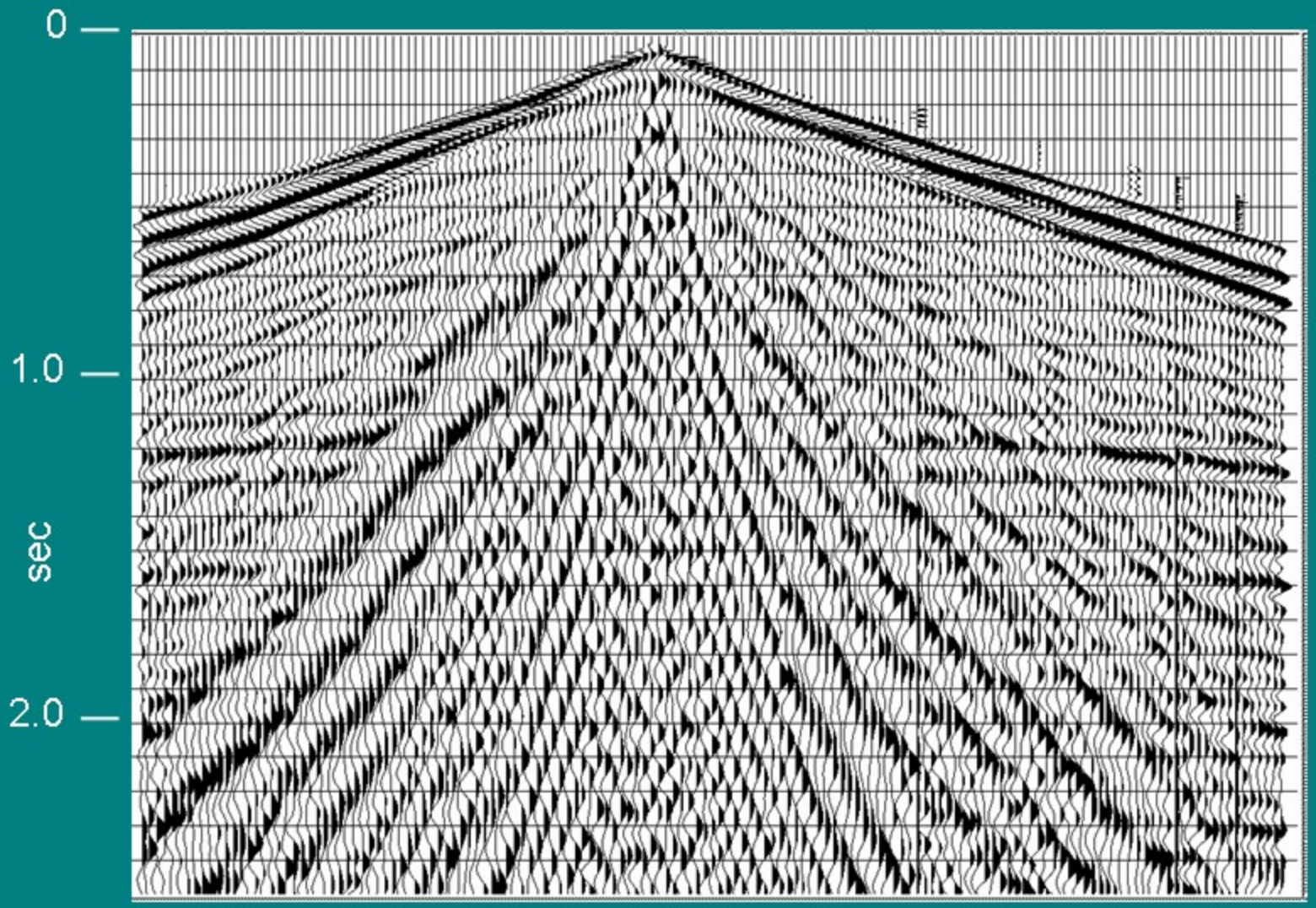
Shot 73 summed vertical and inline trace pairs—plus 90 degree inline component phase alignment—air-coupled wave now aligned..



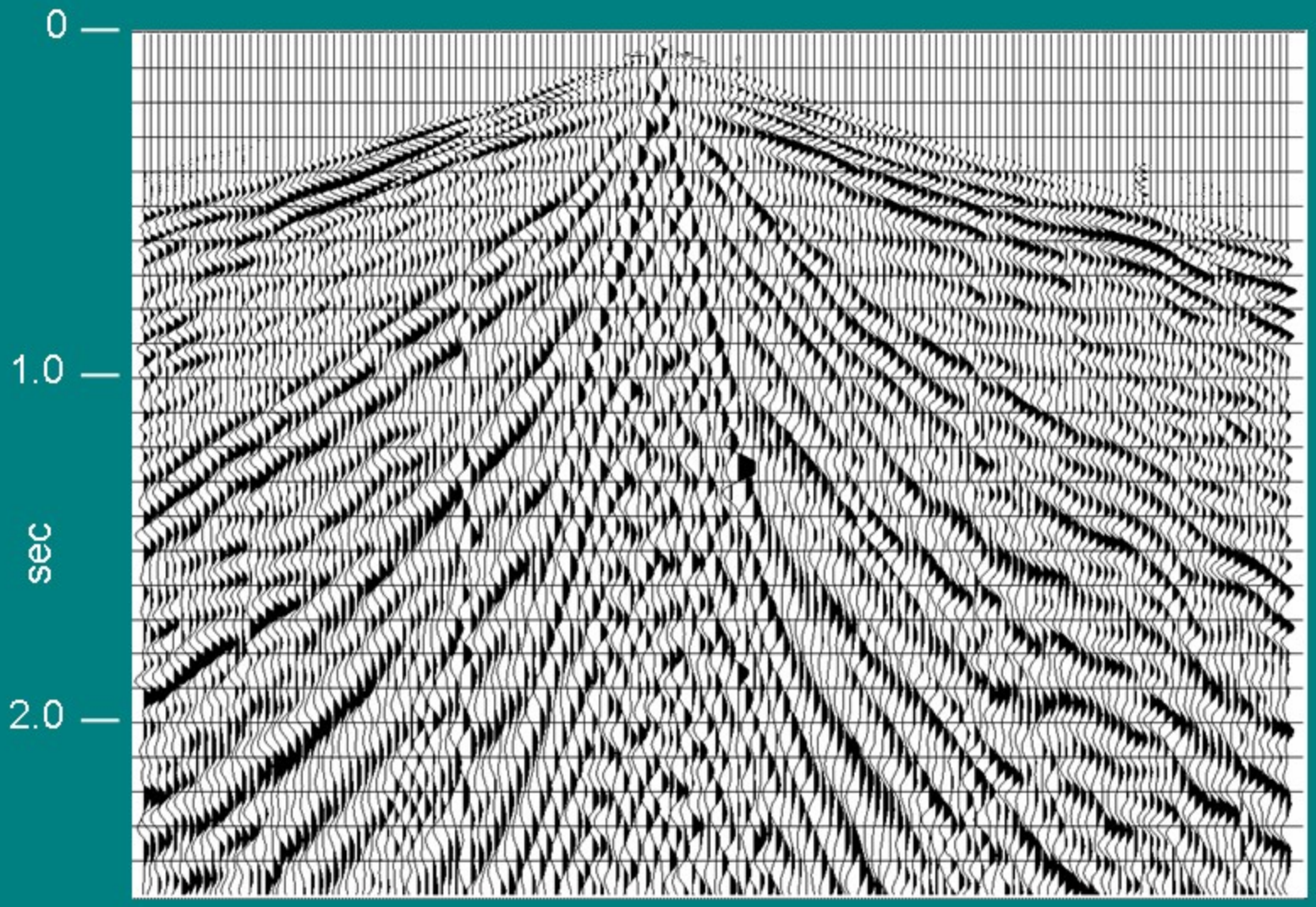
Shot 73 total common-mode noise

RT noise estimate

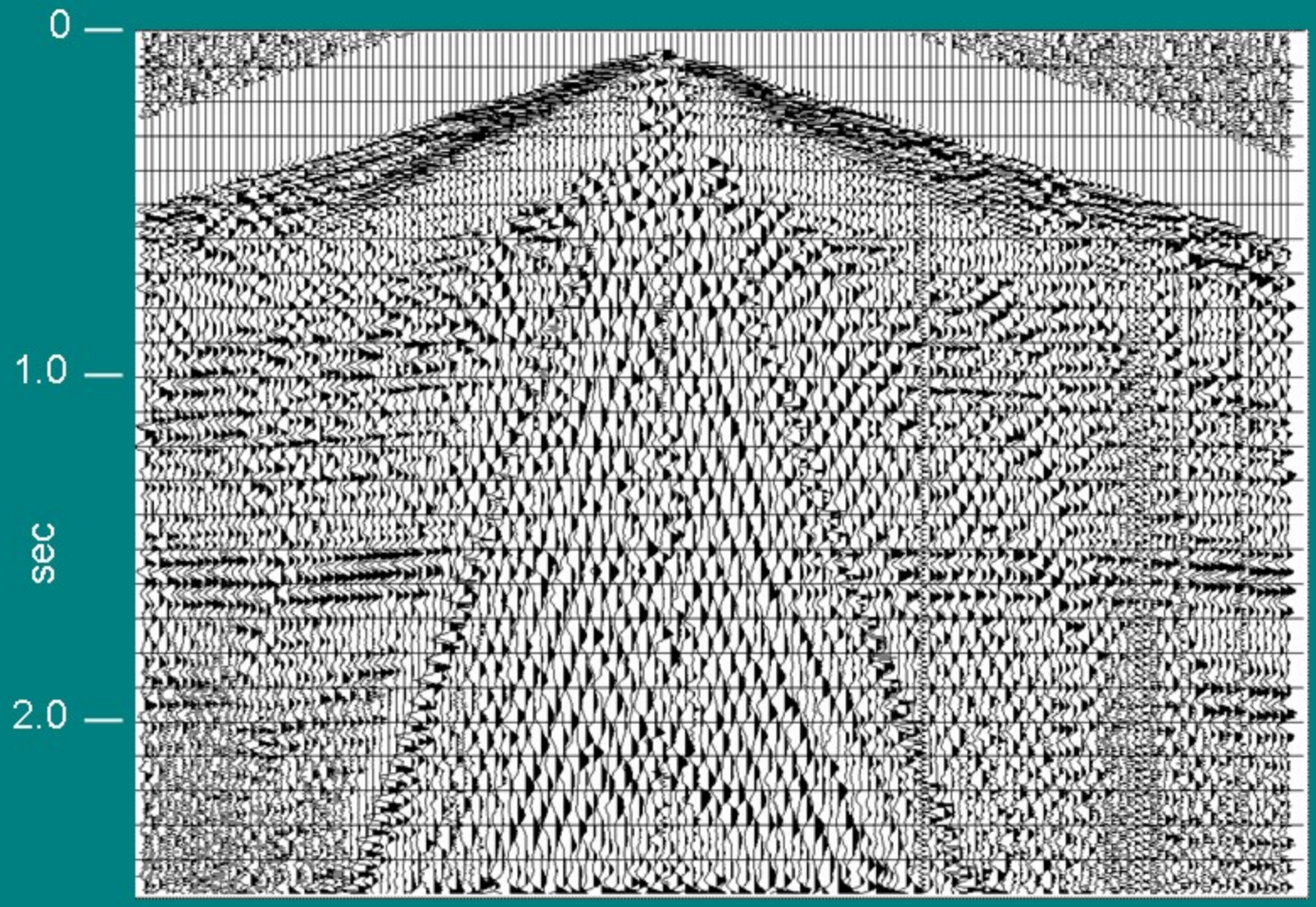
- RT transform XT shot gather
- Low-pass RT panel to attenuate reflection signal
- Inverse RT transform to XT
- Subtract noise estimate from original shot gather



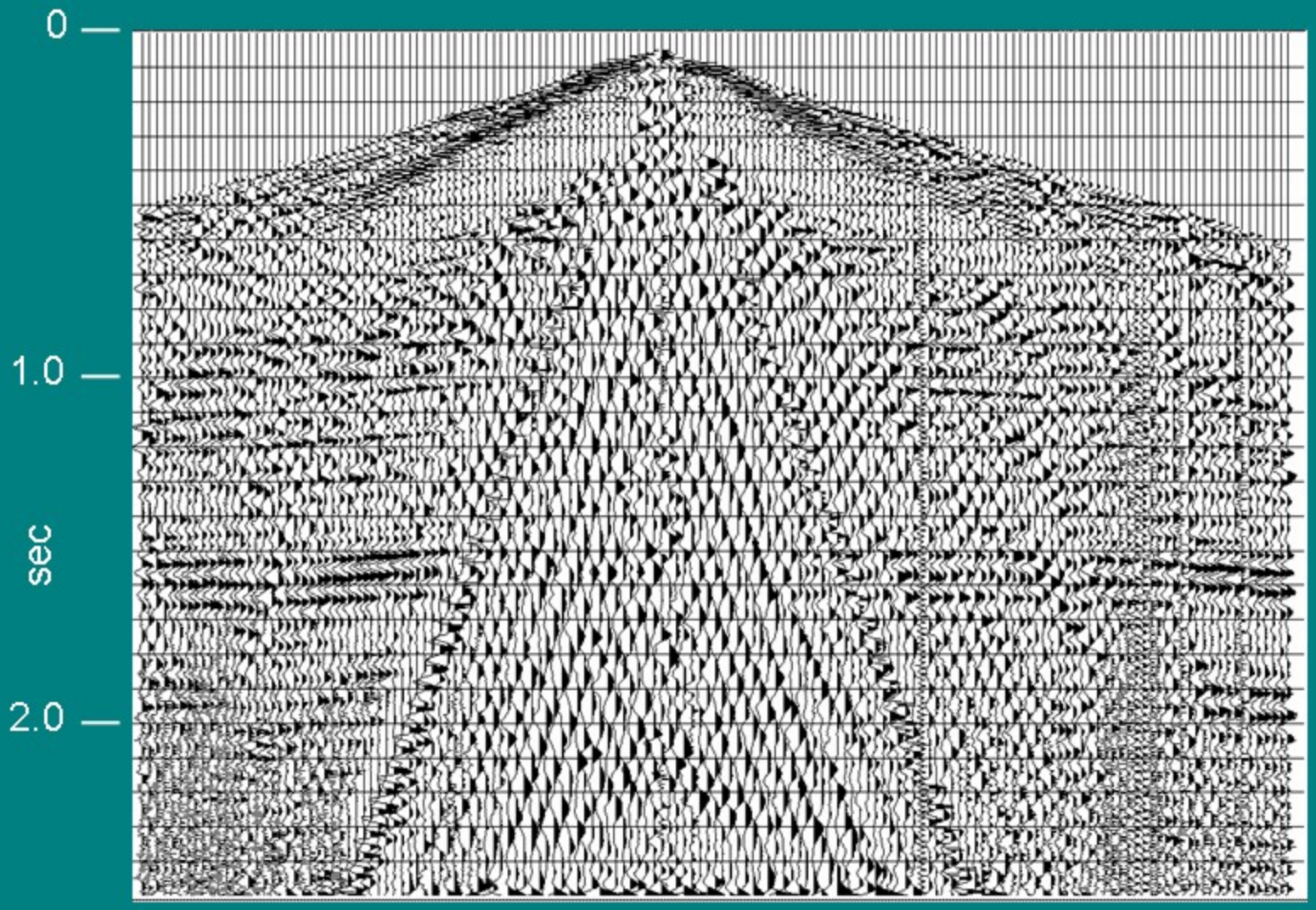
Shot 73 noise estimate from vertical component traces only



Shot 73 noise estimate from inline component traces only



Shot 73 vertical component traces minus common-mode noise estimate.



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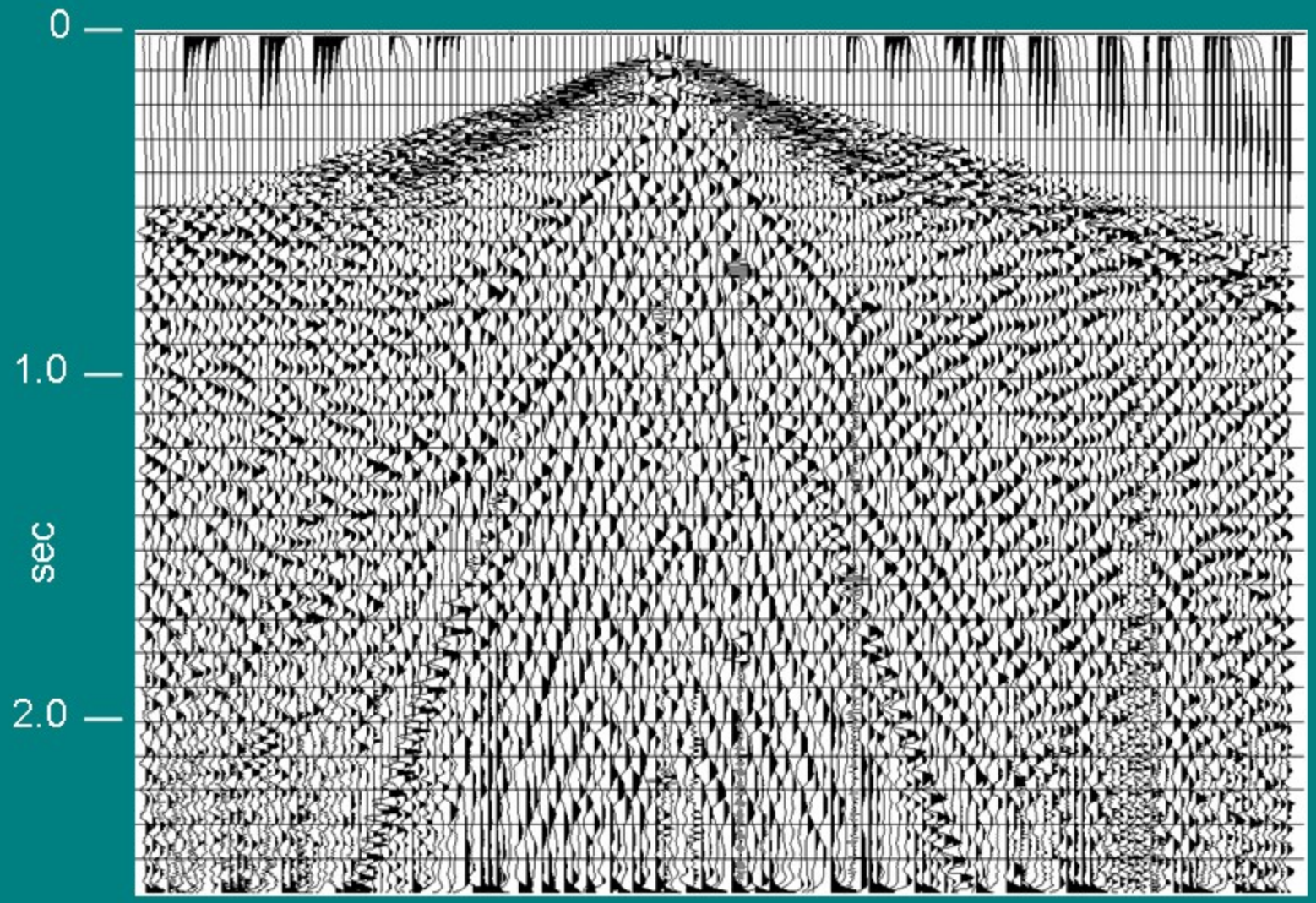
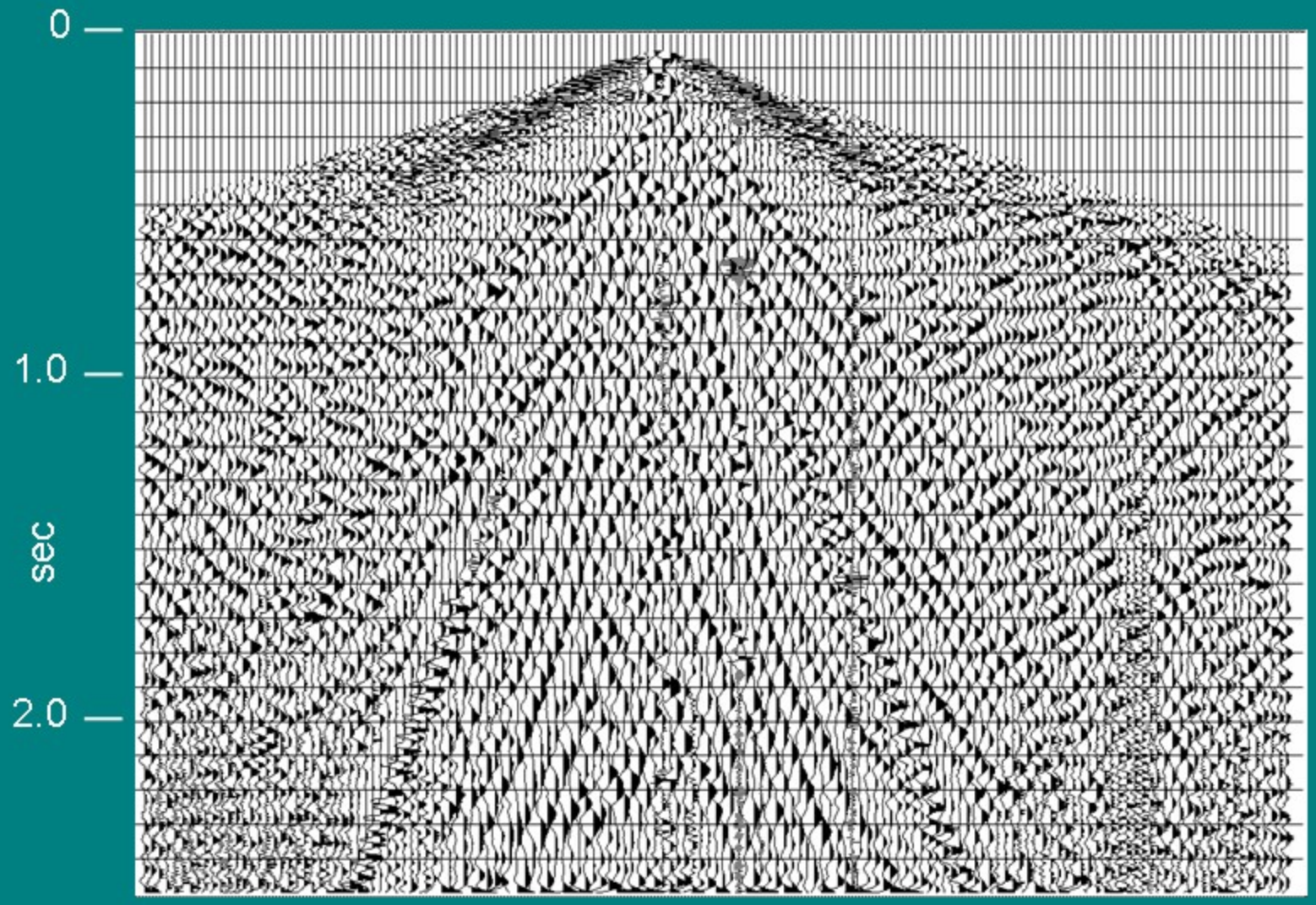
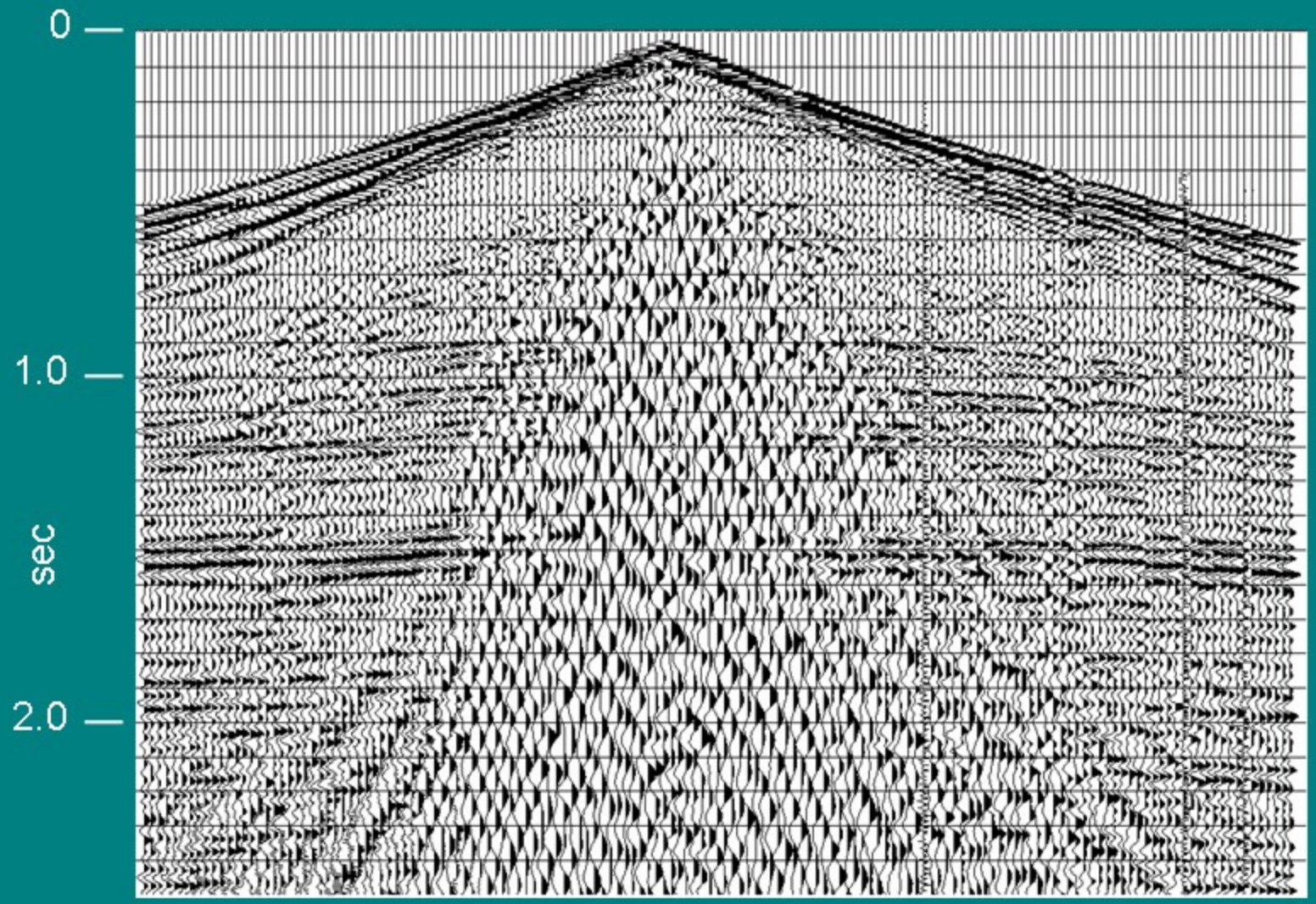


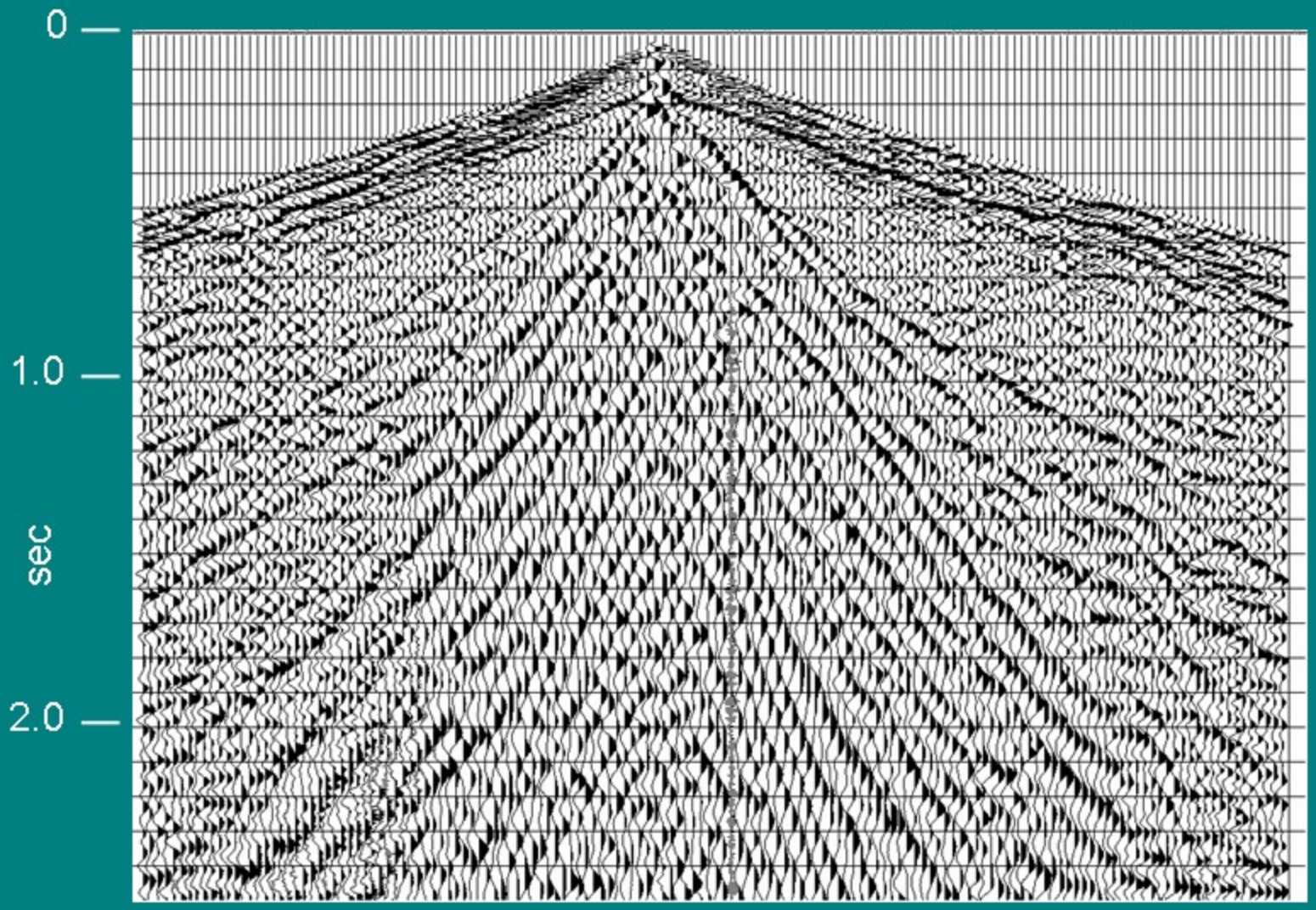
Shot 73 inline component traces minus common-mode noise estimate.



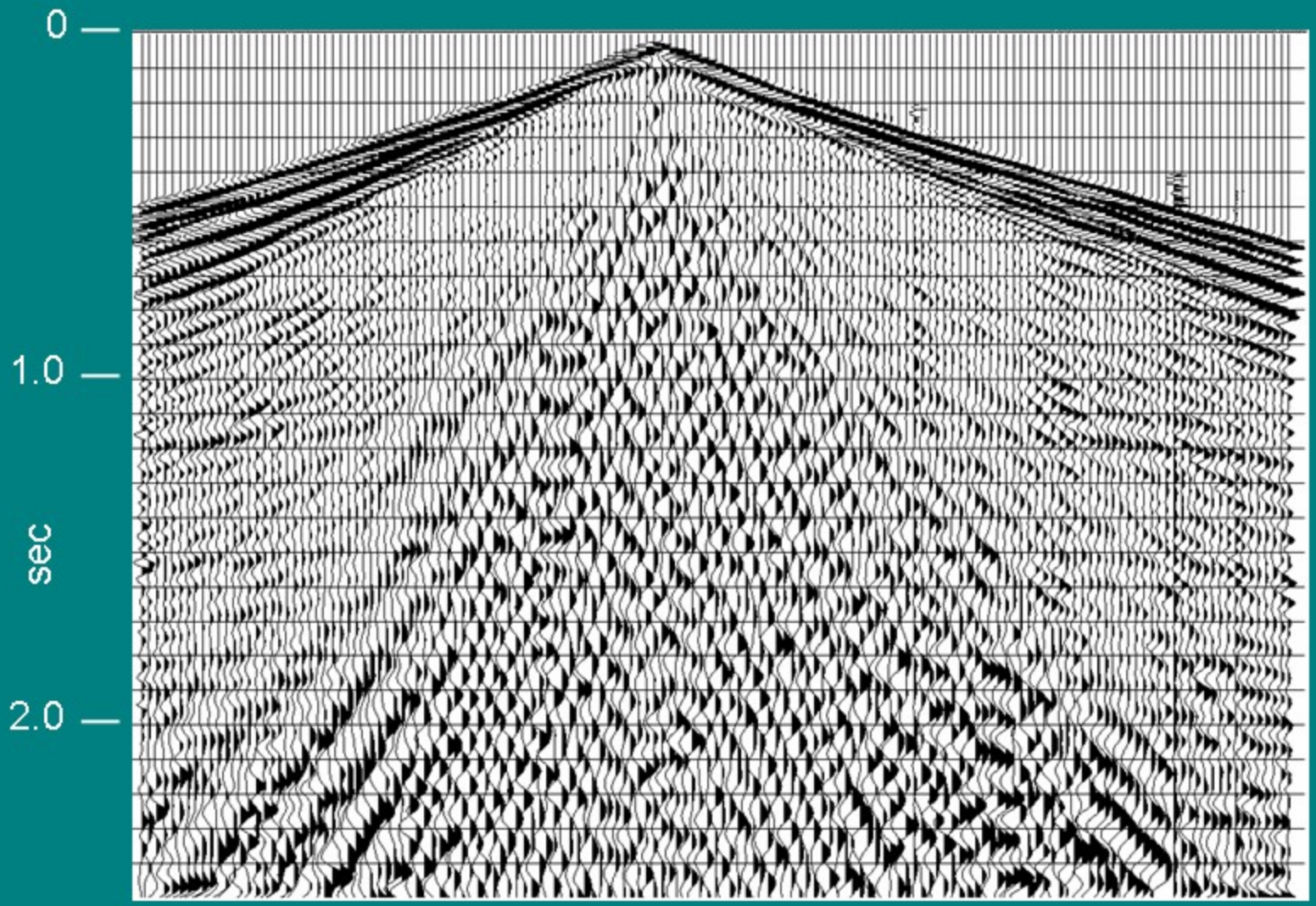
Shot 73 inline component traces minus inline component noise estimate.



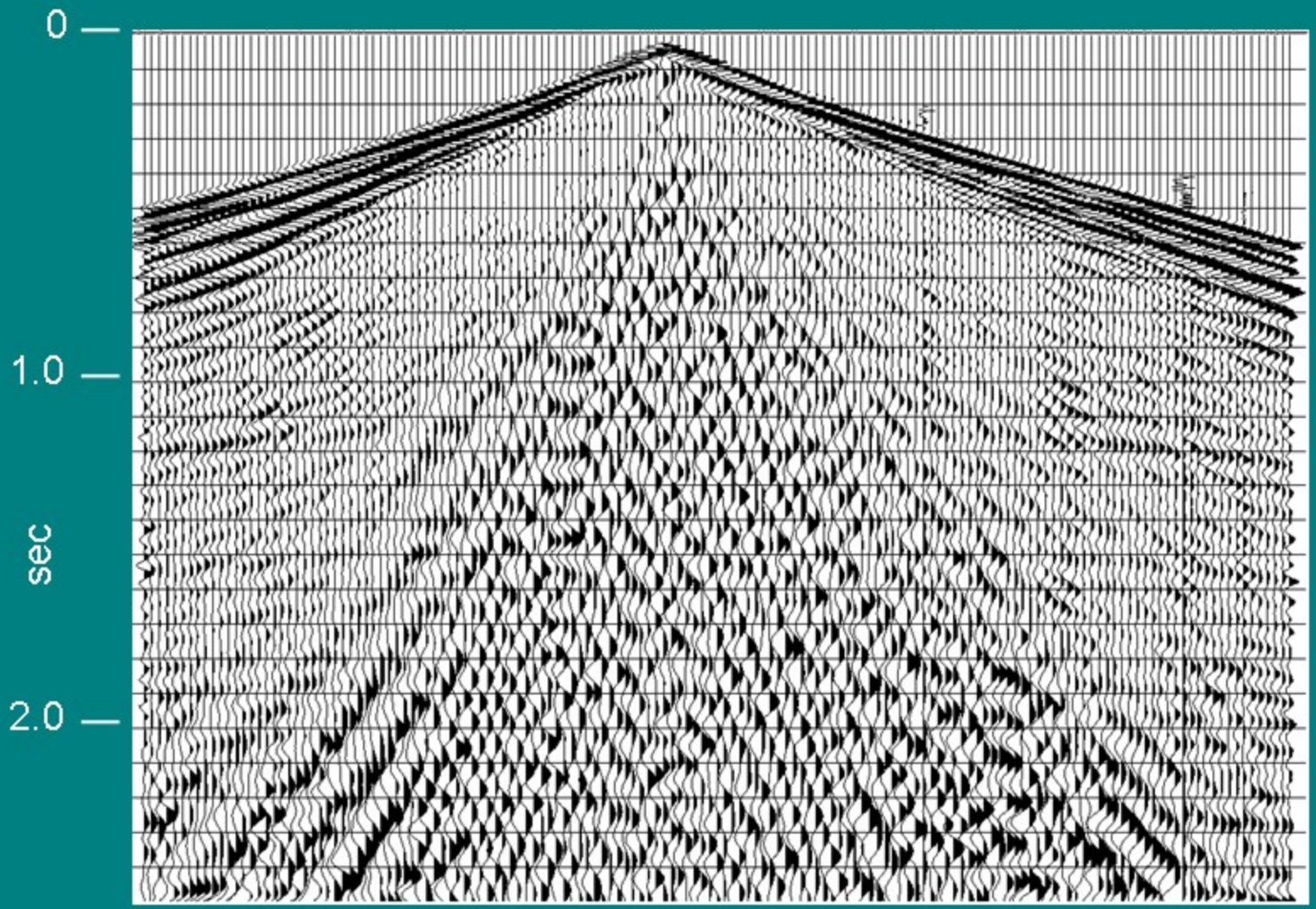
Shot 74 vertical component traces



Shot 74 inline horizontal component traces



Shot 74 common-mode noise estimate



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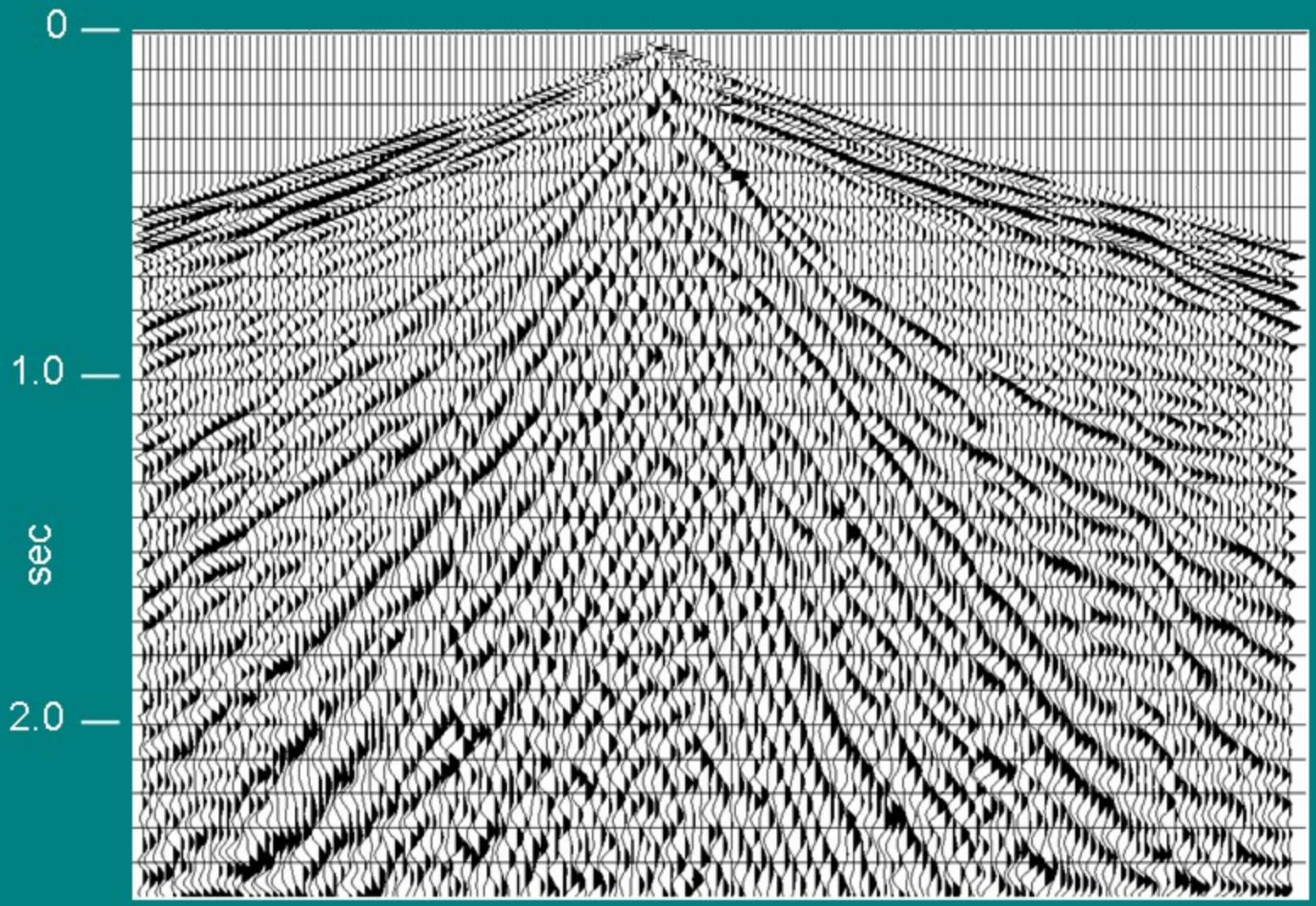
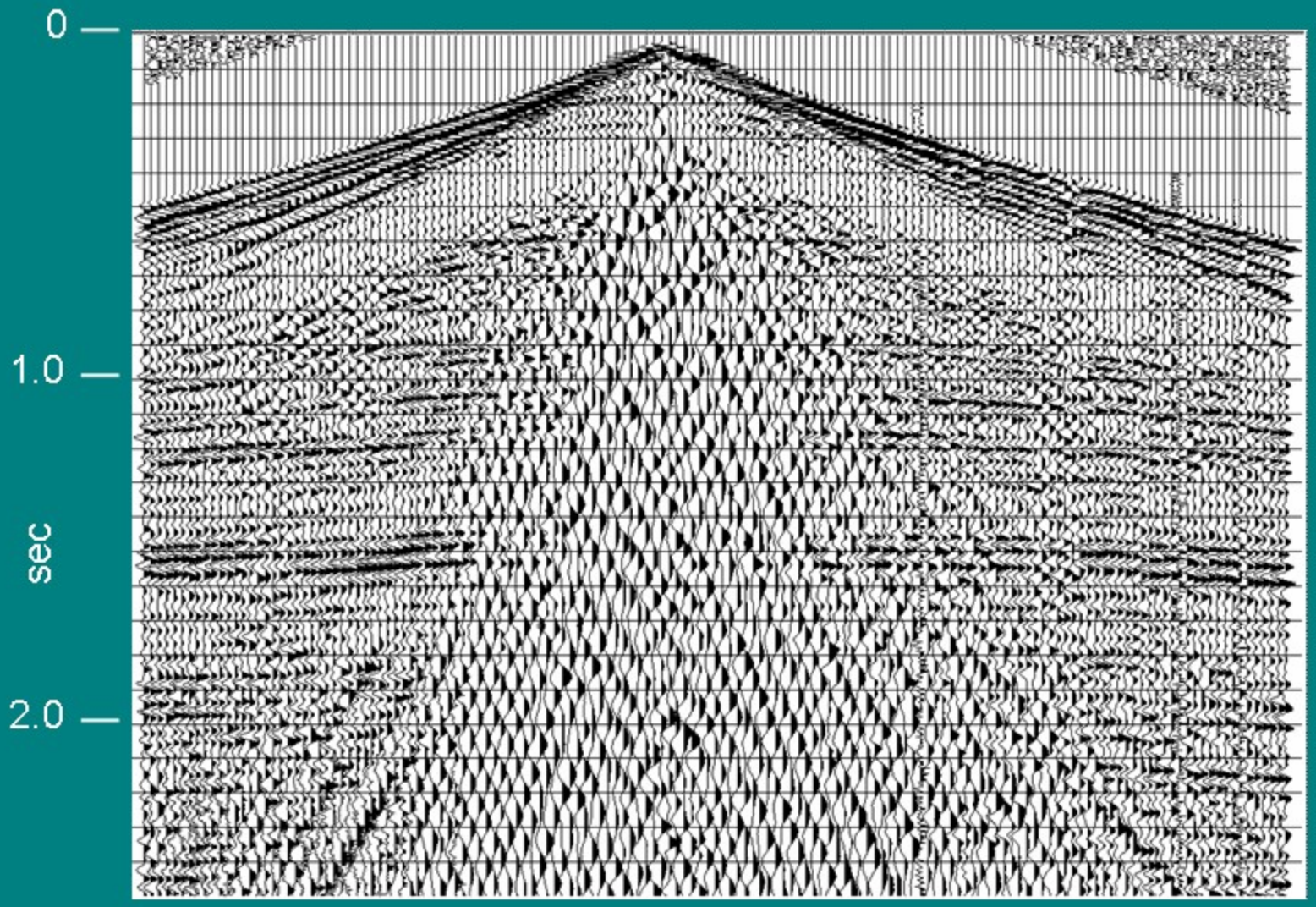
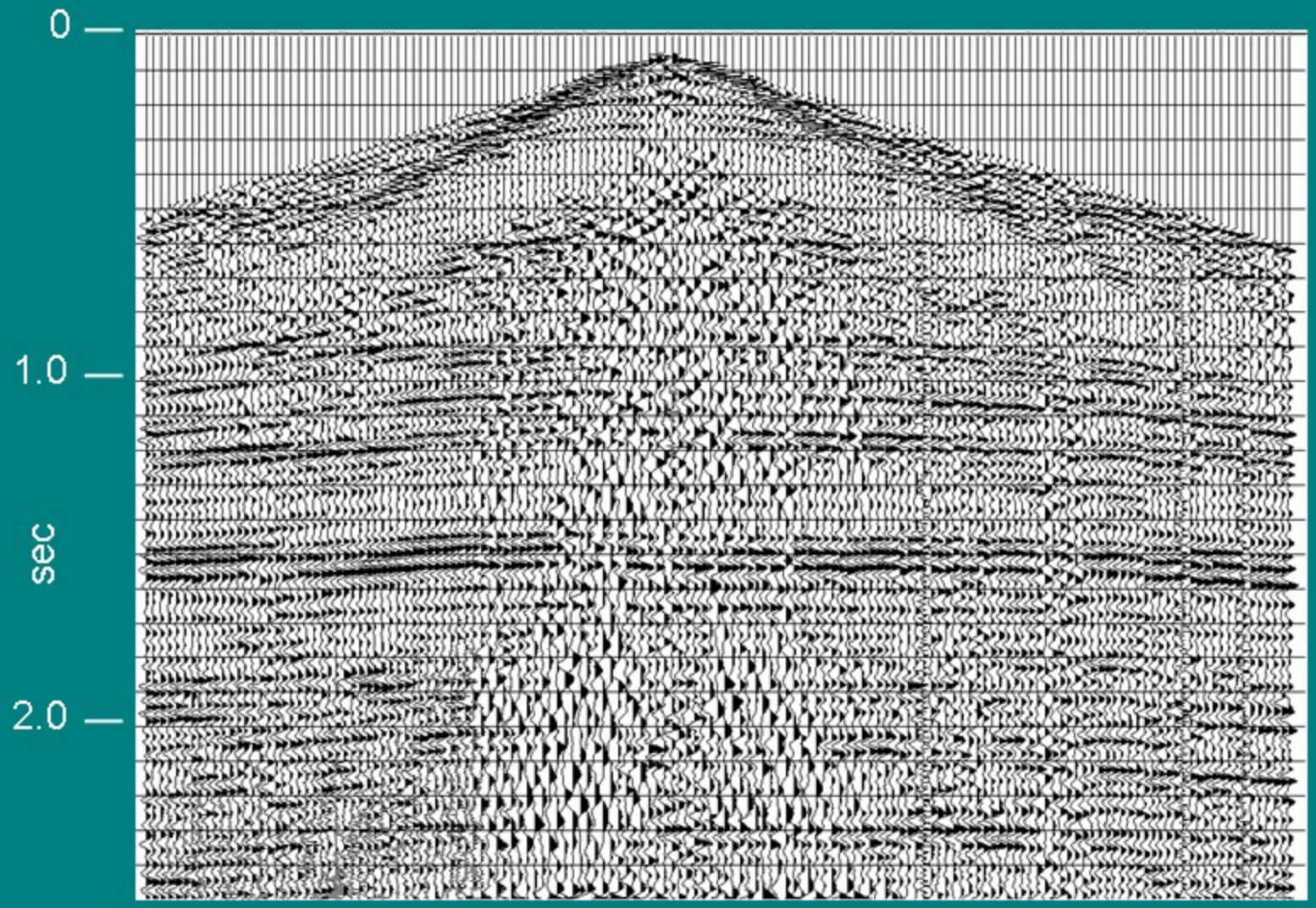


Shot 74 inline horizontal component noise estimate



Shot 74 vertical component minus common-mode noise estimate



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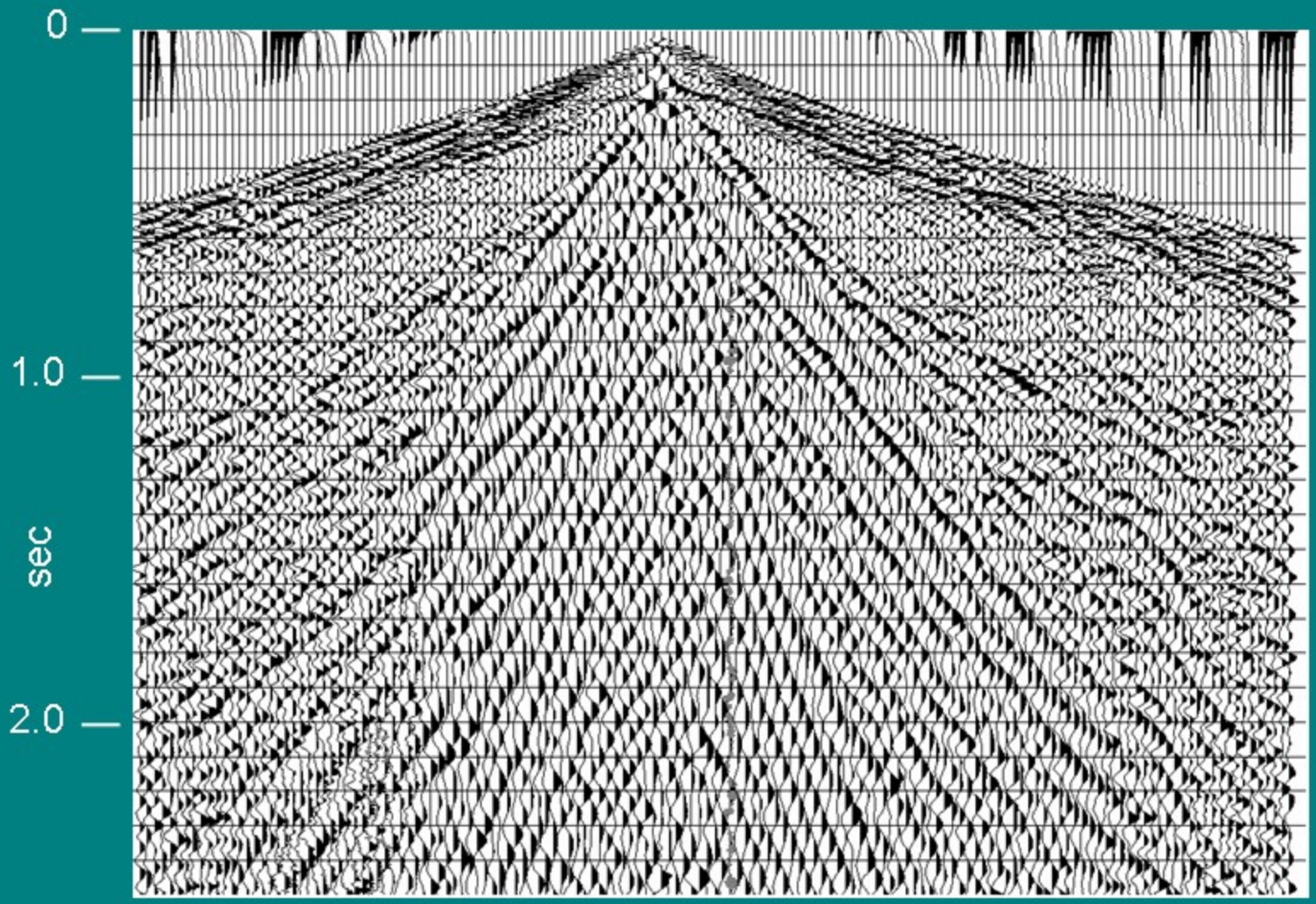
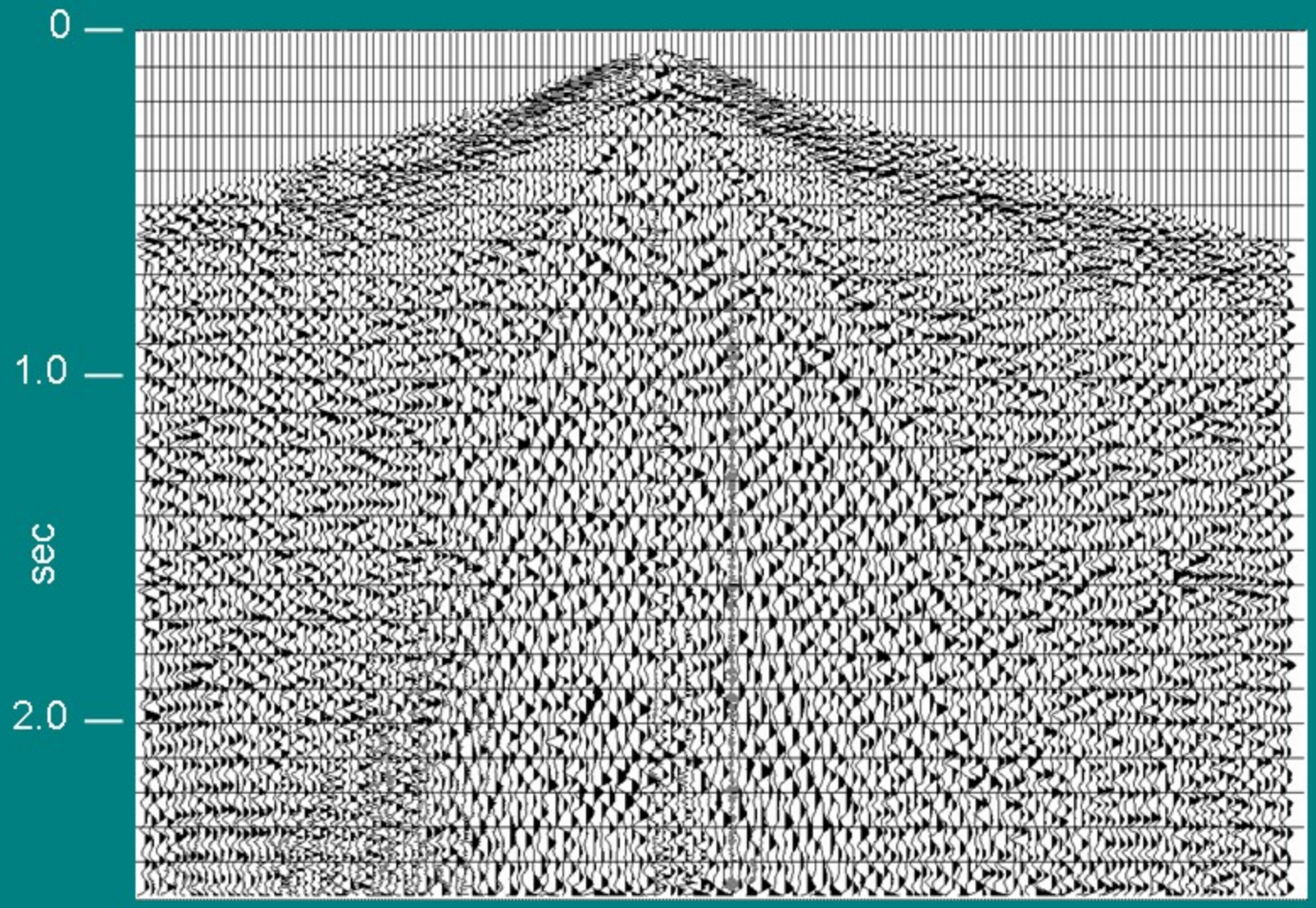


Shot 74 inline horizontal component minus common-mode noise estimate



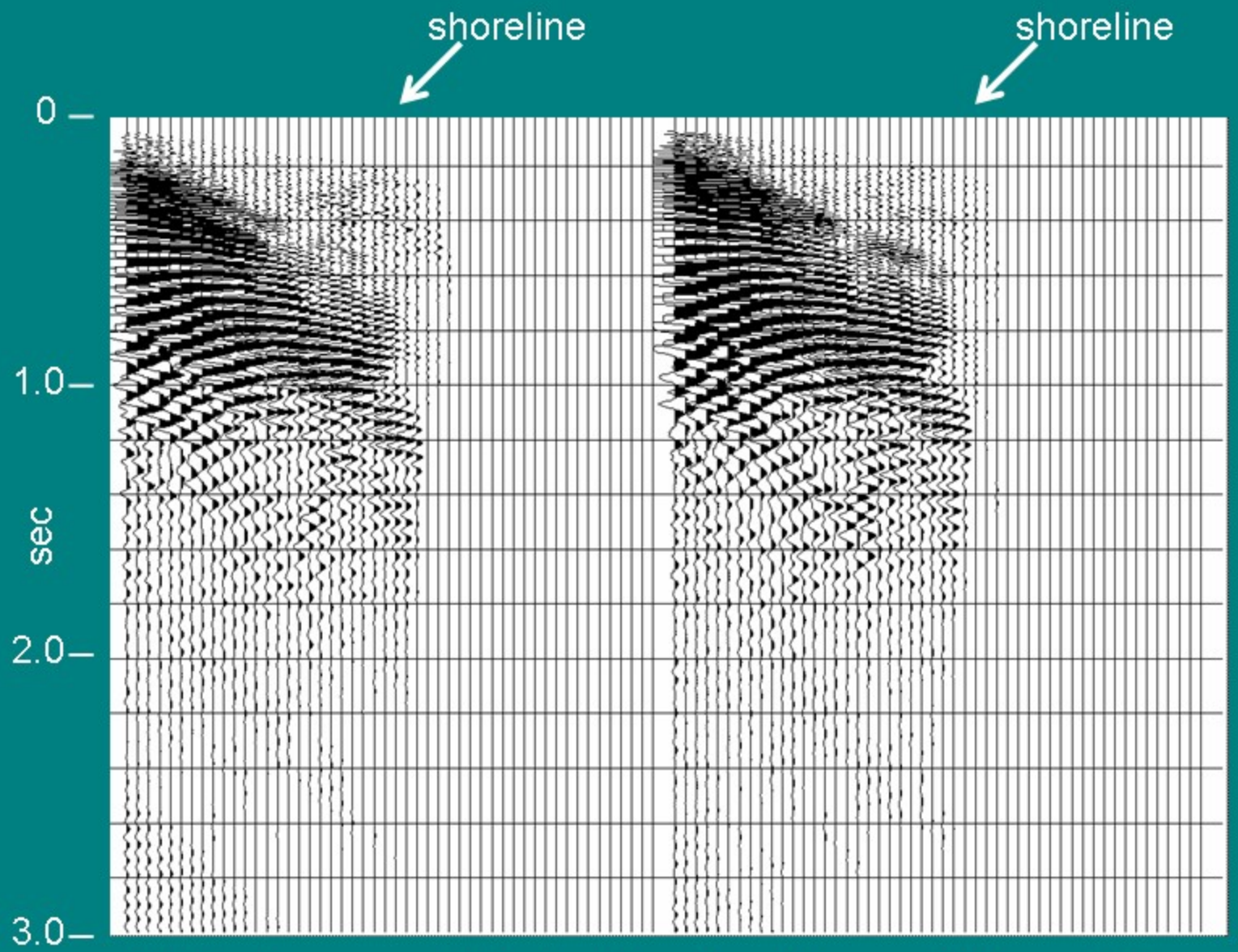
Shot 74 inline horizontal component minus inline noise estimate

Summary

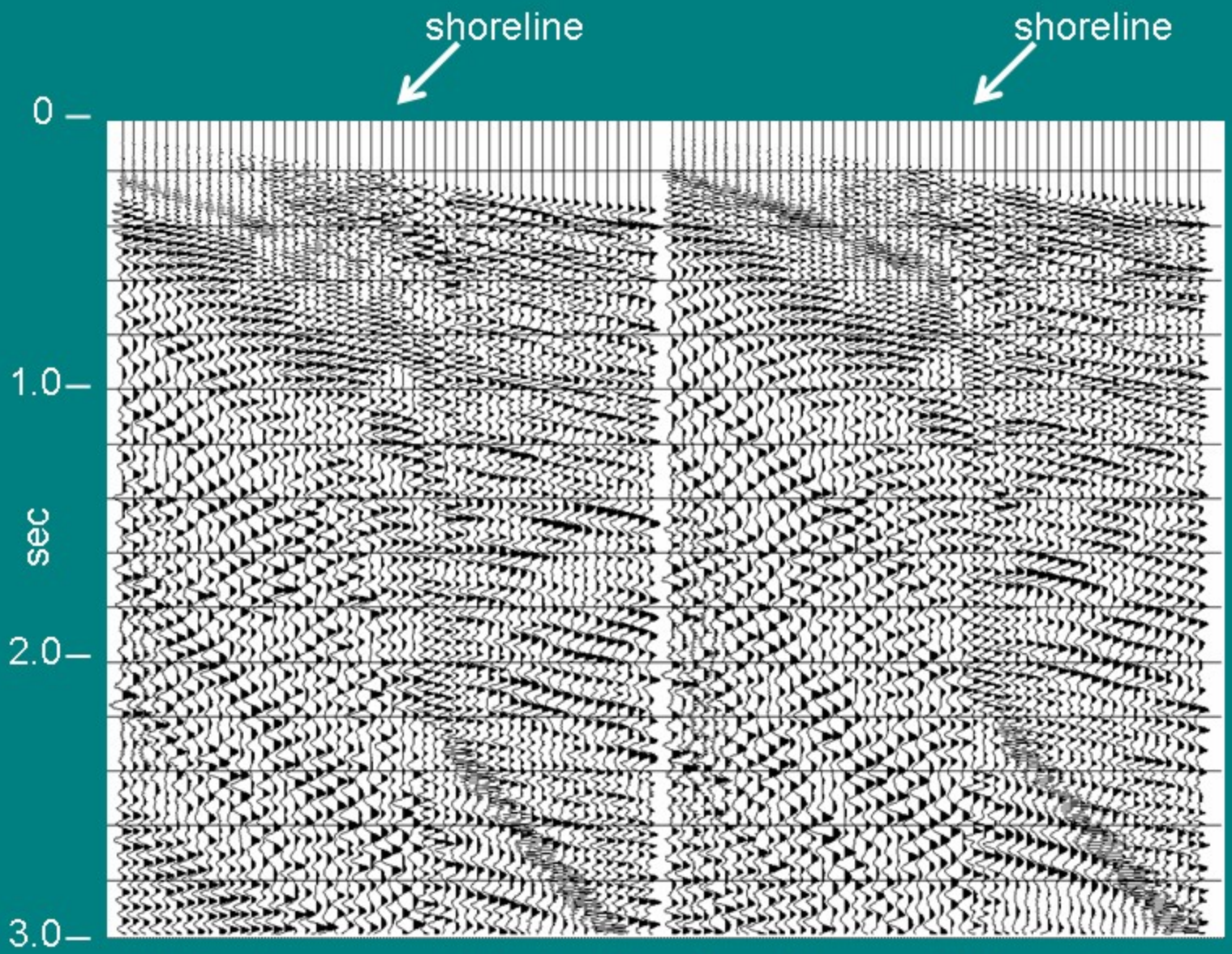
- Common-mode estimate is ***less robust*** for either component than RT coherence estimate done independently for each component
- Polarization does not provide as much mode discrimination as apparent velocity and apparent origin

Ice wave at Hansen Harbour

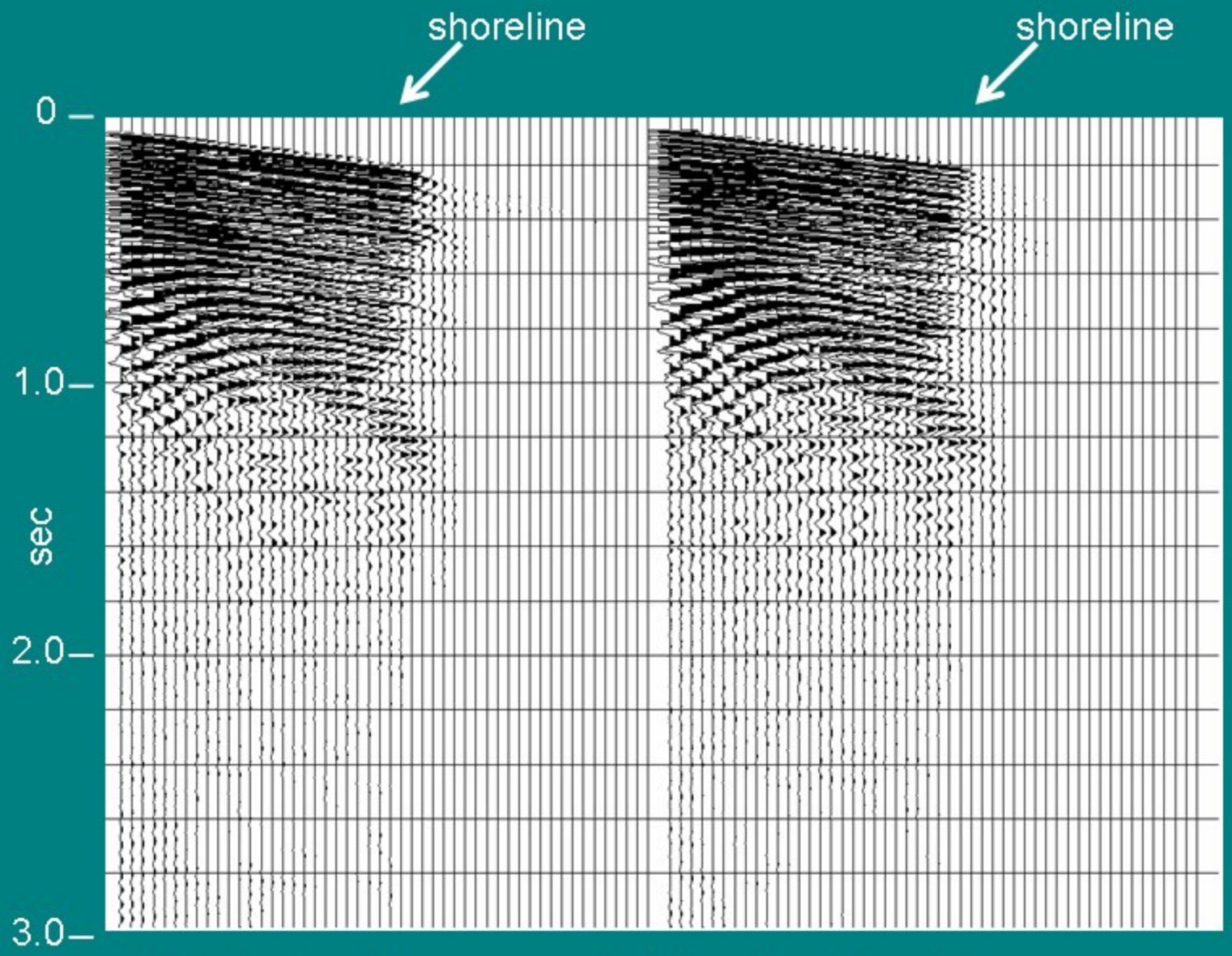
- Hansen Harbour 3-C 2D vibroseis data heavily contaminated with ice flexural wave mode
- Ice wave strongly polarized and very consistent on both vertical and inline horizontal components
- Ice wave does not vary significantly from gather to gather



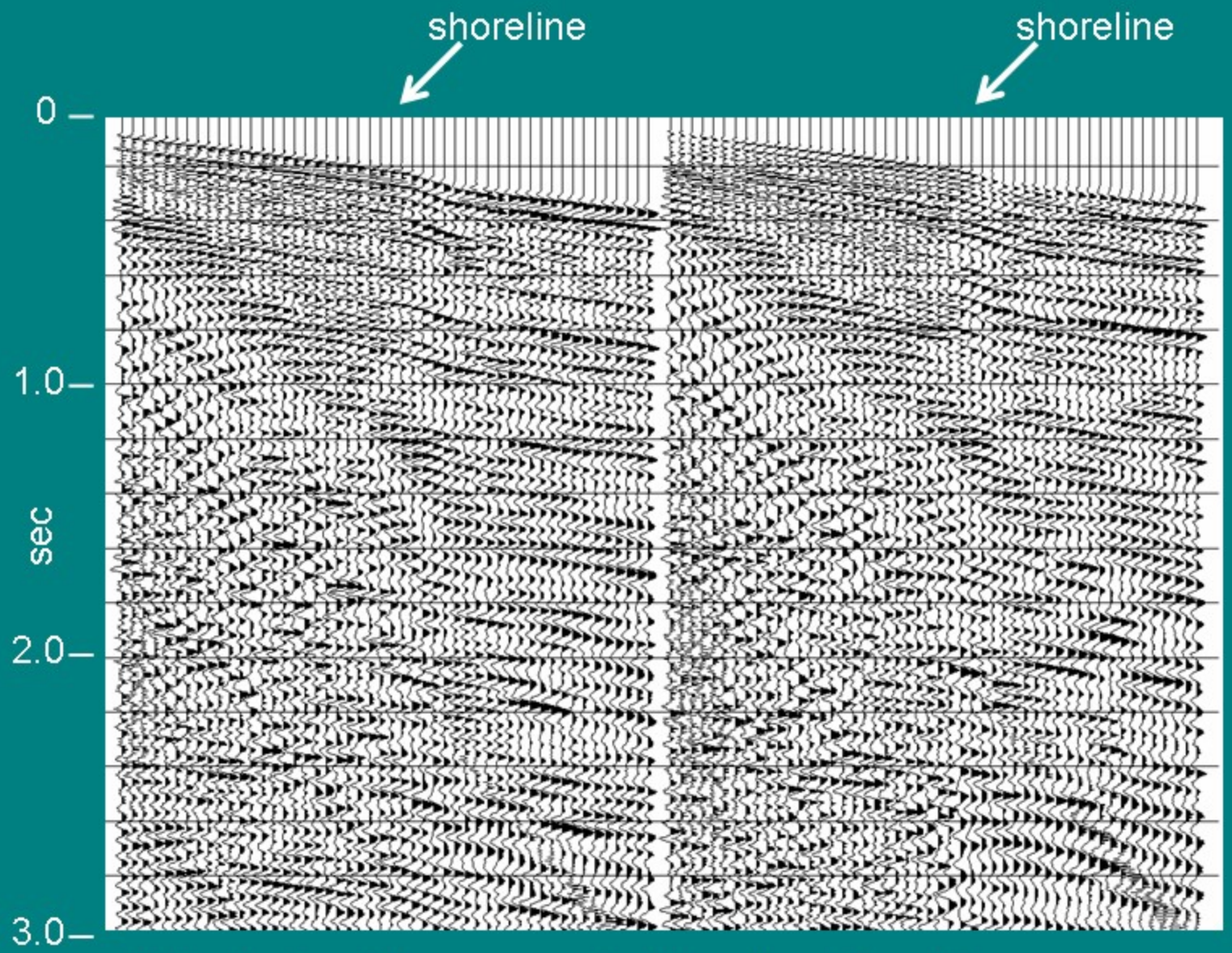
Vertical component shot gathers from Hansen Harbour 3-C seismic survey—no trace scaling applied



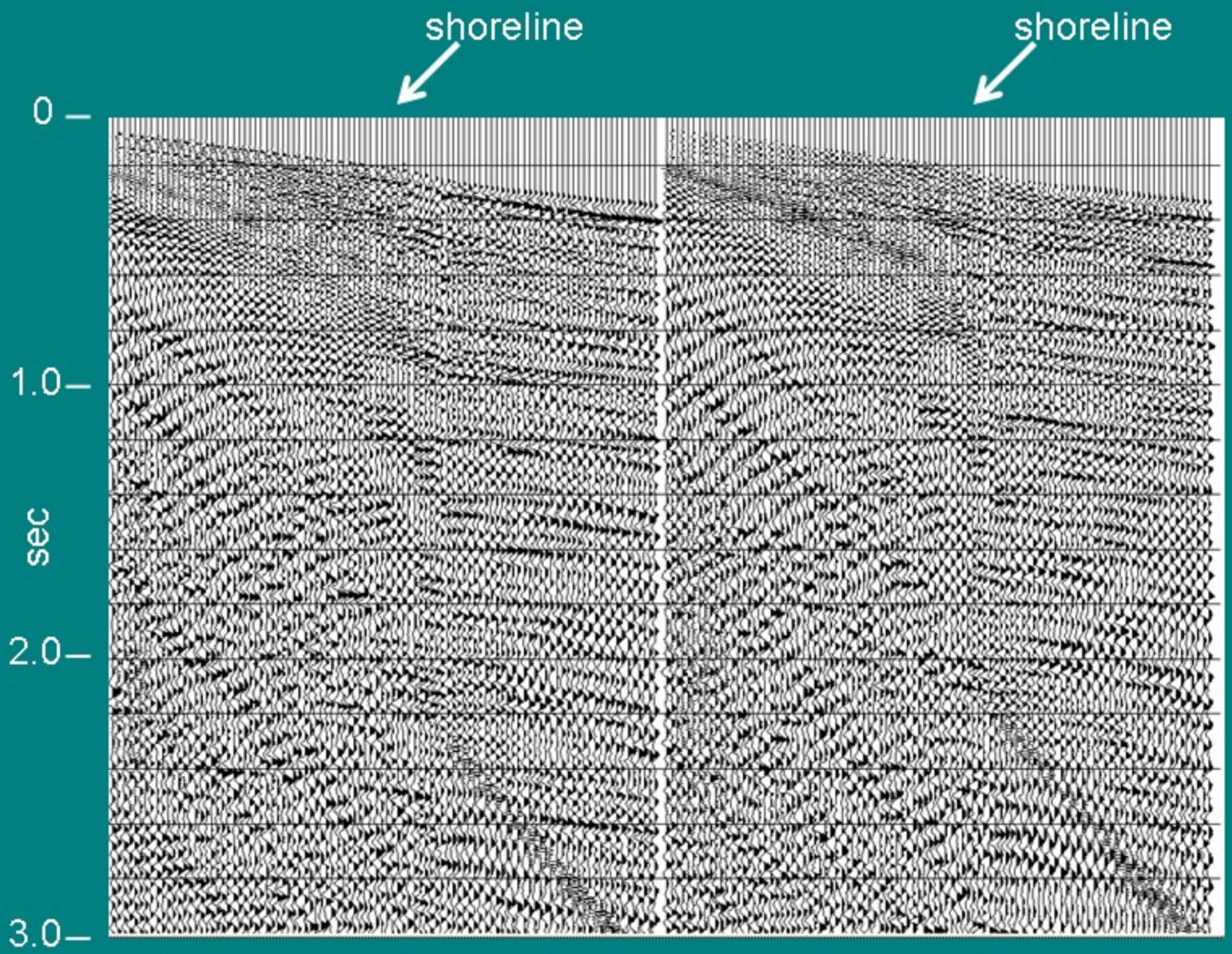
Vertical component shot gathers from Hansen Harbour 3-C seismic survey—AGC applied



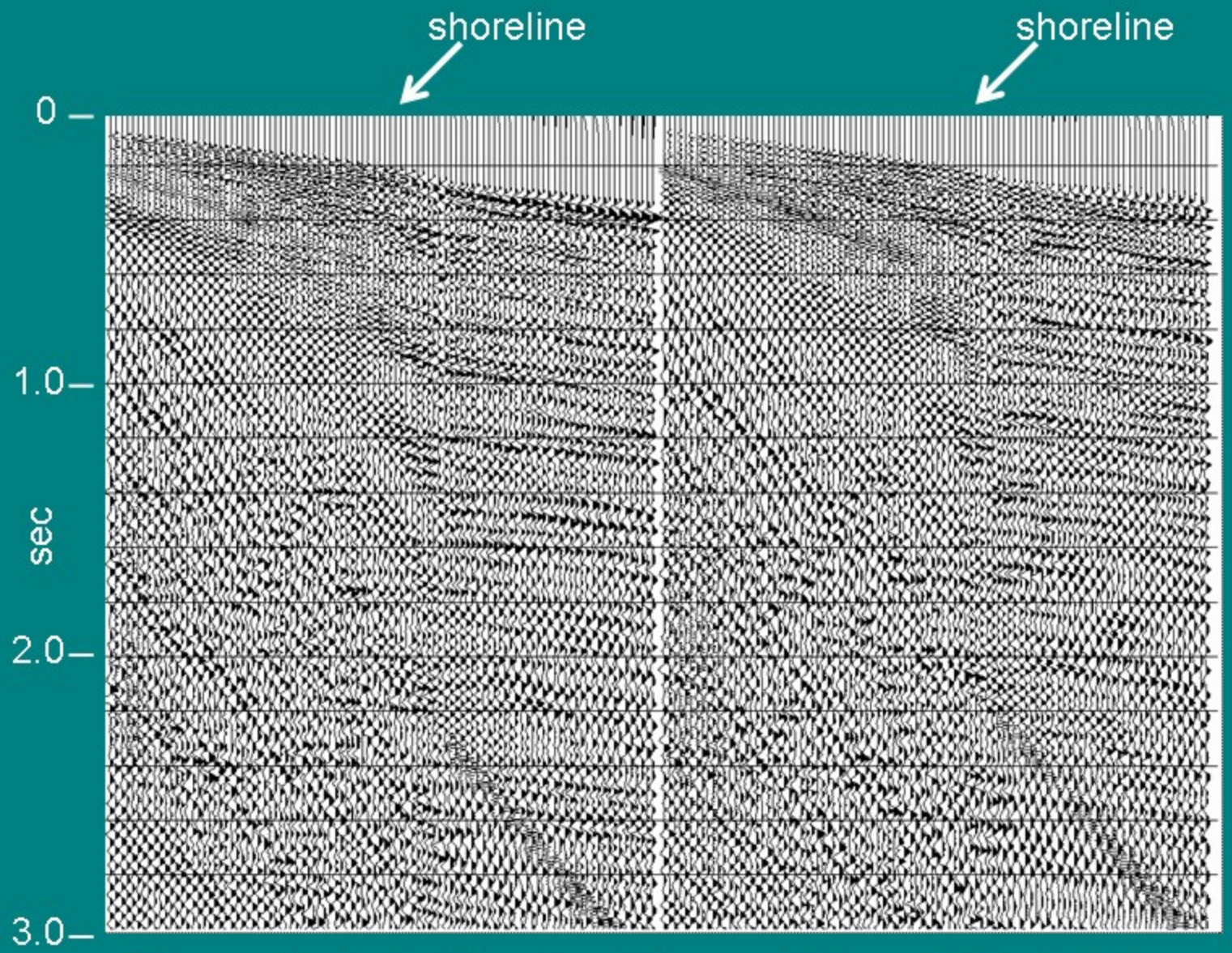
Inline horizontal component shot gathers from Hansen Harbour 3-C seismic survey—no trace scaling applied



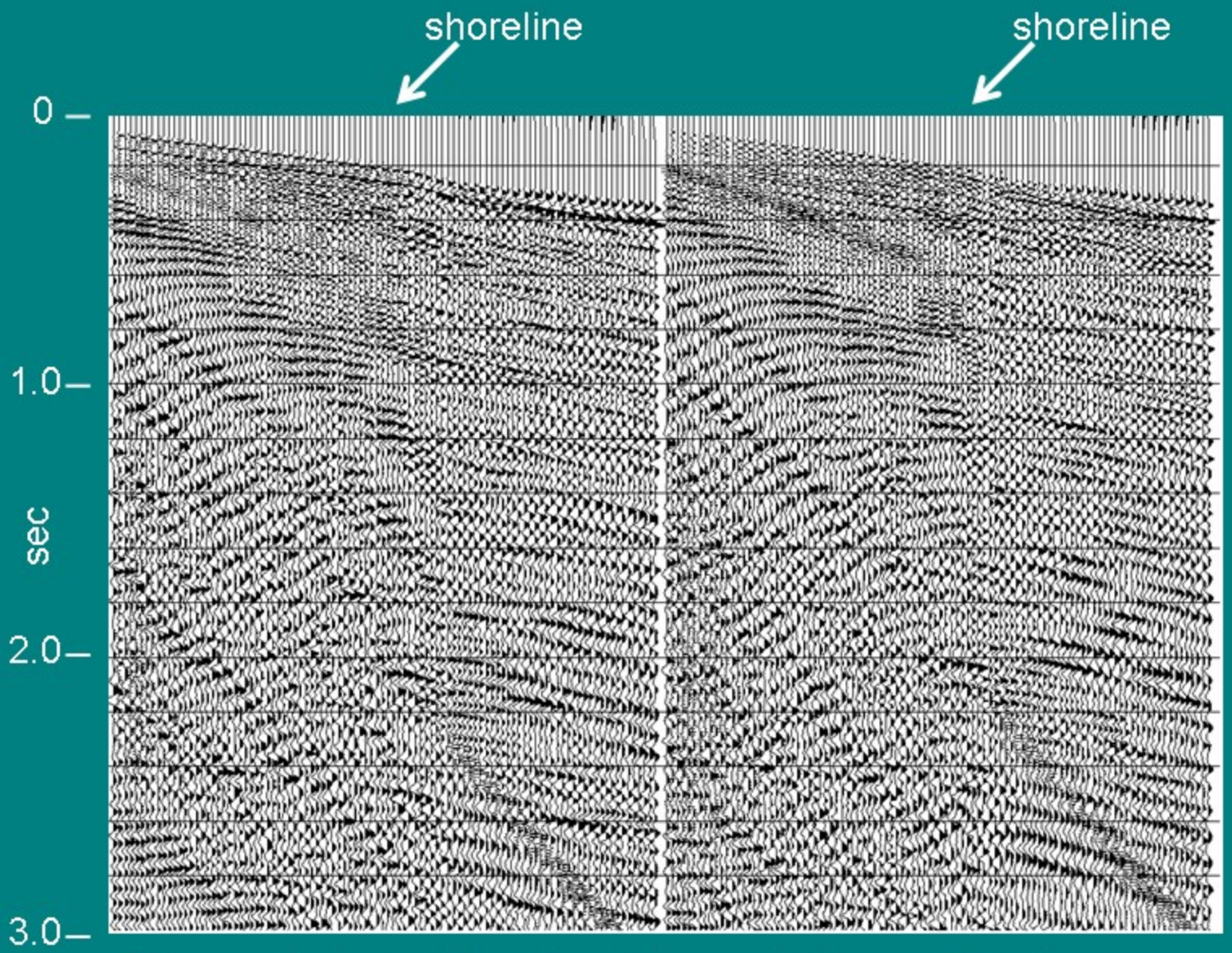
Inline horizontal component shot gathers from Hansen Harbour 3-C seismic survey—no trace scaling applied



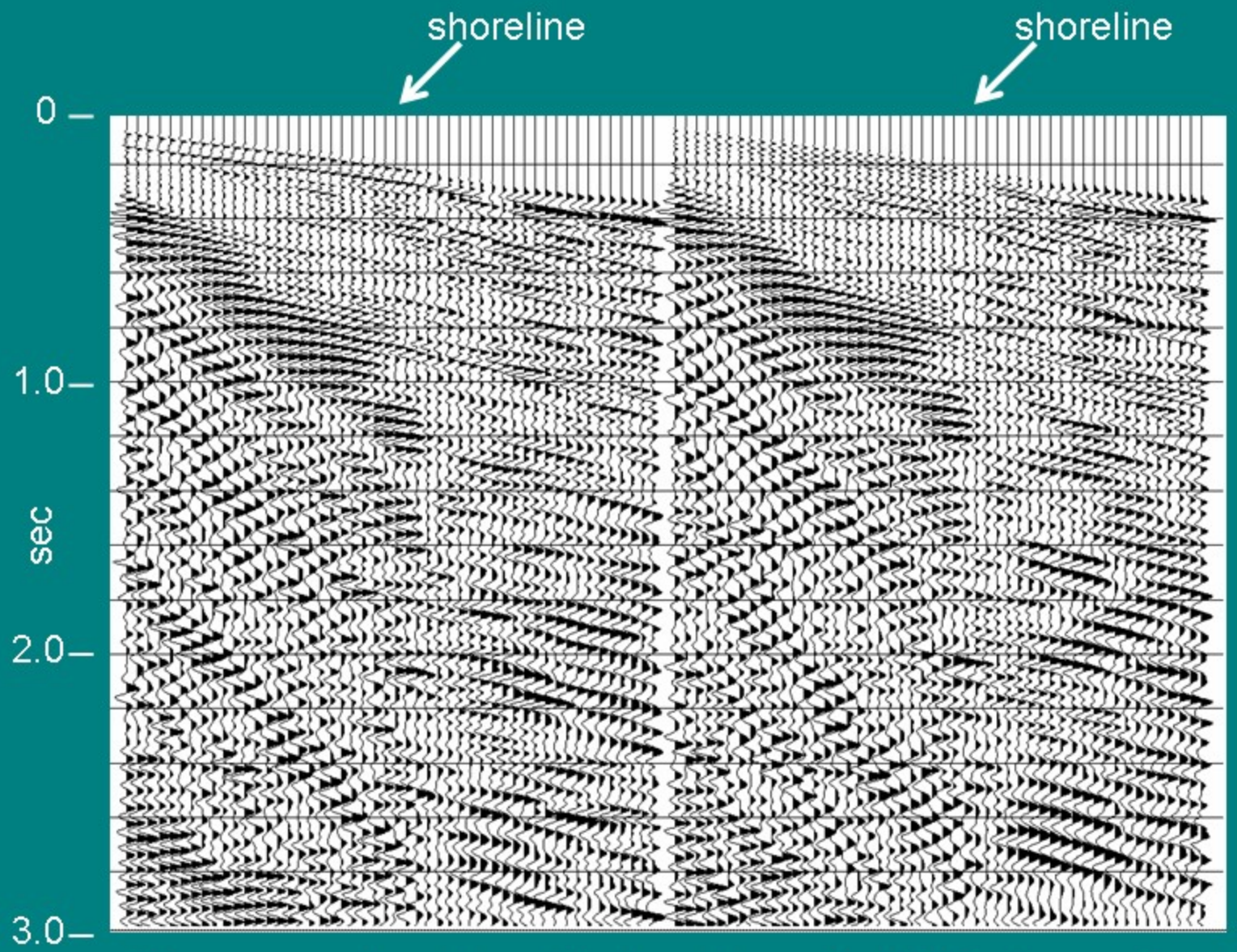
Trace pair shot gathers from Hansen Harbour 3-C seismic survey—no phase adjustment for inline component



Trace pair shot gathers from Hansen Harbour 3-C seismic survey—
plus 90 degree phase adjustment for inline component



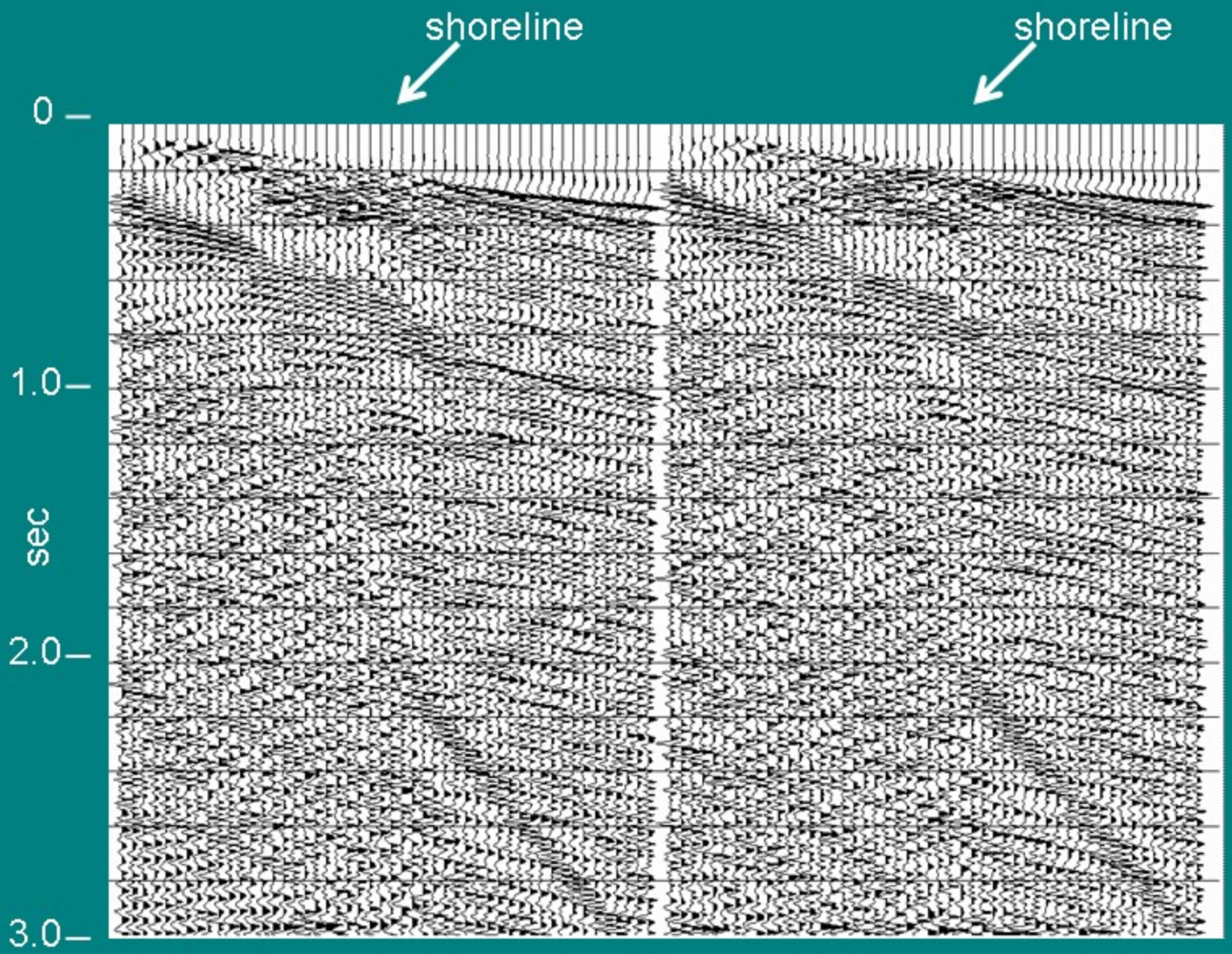
Trace pair shot gathers from Hansen Harbour 3-C seismic survey—minus 90 degree phase adjustment for inline component



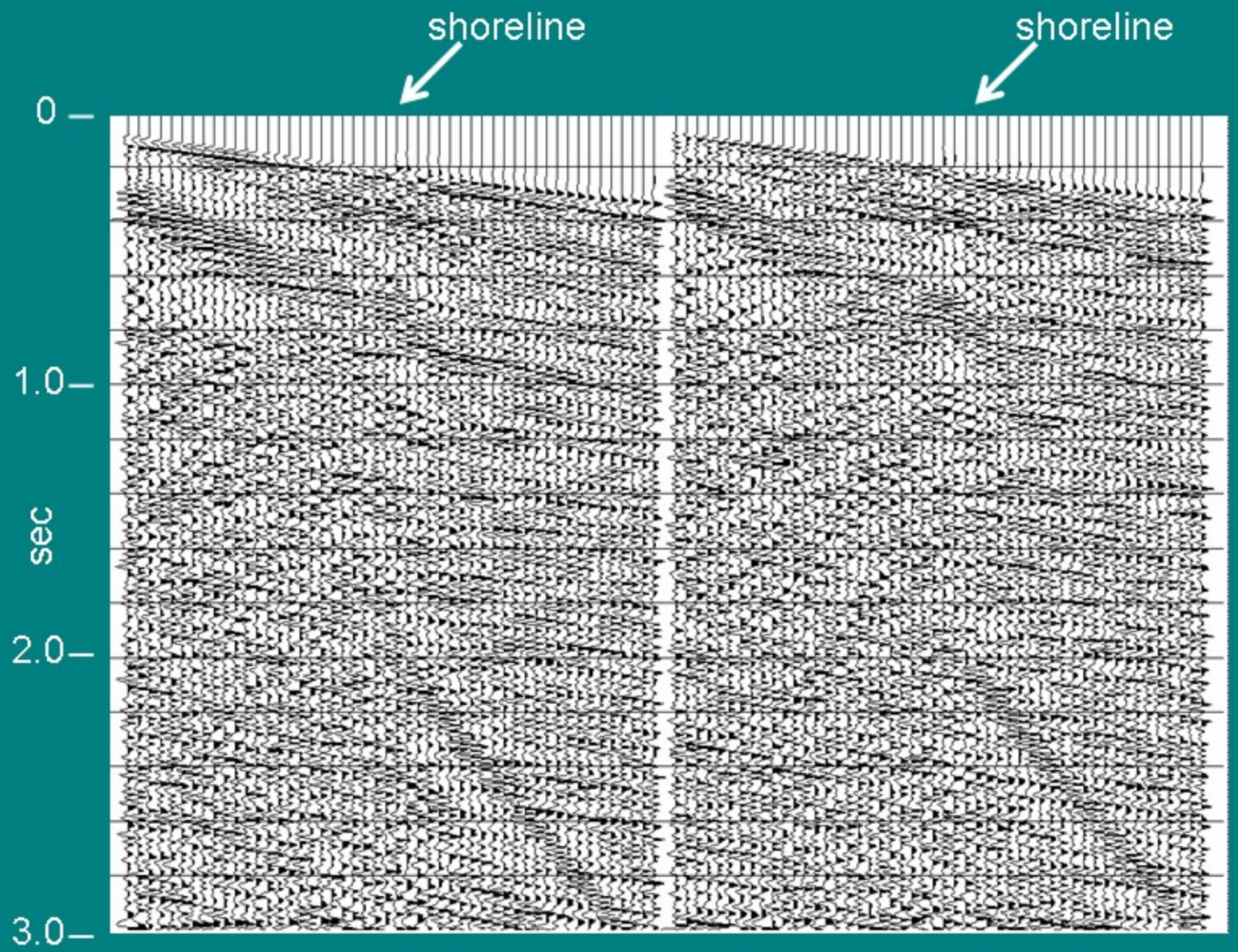
Common-mode noise estimate using vertical/inline trace pairs with -90 degree inline phase adjustment

Alternate ice wave attenuation

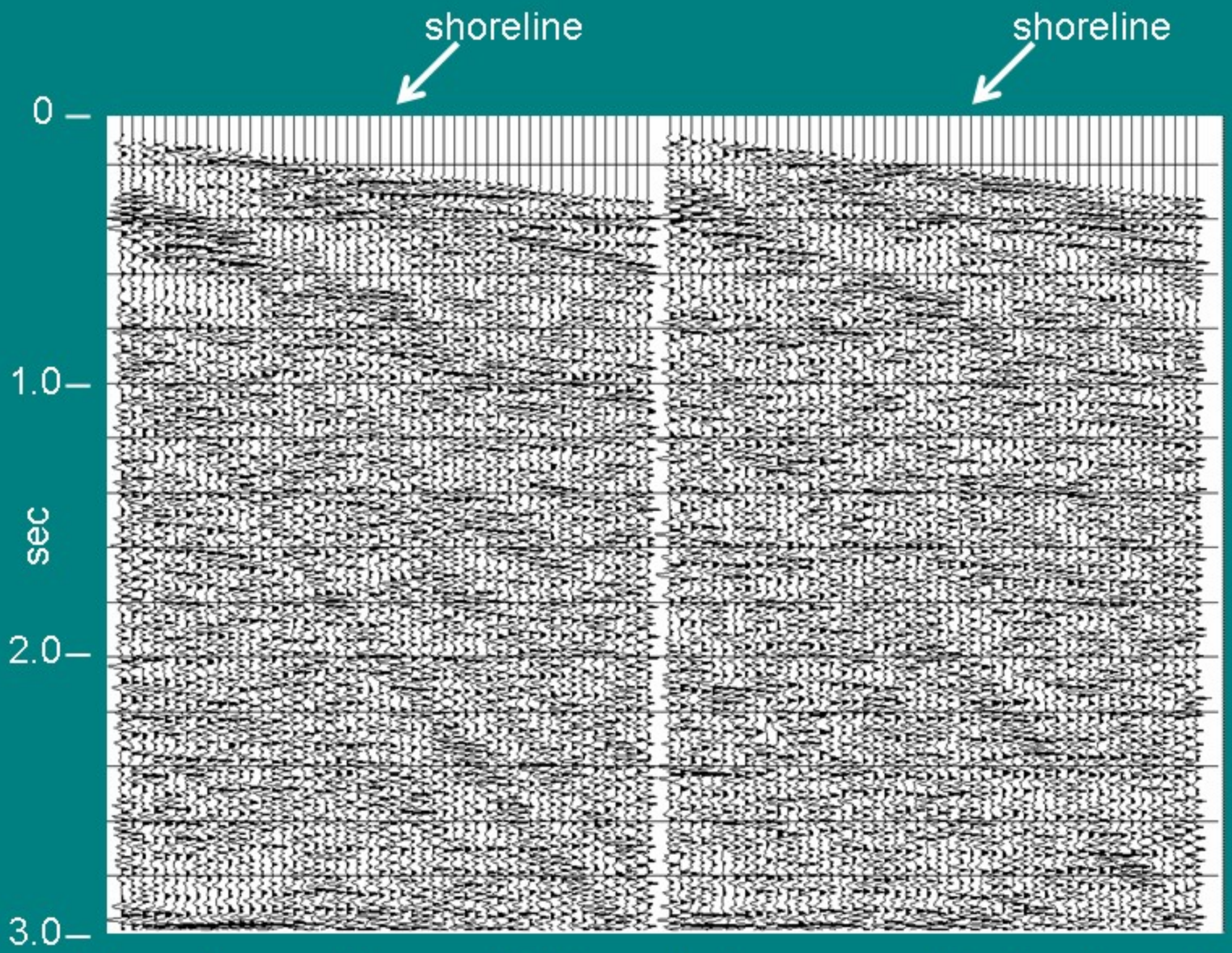
- Transform to RT space—ice wave concentrated in prominent spectral peaks
- Apply spectral clipping to edit RT spectra
- Inverse transform to XT domain
- Apply Gabor deconvolution to boost signal spectrum



Gabor deconvolution applied to raw vertical component shot gathers to boost reflection signal



Gabor deconvolution applied to vertical component shot gathers after subtraction of common-mode noise estimate in Figure 33.



Gabor deconvolution applied to vertical component shot gathers after RT domain spectral clipping. Fragmentary reflections are visible.

Summary

- Common-mode technique provides good noise estimate due to the strength and consistency of the noise on both components. ***However:***
- Common-mode discrimination is not as effective as an RT domain technique using apparent velocity, apparent origin, and dispersion as discriminating characteristics

Conclusions

- Particle motion polarization can be used as a coherent noise discrimination characteristic.

However…

- Even for noise modes very well characterized by polarization, other discriminating characteristics may be more effective for noise attenuation
- Common-mode estimates probably need more than two or three realizations to work effectively, due to statistical considerations

Acknowledgements

- Thanks to CREWES and sponsors for support
- Thanks to Rob Stewart for suggesting the project
- Thanks to P. Daley, A. Haase, G. Margrave for discussions on this topic