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Common-Reflection-Surface Stack and Wavefield Attributes

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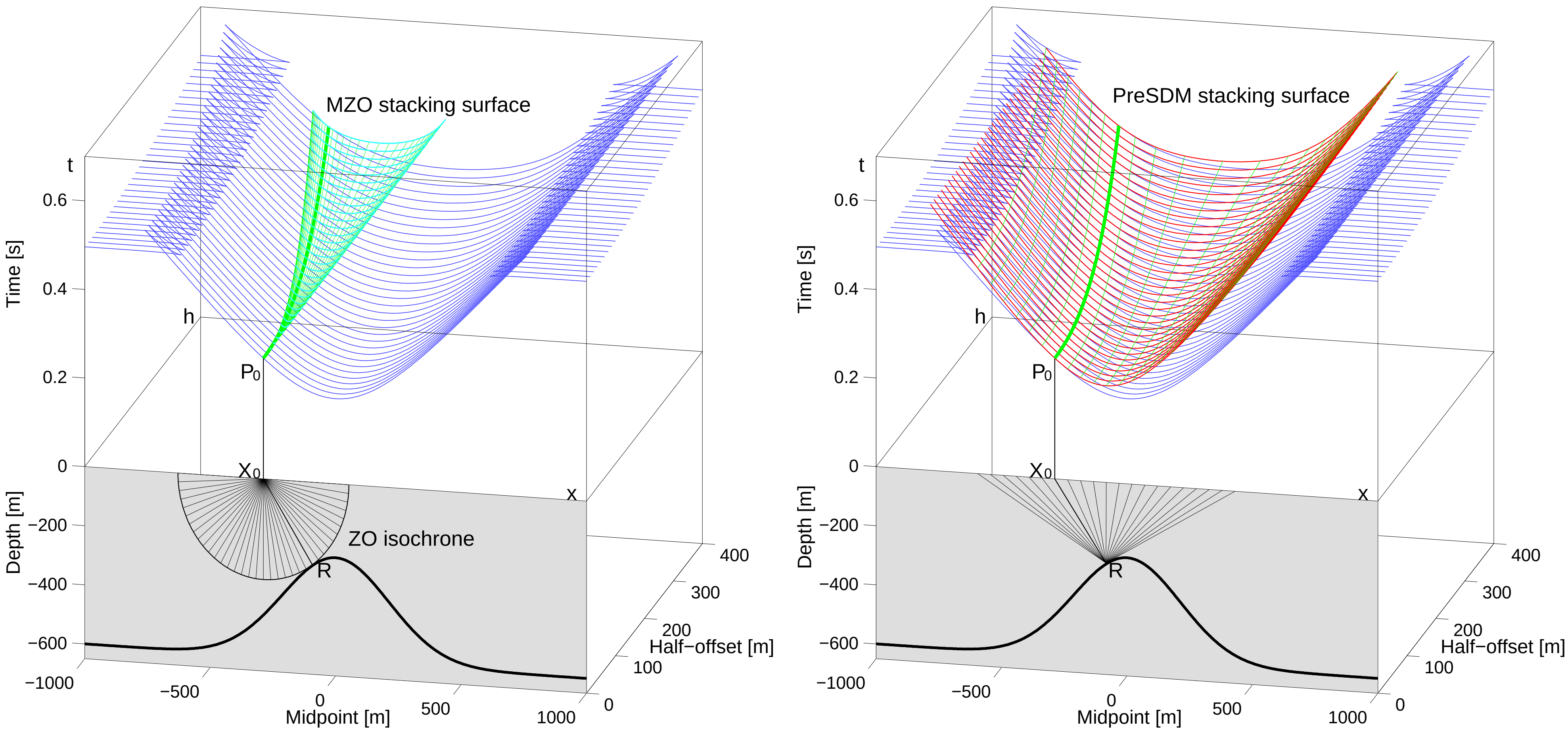
Overview

- Comparison of different stacking operators
- Eigenwave based CRS stacking operator
- Synthetic example vs. forward modeled attributes
- Real data example: imaging a salt dome
- Conclusions and outlook

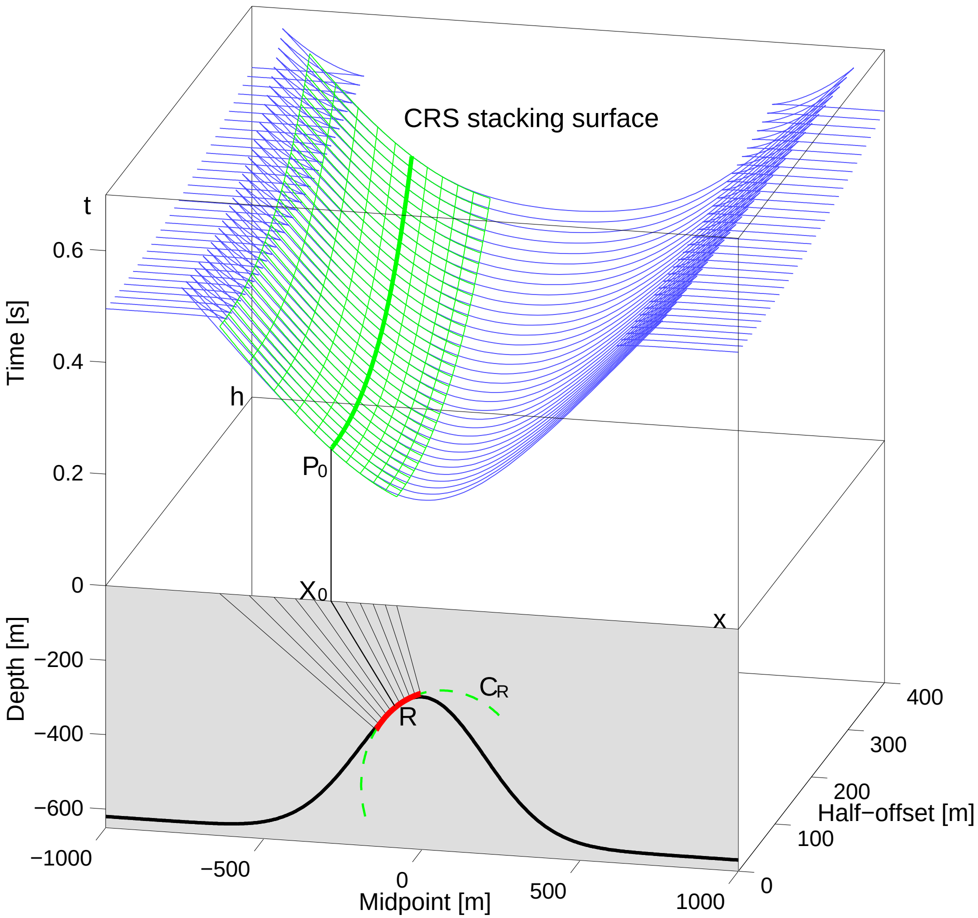
Summary

The common reflection surface (CRS) stack is a macro velocity model independent method to simulate zero-offset (ZO) sections from multi-coverage seismic reflection data for 2-D media.
The CRS stacking operator depends on attributes of hypothetical wavefronts observed at the surface that allow to perform a subsequent inversion.
The CRS stacking operators fitting best to actual reflection events in the data set have to be determined by coherency analysis. The main task is the determination of these operators by variation of the attributes in a reasonable computation time preserving a sufficient accuracy.

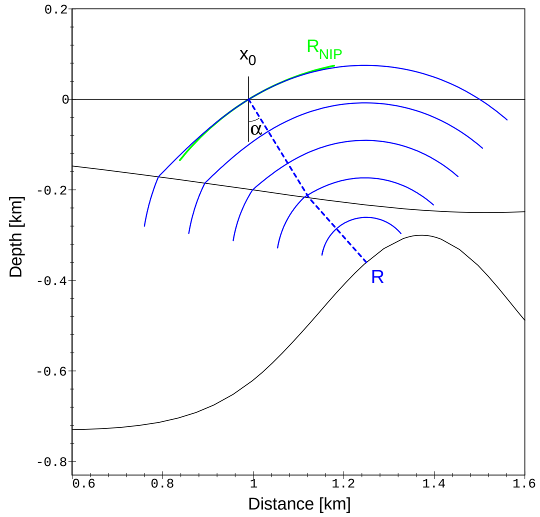
Stacking operators of NMO/DMO/stack and pre-stack depth migration

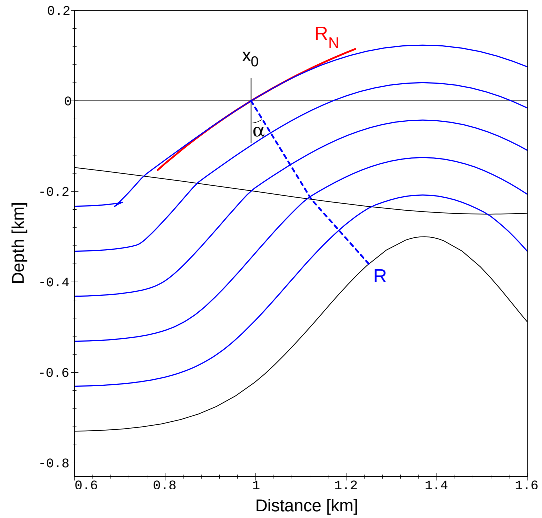


CRS stacking operator



Eigenwave experiments





Common-reflection-surface stacking operator

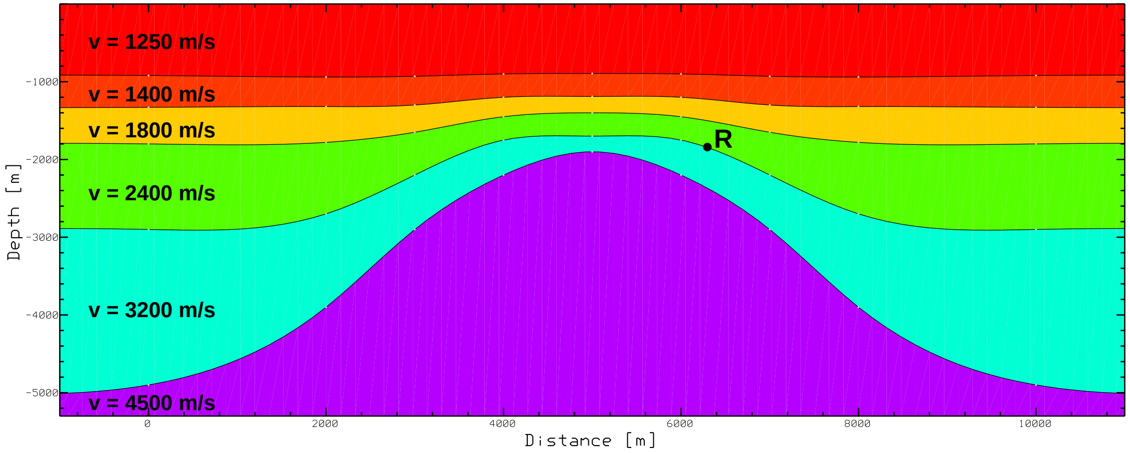
$$t^2\,(\Delta x, h) = \left(t_0 + \frac{2\,\sin\alpha\,\Delta x}{v_0}\right)^2 + \frac{2\,t_0\,\cos^2\alpha}{v_0}\left(\frac{\Delta x^2}{R_N} + \frac{h^2}{R_{NIP}}\right)$$

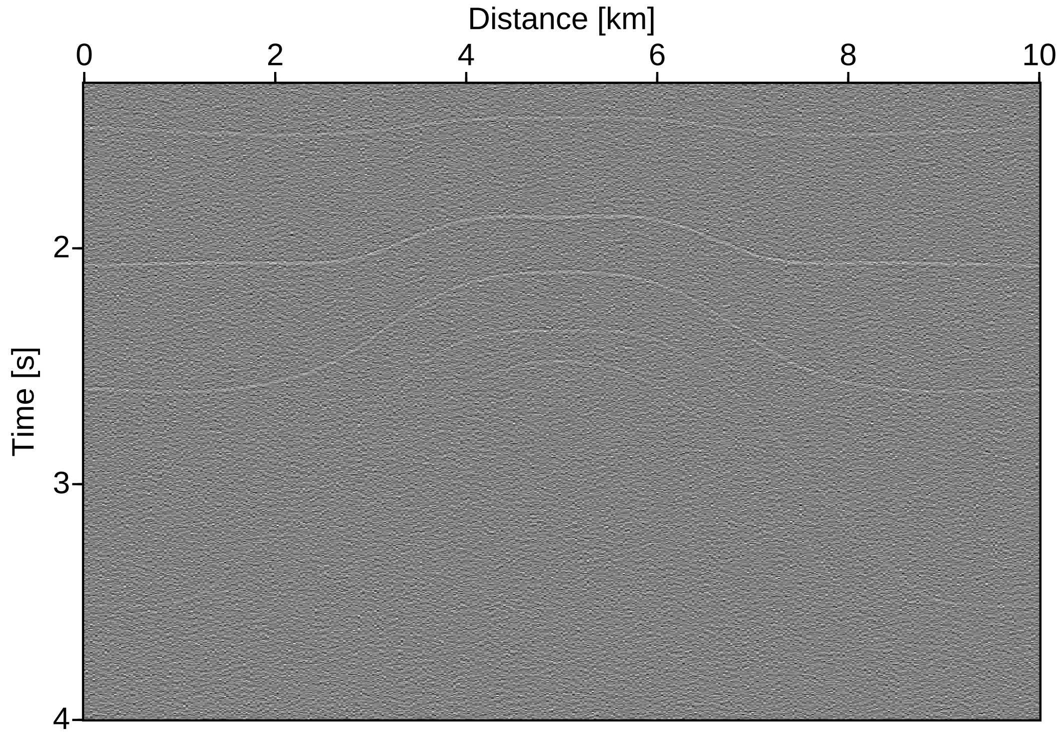
h: half offset between shot and receiver
Δx: midpoint distance
α: emergence angle of the normal ray
R_{NIP}: radius of curvature of the NIP wave
R_N: radius of curvature of the normal wave

In the CMP gather in terms of the stacking velocity v_{NMO}:

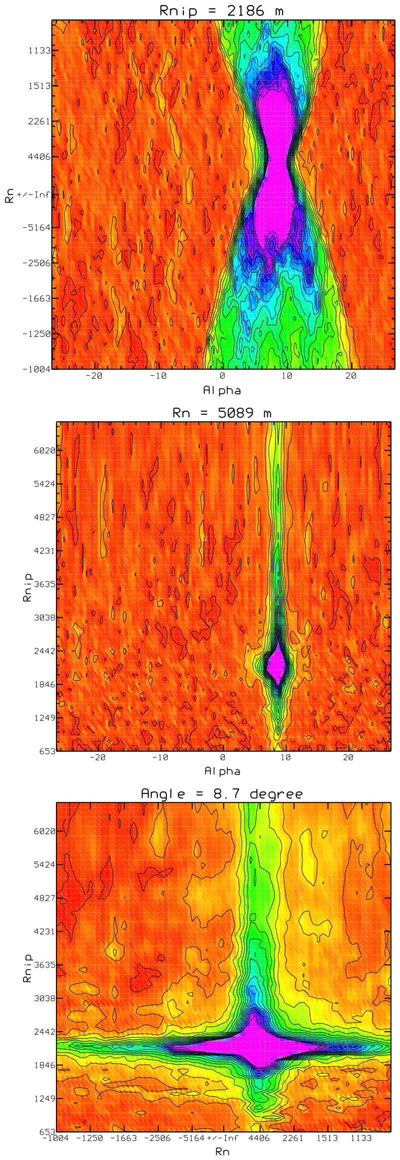
$$t^2\,(h) = t_0^2 + \frac{4\,h^2}{v_{NMO}^2} \quad \text{with} \quad v_{NMO}^2 = 2\,v_0\,R_{NIP}/(t_0\,\cos^2\alpha)$$

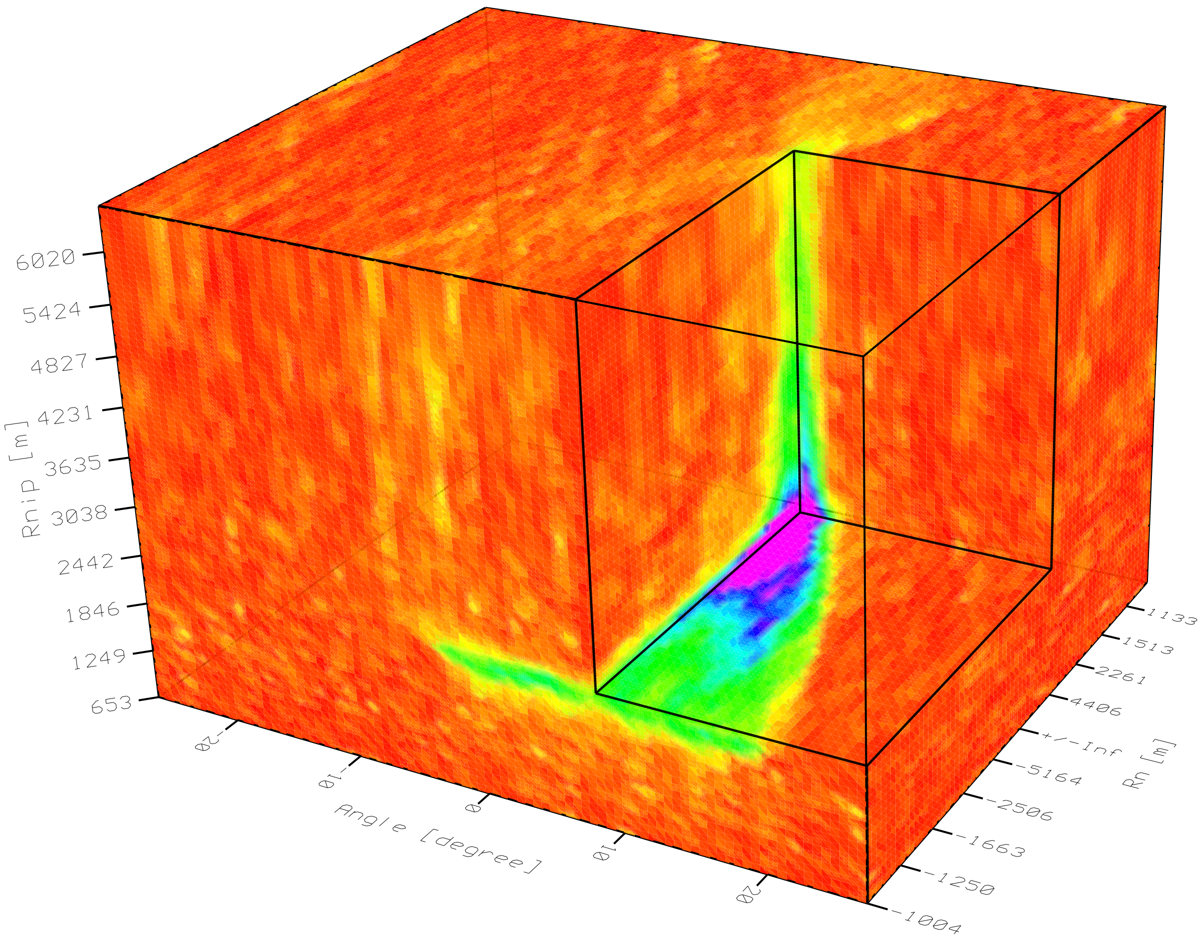
Synthetic example: model and ZO section of multi-coverage data set



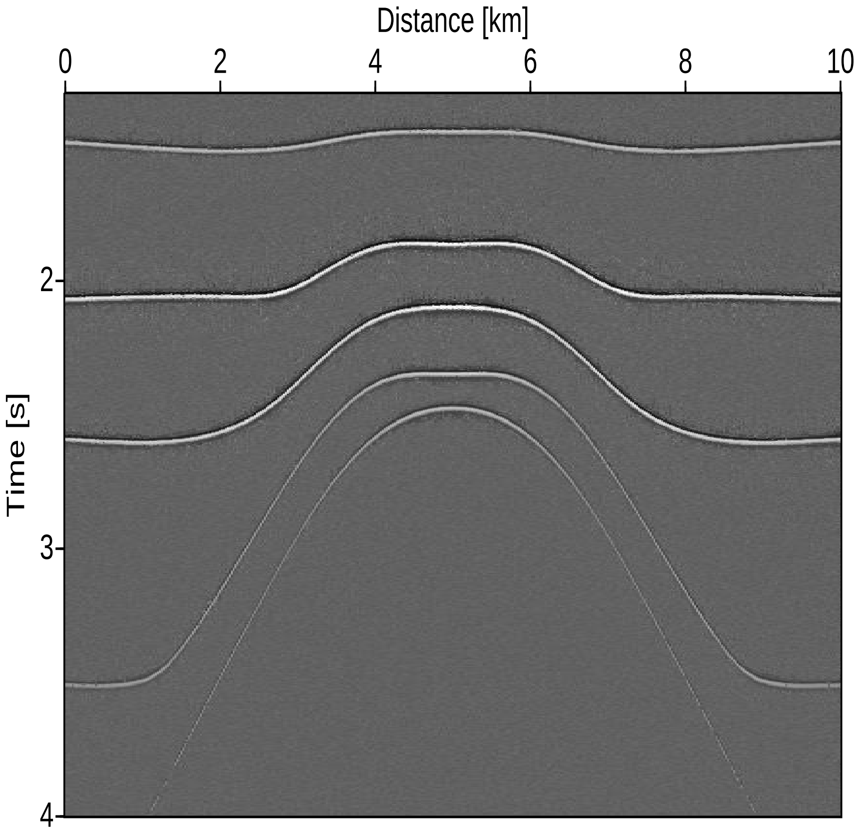


Coherence in the wavefield attribute domain

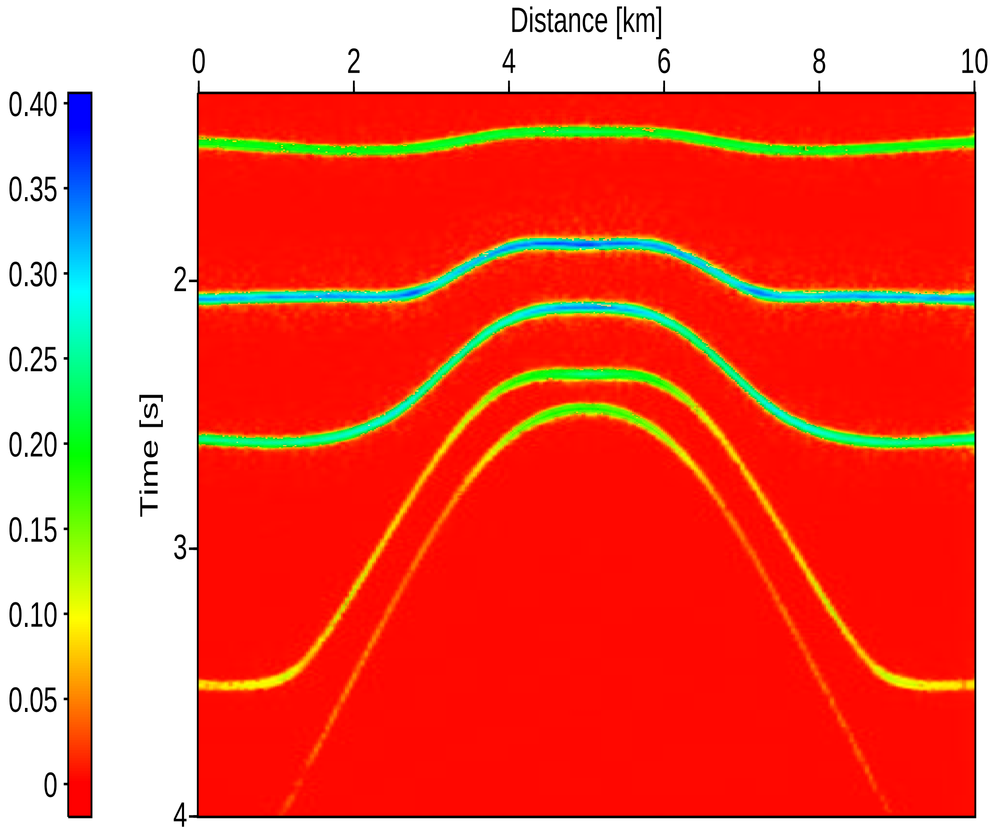




Synthetic example: result of the optimized CRS stack

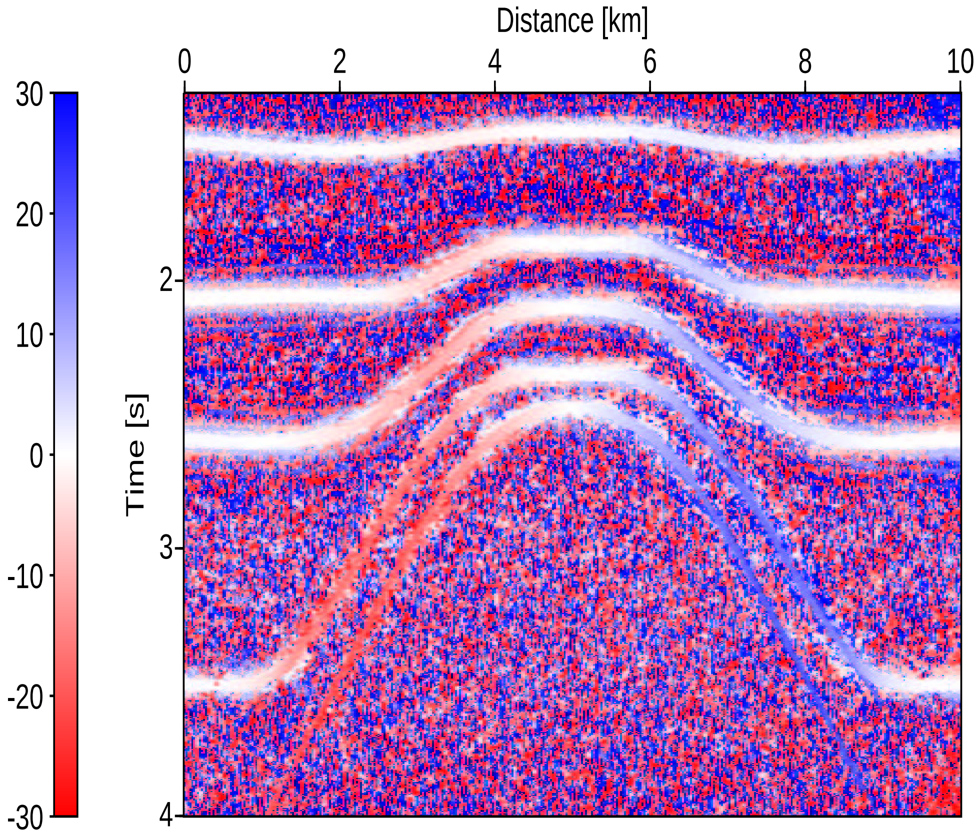


simulated ZO section

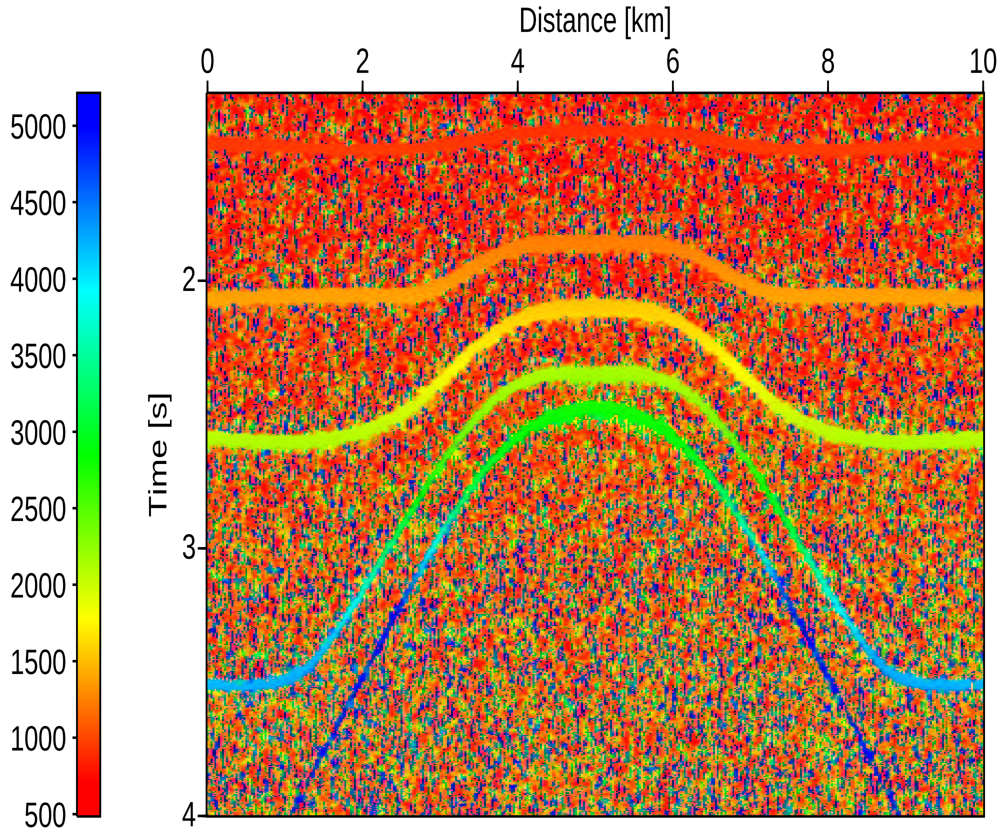


coherency section

Synthetic example: attribute sections

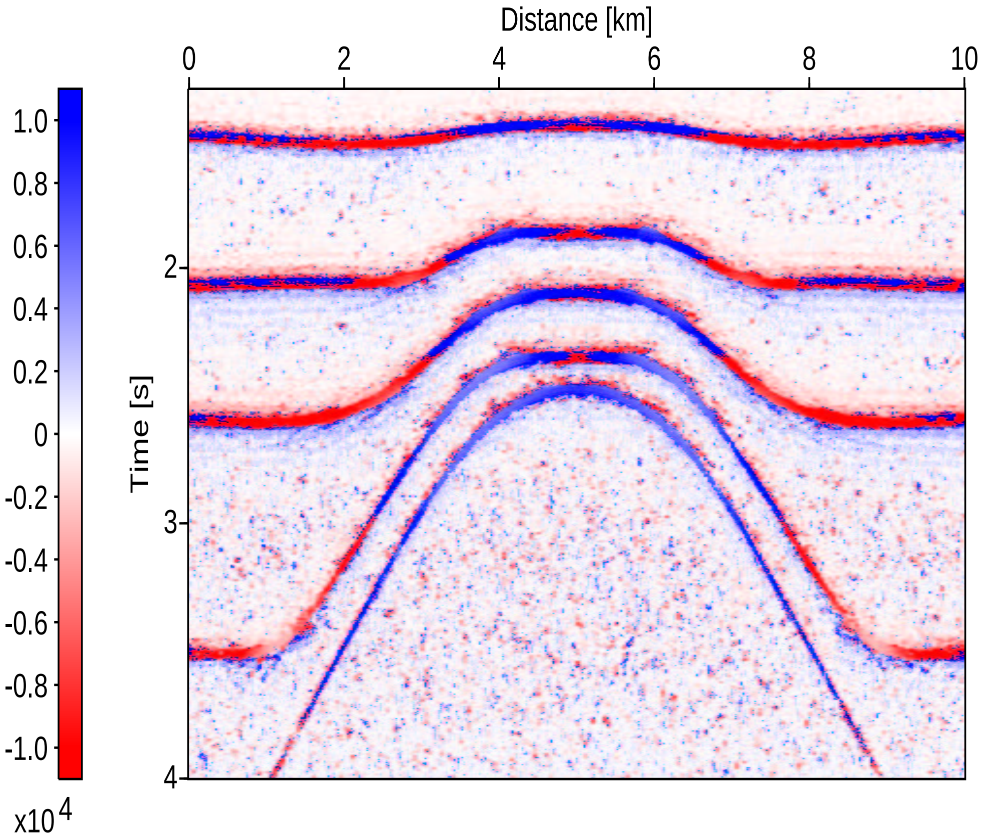


emergence angle [°]

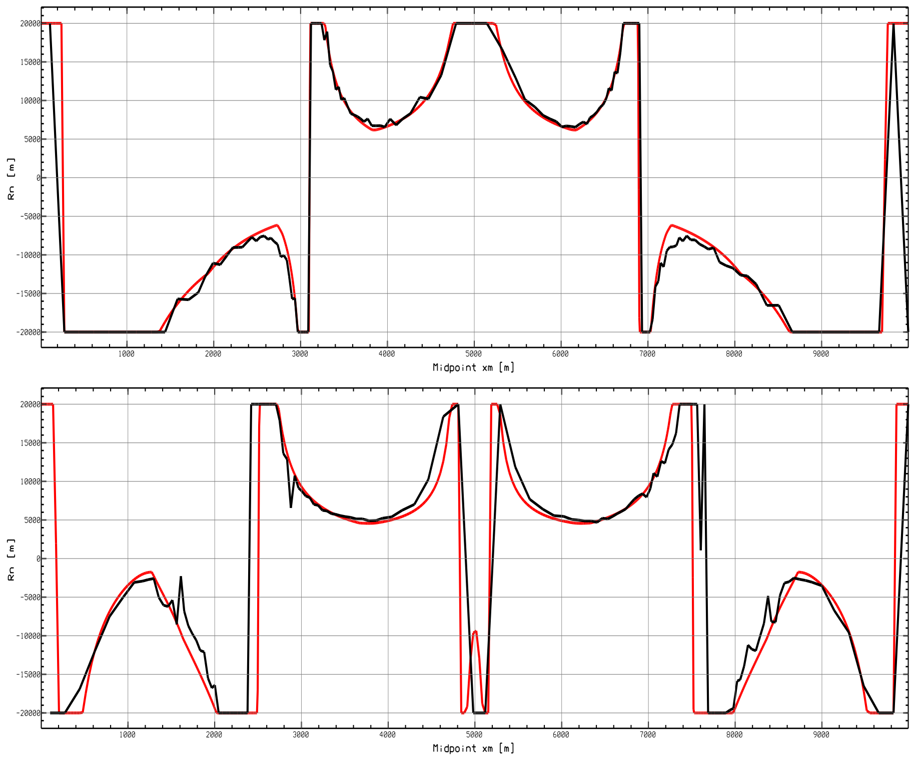


radius of curvature R_{NIP} [m]

Synthetic example: attribute sections

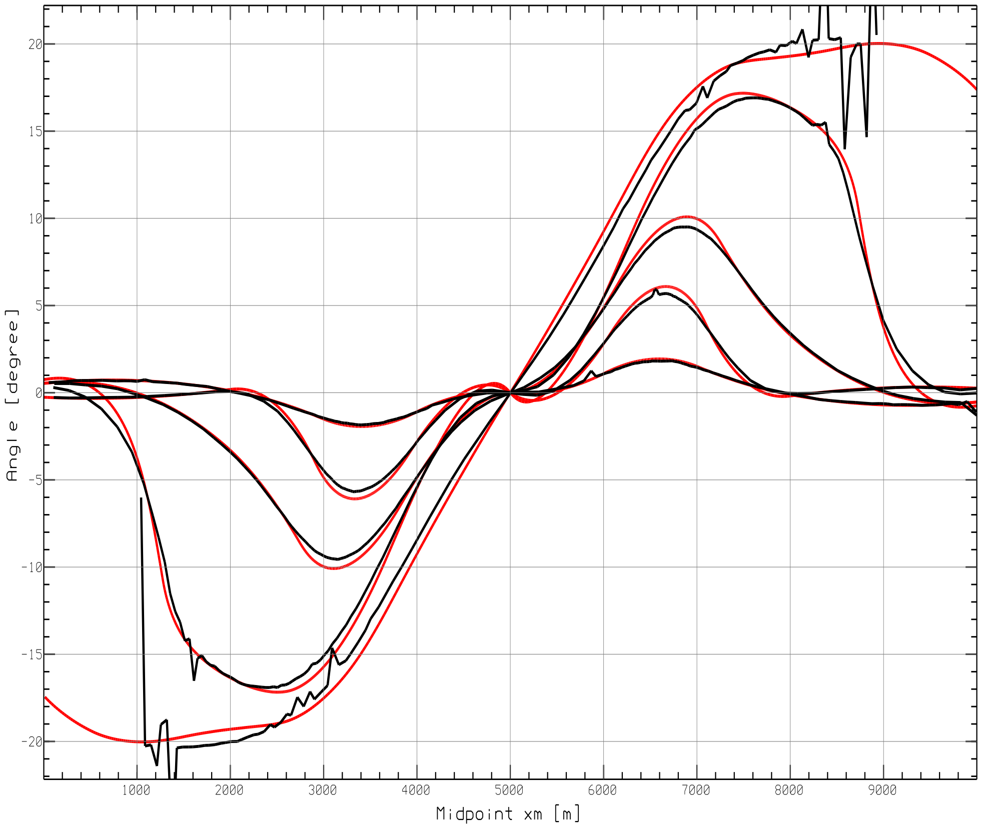


radius of curvature R_N [m]

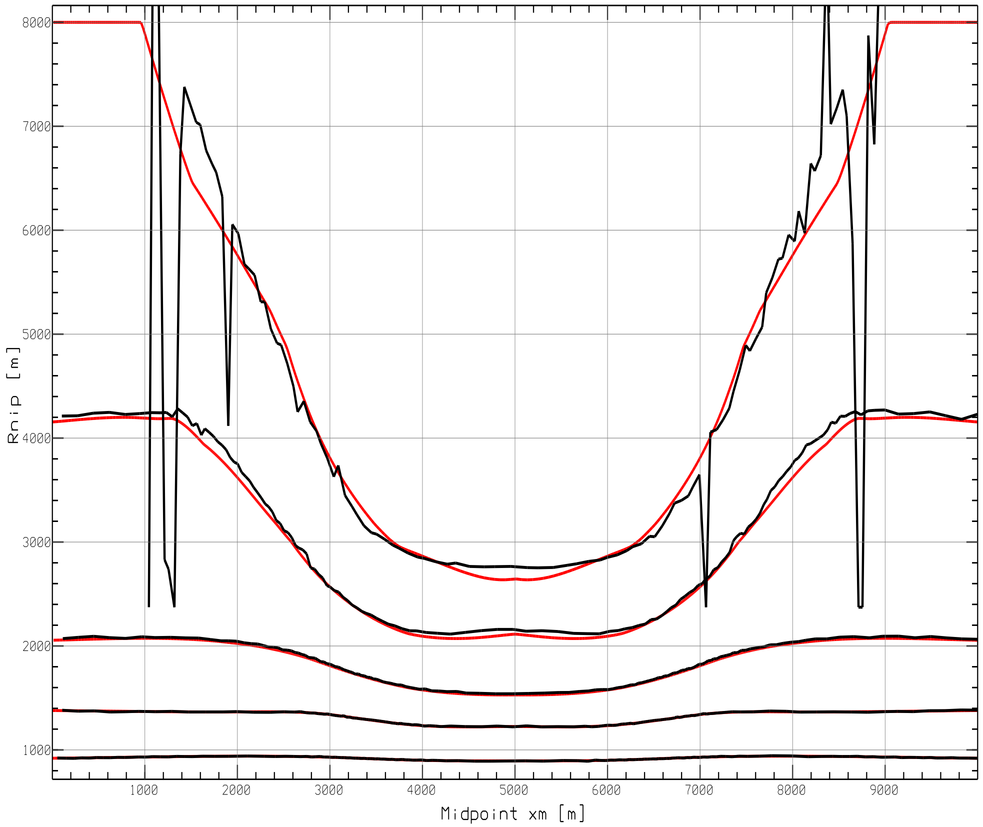


model-derived vs. data-derived R_N

Synthetic example: attribute sections

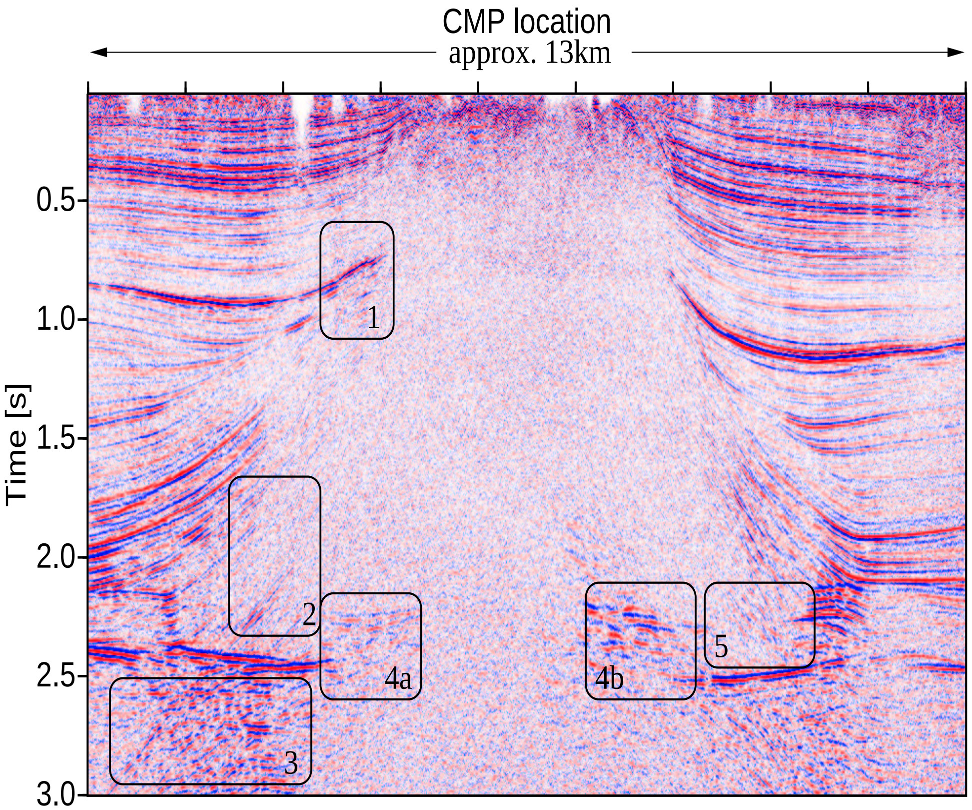


model-derived vs. data-derived emergence angle

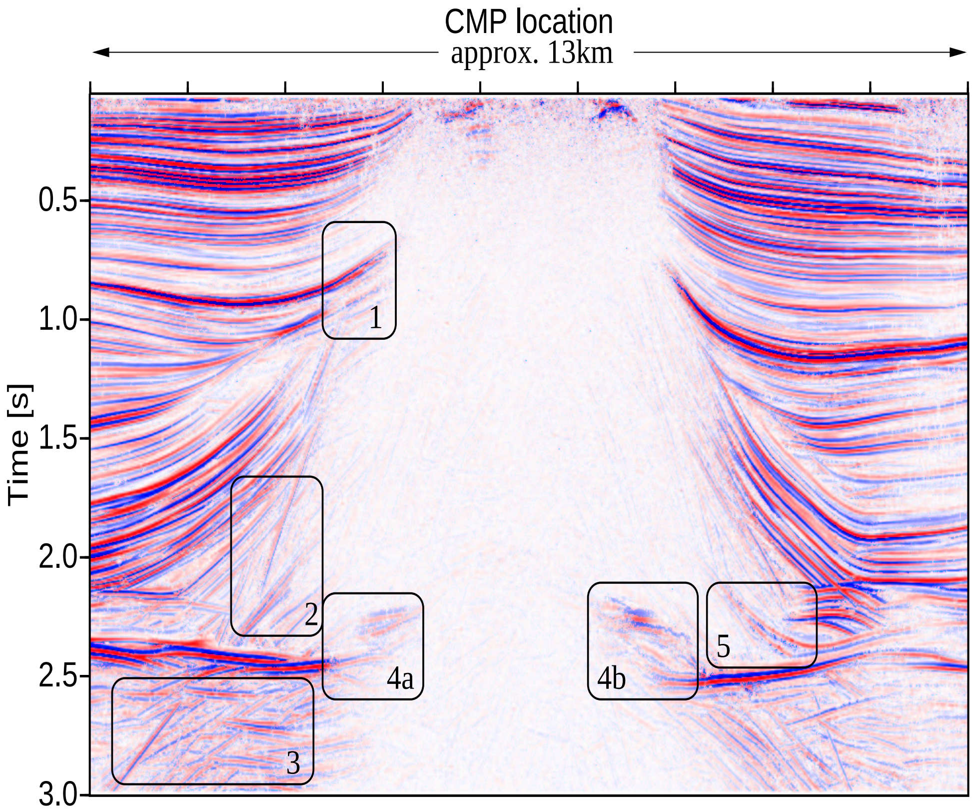


model-derived vs. data-derived R_{NIP}

Real data example: NMO/DMO/stack vs. CRS stack



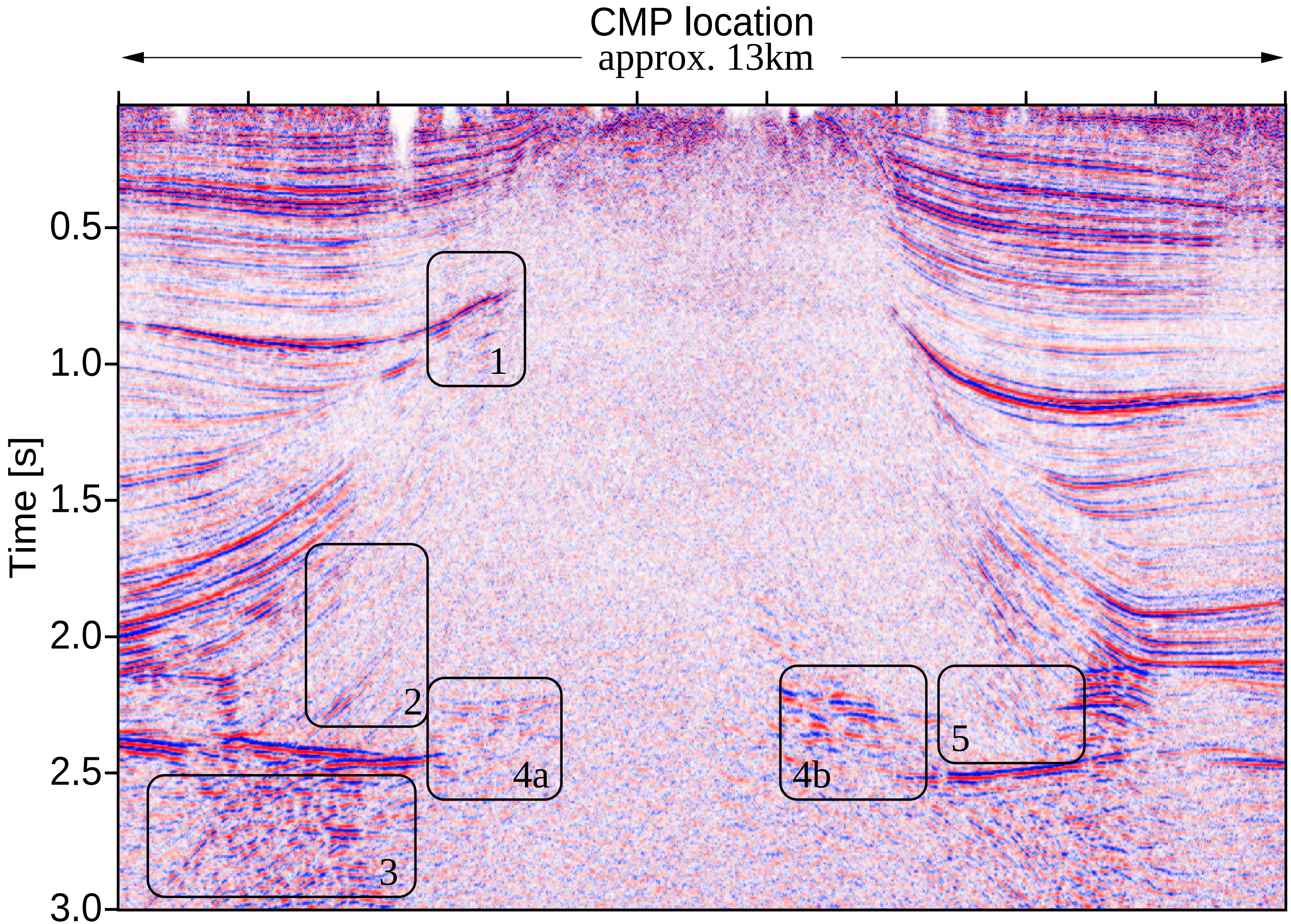
NMO/DMO/stack



Optimized CRS stack

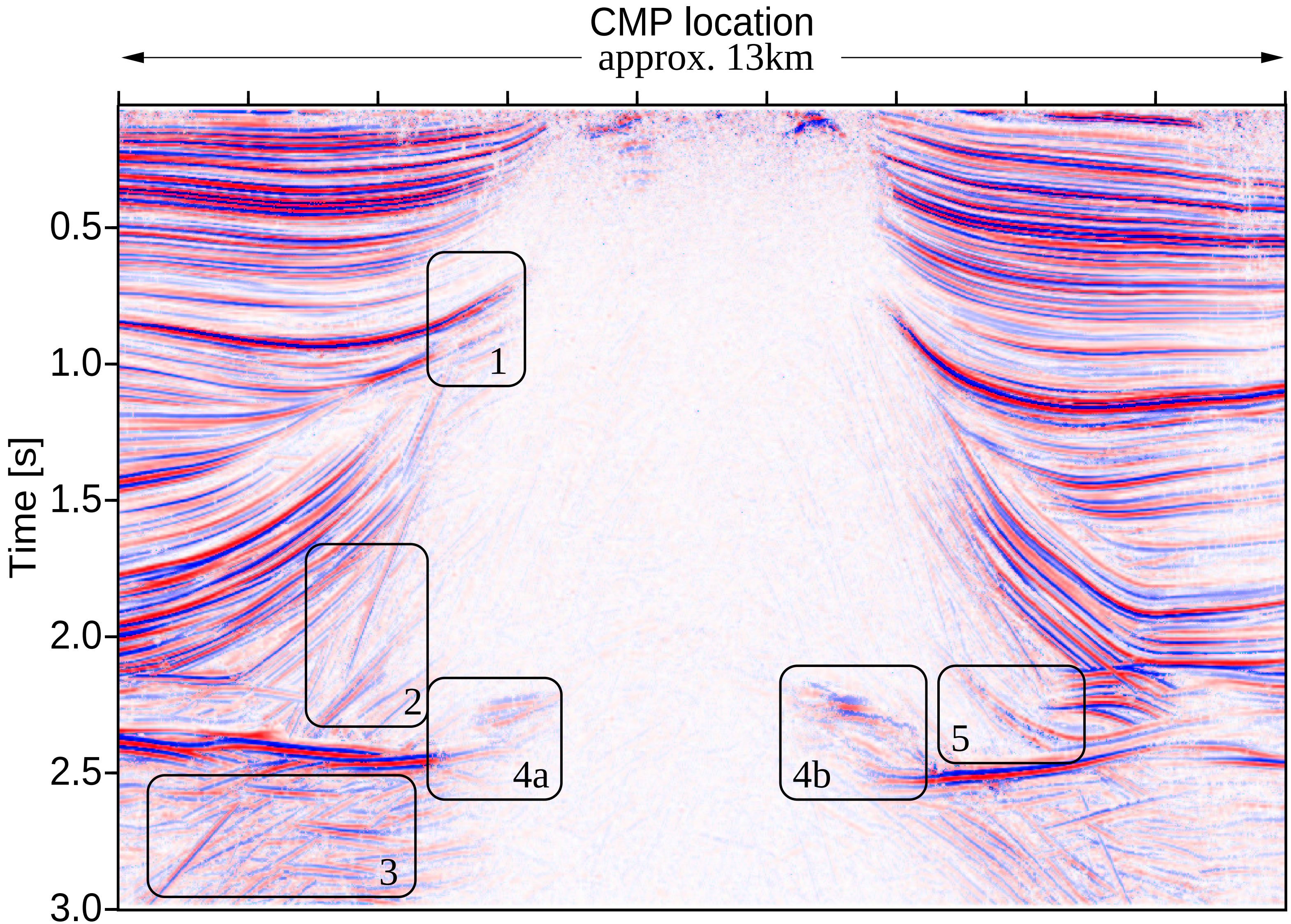
Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Real data example: conventional NMO/DMO/stack



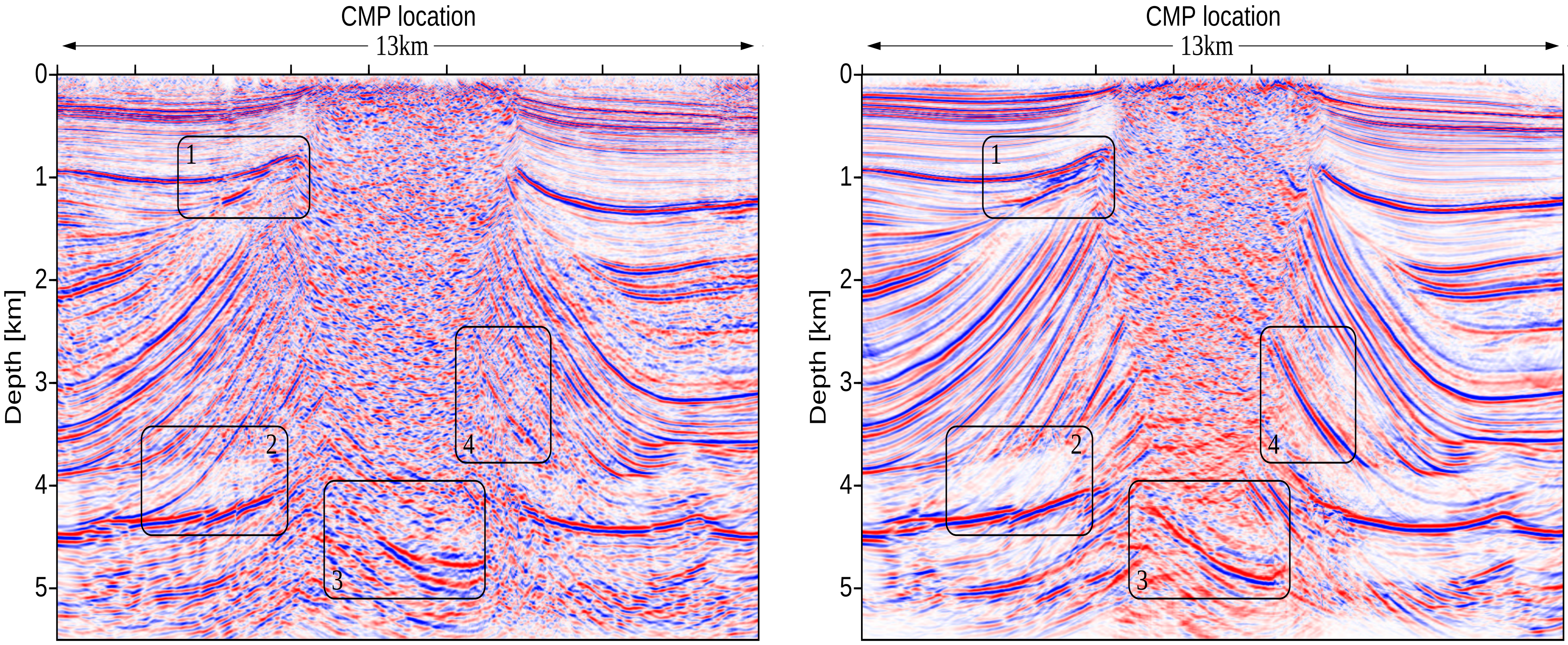
Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Real data example: optimized CRS stack



Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Real data example: post-stack depth migrated sections

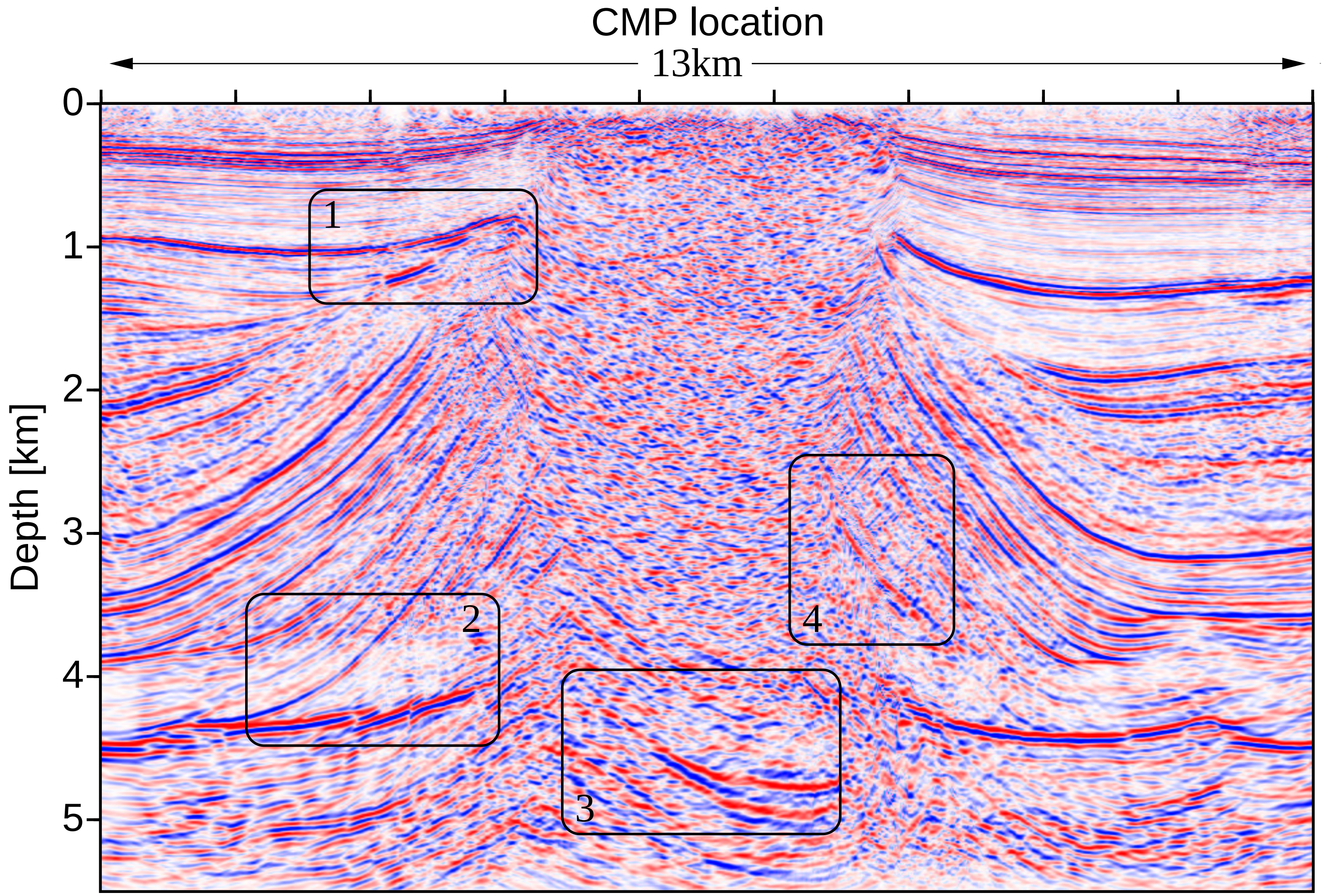


NMO/DMO/stack

Optimized CRS stack

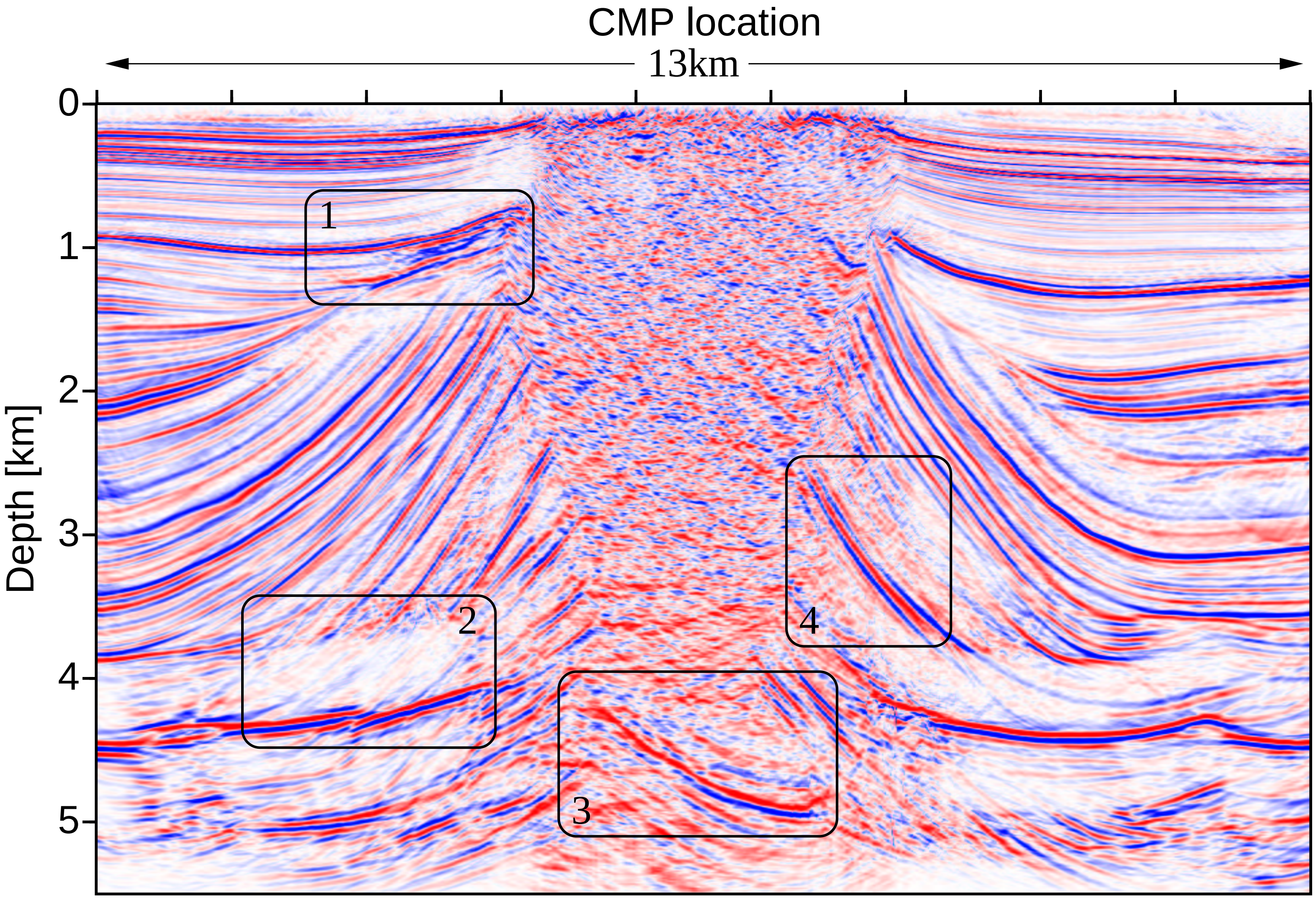
Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Real data example: post-stack depth migrated NMO/DMO/stack



Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Real data example: post-stack depth migrated CRS stack



Data courtesy of *BEB Erdgas und Erdöl GmbH* and *Preussag Energie GmbH*.

Conclusions

The CRS stack is a model independent seismic imaging method and thereby can be performed without any ray tracing and macro velocity model estimation. Only the knowledge of the near surface velocity is required. As a result of a CRS stack one obtains in addition to each simulated ZO reflection time important wave-field attributes: the angle of emergence and the radii of curvature of the NIP and the $normal$ wave.
The application to real and synthetic datasets showed noteworthy results with respect to the stack section and the determined attributes. In view of the authors, the proposed strategies offer an exciting approach to improve the stack section and to allow for a subsequent inversion.

References

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Acknowledgements

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