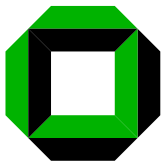
A seismic reflection imaging workflow based on the Common-Reflection-Surface (CRS) stack: theoretical background and case study

T. Hertweck[1] C. Jäger J. Mann*
E. Duveneck[2] Z. Heilmann

[1]now: Fugro-Robertson Ltd, Swanley, UK
[2]now: SINTEF Petroleum Research, Trondheim, Norway

Wave Inversion Technology (WIT) Consortium
Geophysical Institute, University of Karlsruhe (TH)



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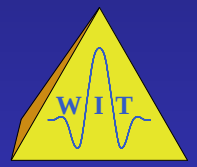


Overview

Introduction

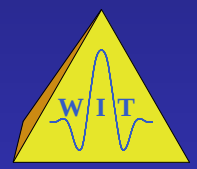
The project

Data example

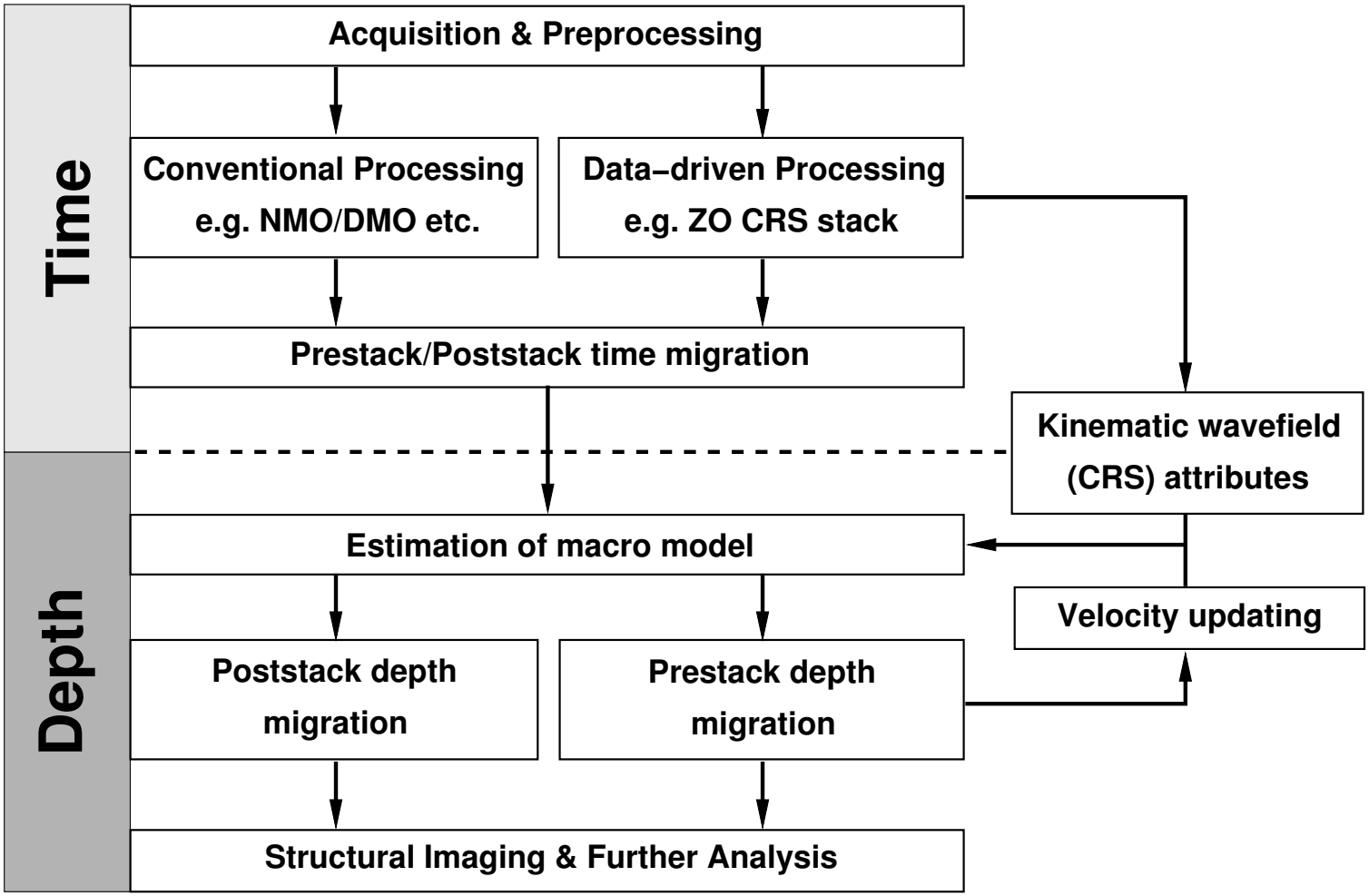
Comparison

Conclusions

Acknowledgments



Seismic imaging



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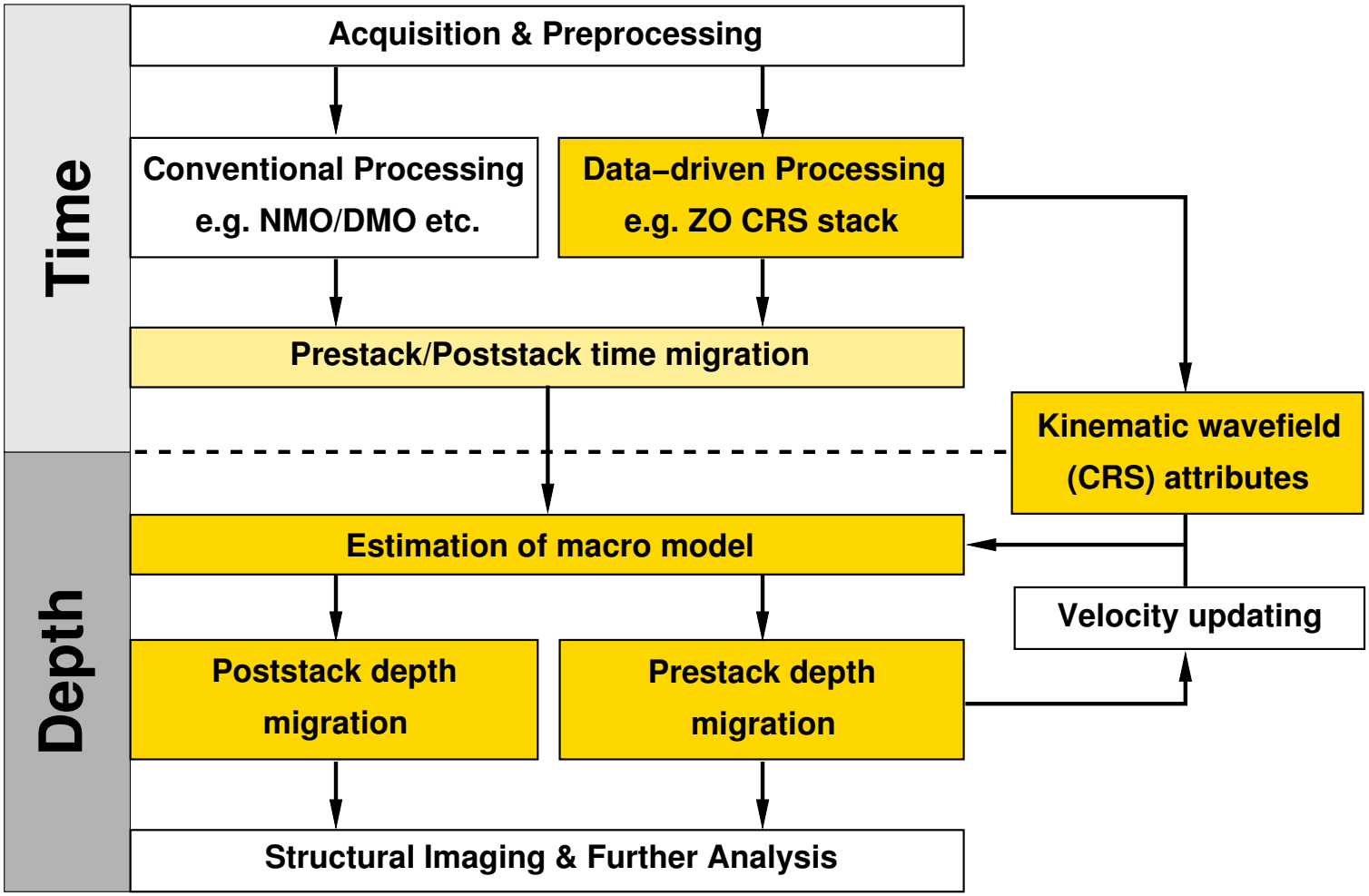

yellow = tools developed at Karlsruhe University

Common-Reflection-Surface stack

- Alternative to standard NMO/DMO/stack approach
- Output: zero-offset section (2D) or volume (3D) of high S/N ratio
- Additional output: variety of kinematic wavefield attributes (so-called CRS attributes)
- Principle: generalized, high-density, multiparameter, multidimensional stacking velocity analysis tool
- Automated coherence-based application

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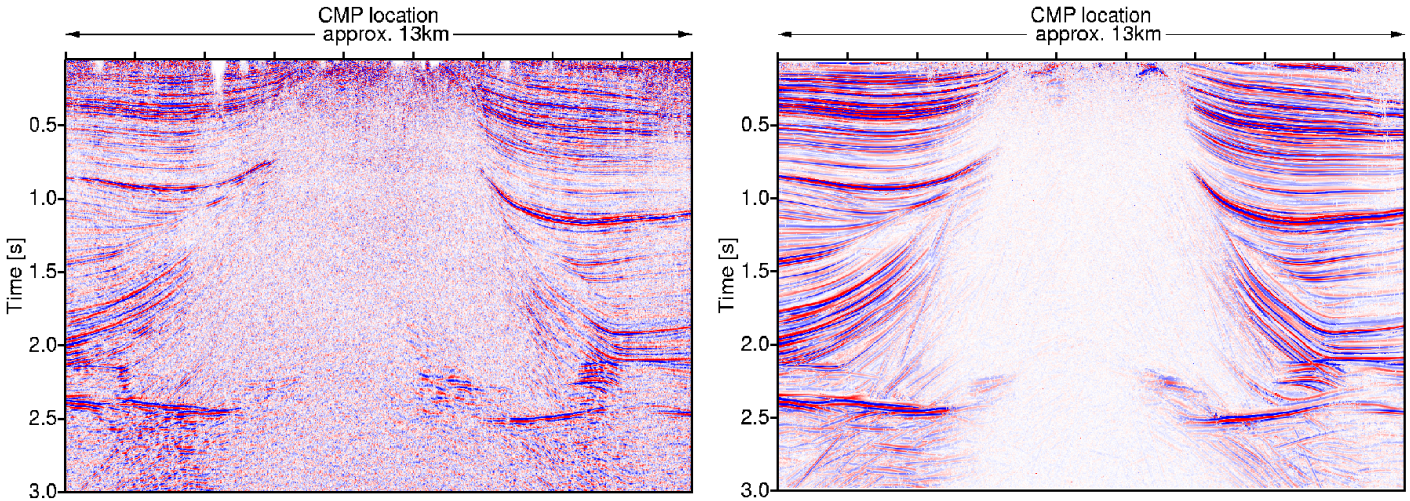

(from Müller, "The Common Reflection Surface Stack Method", 1999)

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- second-order approximation of reflection events
- spatial stacking operator
- limited number of stacking parameters:
  first and second spatial derivatives of traveltime
- geometrical interpretation:
  propagation direction and curvatures of hypothetical wavefronts

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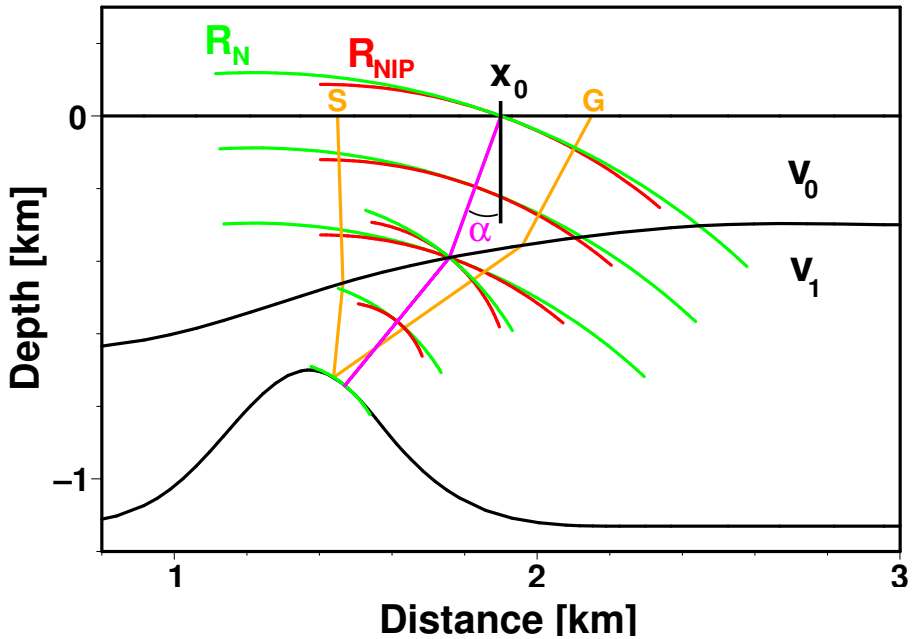

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- Automated, approximate, data-driven time migration
- Approximation of geometrical spreading factor
- Approximation of projected Fresnel zone
  - ⇒ Optimization of limited-aperture (true-amplitude) Kirchhoff depth migration
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CRS stack ✔

\+ Attribute-based tomography ✔

\+ (True-amplitude) Kirchhoff depth migration ✔

= CRS-stack-based imaging workflow

- Consistent imaging workflow from prestack time domain to depth domain
- Flexible, largely automated strategies
- Various useful auxiliary results

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- Geothermal project: power station planned
- Seismic survey performed to
  - Image fractures and faults $\Rightarrow$ water flow
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- 2 parallel seismic lines, 12 km length each
- Source: 3 vibrators, linear upsweep 12-100 Hz, source separation Δs=50 m
- Receivers: $\approx$ 240 groups (12 geophones each), receiver group separation Δr=50 m
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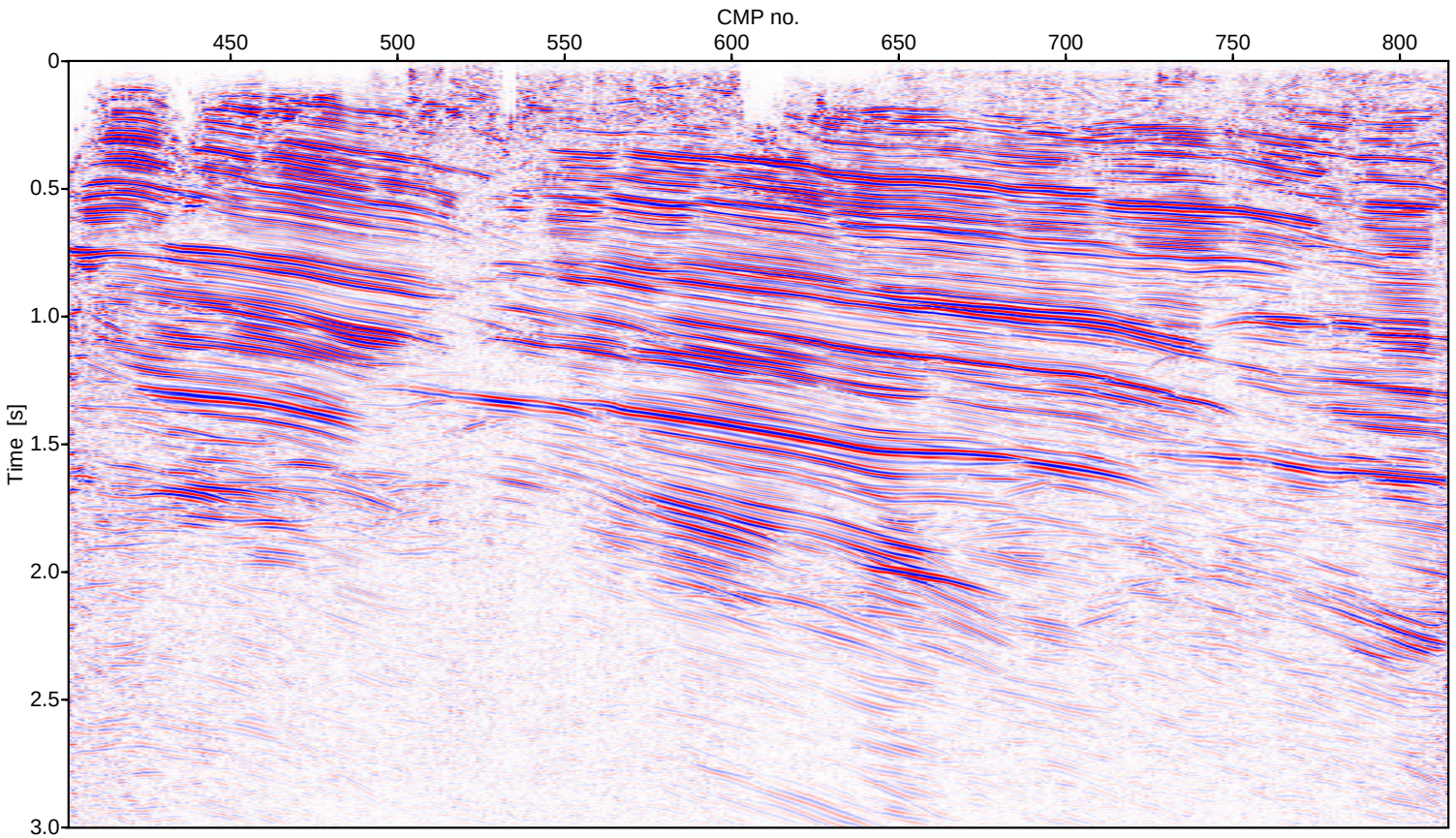
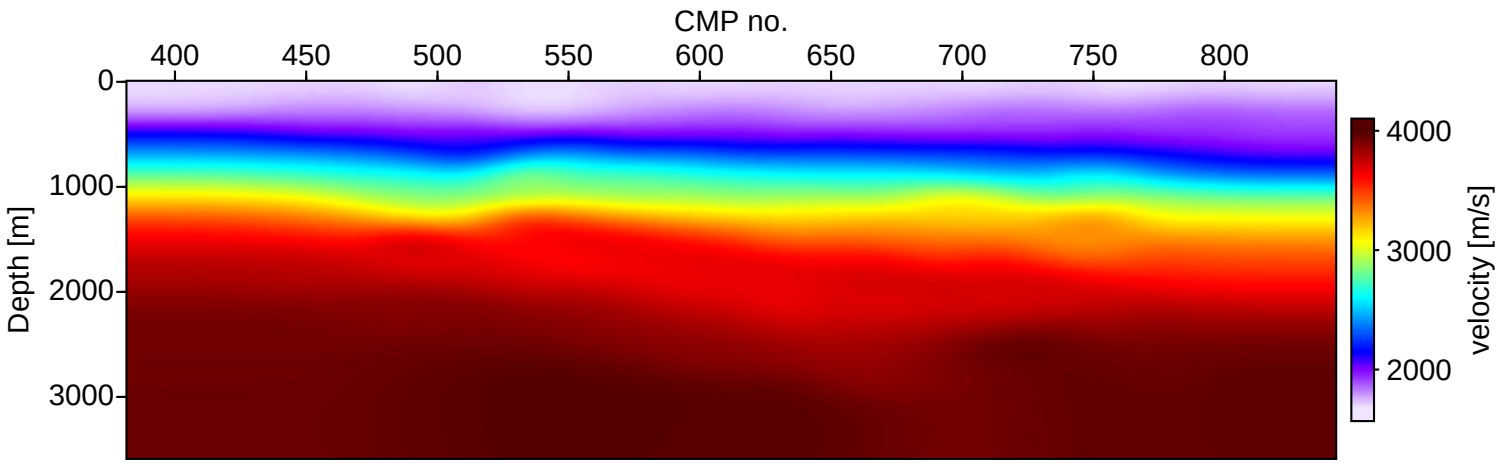
CRS stack: simulated ZO section



horizontal extent ≈ 12 km

Tomographic inversion: velocity model



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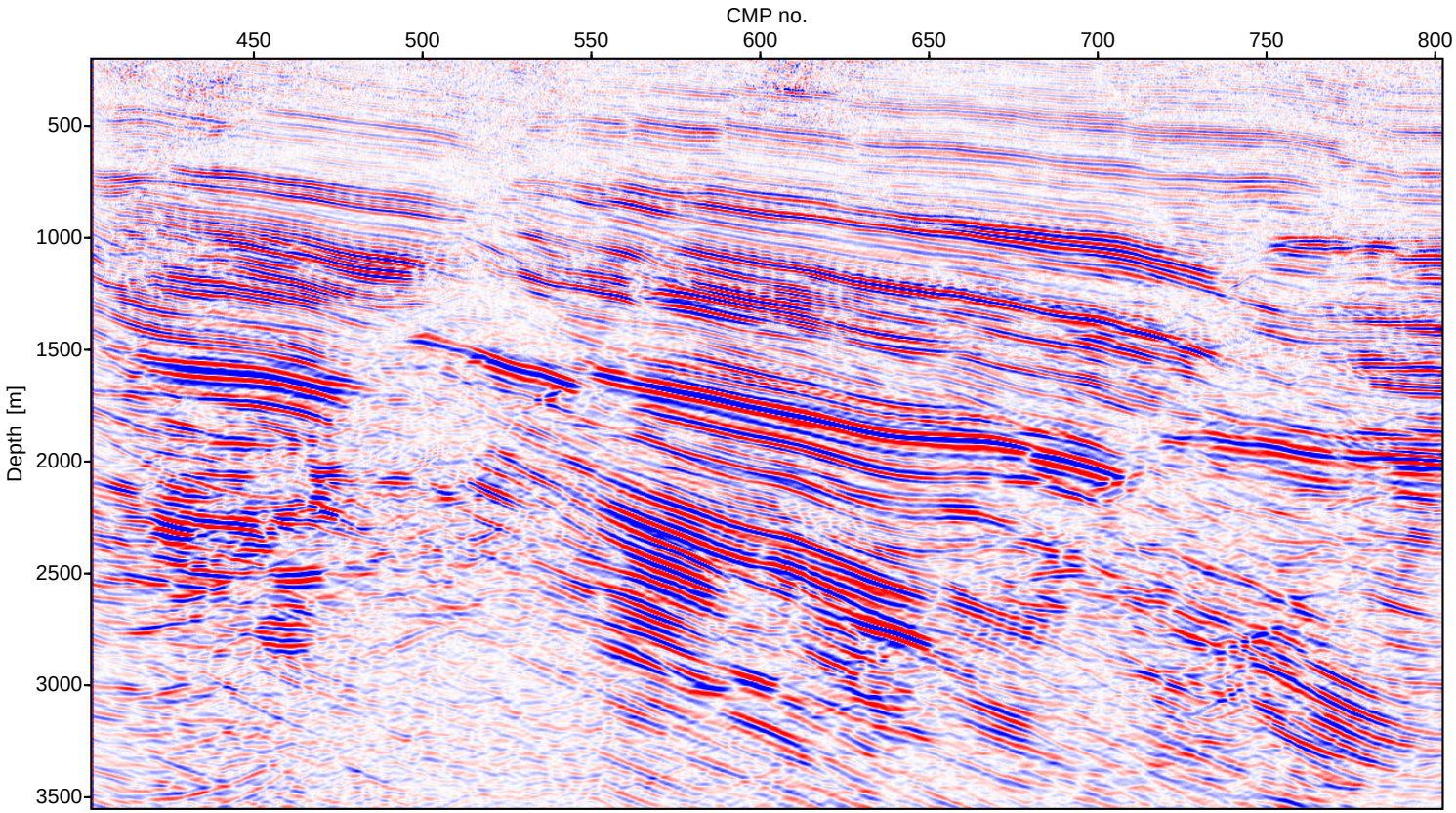
Kirchhoff poststack depth migration



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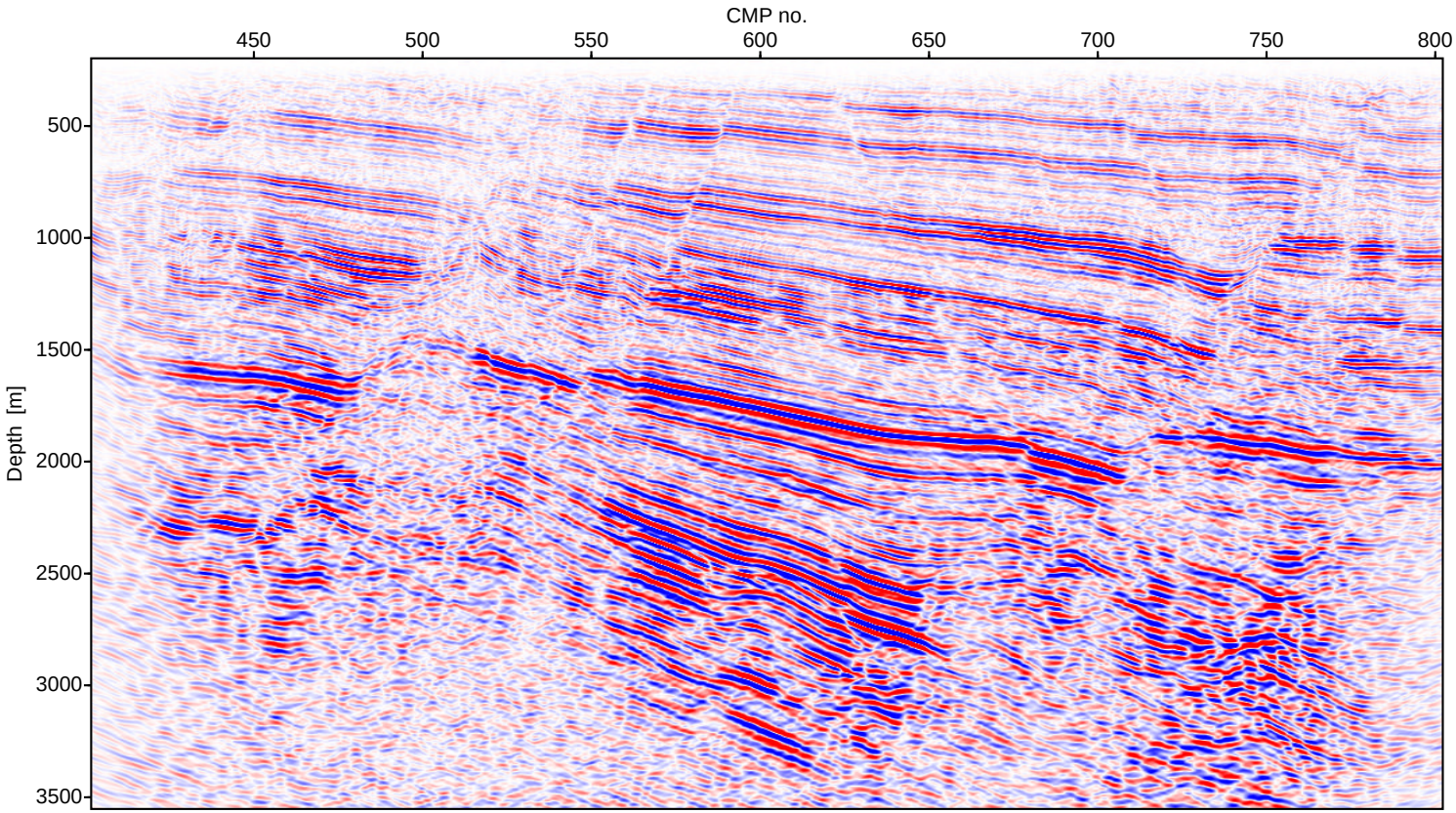

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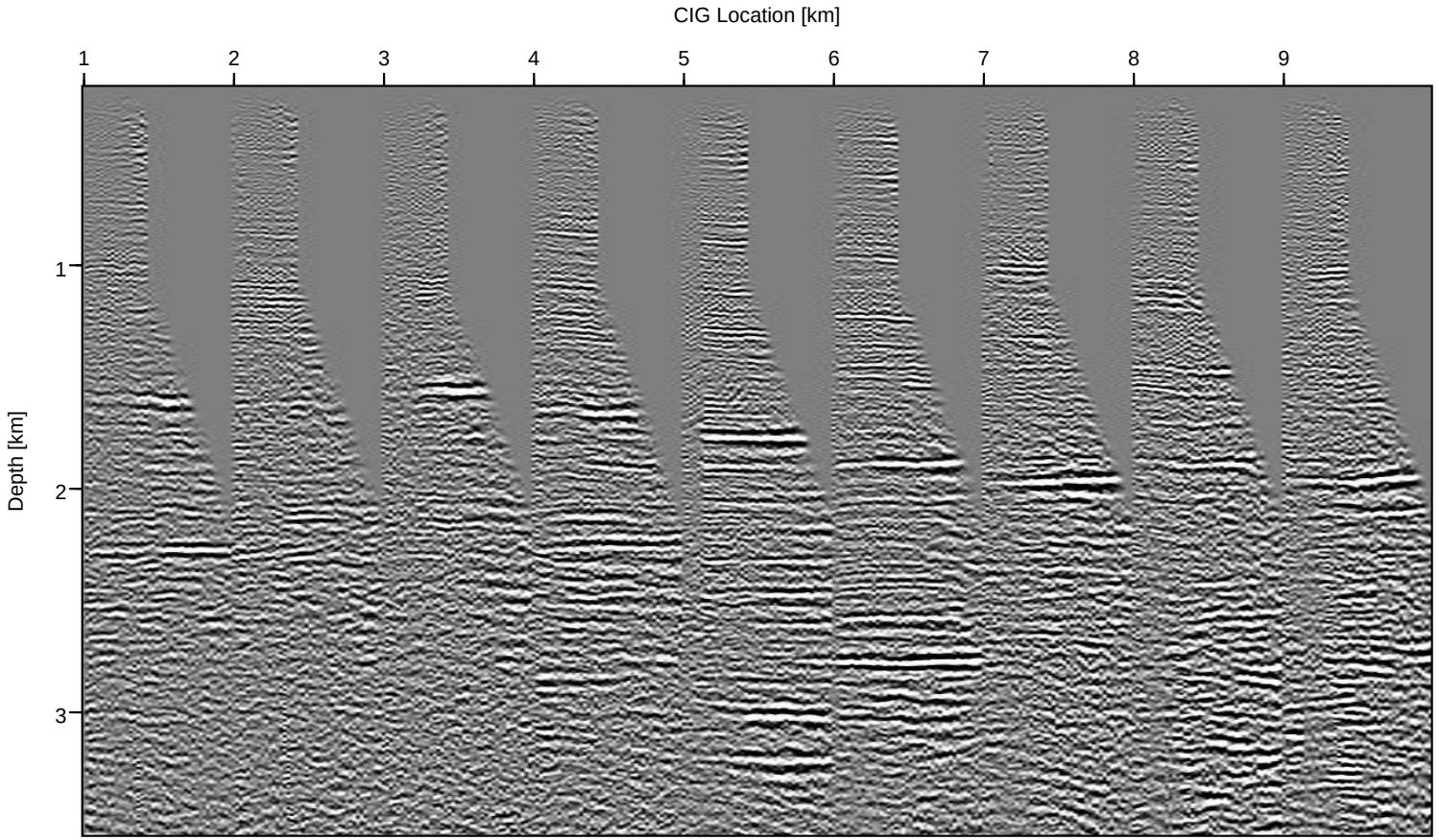
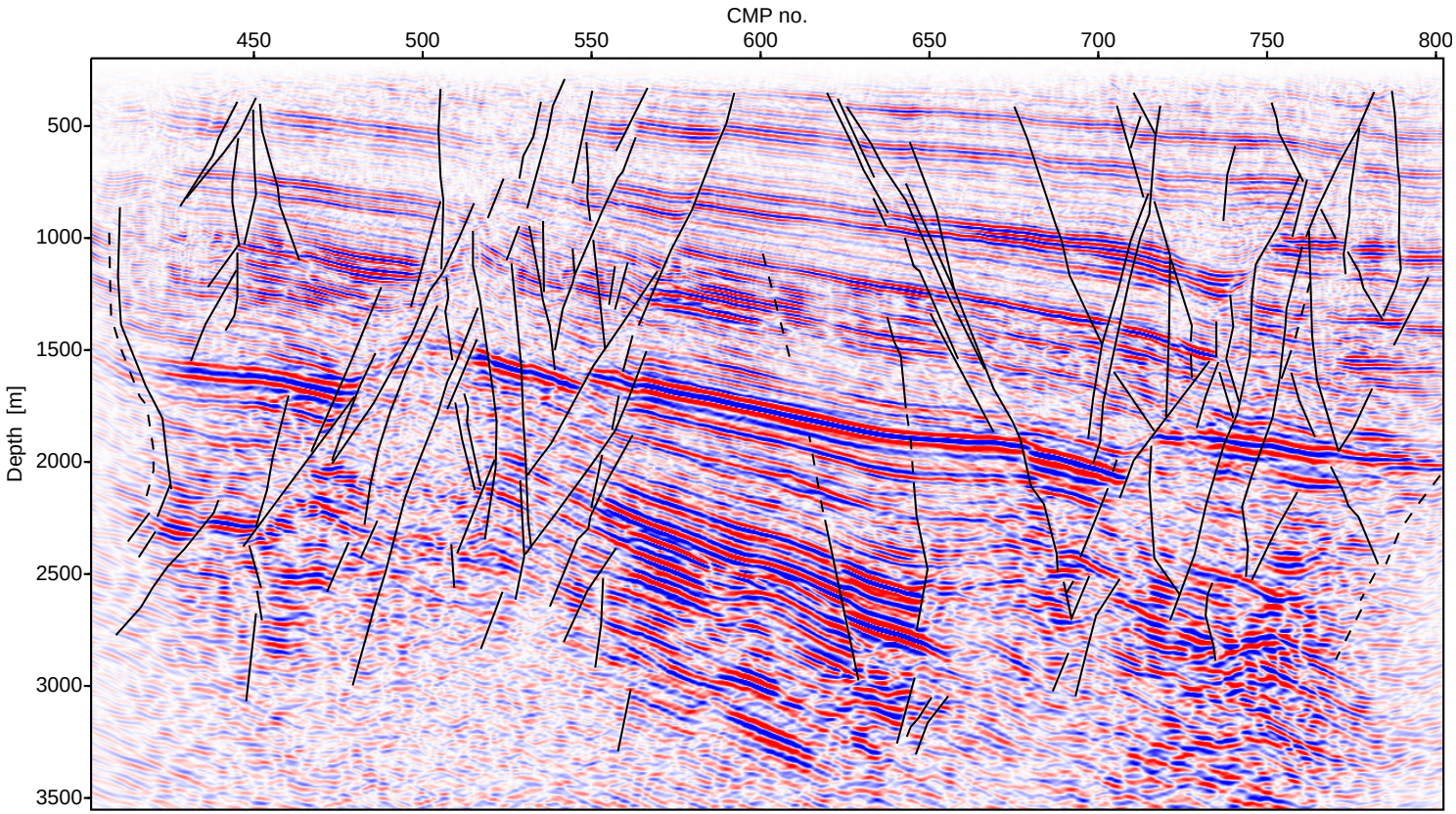
Common-image gathers



maximum offset $\approx$ 3000 m

Preliminary structural interpretation



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Comparison to standard processing

- Largely automated processing
- Generally higher resolution of reflectors and faults, particularly in the target area
- Reliable depth location of reflectors, according to well data and other geological and geophysical information
- Faults can be traced from near-surface to depths as large as 3 km

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- Workflow: from time to depth domain
- Successful application in recent exploration project
- Basis: CRS stack producing high quality stack sections and very useful attribute sections
- Subsequent application of tomographic inversion with CRS attributes and Kirchhoff depth migration
- Various workflow extentions possible (finite-offset CRS stack & inversion, static corrections, topography handling, AVO analysis, etc.)
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Related presentations

In this session:

- SP 4.5 CRS imaging and tomography versus PreSDM: a case history in overthrust geology
- SP 4.6 CRS stack and redatuming for rugged surface topography: a synthetic data example
- SP 4.8 3D focusing operator estimation using sparse data