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UNIVERSITY OF CALGARY

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WHICH WAY IS UP?--EXPERIENCES WITH PROCESSING PHYSICAL MODELING DATA

Summary

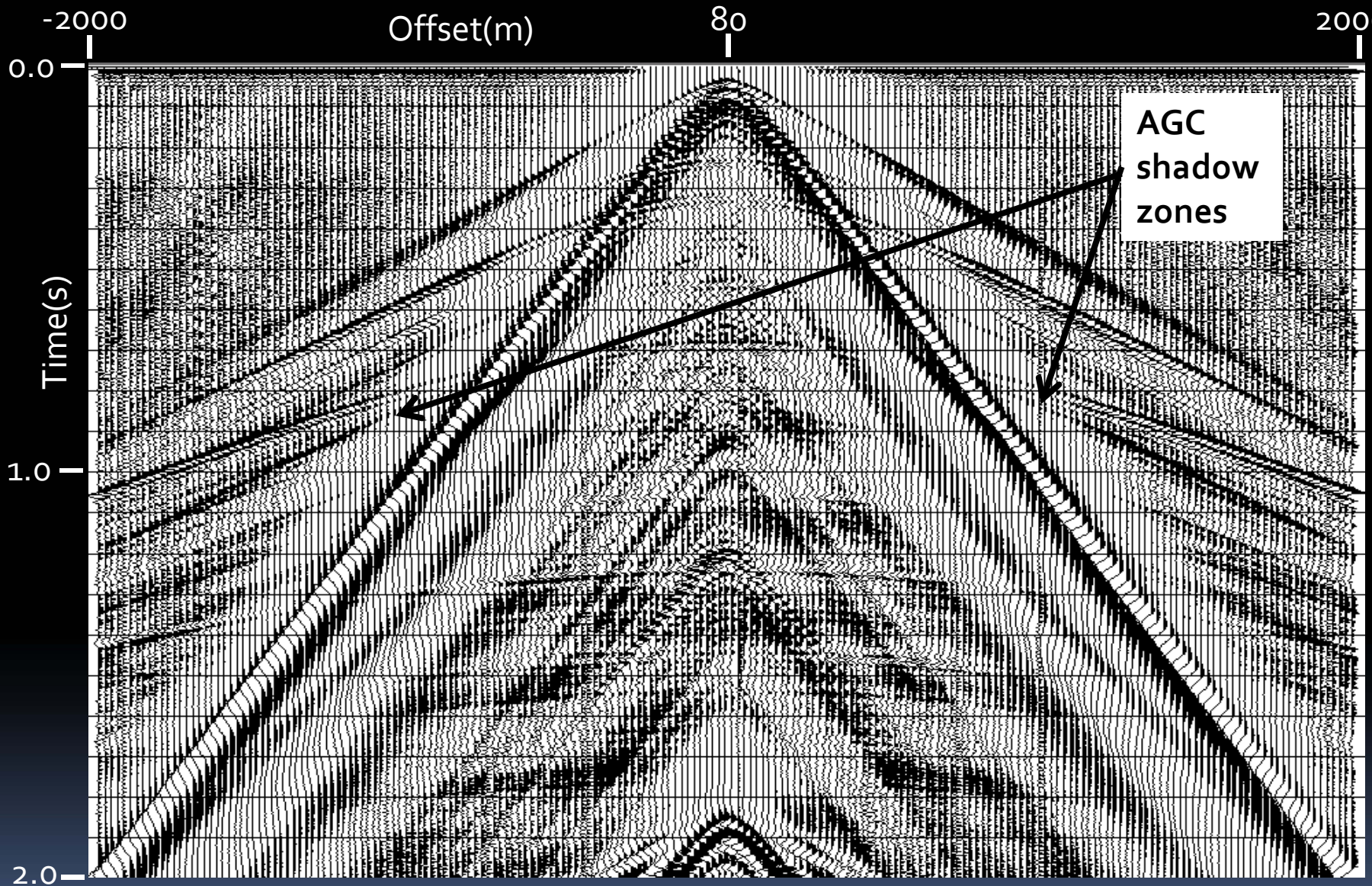
- Objective—gain experience processing and interpreting physical model data
  - Develop processing stream for:
    - Coherent noise attenuation
    - CMP imaging
    - ***Surface-related multiple attenuation***
  - Interpret processed data to constrain 'model'
- Goal—***'invert'*** seismic data to get ***unambiguous 'model'***
- ***Success?***

Modeling and Processing

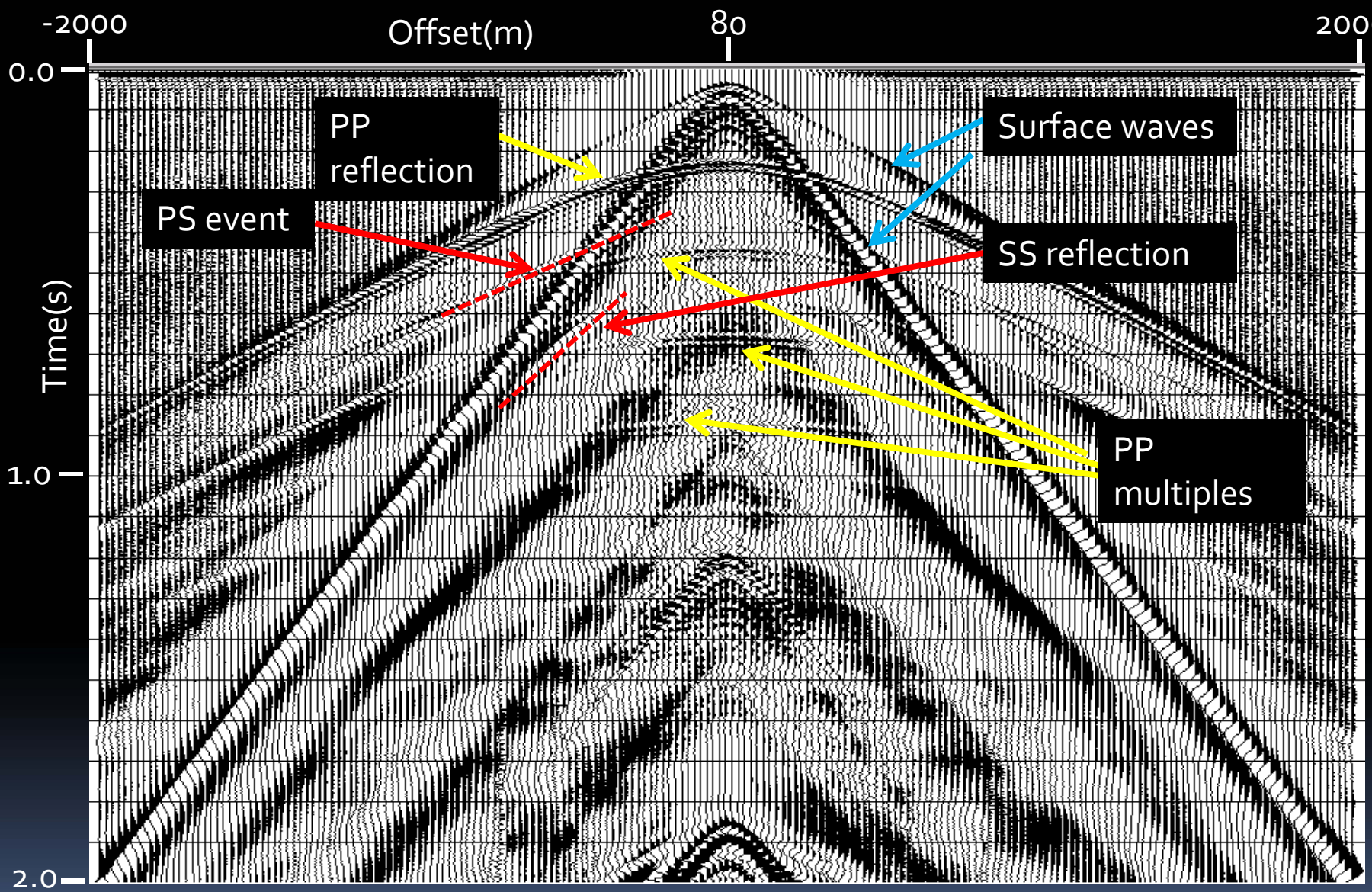
- Physical modeling—purposes:
  - Confirm seismic theory
  - Produce selected wave modes
  - Test processing strategy
- Processing—purposes:
  - Measure event attributes
  - Enhance selected wave modes
  - Produce useful images in order to…
  - Confirm model

Procedure

- Two versions, 'B' and 'E', of unknown physical model surveyed identically
- Both data sets processed independently to image reflections
- CMP images produced and compared
- Model determined using seismic constraints



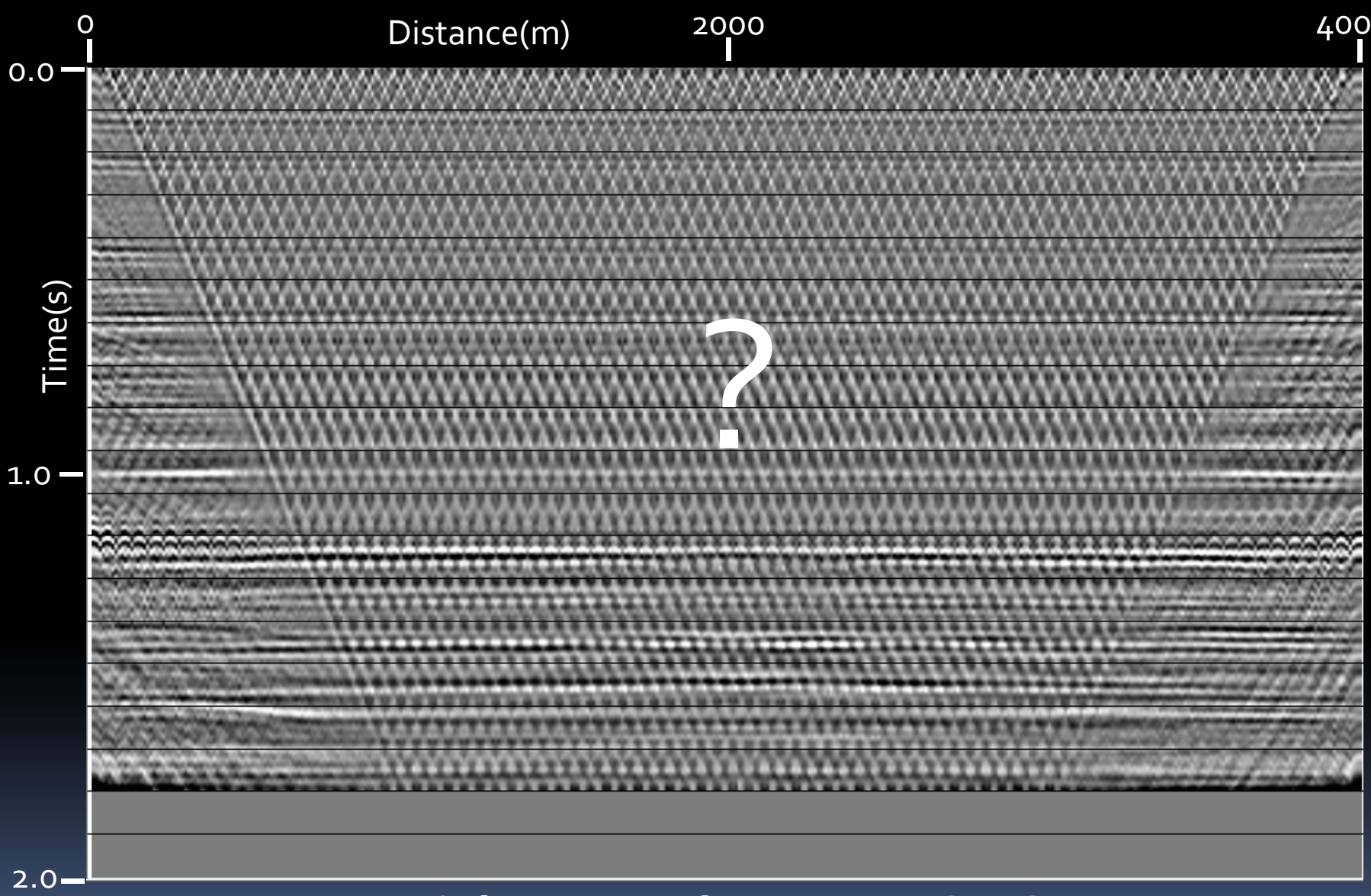
Raw trace gather from near the centre of 'E' survey



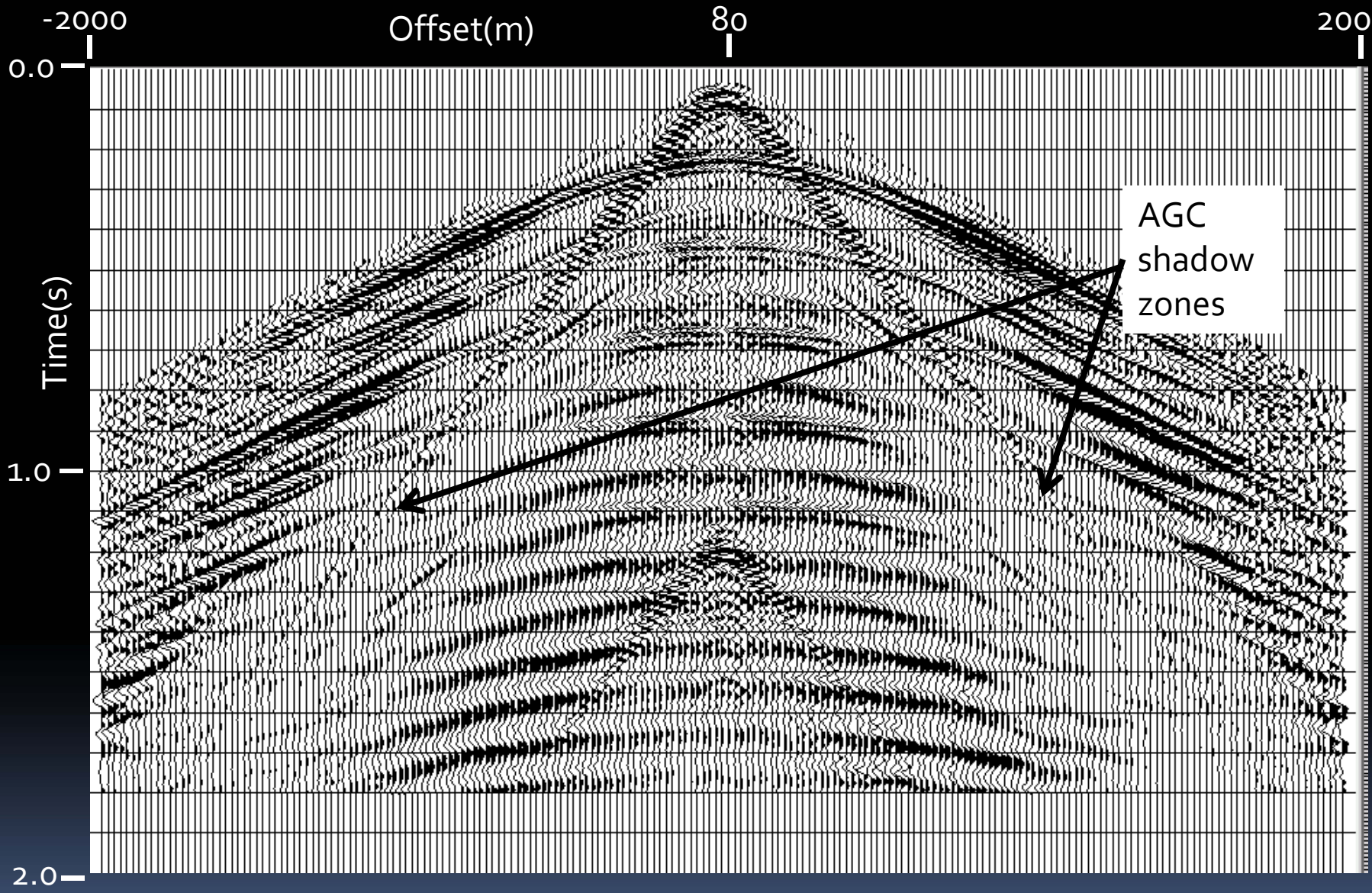
Raw trace gather from near the centre of 'B' survey

Raw trace gather analysis

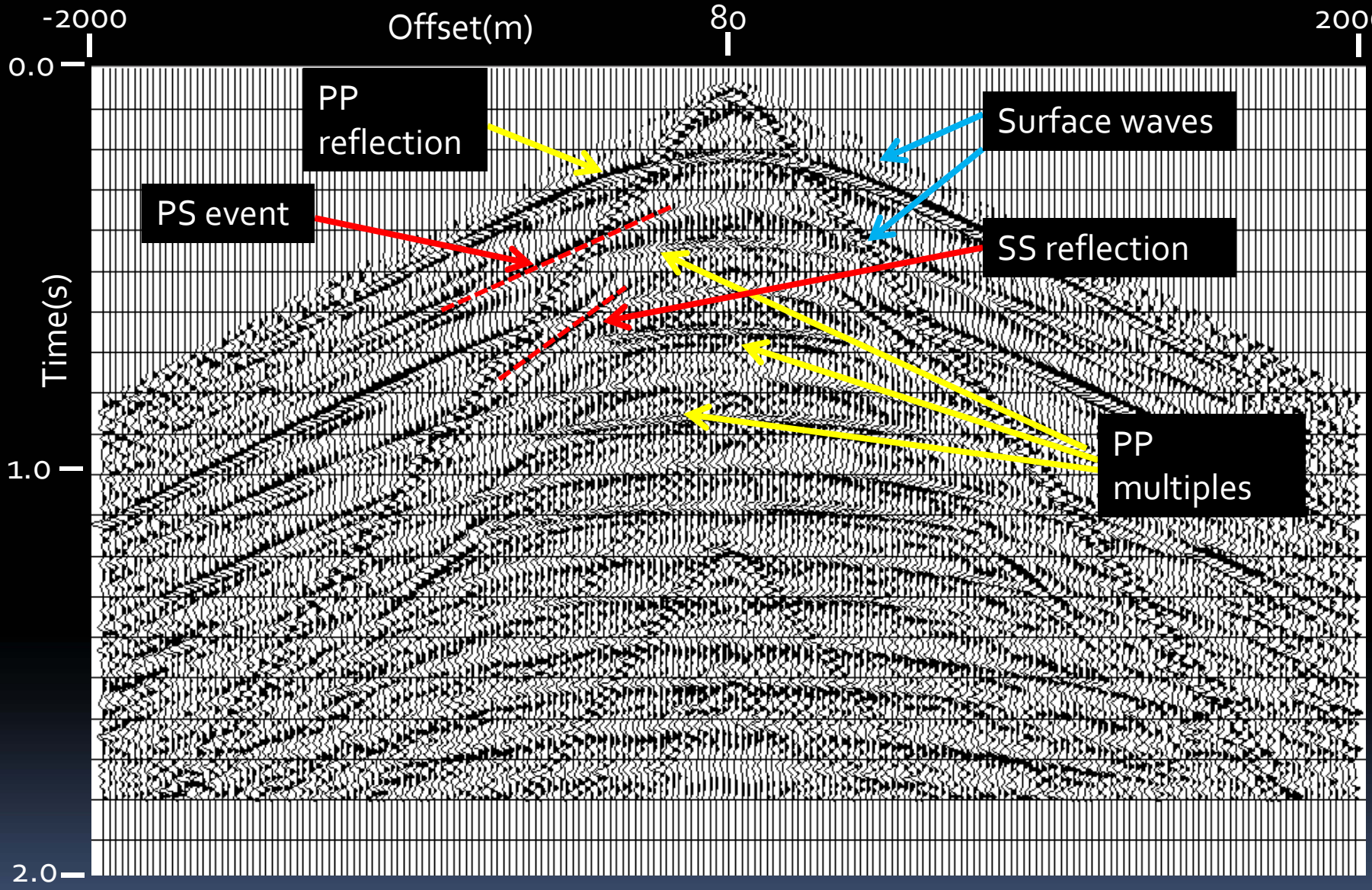
- Very strong surface wave—solid surface layer
- Hyperbolic surface wave pattern—source offset from receiver line
- Weak hyperbolic events—reflections and/or converted waves present
- Surface-related multiples—strong near-surface reflecting interface present on 'B'



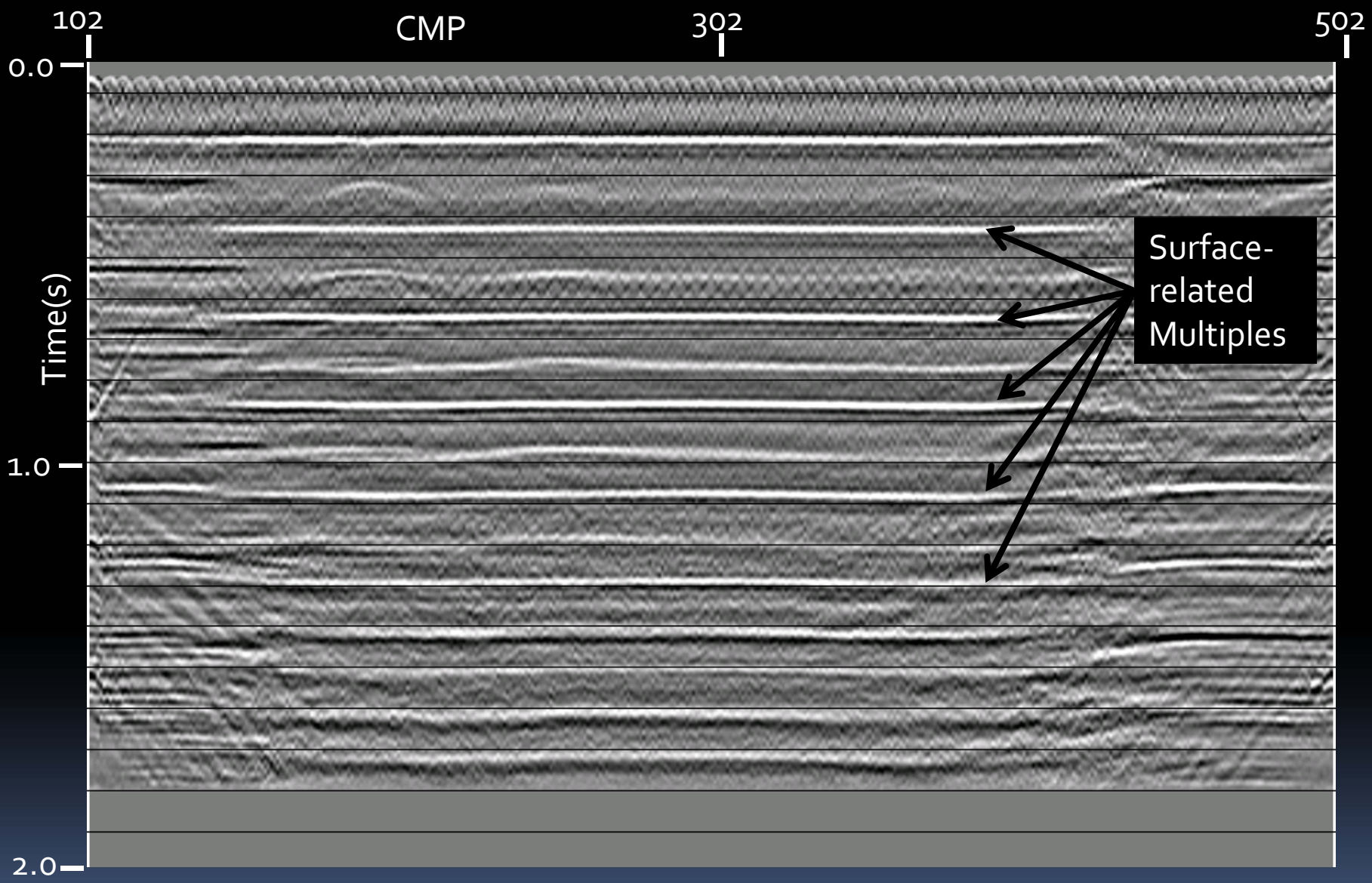
CMP stack for ‘E’—**surface waves dominant**



'B' gather RT-filtered for surface waves



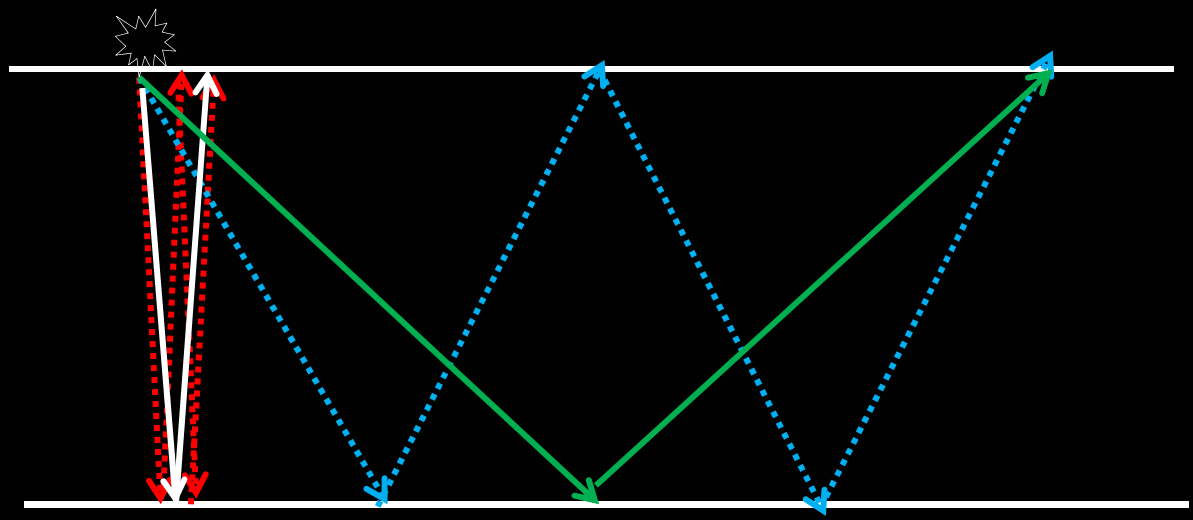
Filtered 'B' gather, AGC restored, then AGC reapplied



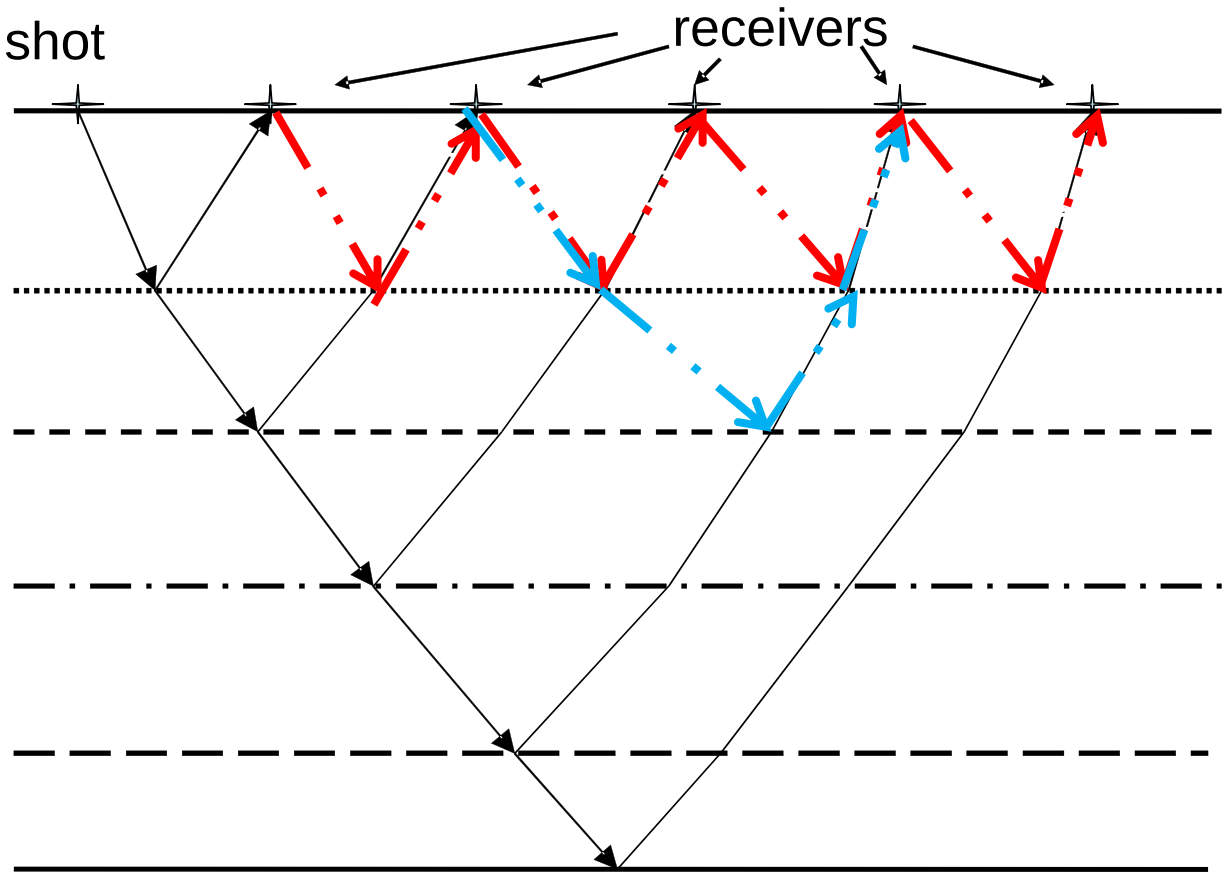
'B' brute CMP stack—**surface-related multiples dominant**

De-multiple techniques

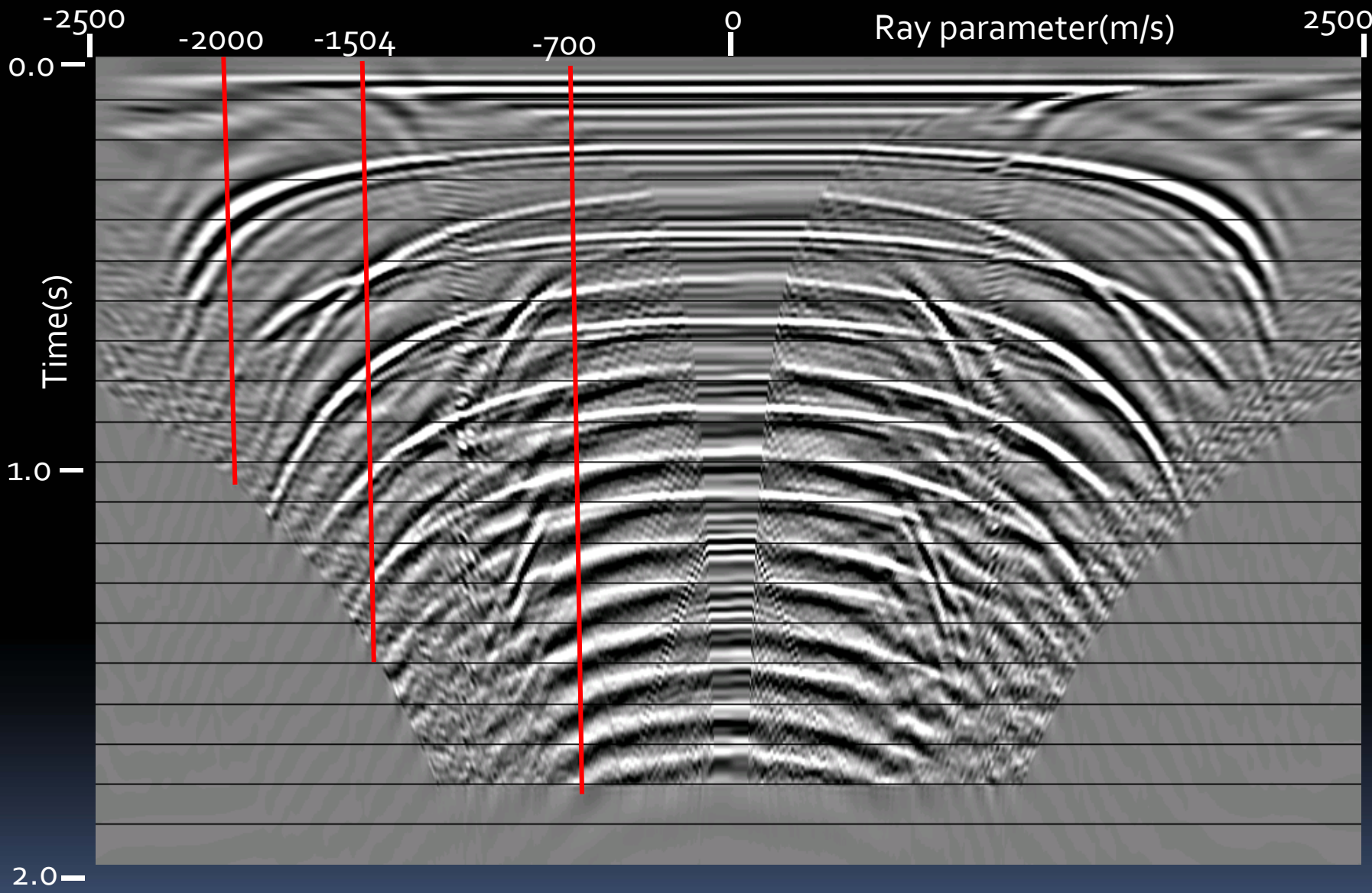
- **Differential NMO** used to separate primary reflections and multiples
- **Multiples modeled** from estimated primary reflections and subtracted
- **Periodicity** used to deconvolve multiples
  - X-T domain—applied after NMO
  - **RT domain (Taner)—applied** before **NMO**



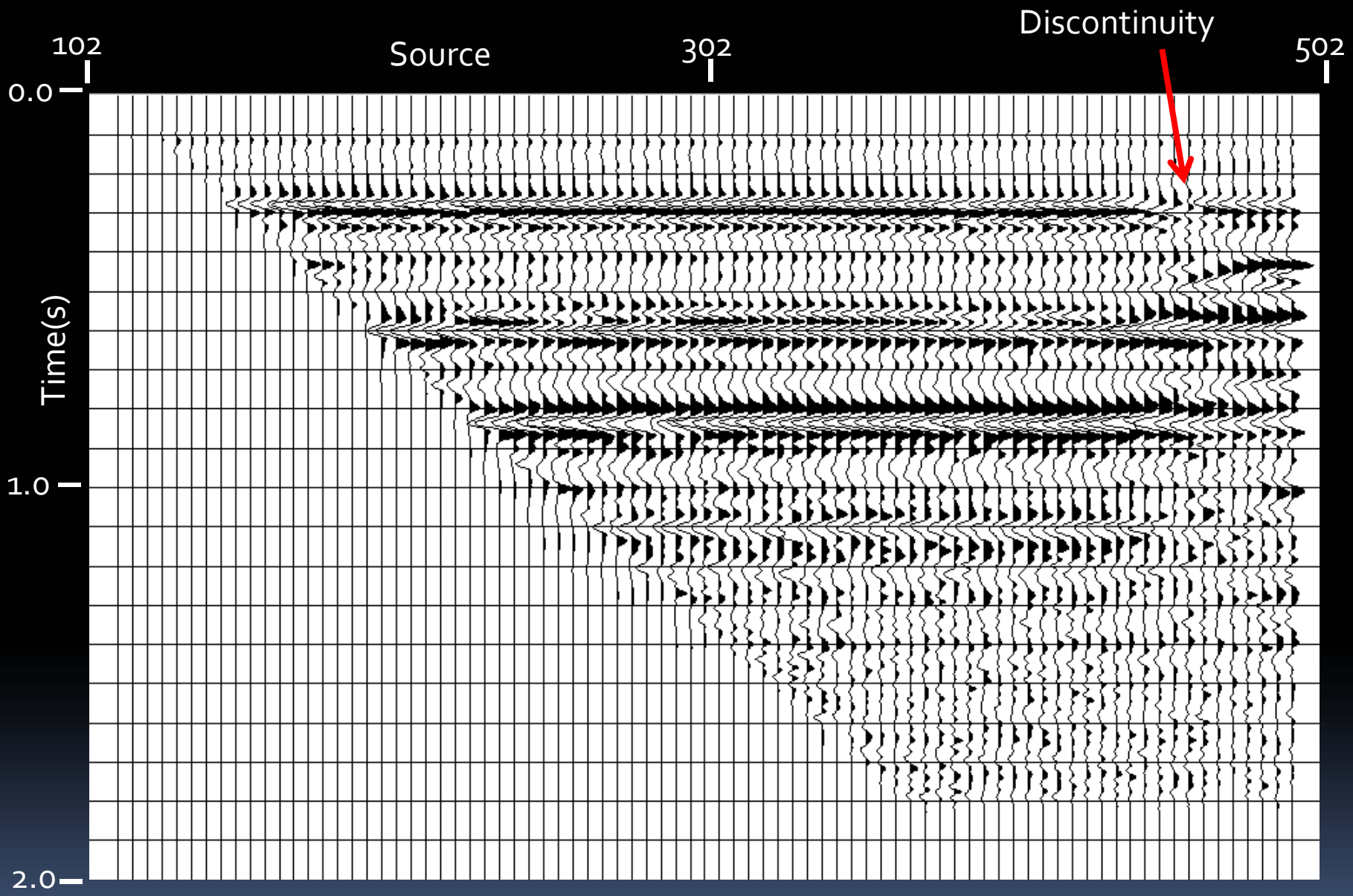
At near-zero offset, the surface-related multiple path (red) is approximately ***twice*** that of the primary reflection (white), and the reflection points nearly coincide; at longer offsets, the multiple path (blue) is significantly ***less than twice*** the primary path (green), and no reflection points coincide.



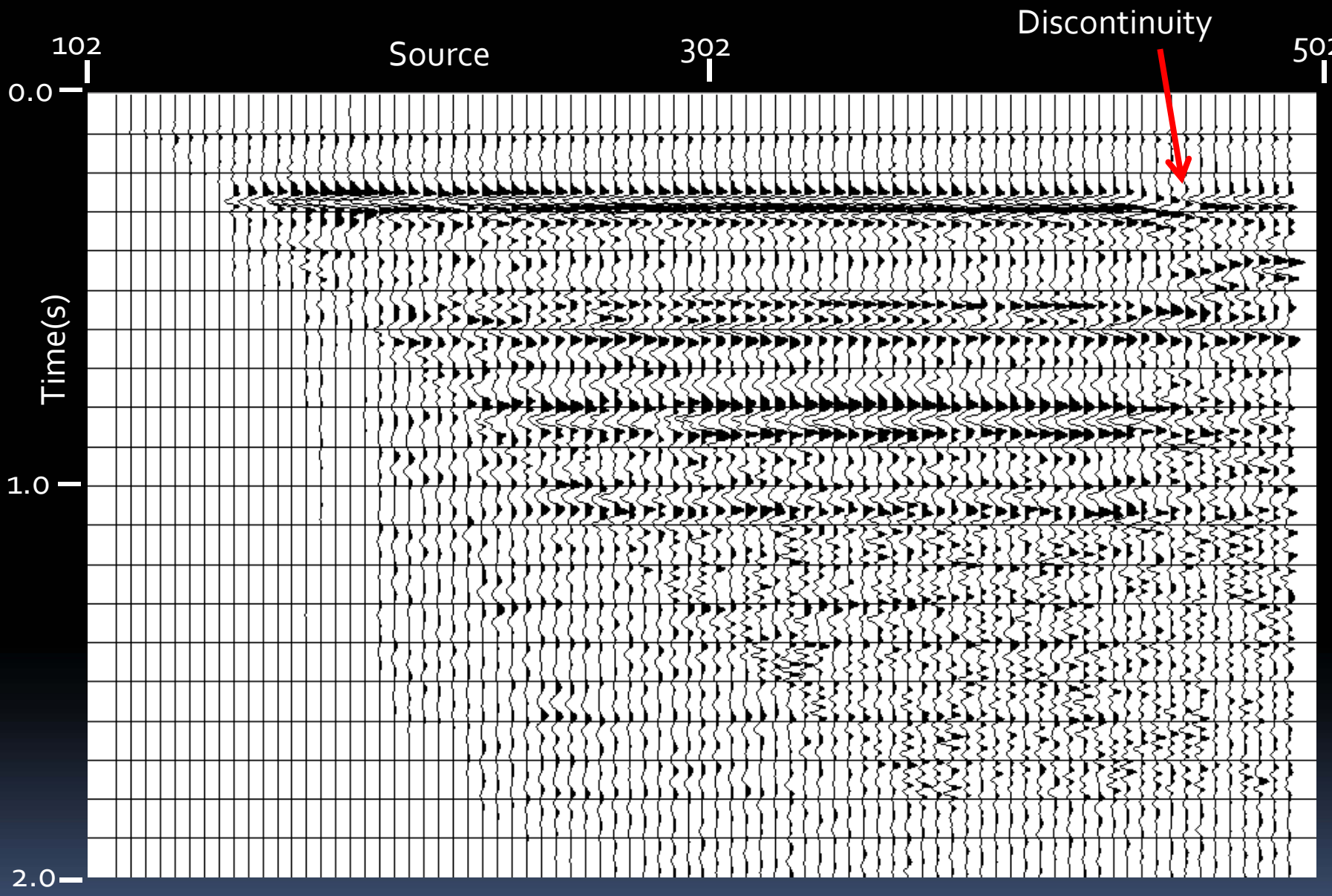
Raypath geometry for RT domain seismic trace
Surface-related multiple paths are an integral multiple of their primary reflection paths



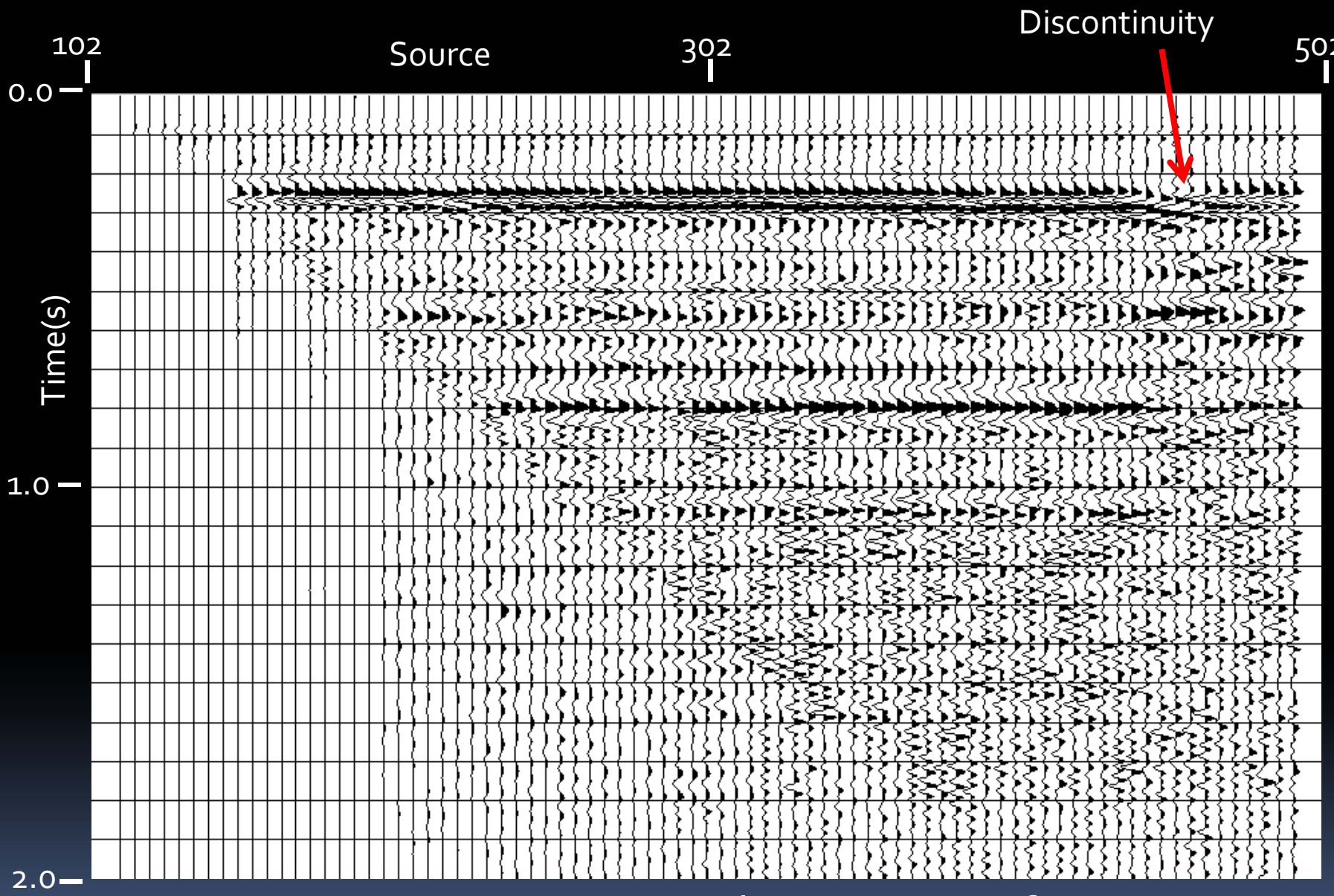
RT transform of 'B' source gather—no NMO applied



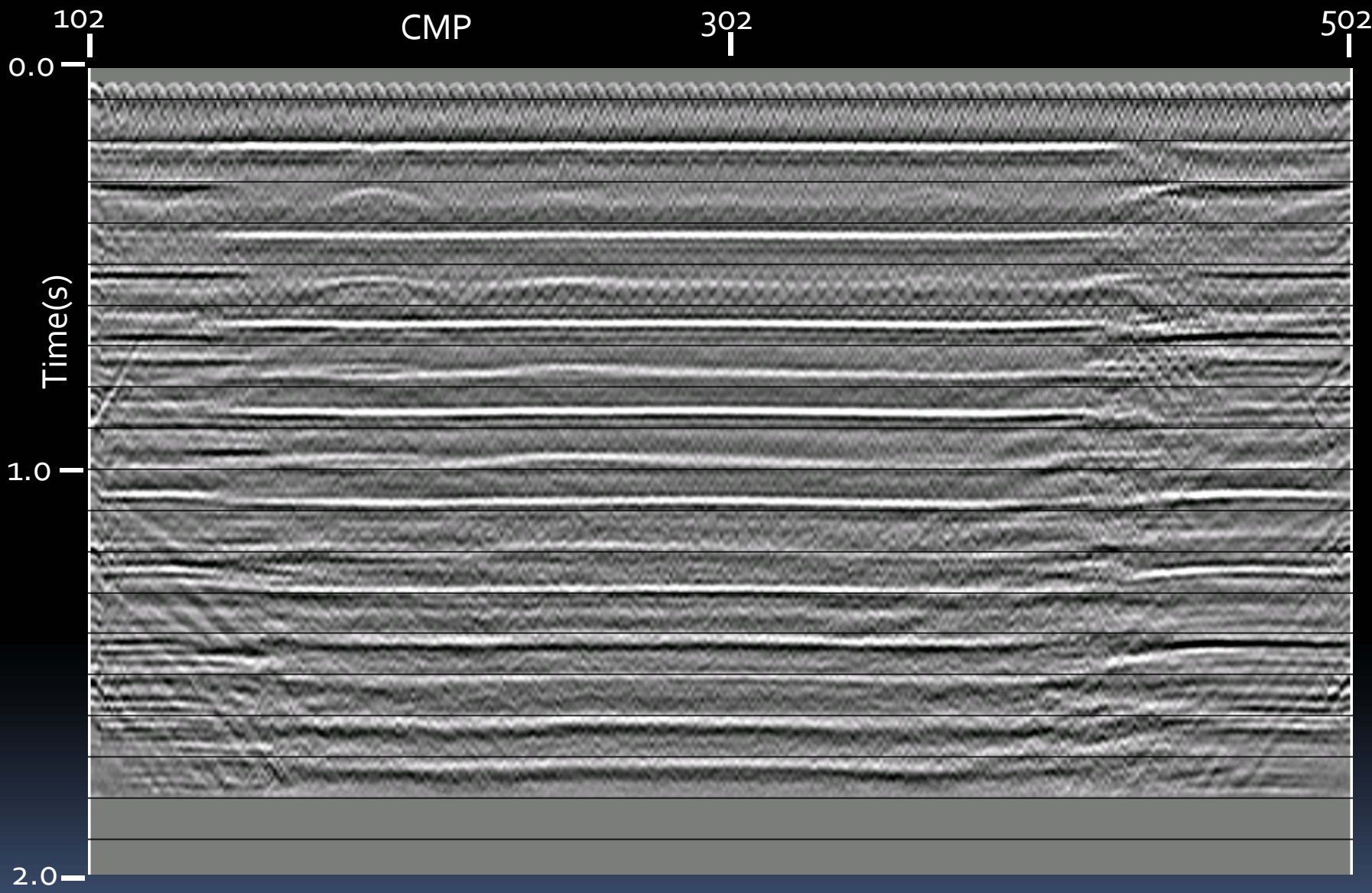
'B' Common ray-parameter panel at -1504m/s



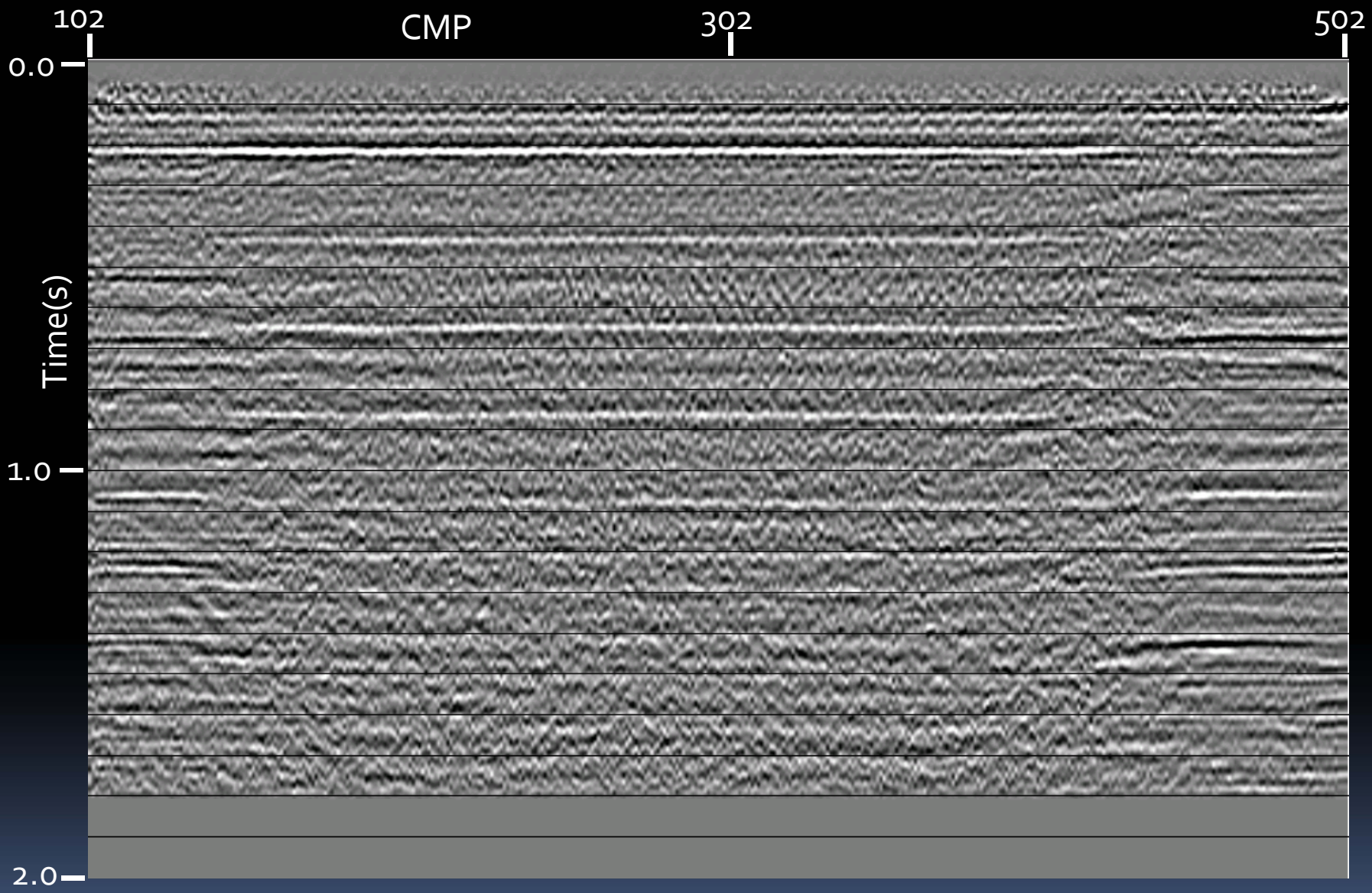
'B' common ray-parameter panel at -1504m/s after spiking decon



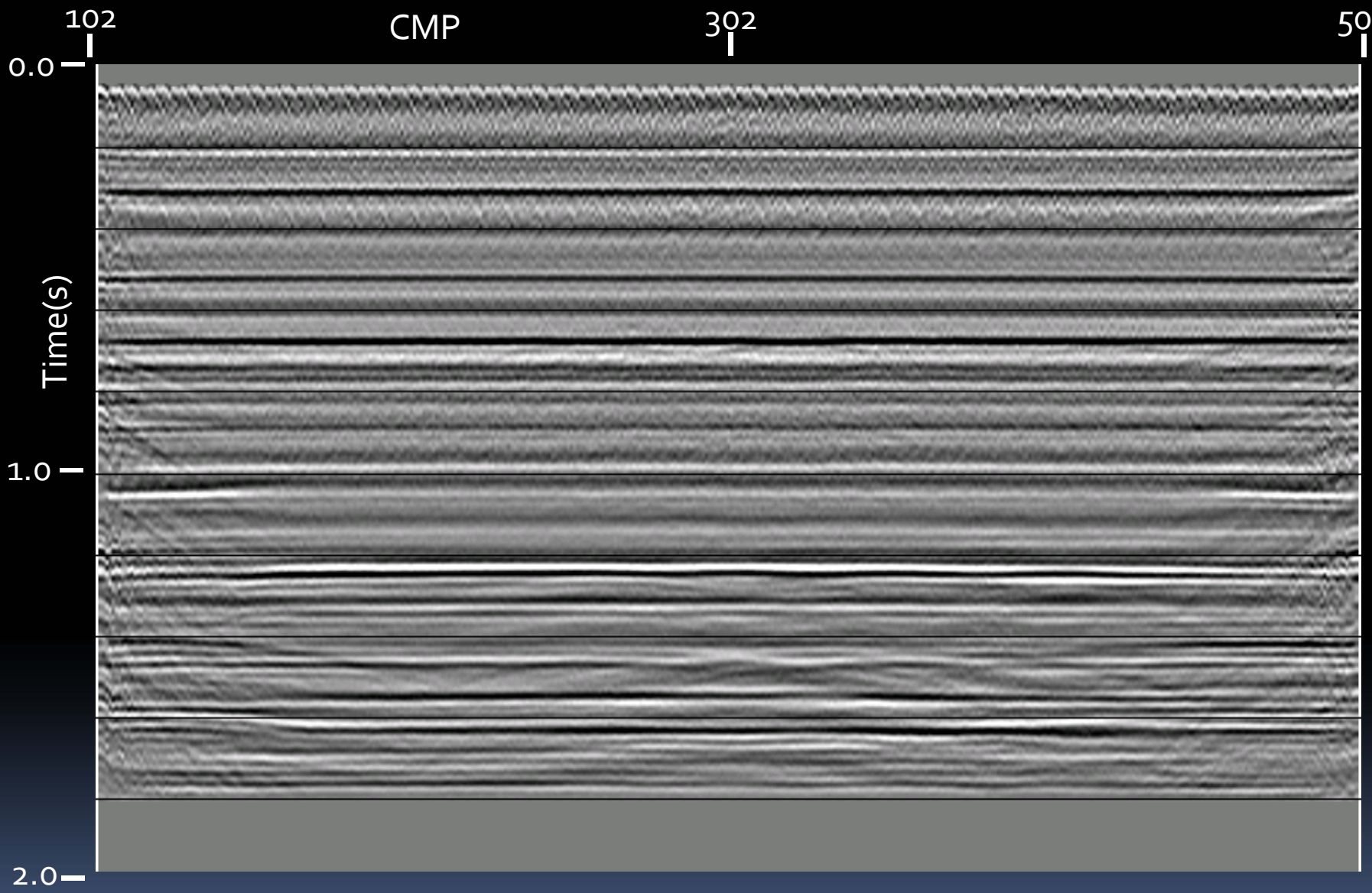
'B' common ray-parameter panel at -1504m/s after two passes of spiking decon



'B' brute CMP stack—**surface-related multiples dominant**



‘B’ CMP stack after de-multiple



‘E’ CMP stack after de-multiple

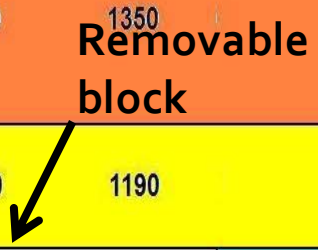
De-multiple summary

- ***Periodicity*** more important than ***amplitudes*** for filter derivation
- Harsher de-multiple possible by 'conditioning' autocorrelation
- Autocorrelation/spiking decon can be iterated—reflections may suffer

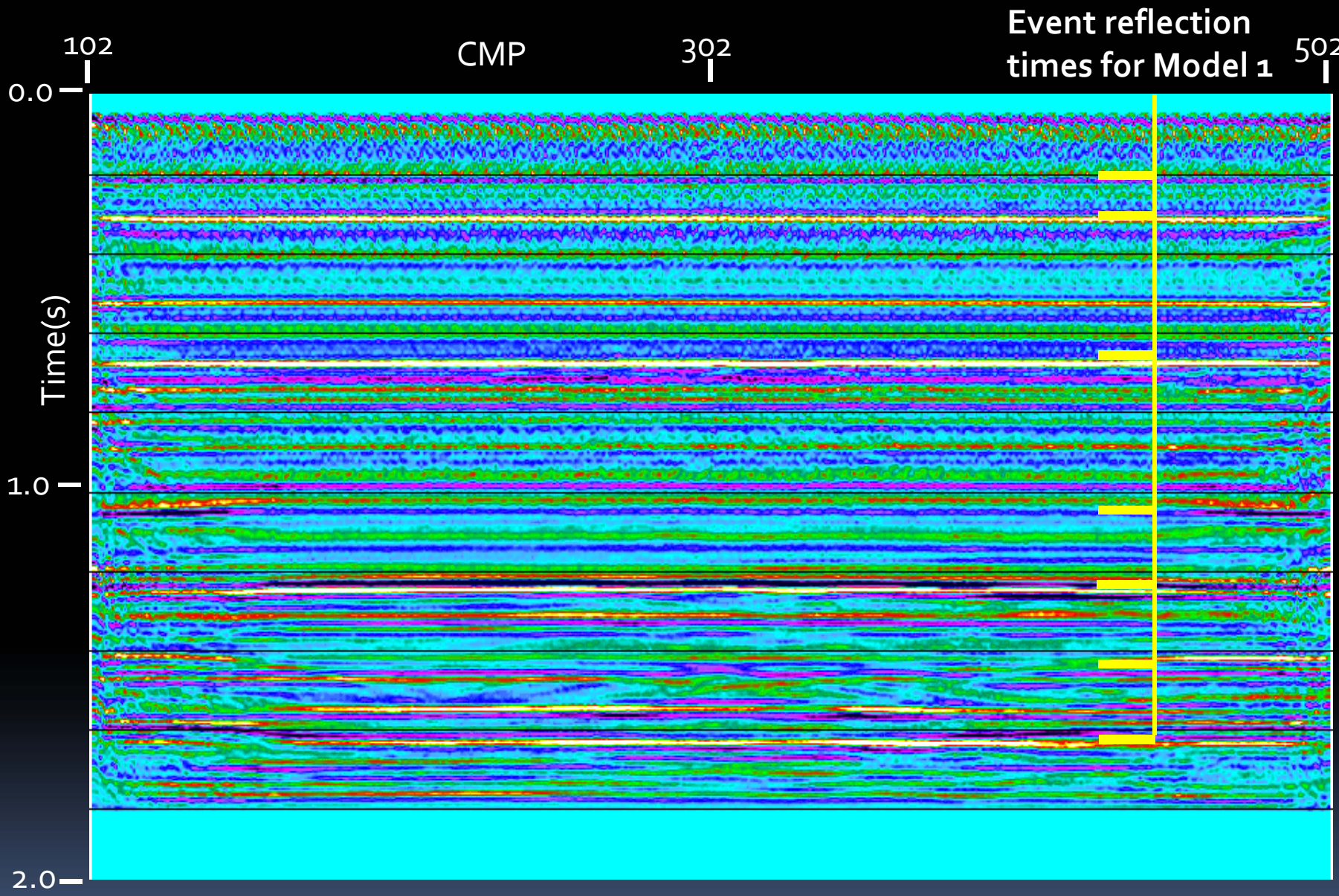
Deducing the model

- ***Consider all processing 'clues'*** :
  - Imaged reflections and their traveltimes
  - Differences in data between 'B' and 'E'
  - Artifacts on gathers (discontinuities)
- ***Avoid preconceptions***

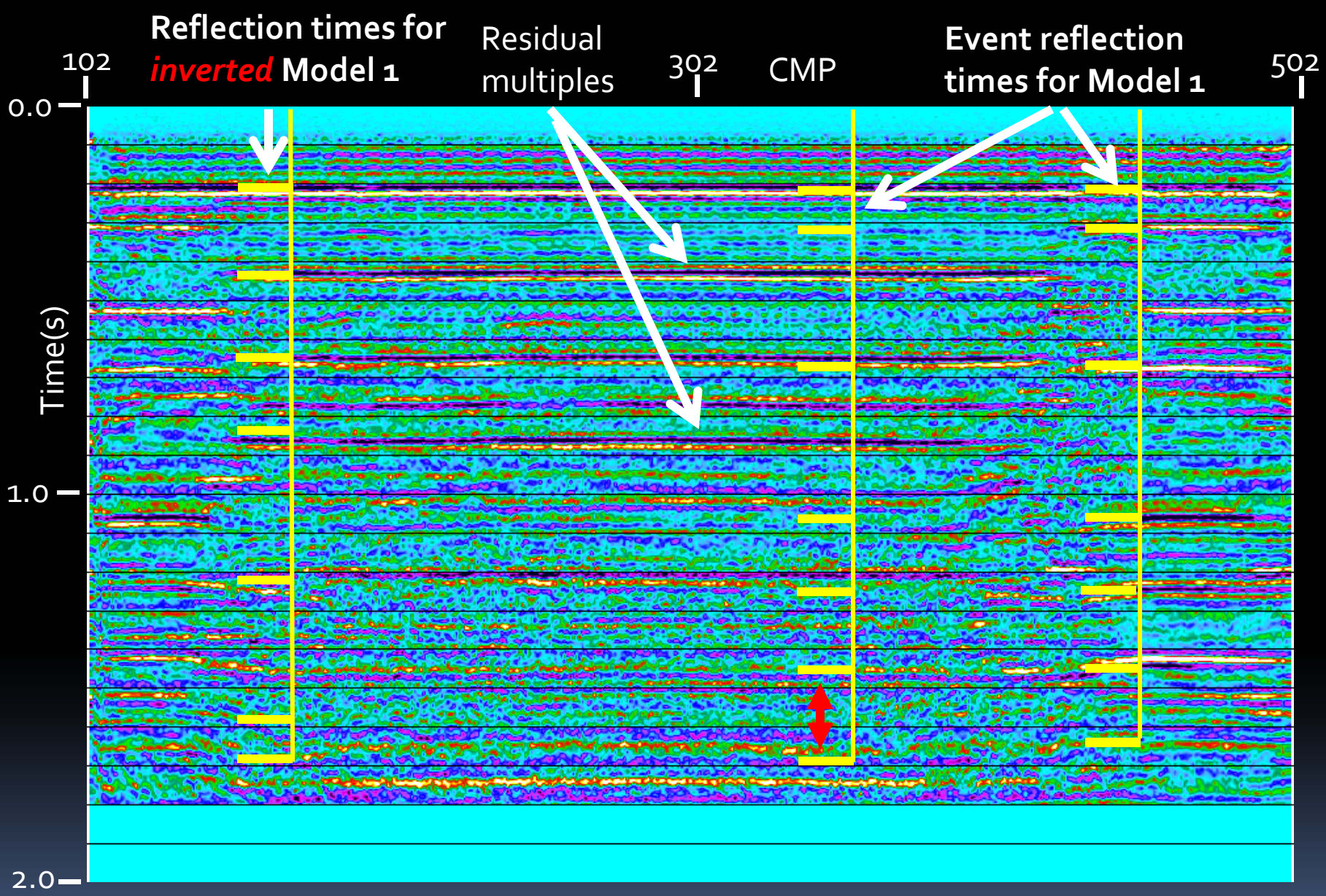
1	PVC		25.4mm	2350	1120	1300	
2	WATER		6.7mm	1480	0	1000	
3	PLX		50.8mm	2750	1380	1190	
4	PHN		66.9mm	3500	1700	1350	
5	PLX		25.4mm	2750	1380	1190	
6	WATER	TEFLON	12.8mm	1360	470	2200	WATER
7	PLX		25.4mm	2750	1380	1190	



Proposed model no. 1—Teflon block is removed for 'E' survey



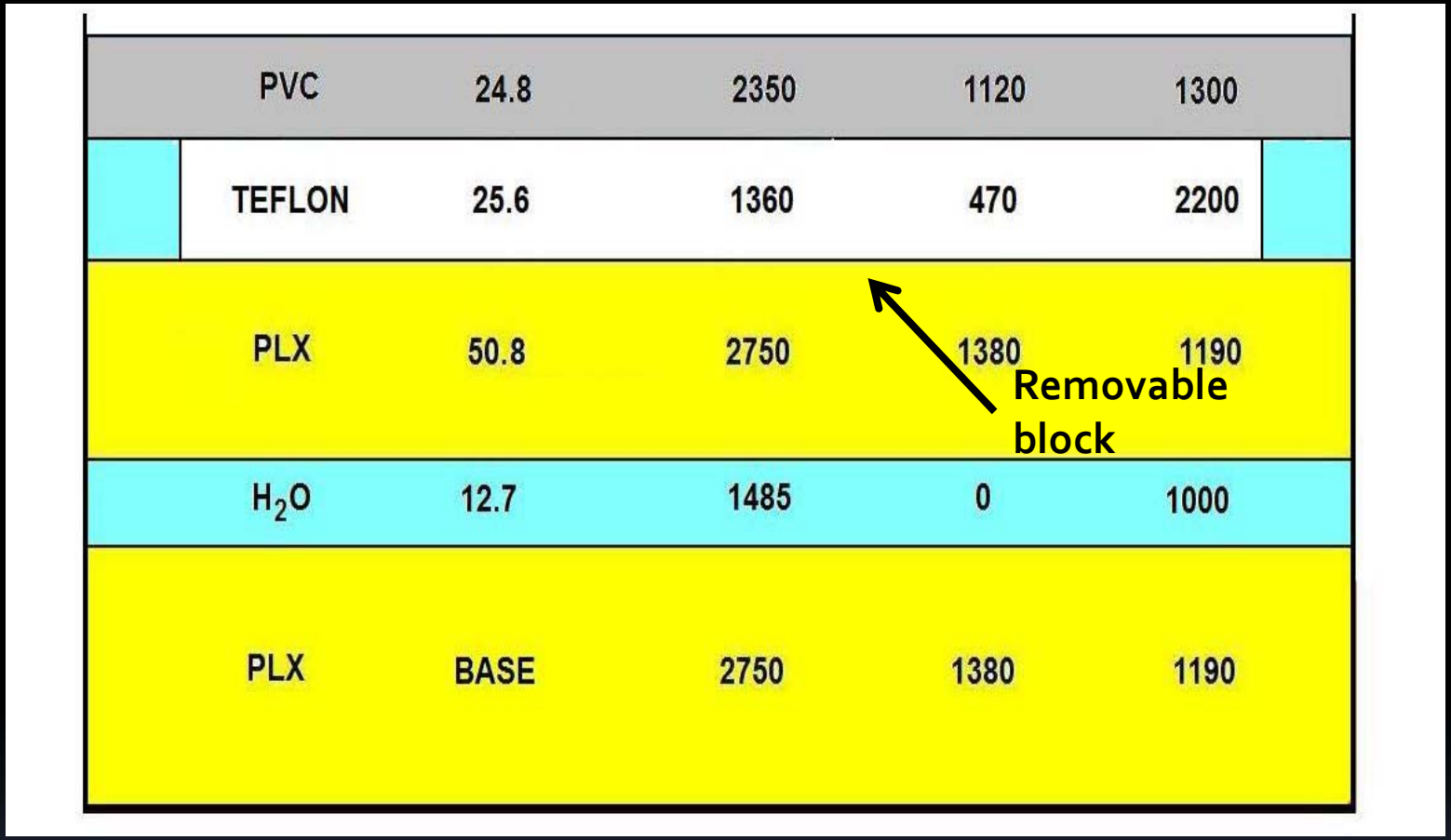
'E' CMP stack after de-multiple



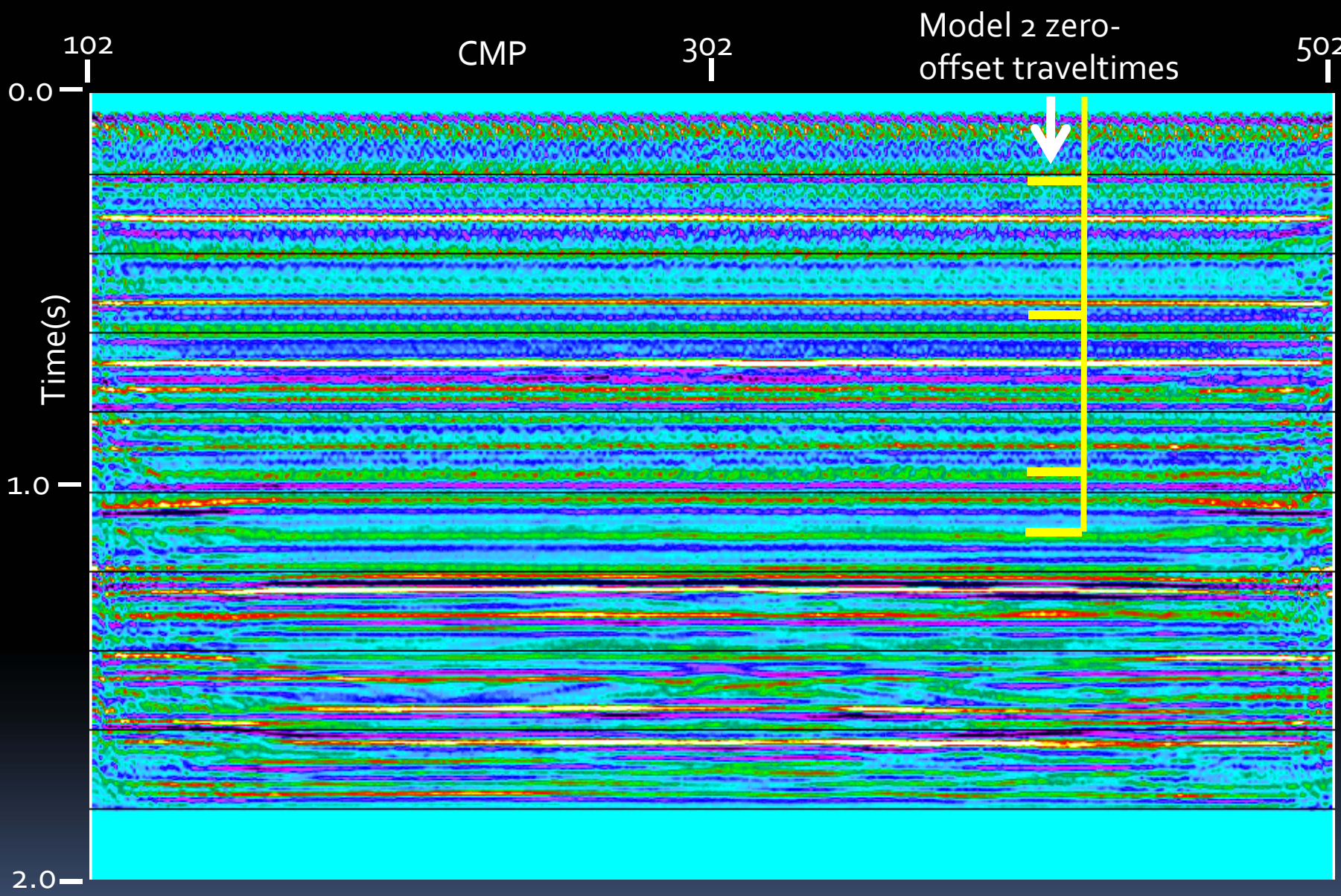
'B' CMP stack after de-multiple

Model 1 results

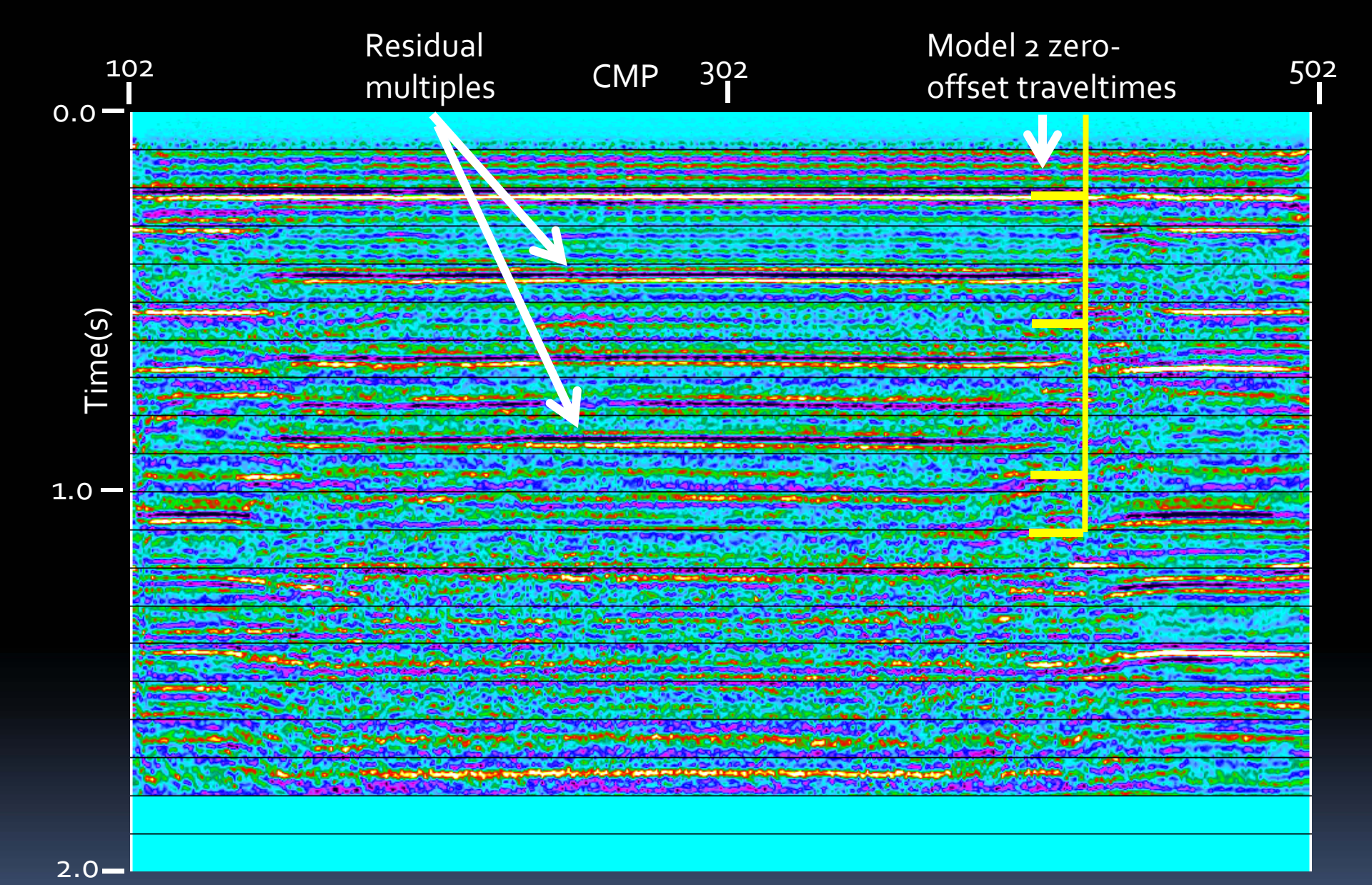
- Reflection timing matches 'E' image
- Timing for centre region of 'B' is ***ambiguous*** but ***should*** be the ***same*** as 'E', ***above the anomalous layer***
- ***Inverted*** Model 1 could explain 'B' image centre region…but…
- ***Inverted*** model reflection timing does ***not*** match 'E' image events



Proposed model no. 2—Teflon block is removed for 'E' survey



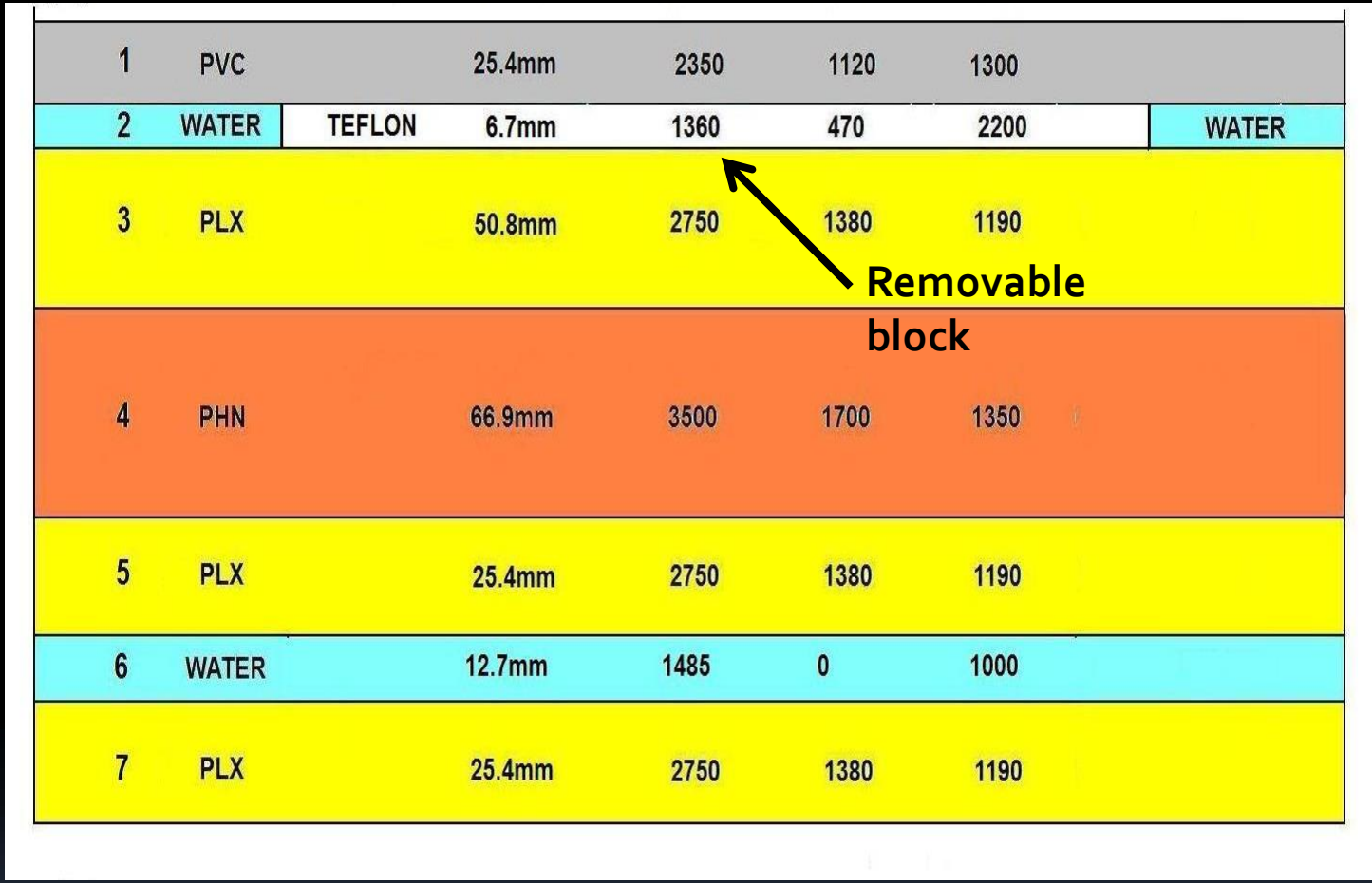
'E' CMP stack after de-multiple



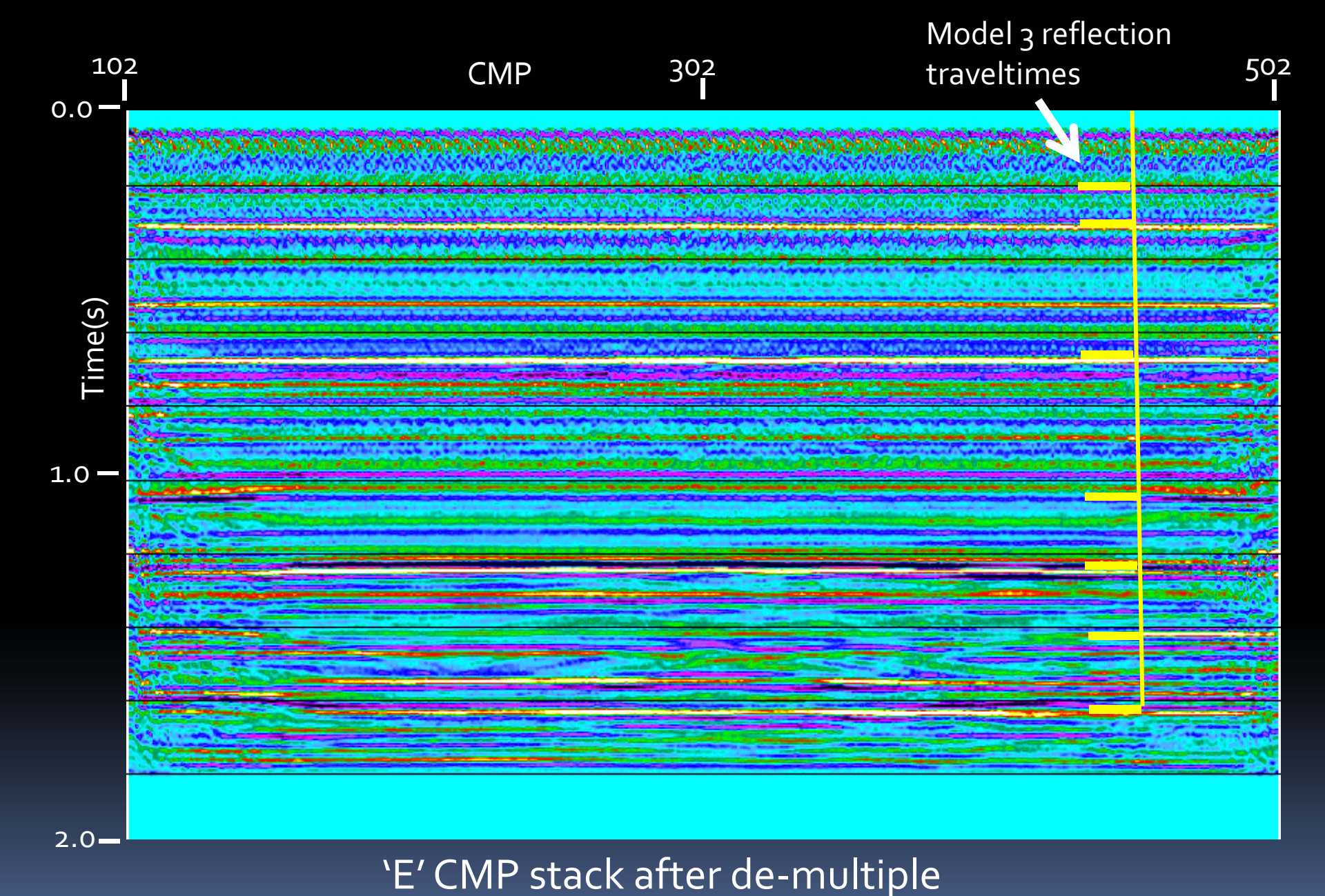
'B' CMP stack after de-multiple

Model 2 results

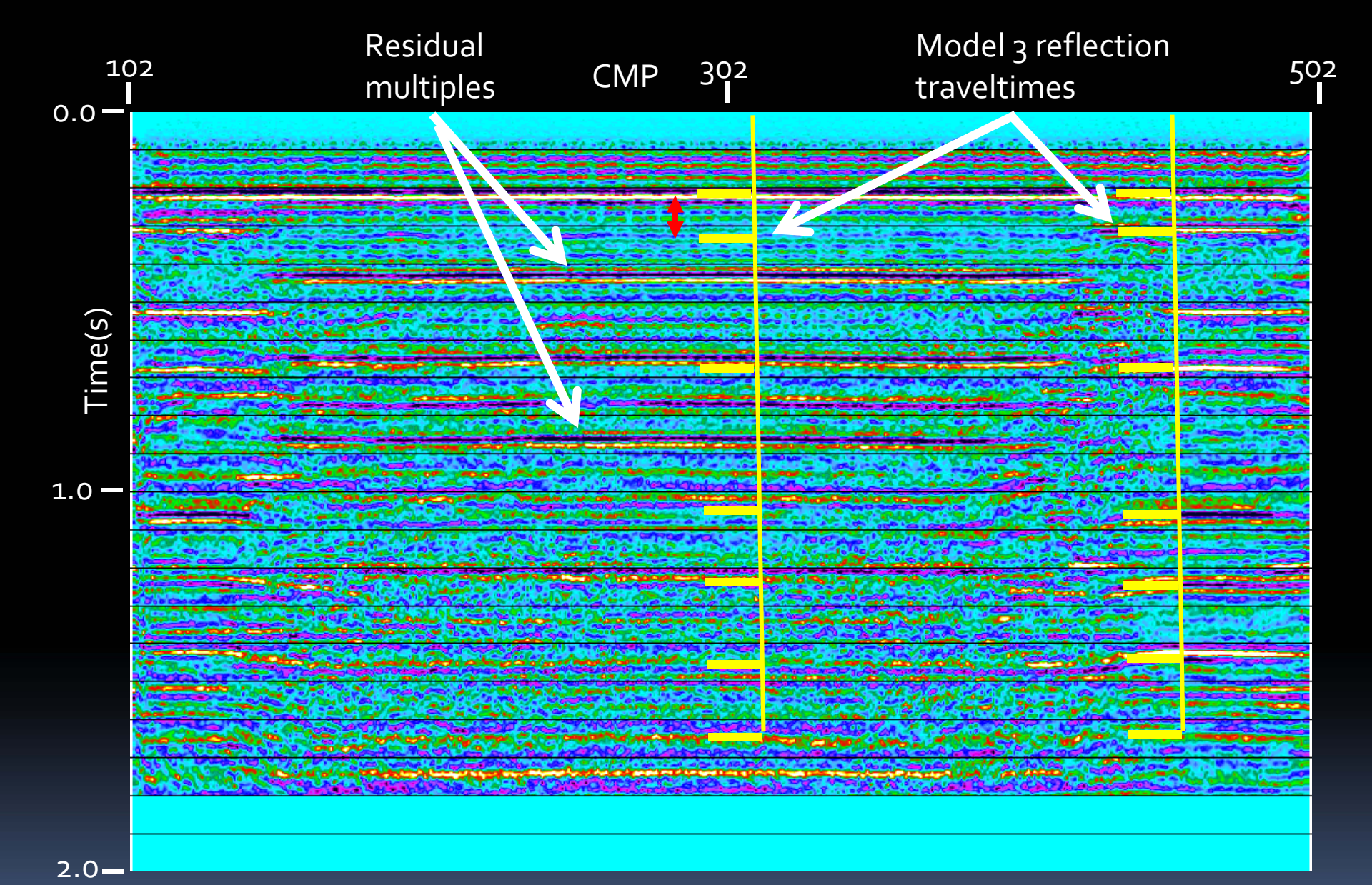
- Shallow teflon layer might explain 'B' ***attenuation and multiples*** as well as discontinuity artifacts
- ***Traveltimes*** for this model do ***not*** match observed reflection events on 'B' or 'E'
- ***Traveltimes*** do not extend deep enough to explain seismic data—too few layers



Proposed model no. 3—Teflon block removed for 'E' survey



'E' CMP stack after de-multiple



'B' CMP stack after de-multiple

Model 3 results

- Removable teflon layer **near the surface** explains SRM, attenuation, and discontinuities on 'B' image
- **Traveltimes** match observed 'E' reflections
- **Traveltimes** match 'B' reflections, but ***not perfectly—NMO velocity tuning might help***

Observations

- For physical model with **flat layers** and **regular acquisition geometry**, RT domain de-multiple can be effective
- ***Preconceived notions can mislead***
- ***Always believe the data***
- ***Ambiguity can remain*** even with good match of model and seismic data

Acknowledgements

- CREWES and NSERC for funding
- CREWES staff for discussions