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INTERFEROMETRY, RAYPATHS, AND CONVERTED WAVE STATICS

Outline

- Introduction—converted wave statics
- Why *interferometry*?
- Why *raypaths*?
- *Common angle* gathers
- The Spring Coulee survey
- *Pilot trace Interferometry*
- *Differential Interferometry*
- Conclusions

Converted wave statics

- Receiver statics usually ***much larger*** than source statics
- S/N of CW events usually ***less*** than that of P-wave events
- ***Brute force*** methods often required (hand picking, trim statics methods)
- ***Stationarity/surface-consistency*** can be an issue

Why *interferometry* ?

- *Interferometry* avoids hand picking
- Very *large* statics can be found and removed
- *Scattered* and *multi-path* events automatically accommodated
- *Interferometry* proven successful on difficult Arctic data

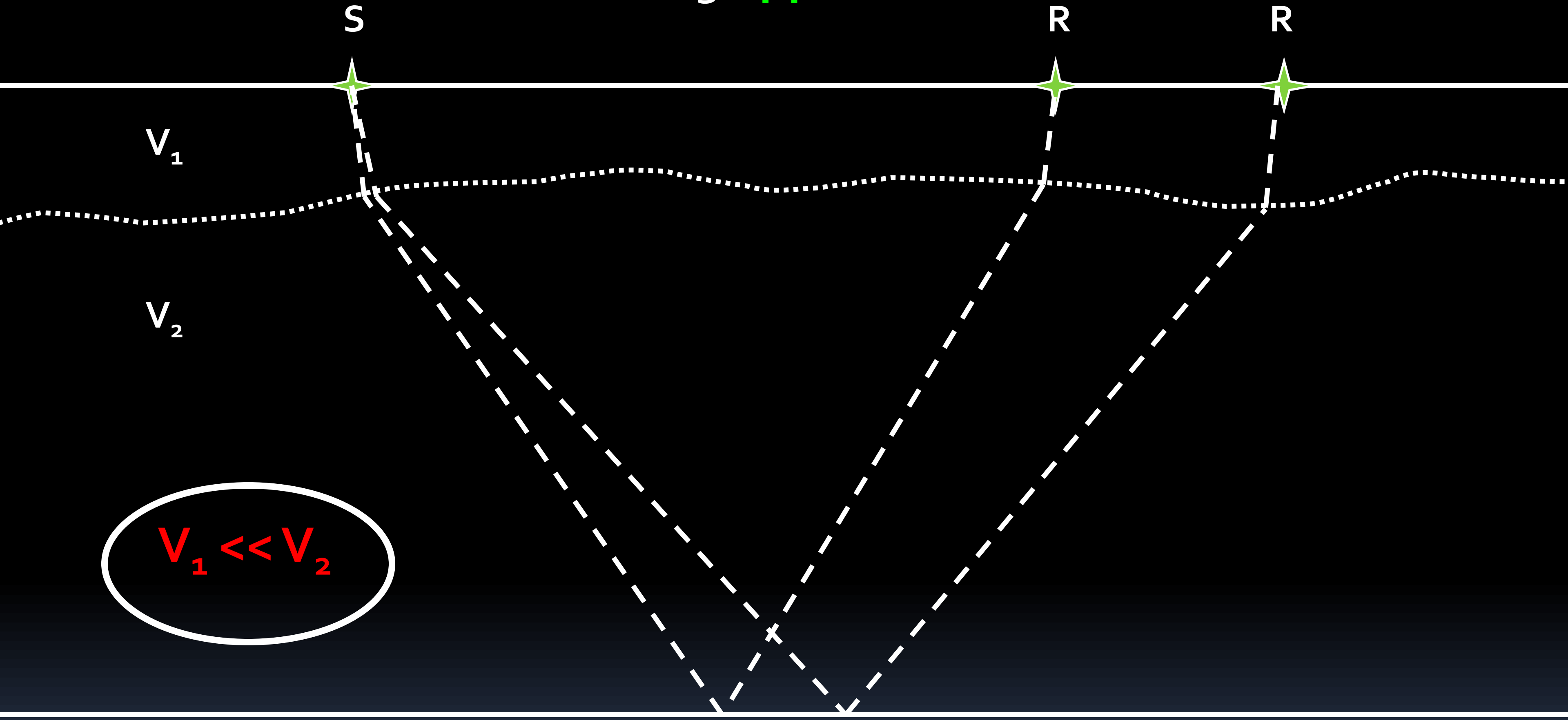
Why *raypaths*?

- Surface-consistency ***not*** required
- Event S/N often ***better*** on raypath gathers
- ***Non-stationary*** statics possible
- ***Raypath*** approach proven successful on difficult Arctic data

Conventional statics method approximations

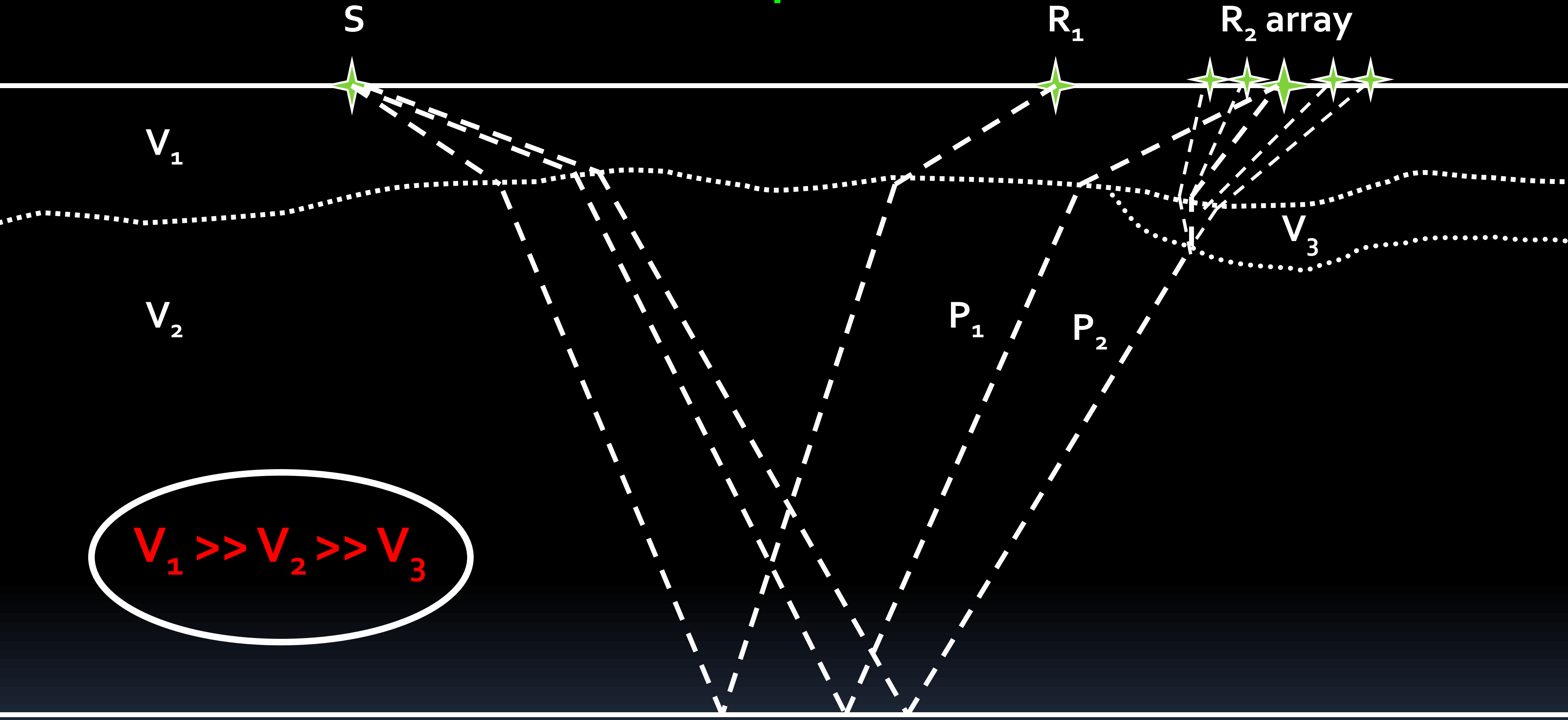
- **Single time shift** *approximately* corrects for **event mismatch** on neighbouring traces
- **Stationarity** assumed (single shift corrects all events on a trace)
- **Surface-consistency** assumed (traces with common shot or receiver have a common static correction
- **Single event arrival** assumed (no scattered or multi-path arrivals)

Conventional statics model assumptions and resulting approximations

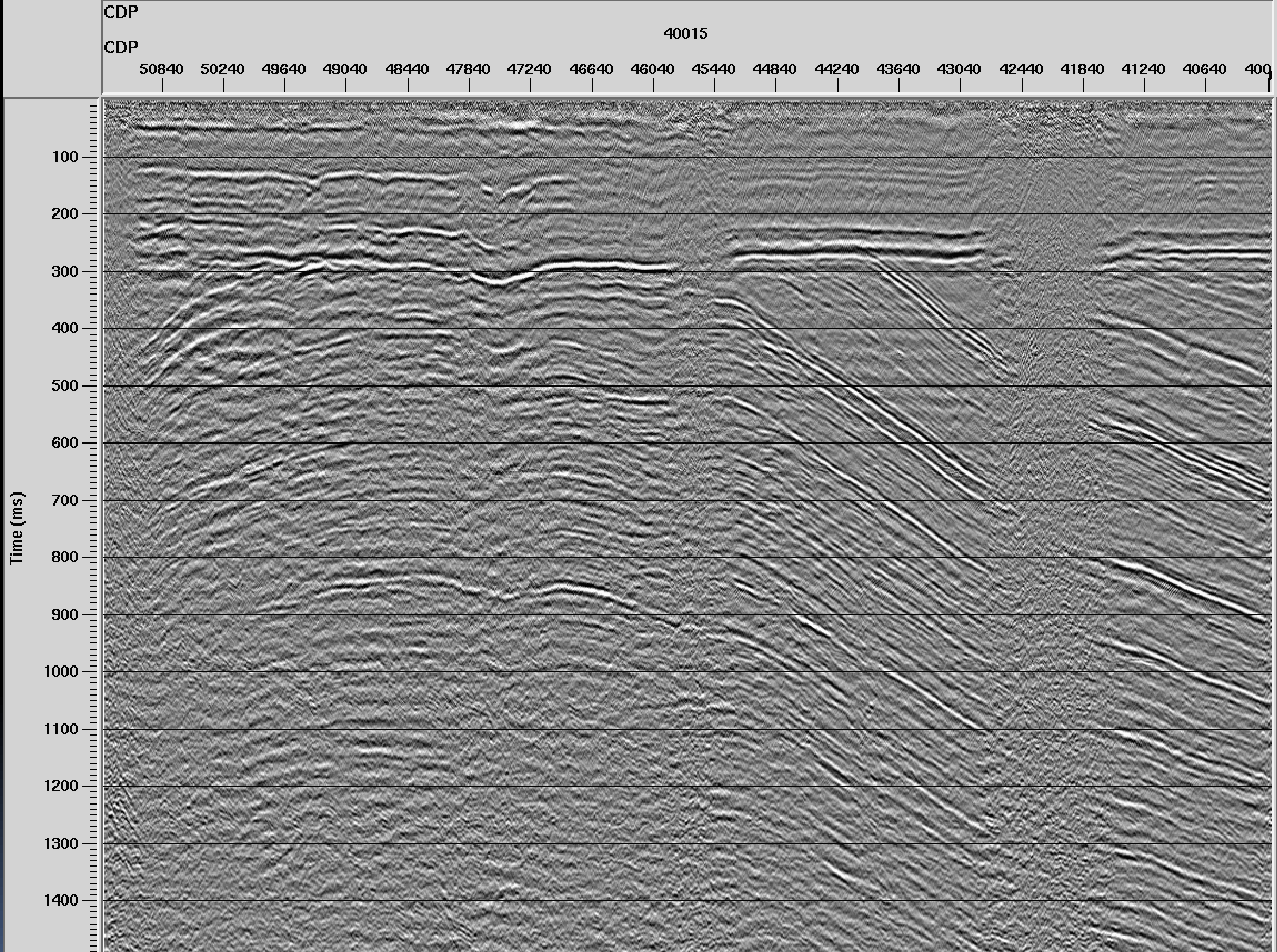


- Near-surface raypath segments vertical: surface-consistent, stationary
- Single point Sources and receivers: surface-consistent, single event arrival
- No scattered or multi-path events: single event arrival

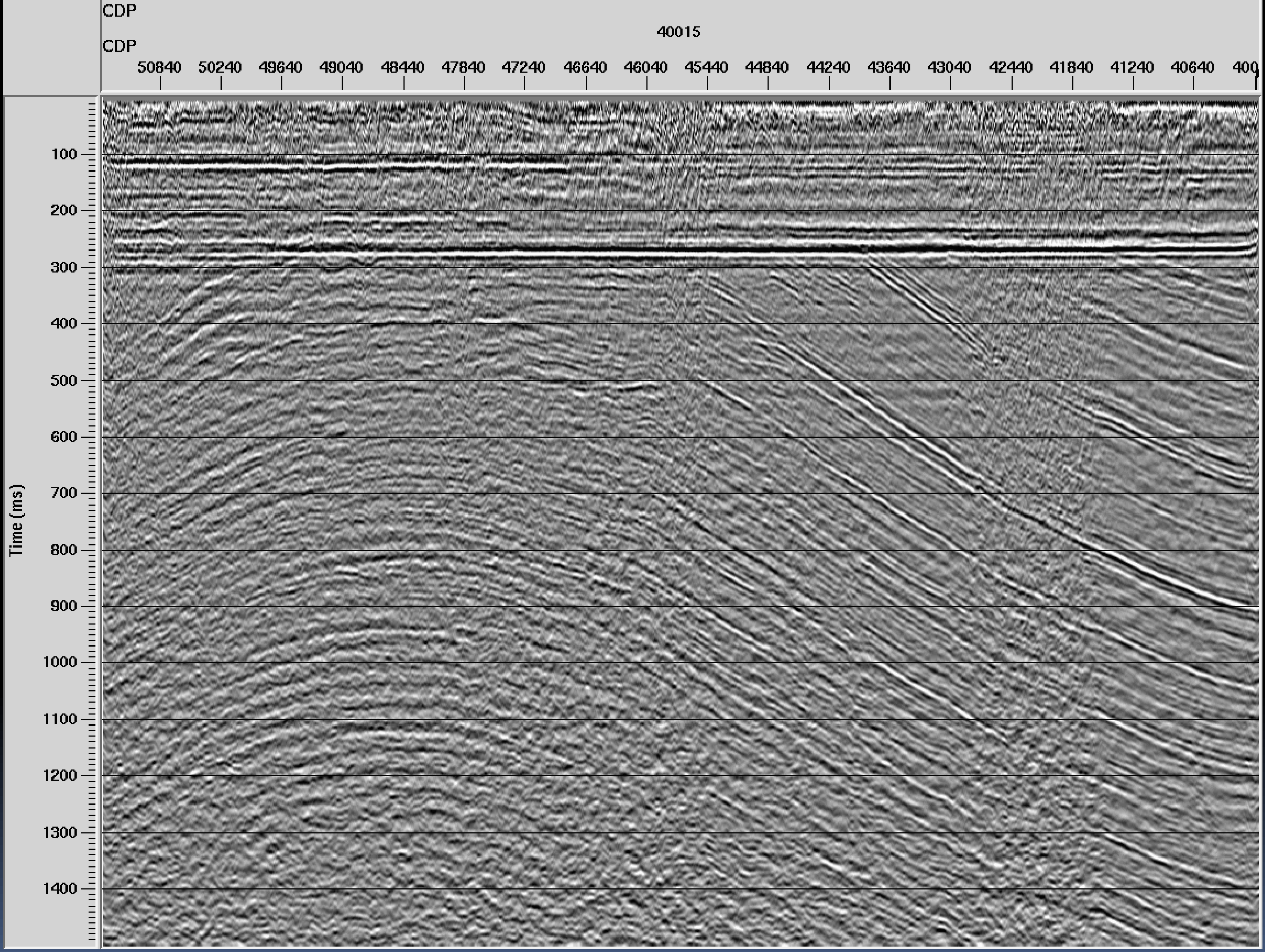
Generalizing the statics model and the **consequences**



- Near-surface raypath segments *not* vertical: *not* surface-consistent, stationary
- Source or receiver *arrays*: *not* surface-consistent, multiple event arrivals
- *Multi-path* events and *scattering* allowed : multiple event arrivals



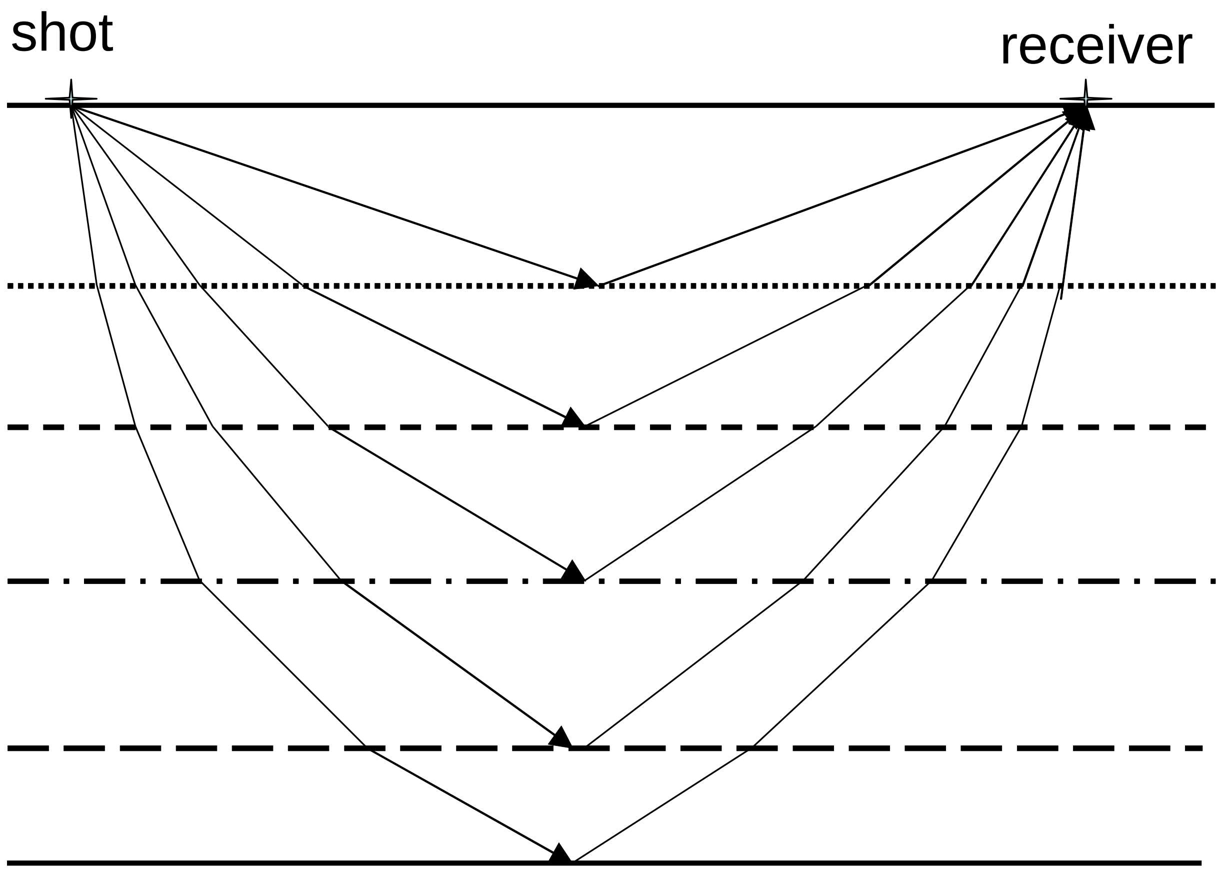
Brute stack of MacKenzie Delta high resolution line



MacKenzie Delta line after raypath interferometry

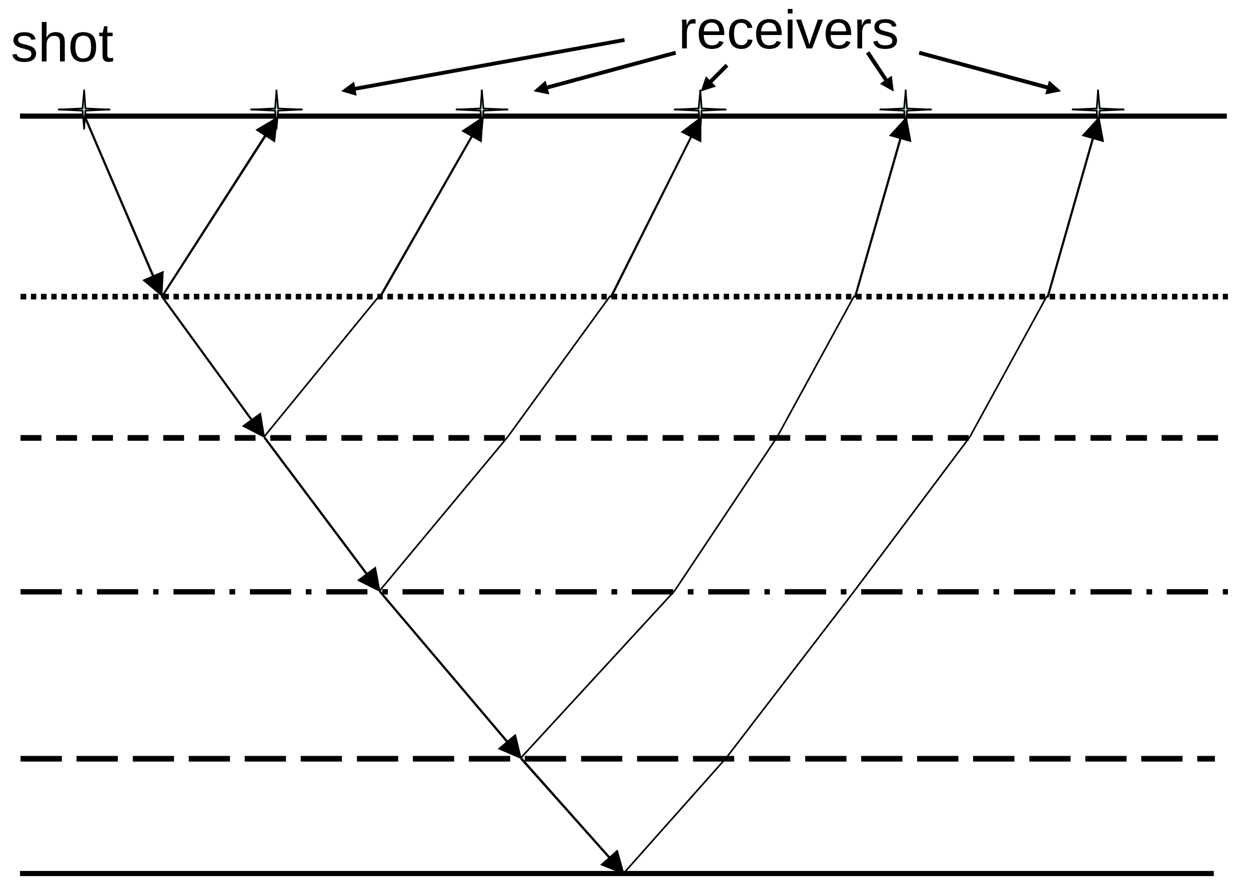
The *raypath* domain—common angle gathers

- Transform ***shot*** or ***receiver*** gathers to the ***radial trace*** domain
- Sort the ***radial traces*** by apparent velocity (***raypath*** angle) and surface location
- Apply ***interferometry*** to common ***angle gathers***
- Sort common ***angle gathers*** back to ***radial trace gathers***
- Invert ***radial trace*** gathers to ***shot*** or ***receiver***



Geometry of a trace in X-T domain

Near-surface raypath angle is an increasing *function of reflection time* for each trace in the X-T domain



Geometry of a trace in R-T domain

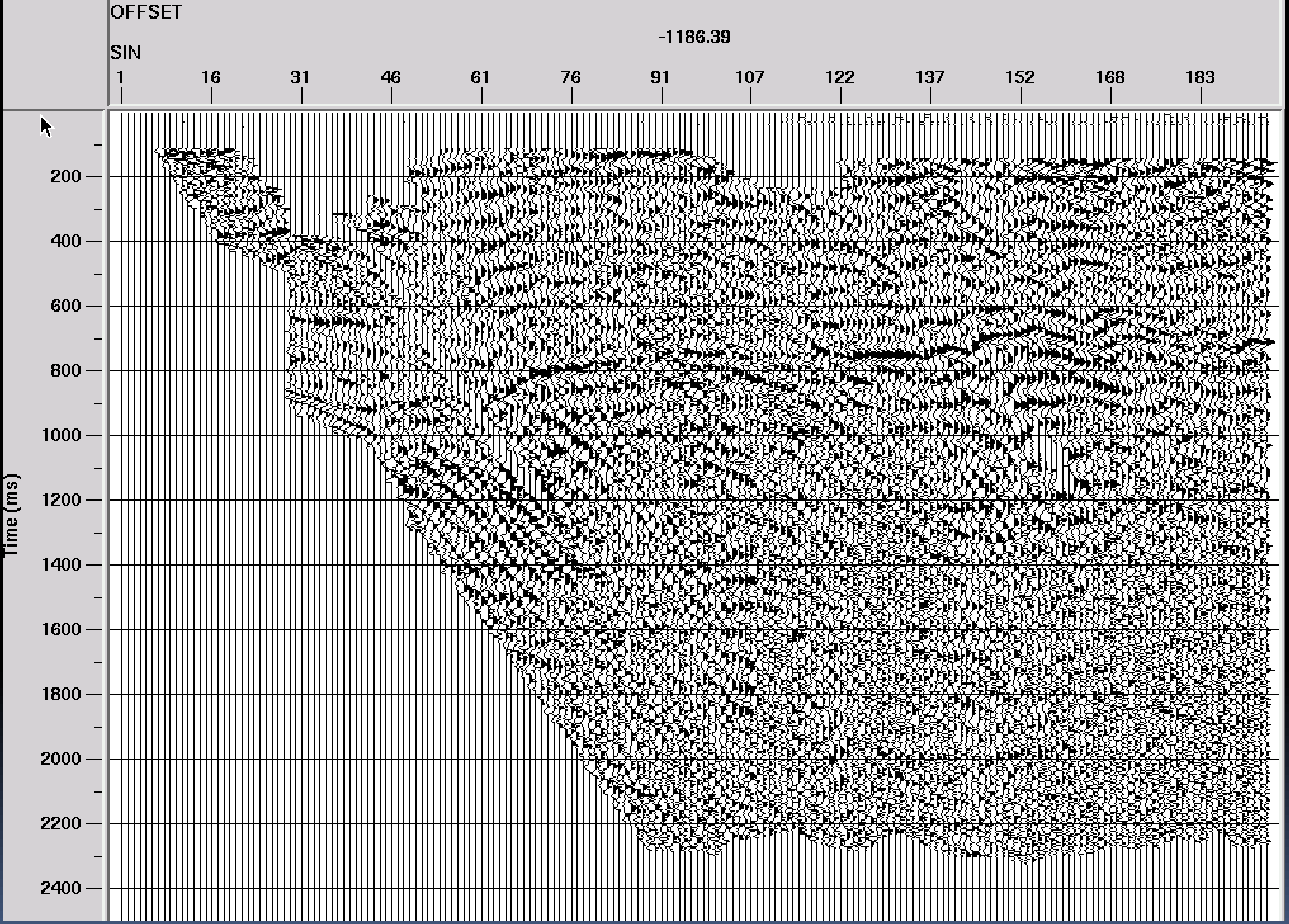
Near-surface raypath angle is *constant* for all reflection times for each trace in the R-T domain

Pilot trace interferometry

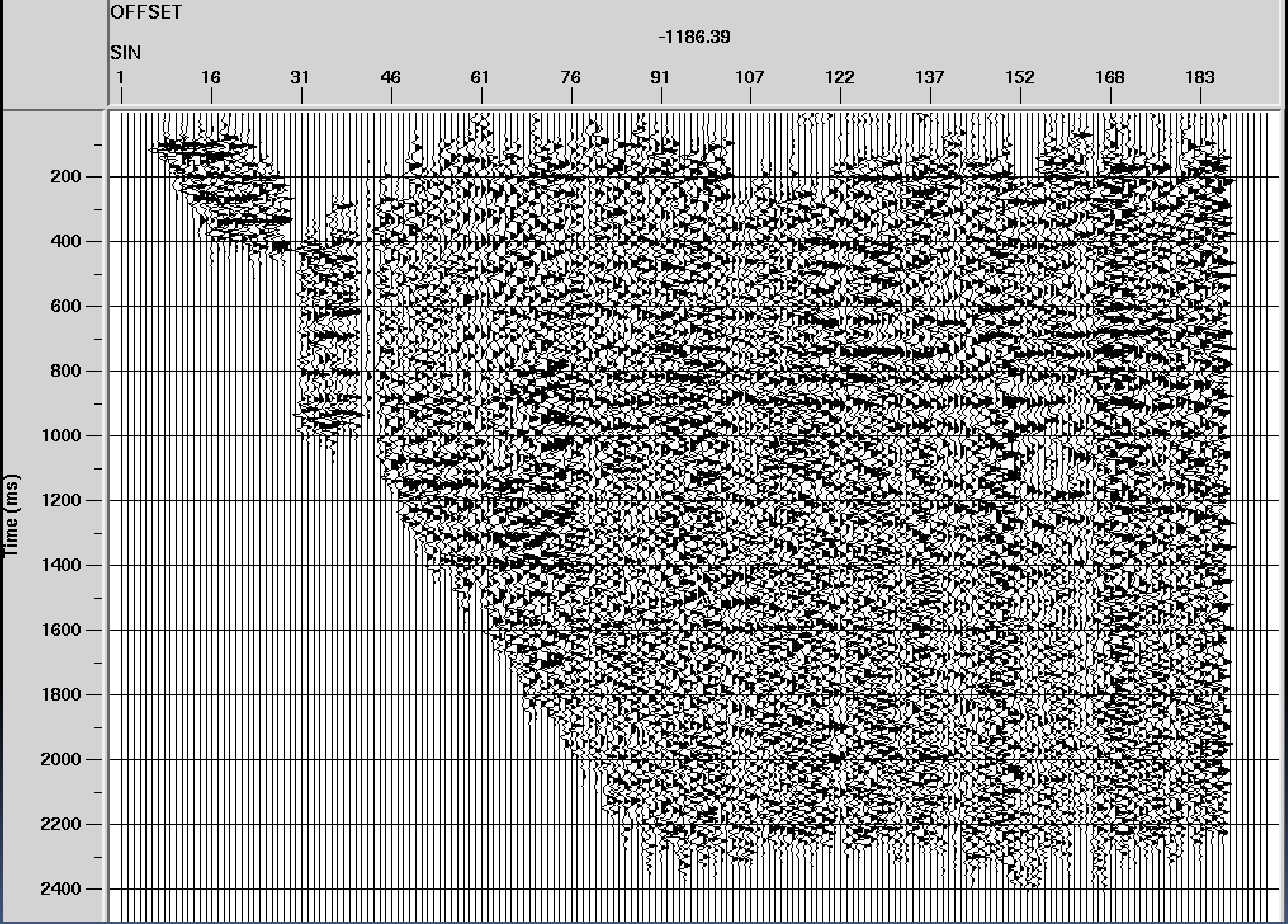
- Choose an ***ensemble*** (shot, receiver, etc.)
- ***Flatten events*** on each ensemble, using picked horizon or trim statics approach
- Apply ***trace mix*** to flattened ensemble to produce ***pilot traces***
- ***Cross-correlate*** raw ***ensemble traces*** with corresponding ***pilot traces***
- Derive ***inverse filters*** from cross-correlations
- Apply ***inverse filters*** to raw ***ensemble traces***

Differential interferometry

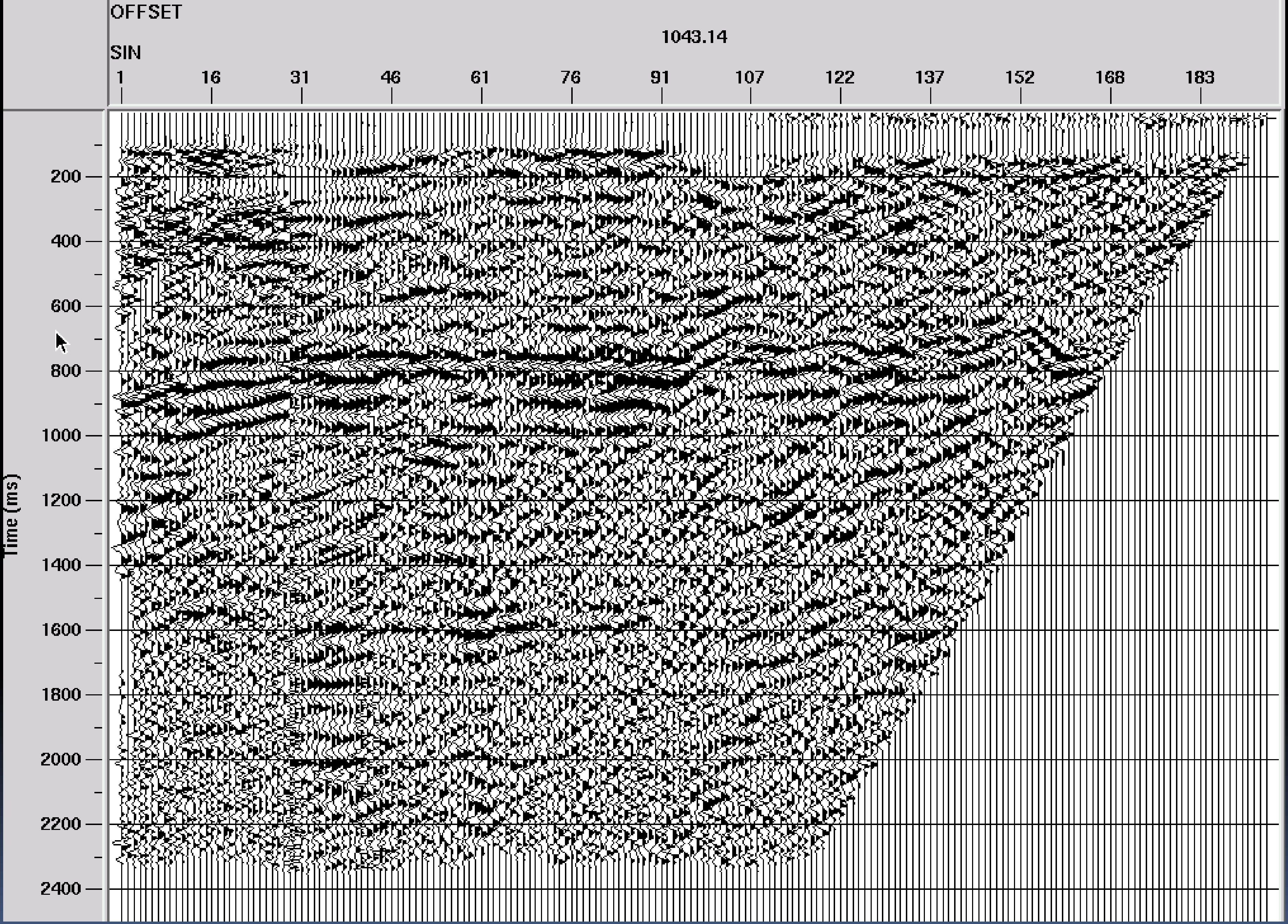
- Choose ***ensemble*** type (shot, receiver, angle)
- ***Cross-correlate*** sequential ***pairs*** of ***raw traces***
- Derive ***inverse filters*** from cross-correlations
- Apply ***inverse filter*** for each ***trace pair*** to the second ***trace*** of the pair—this is the first-order differential correction



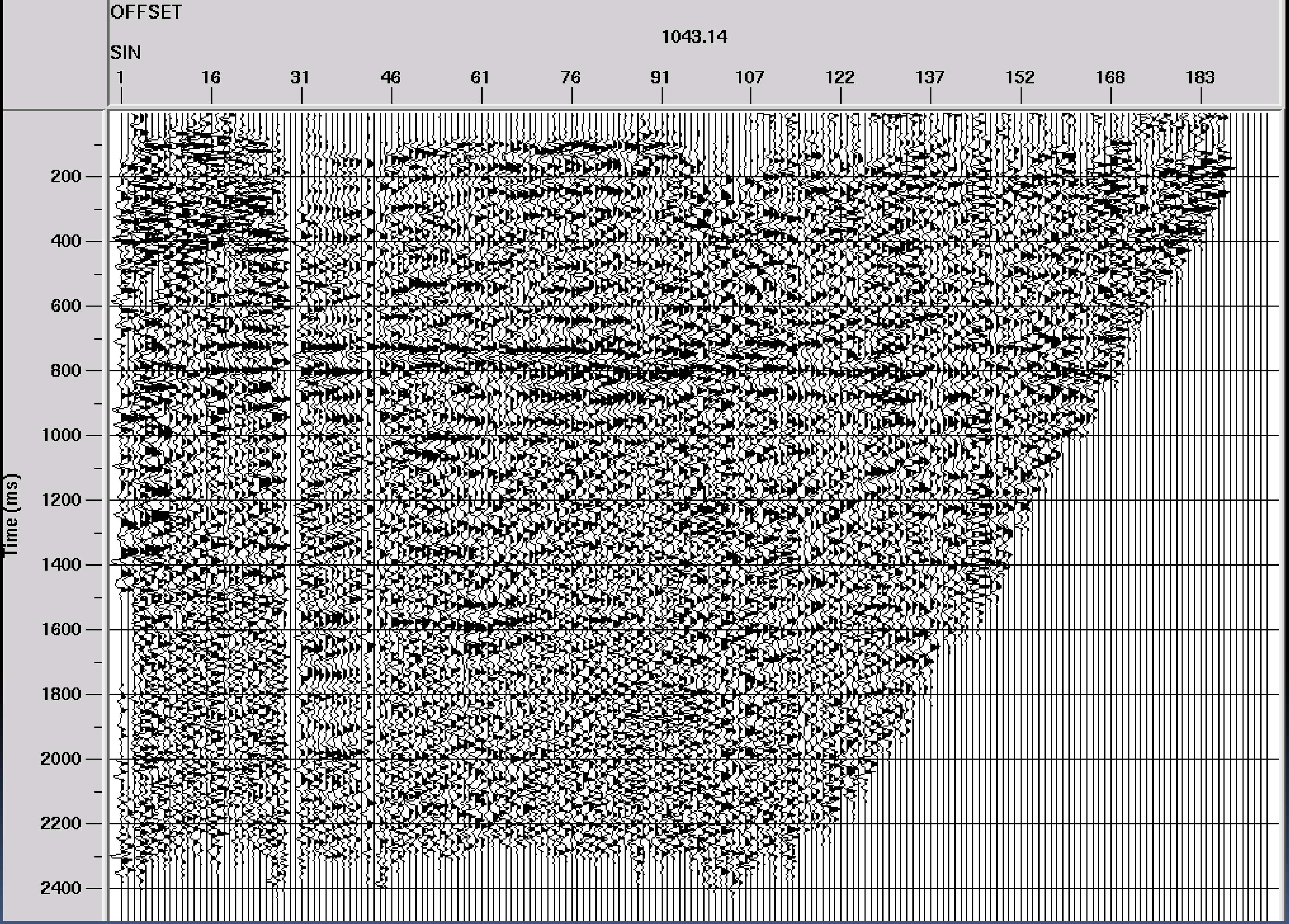
Typical common ***angle gather*** before ***interferometry***



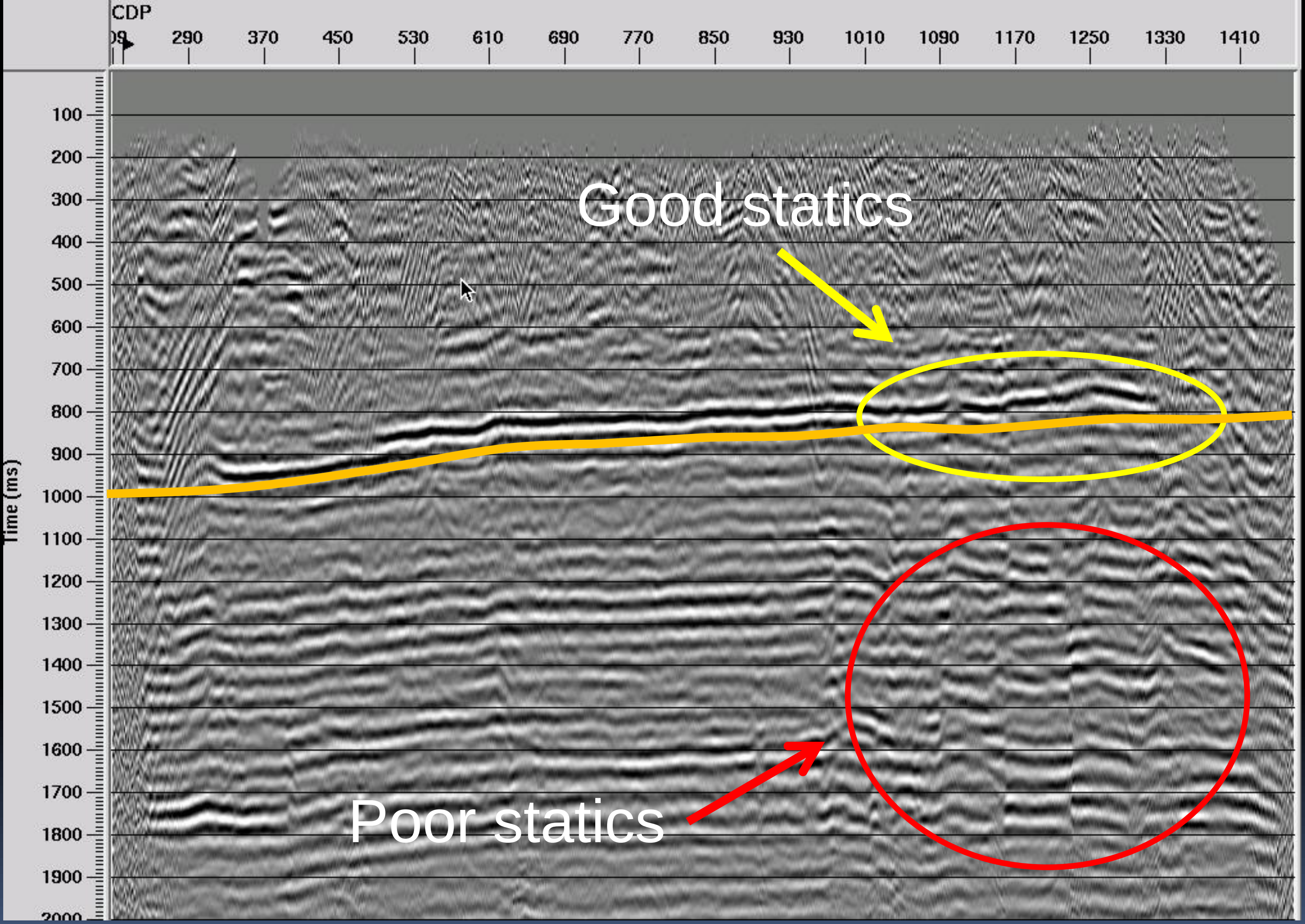
Common ***angle gather*** after ***interferometric*** correction



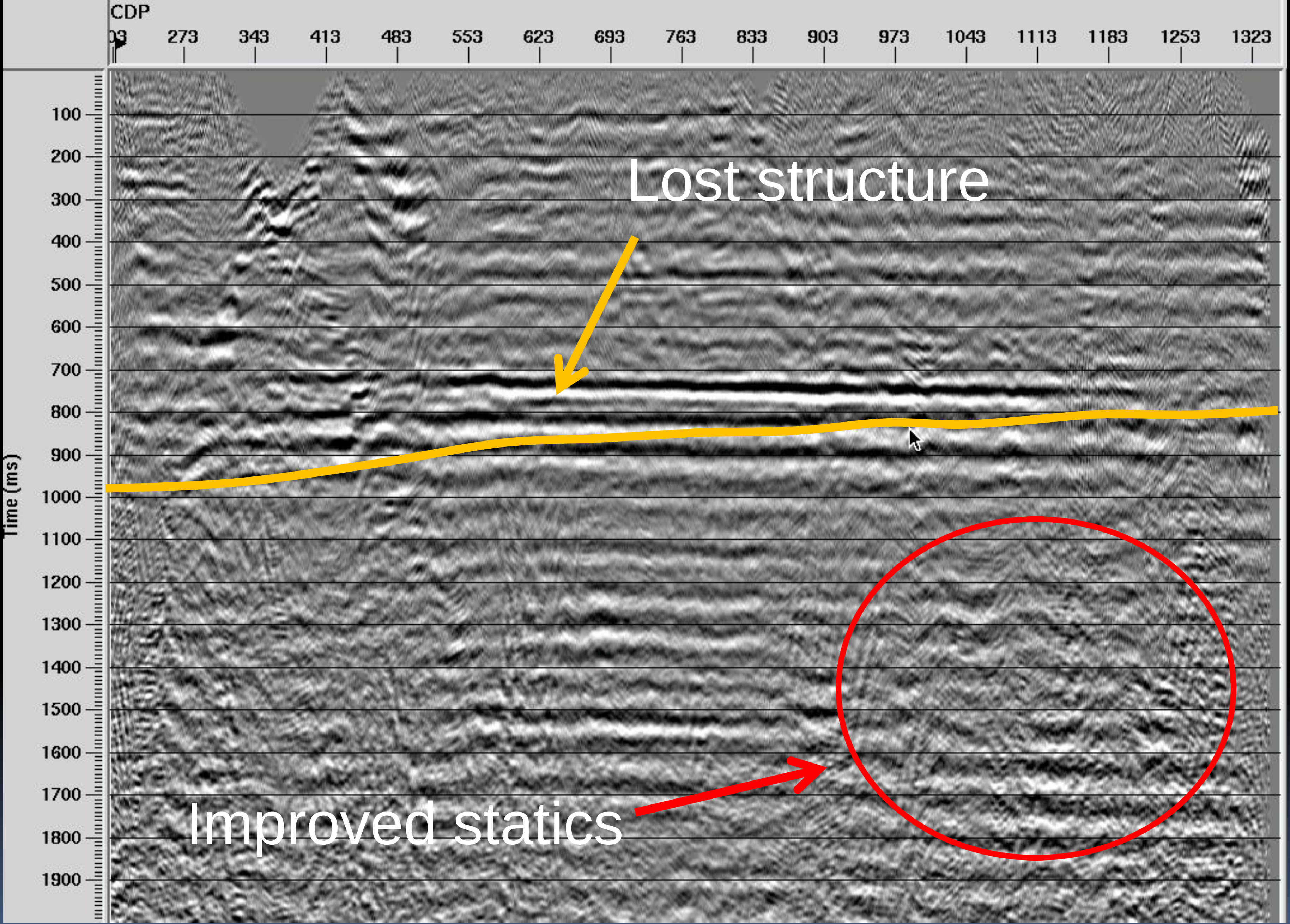
Typical common ***angle gather*** before ***interferometry***



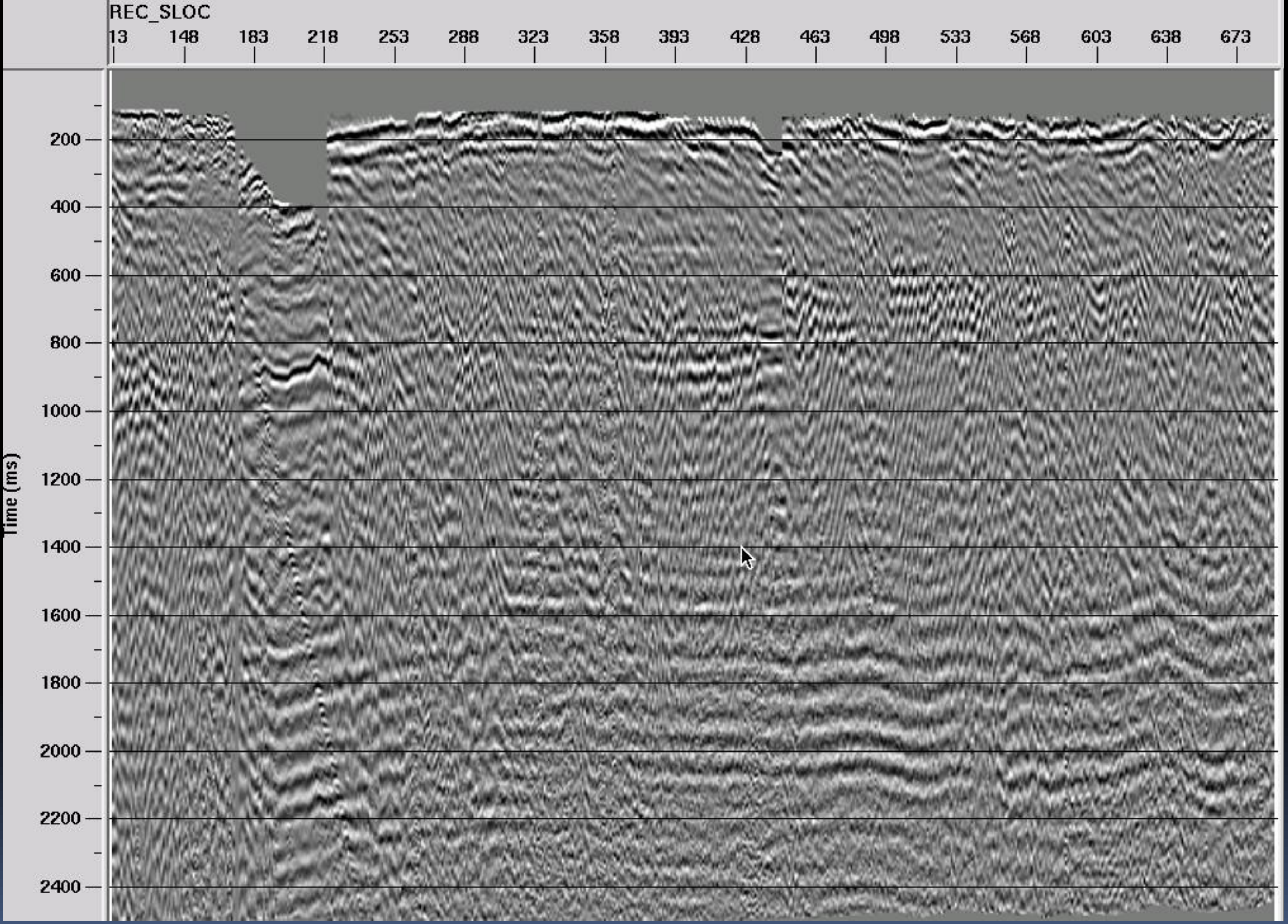
Common ***angle gather*** after ***Interferometric*** correction



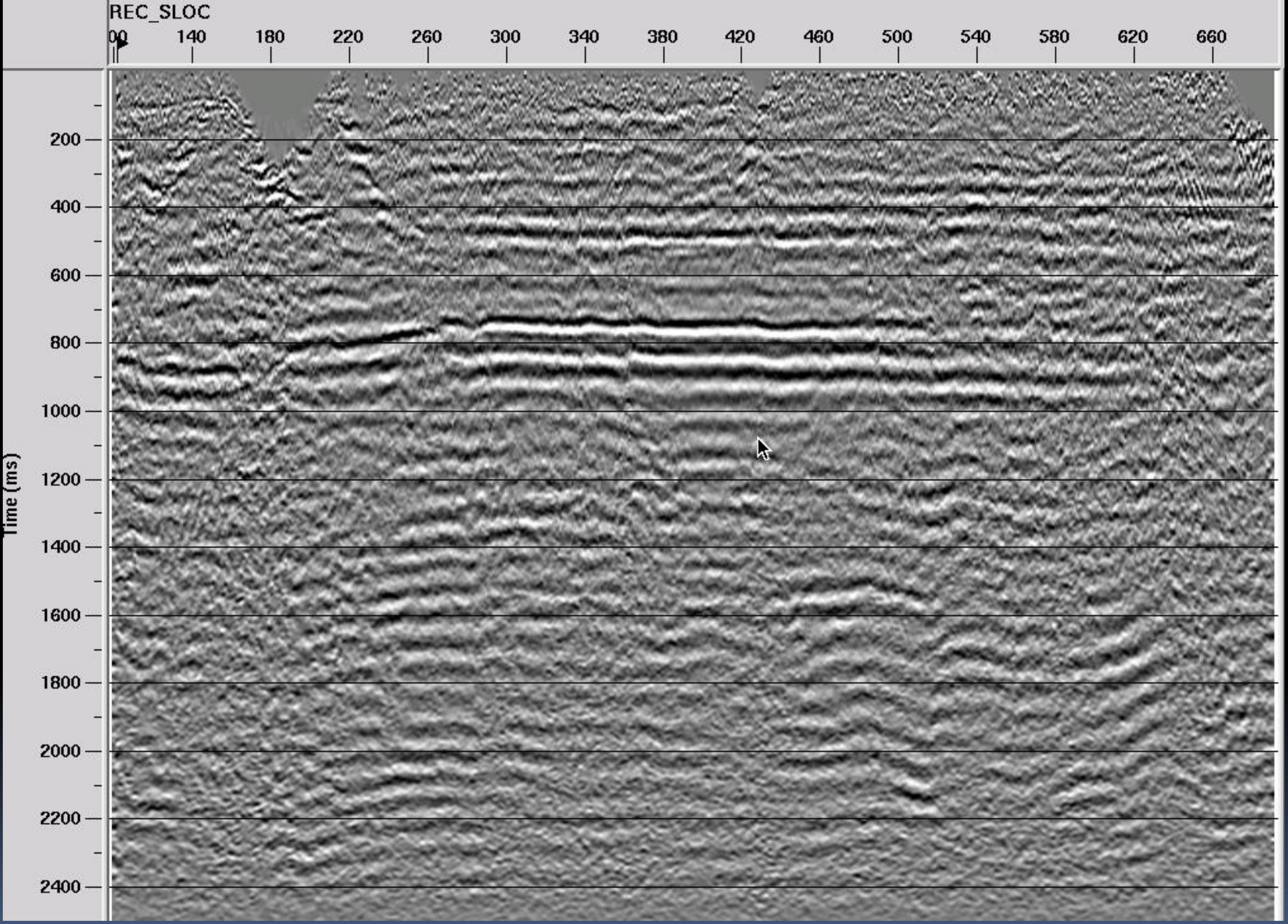
Original processing—***CCP stack***



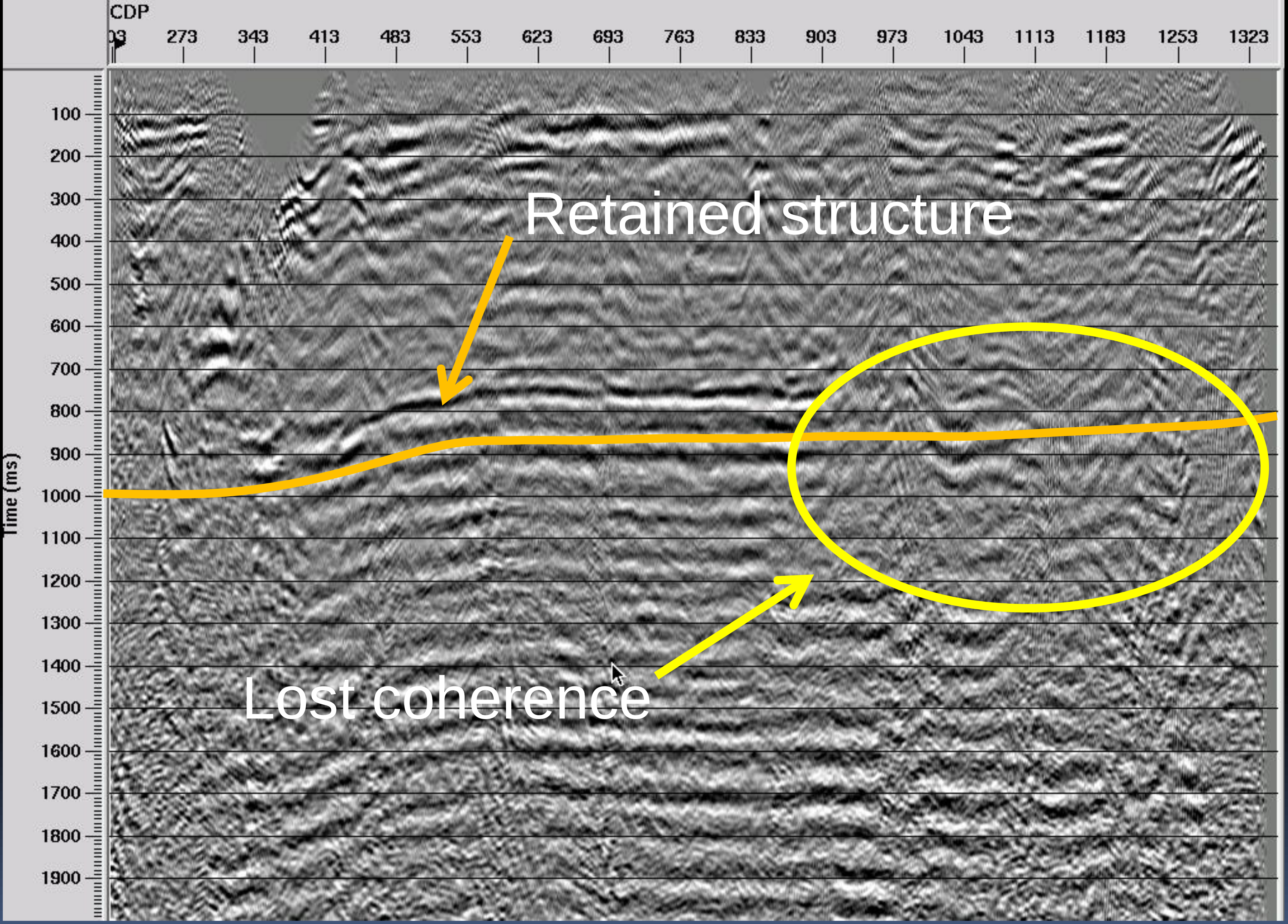
Interferometry applied to ***angle gathers***—approx. ***CCP stack***



Receiver stack of original shot gathers



Receiver stack, ***interferometry*** on ***angle gathers***



Differential ***interferometry*** on ***angle gathers***—approx. ***CCP stack***

Conclusions

- *Interferometric* methods improve event coherency
- *Raypath* methods solve for both shallow and deep events simultaneously
- Events on common *angle gathers* often have high S/N
- *Pilot trace* methods may lose geological structure, but work well on noisy traces
- *Differential* methods keep approximate structure, but are susceptible to noisy traces

Acknowledgements

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