HYBRID INTERFEROMETRY:
SURFACE CORRECTIONS FOR CONVERTED WAVES

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Outline

- *Introduction*—interferometry for surface corrections
- *Hybrid interferometry*—PP vs. PS
- *Assumptions*
- *Complications*—spurious events, structure
- *Model study*
- *Real data example*
- *Discussion*

Interferometry for surface corrections

- **Raw traces** summed to form **pilot traces**
- **Raw traces** cross-correlated with **pilot traces**
- **Inverse filters** derived from **cross-correlations**
- **Inverse filters** convolved with **raw traces** to apply surface corrections
- **Surface**-consistency generalized to **raypath**-consistency
- **Stationarity** abandoned

Example: MacKenzie Delta
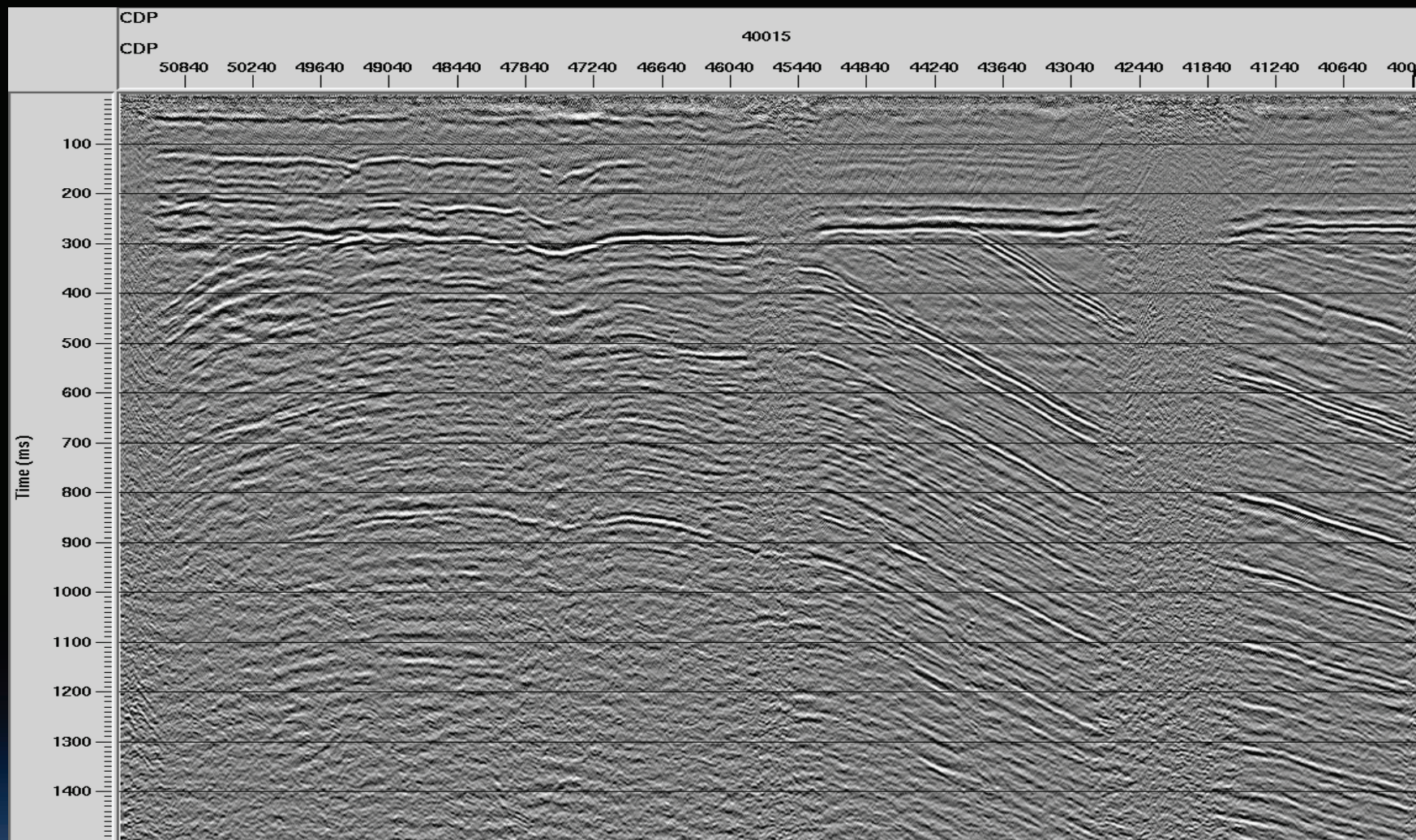
Brute stack of MacKenzie Delta high resolution line

Example: MacKenzie Delta
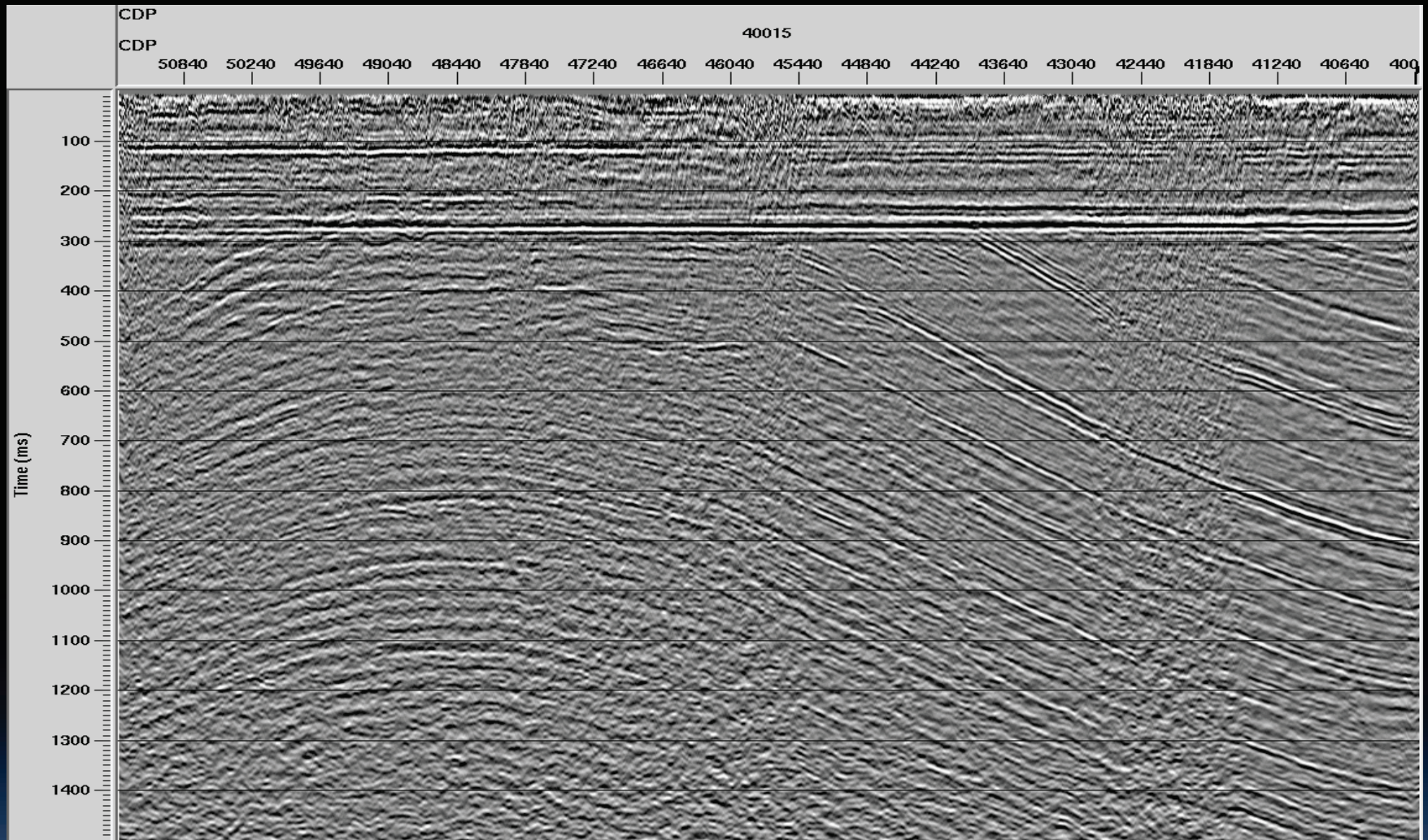
MacKenzie Delta line after raypath interferometry

Hybrid interferometry: PP vs. PS

- Stimulated by an idea presented by **DeMeersman and Roizman (2009)**
- 3C **radial** component traces cross-correlated with **vertical** component traces
- **Inverse filters** derived from **cross-correlations**
- **Inverse filters** applied to **radial** component traces to remove *differences* between PP and PS receiver corrections
- Can be **surface**-consistent or **raypath**-consistent

Assumptions

- **Vertical component** data corrected previously

- **Radial component** data corrected for shot statics

- Strong **PS event** can be matched with the corresponding **PP event**

- Corrected PP event traces act as **pilot traces** for PS event traces sharing the same receiver location on a similar trace gather

Complications

- Only the *differences* between PP and PS receiver corrections are removed
- Difference in *structure* between PP and PS is **also removed**
- Secondary peaks and side-lobes in cross-correlations lead to *spurious events* in deconvolved PS data
- Difference between *reflectivity* and '*convertivity'* not accounted for

Model study

- ***Non-geological synthetic models*** were constructed to study 'hybrid' interferometry:

1. **Effectiveness** of 'statics deconvolution'
2. **Spurious events** introduced by unwanted correlations
3. Effects of **random noise**
4. **Processing tricks** for improving results
5. **Surface**-consistent vs. **raypath**-consistent
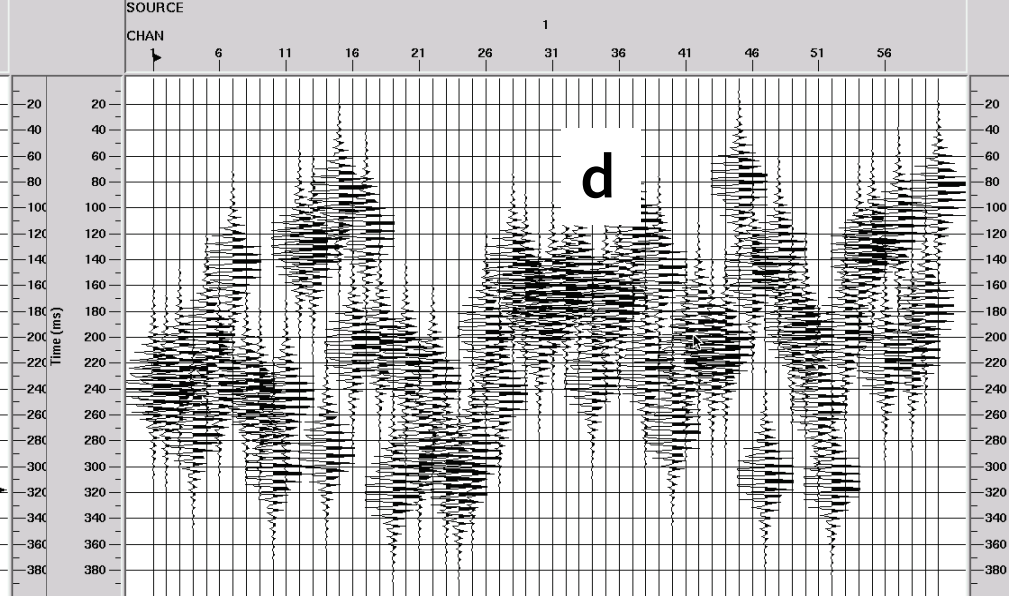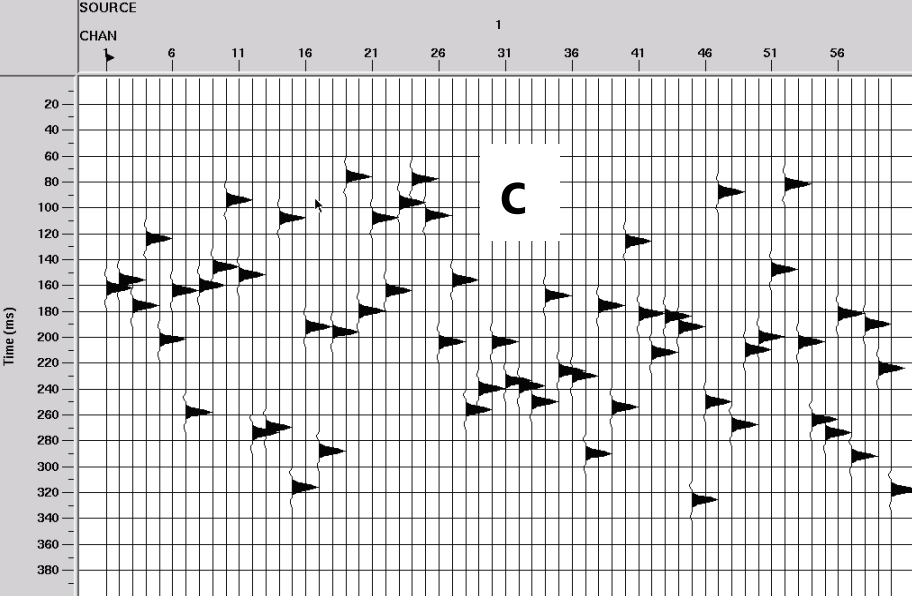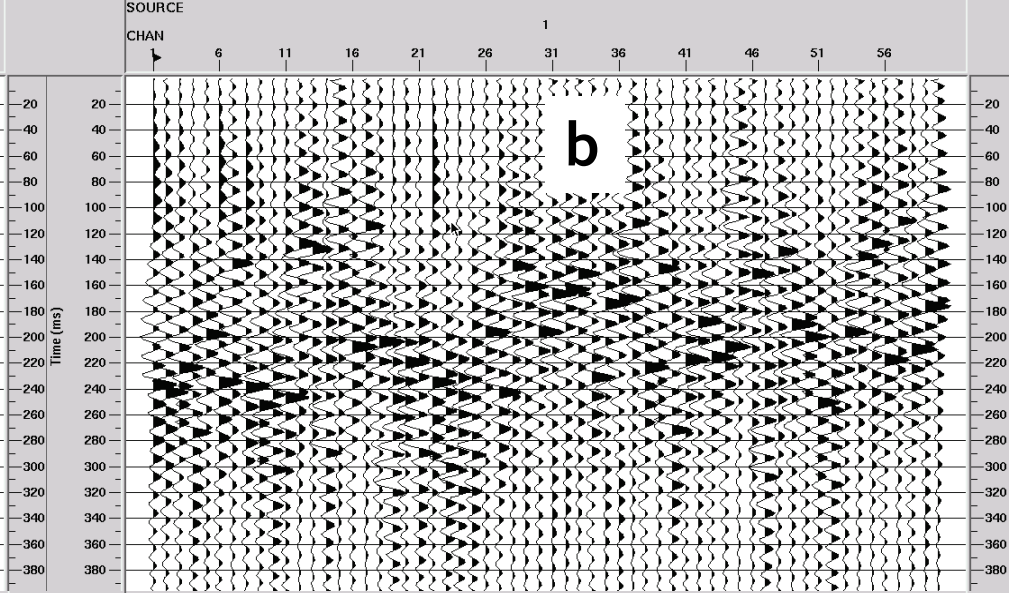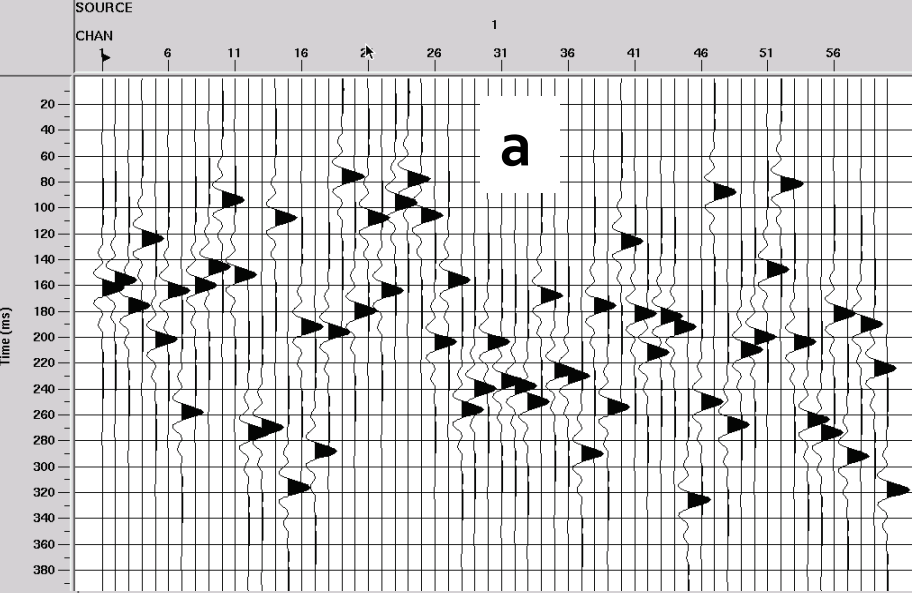
Effect of 'conditioning': (a) raw cross-correlations; (b) resulting inverse filters; (c) 'conditioned' cross-correlations; (d) resulting inverse filters
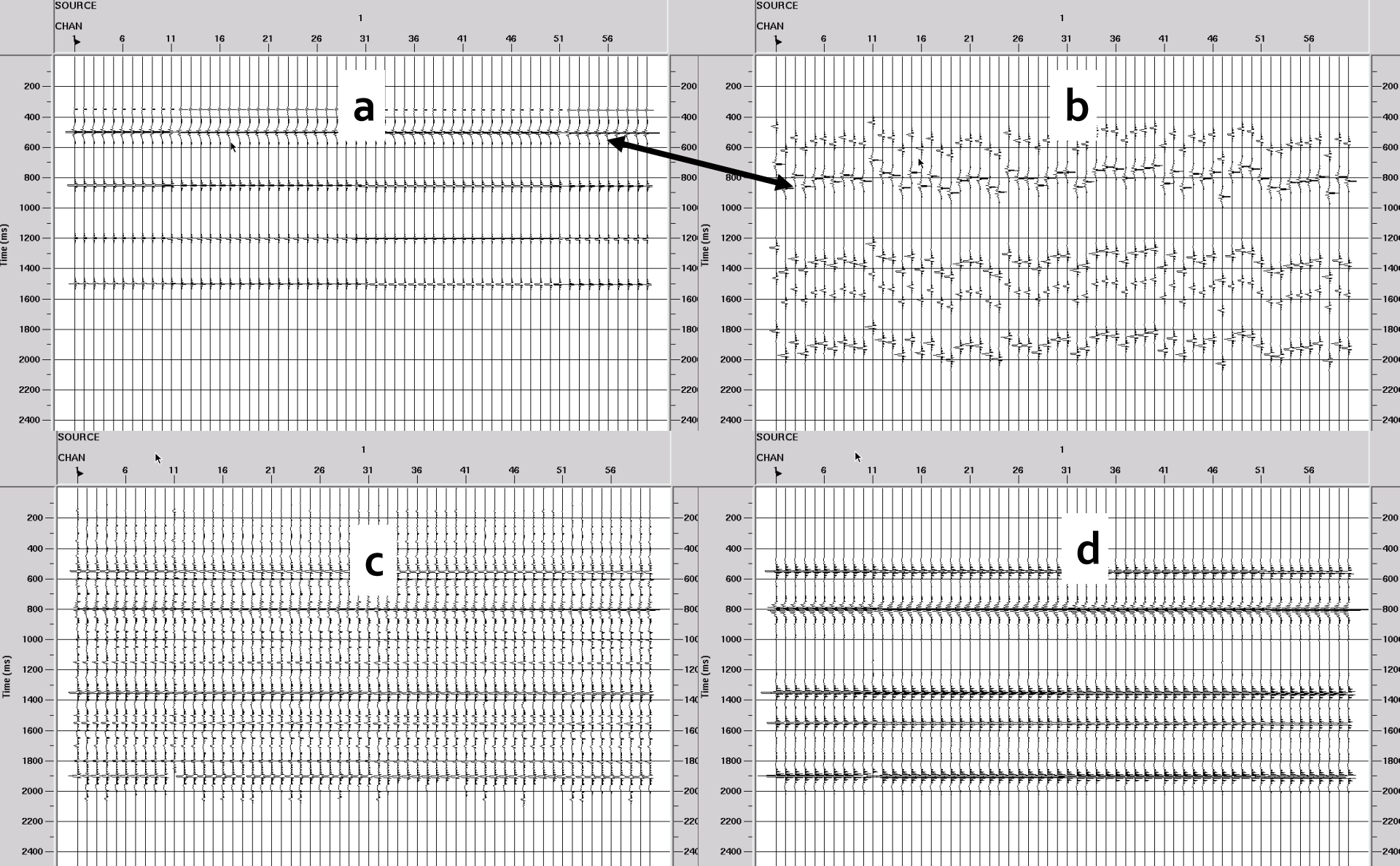
Five PP events (a) and PS events (b). Raw correlations correct statics but introduce spurious events (c). 'Conditioned' correlations correct statics *and* suppress spurious events (d)
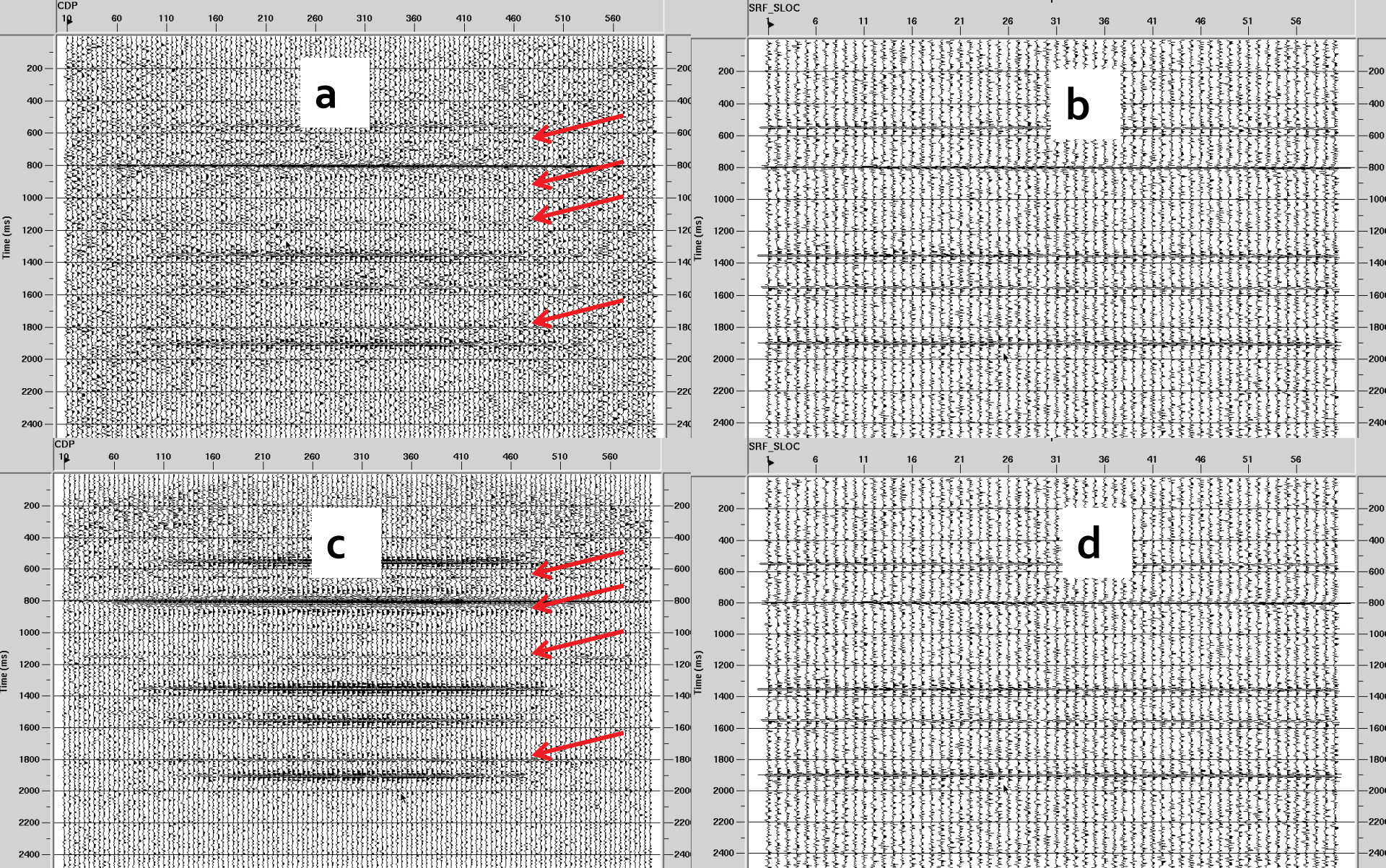
Stack after surface-consistent interferometry (a). Stack after raypath-consistent interferometry (c). No-statics PS gathers in (b) and (d). Arrows mark spurious events

Spring Coulee

- Data quality excellent on PP, good on PS
- Positive identification between PP **reflected event at 500 ms** and PS **converted event at 800 ms**
- **Surface**-consistent approach used vertical and radial component **shot gathers**
- **Raypath**-consistent approach used vertical and radial component **receiver gathers**
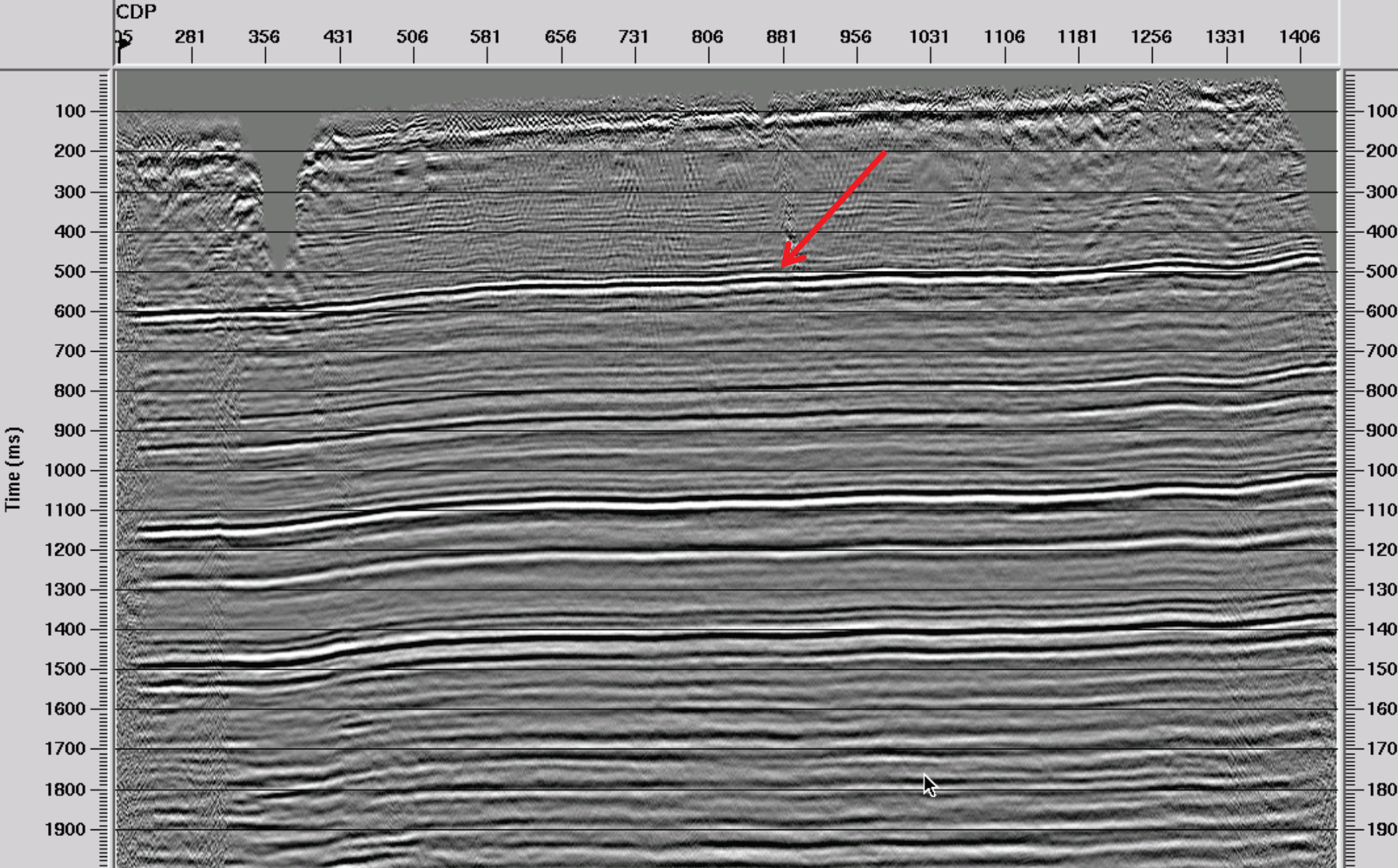
CDP stack of *vertical* component (P reflection section). Arrow marks reflected event at 500 ms, matching a converted event at 800 ms.
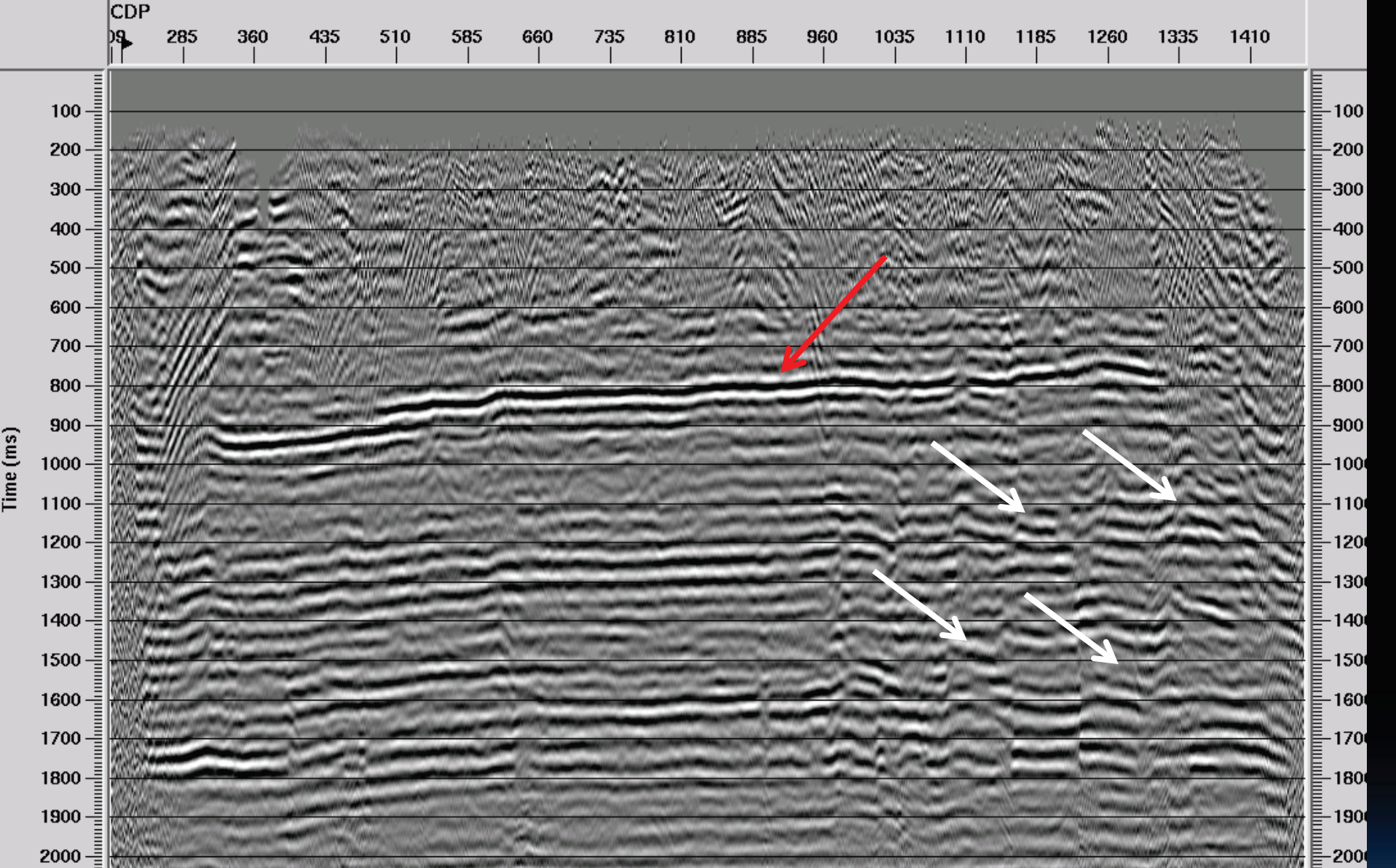
CCP stack of *radial* component after hand, residual, trim statics. Red arrow marks converted event matching the reflected event at 500 ms. White arrows indicate statics problems
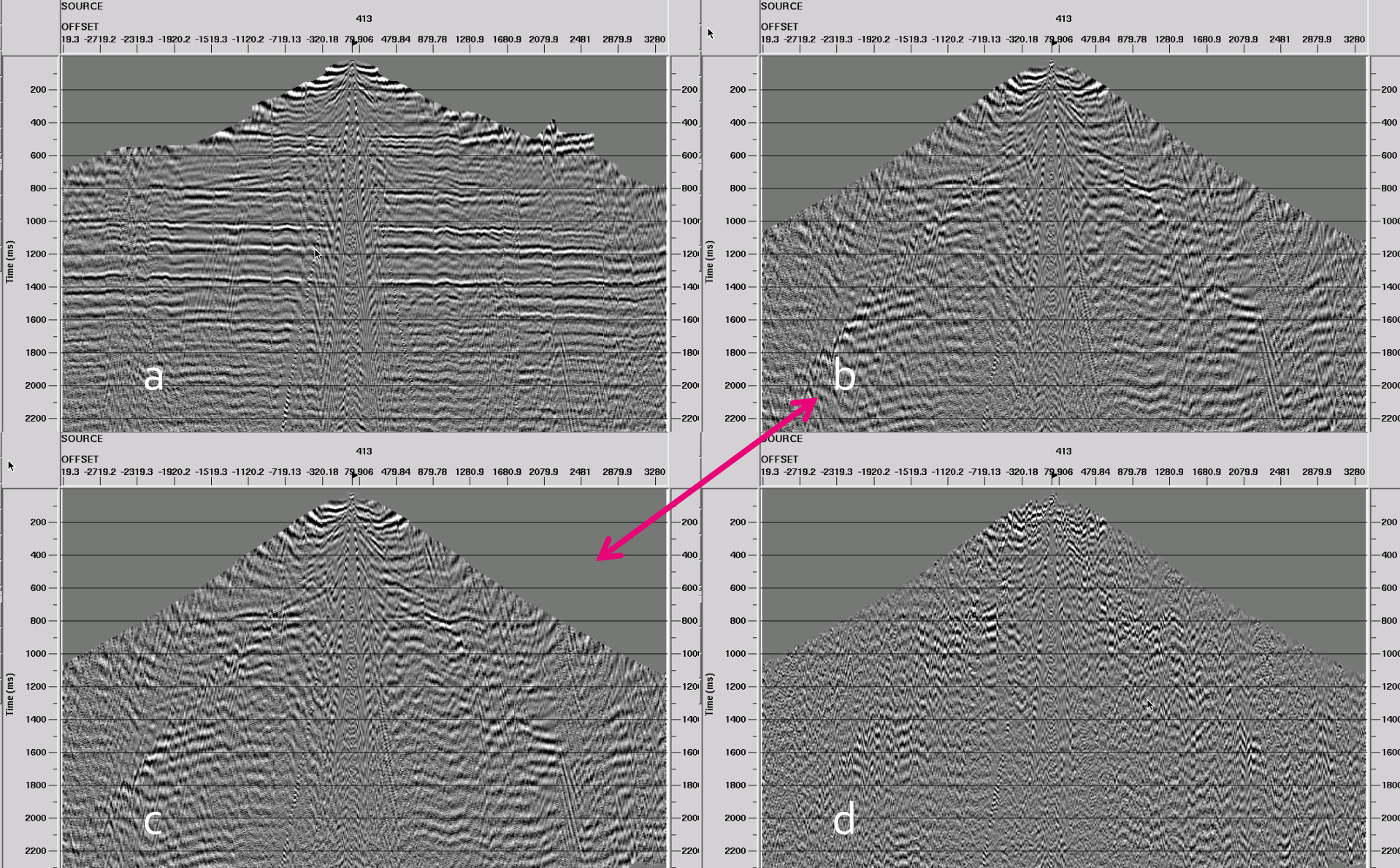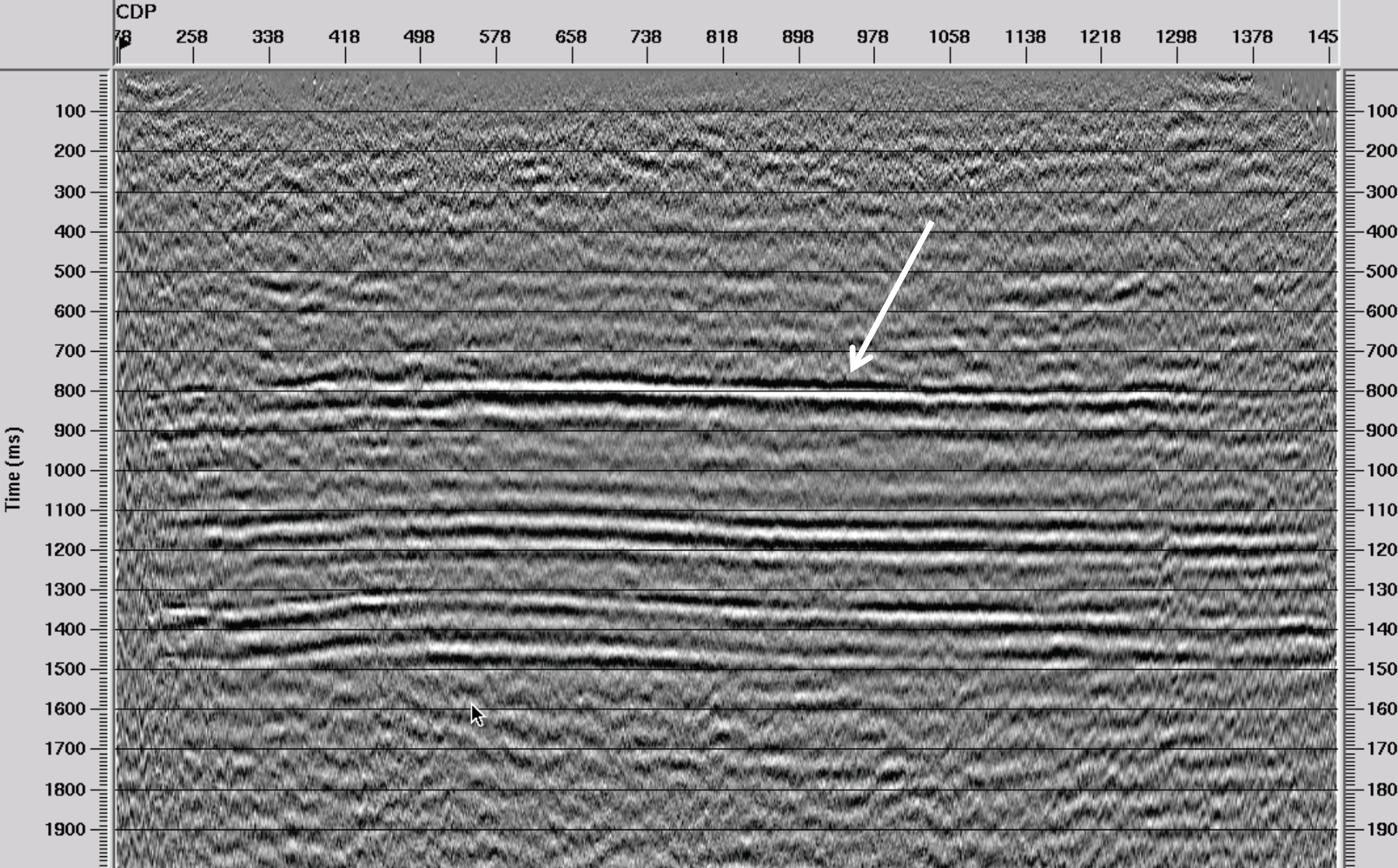
(a) NMO-corrected PP shot gather; (b) NMO-corrected PS shot gather; (c) Same as (b); (d) PS shot gather after shot gather interferometry
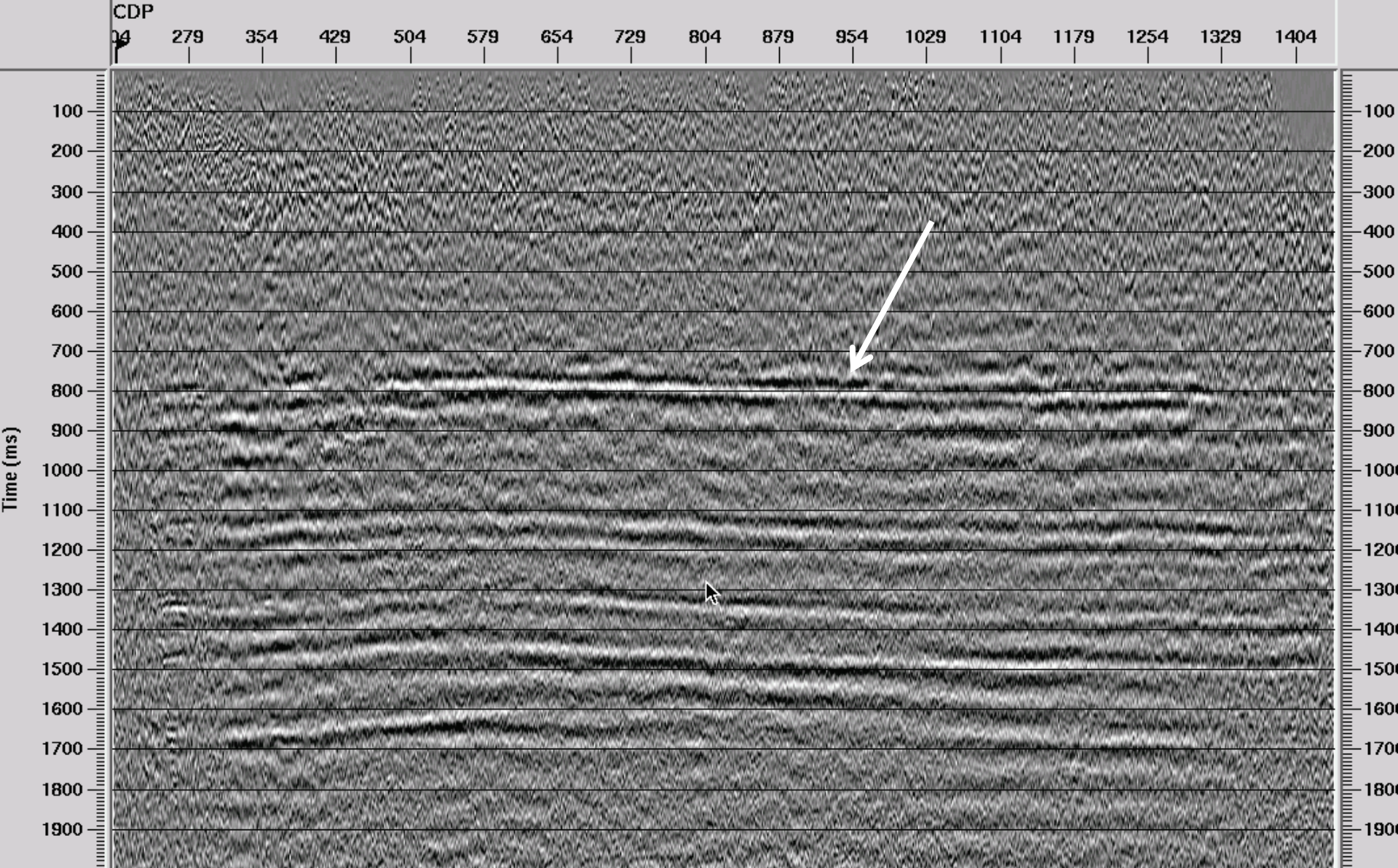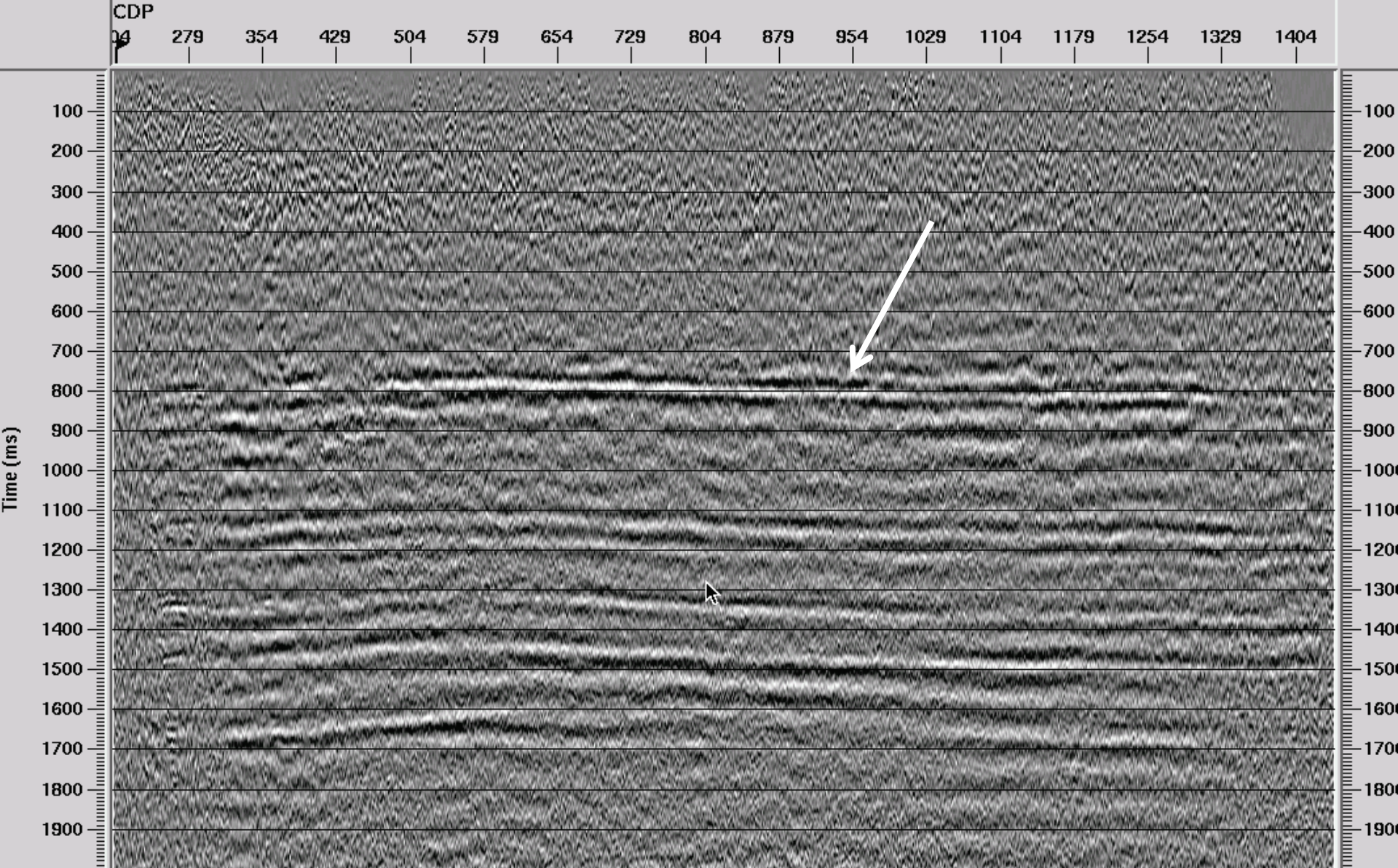
CCP stack of PS-wave corrected by *shot gather interferometry*. Event match was done for arrowed event. Geological structure is lost, since statics are 'difference' statics between P and PS
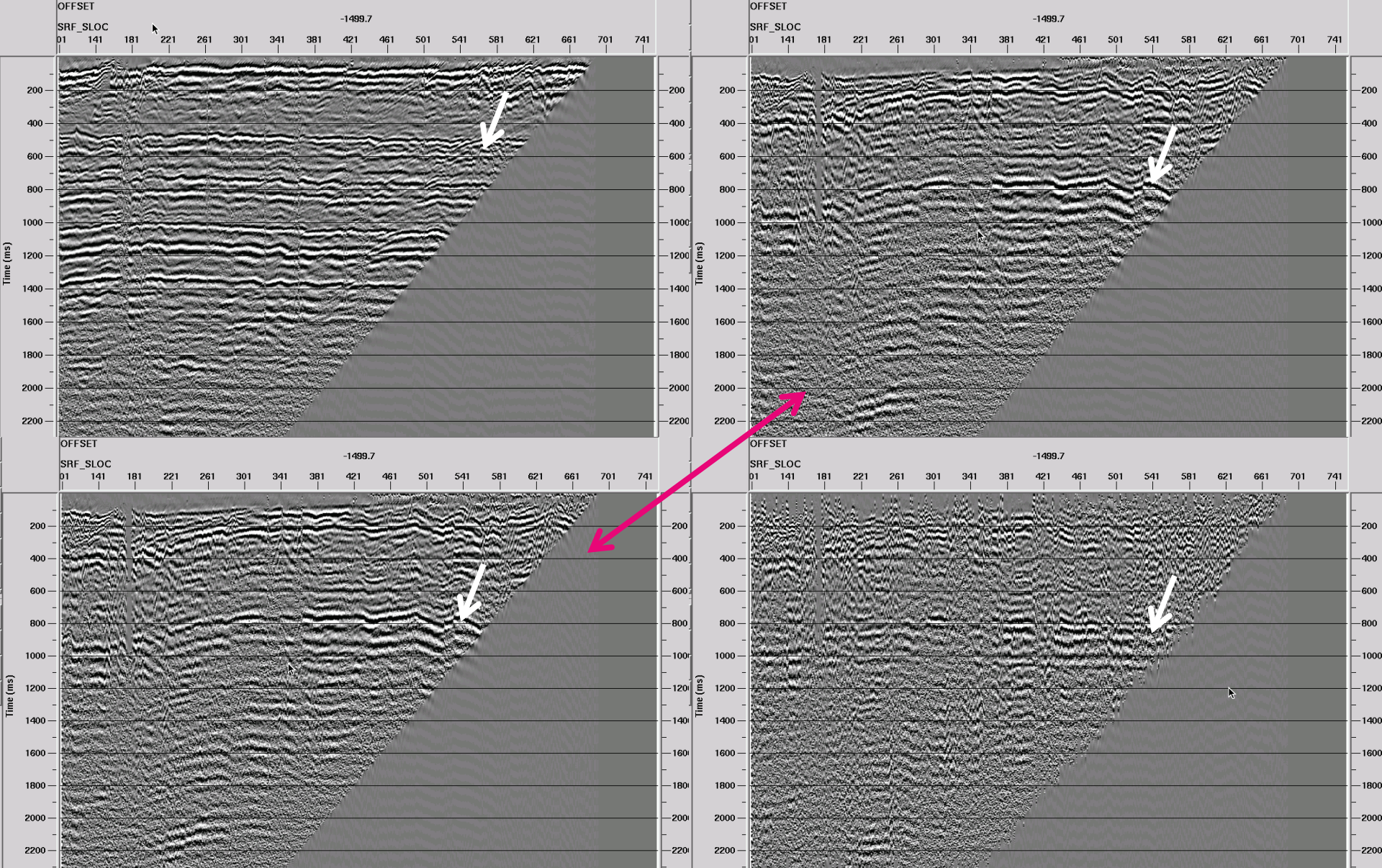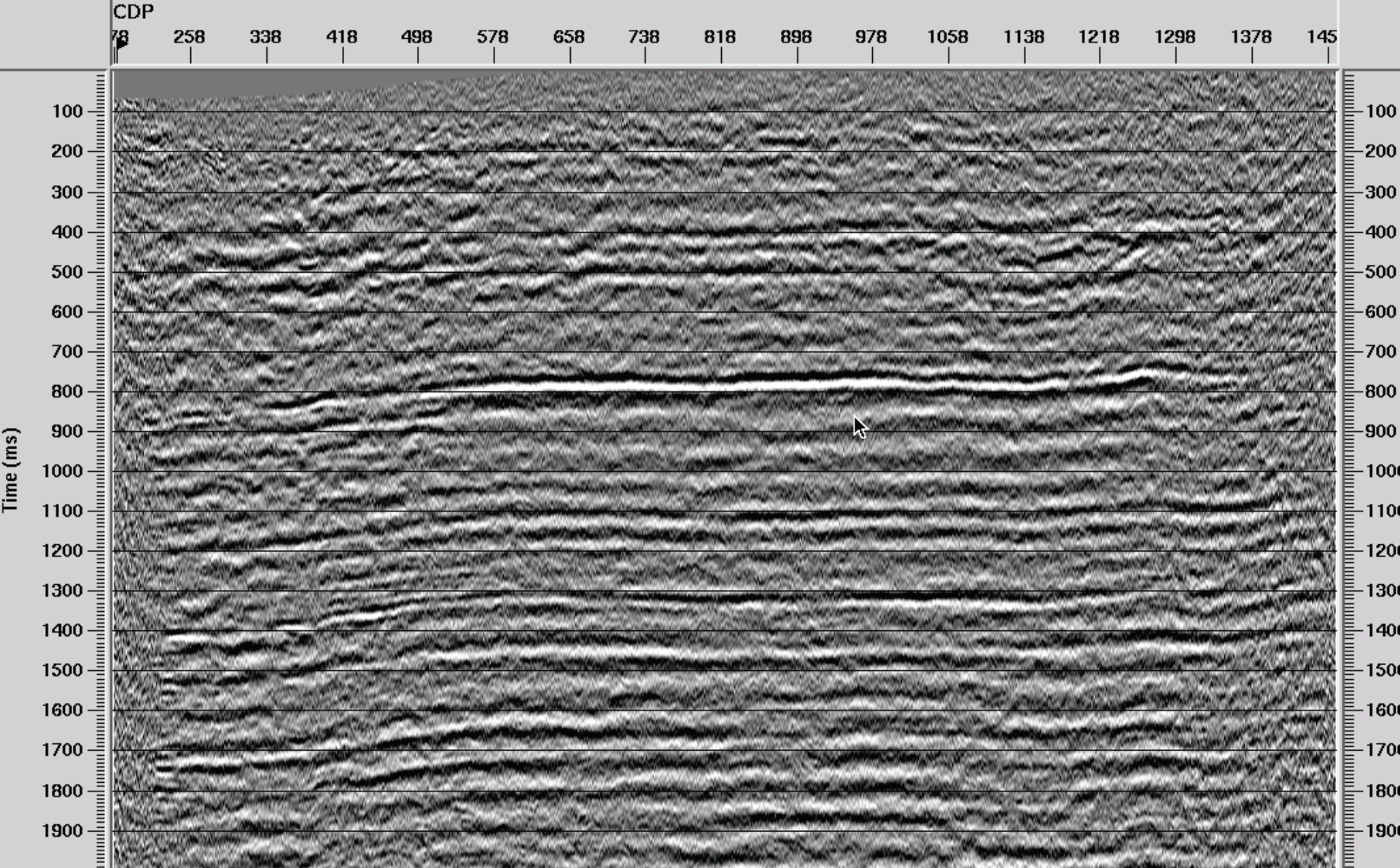
(a) PP common-angle gather, 500 ms event; (b) PS common-angle gather, 800 ms event; (c) same as (b); (d) PS common-angle gather *after* raypath interferometry
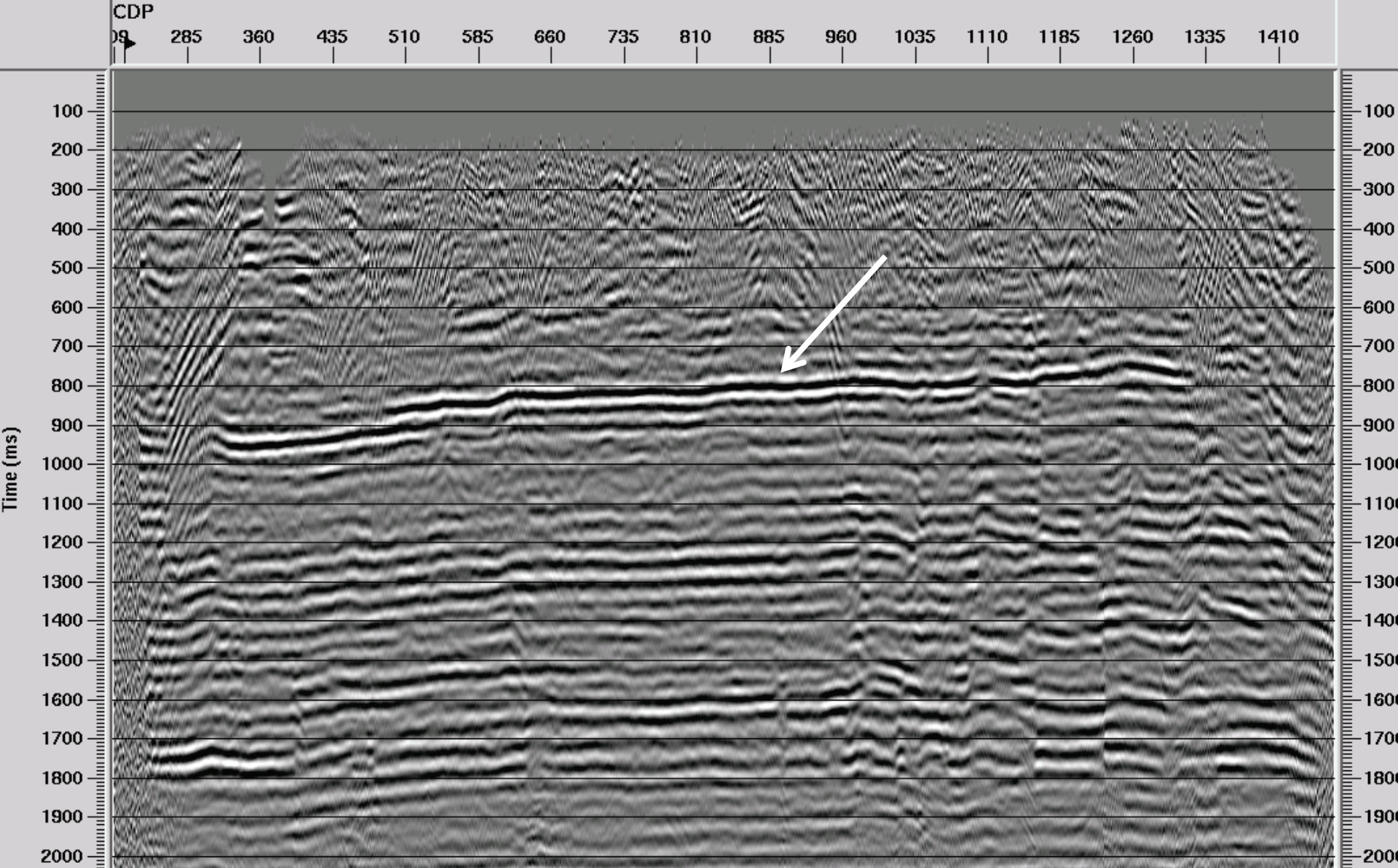
CCP stack of PS-wave data corrected by *raypath interferometry*. Correlation window 1000 ms. S/N is better than for *shot gather interferometry* results

CCP stack of PS-wave corrected by *shot gather interferometry*.

CCP stack of PS data *after raypath interferometry*—2000 ms correlation window. PP horizon structure added. Post-stack Gabor deconvolution, FX decon.

CCP stack of PS data after hand statics, trim statics

Observations

- ***Raypath interferometry*** yields result with higher S/N than ***shot gather interferometry***

- Structure likely not yet correct

- Results are *coherent* and broadband

- Fundamental questions remain to be resolved

Outstanding questions

- What are the effects of *low-level spurious events*?

- What are the effects due to differences between *reflectivity* and *'convertivity'* functions for the same lithological sequence?

Acknowledgements

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