

Anisotropic 3D FWI

Tommeliten Alpha field

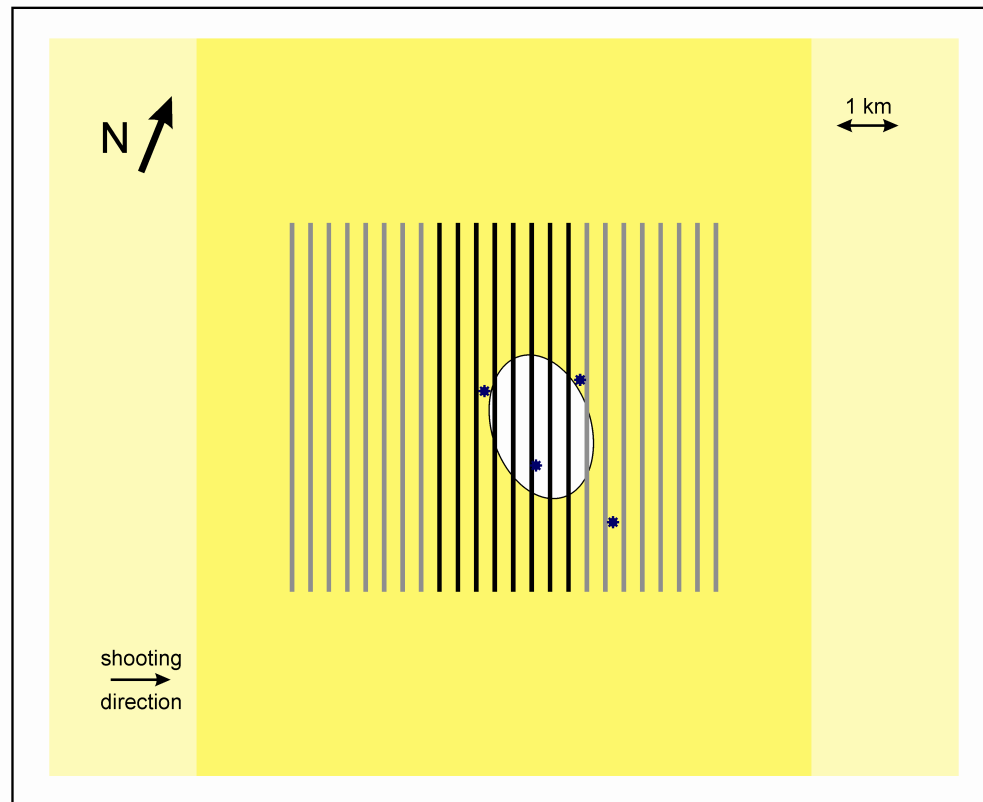
Mike Warner

Imperial College London

Overview

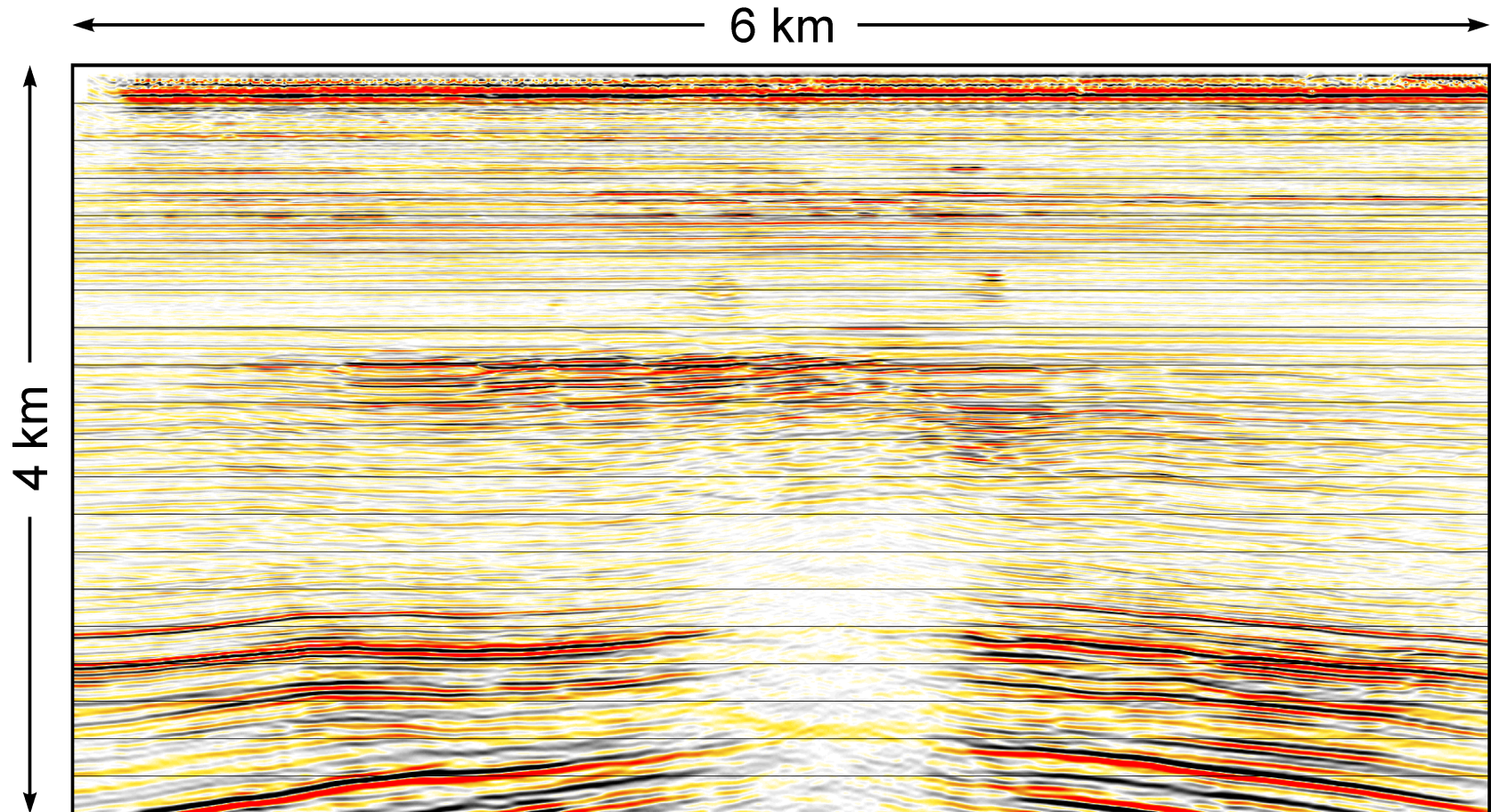
- OBC dataset
- 3D FWI
- Results
- Elastic FWI

3D OBC field data

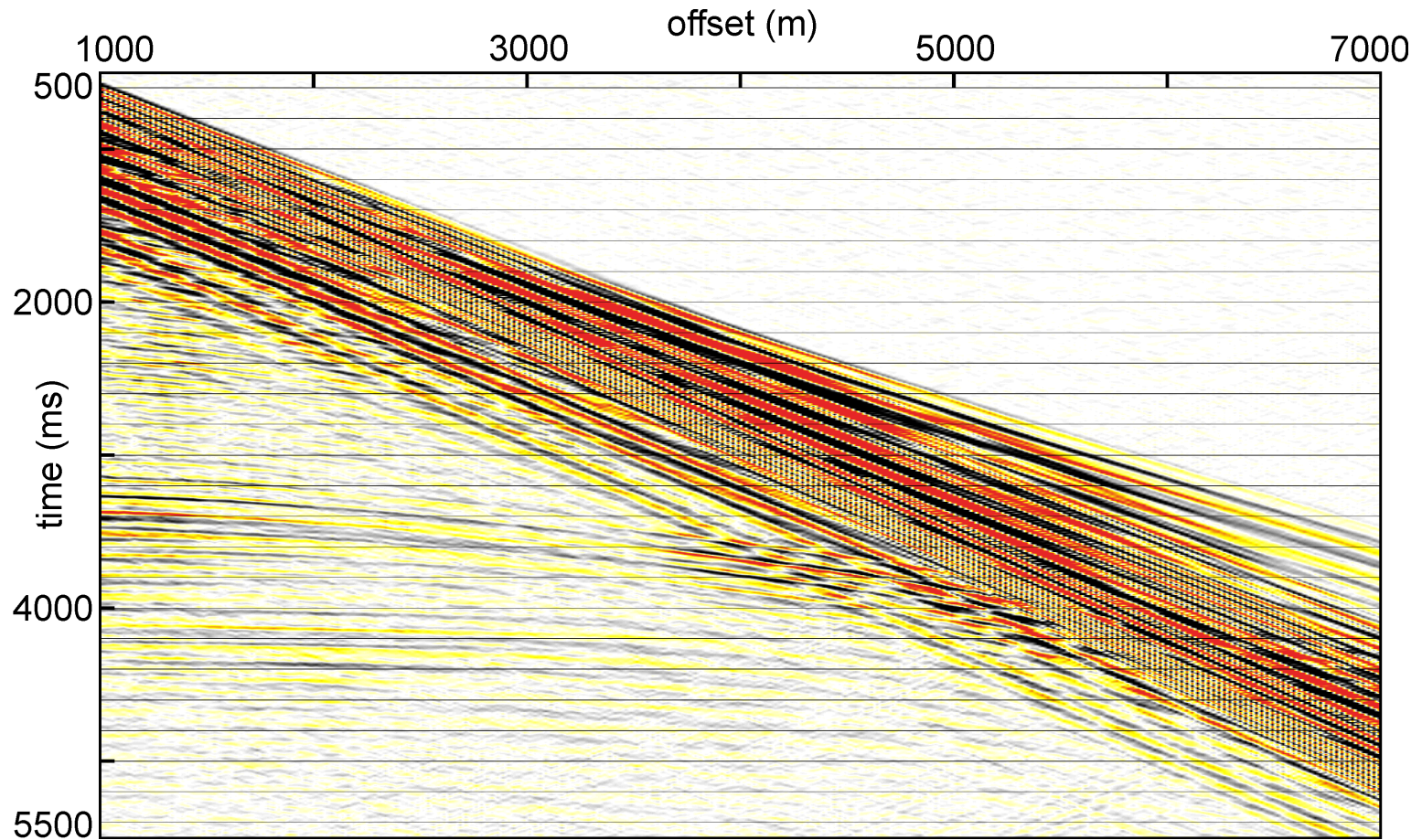


- 4C OBC
- 3 swaths of 8 cables
- 75 m water depth
- 6 km cables
- 25 m receiver spacing
- 300 m cable spacing
- 6000 receivers
- 25 m shot interval
- 75 m shot-line spacing
- 100,000 shots
- full azimuth to 7000 m
- max offset 11,000 m
- 180 sq km

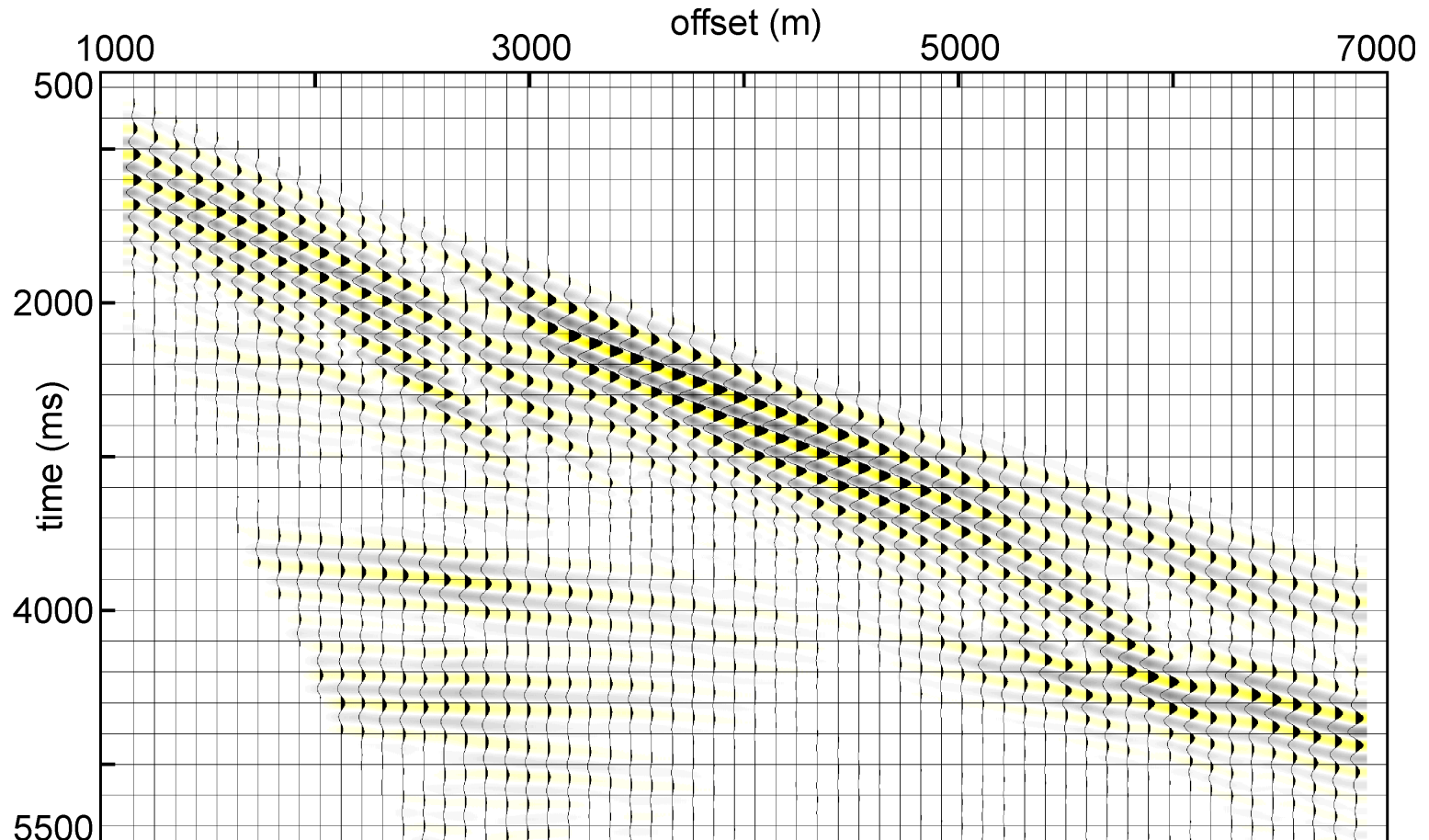
PP PSDM



Raw shot record

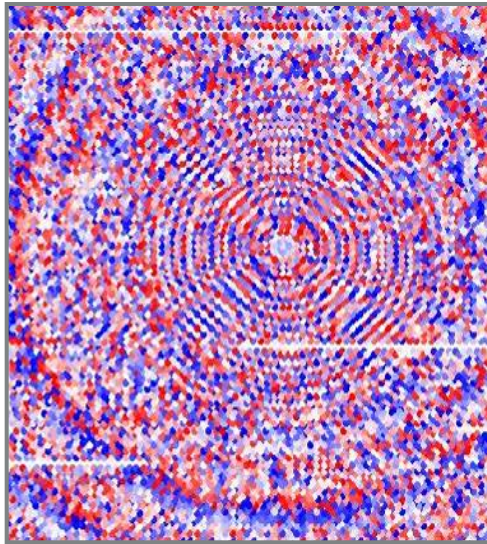


Pre-processed for acoustic FWI

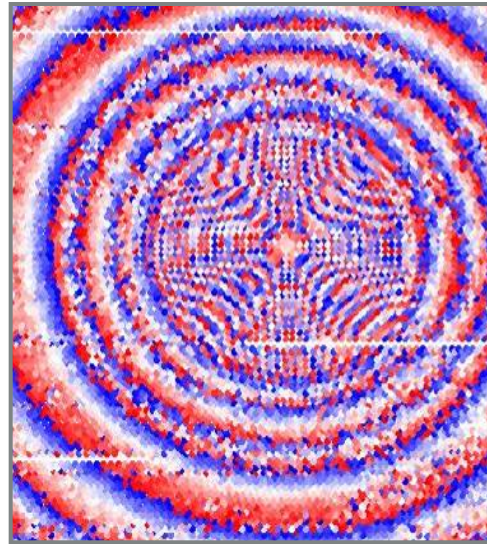


Picking the starting frequency

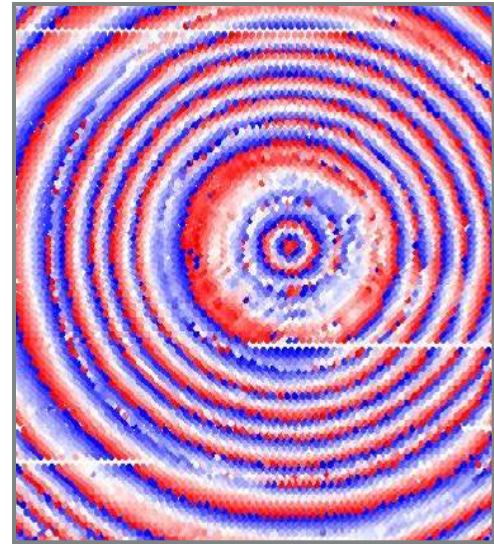
single-frequency phase



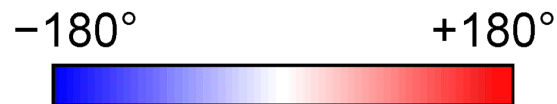
2.4Hz



3.0Hz

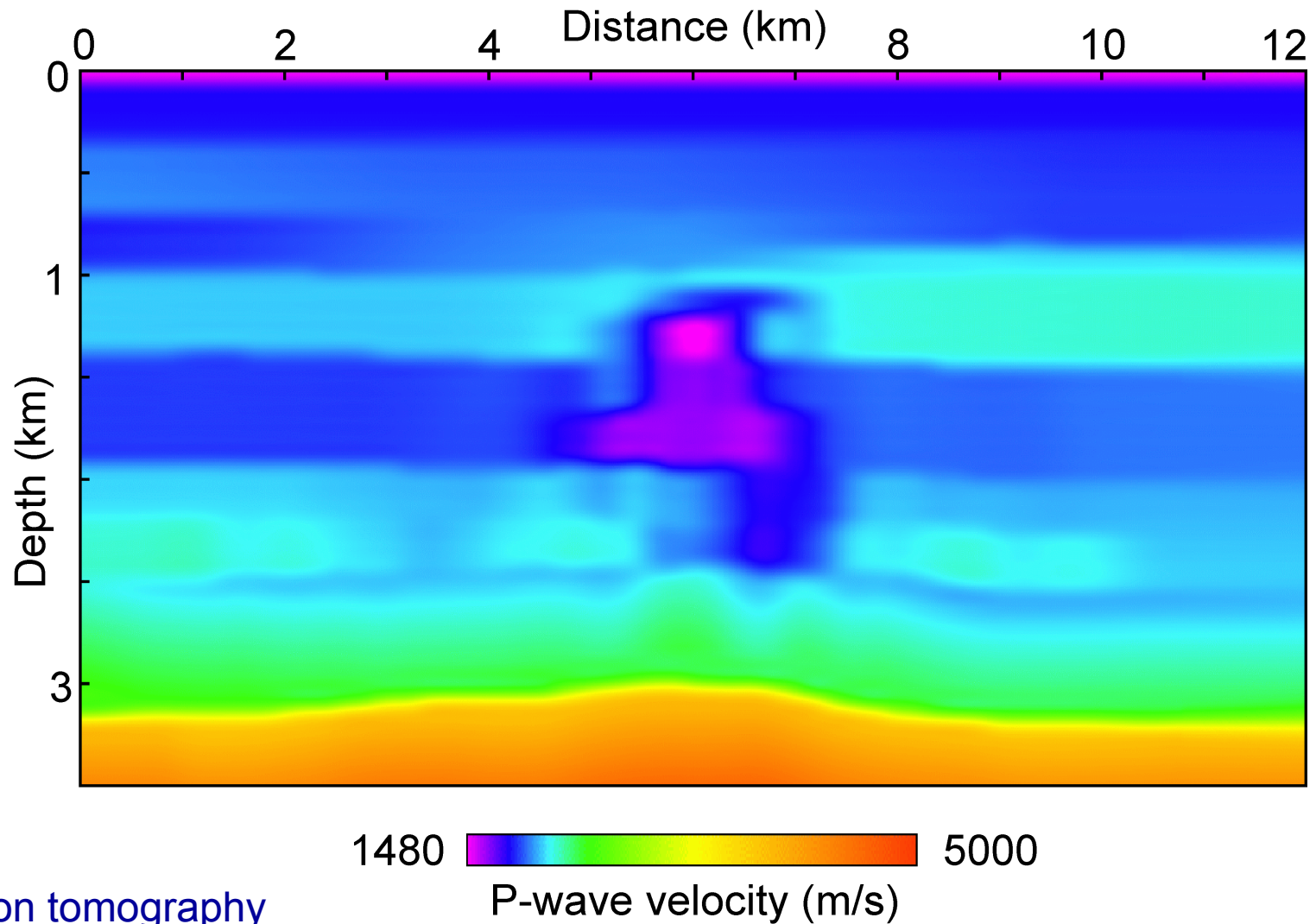


3.6Hz

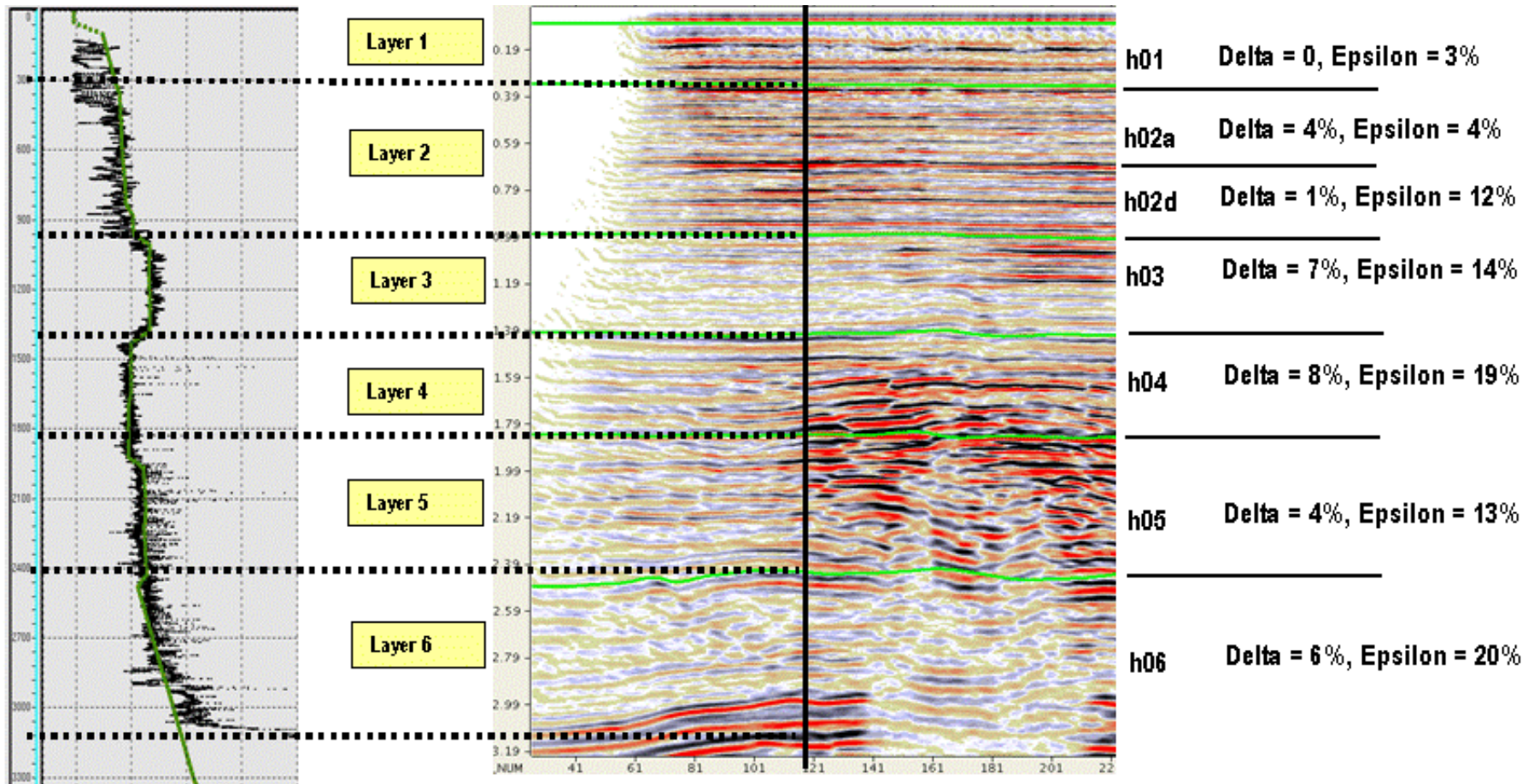


common receiver gather

Starting model



Anisotropy

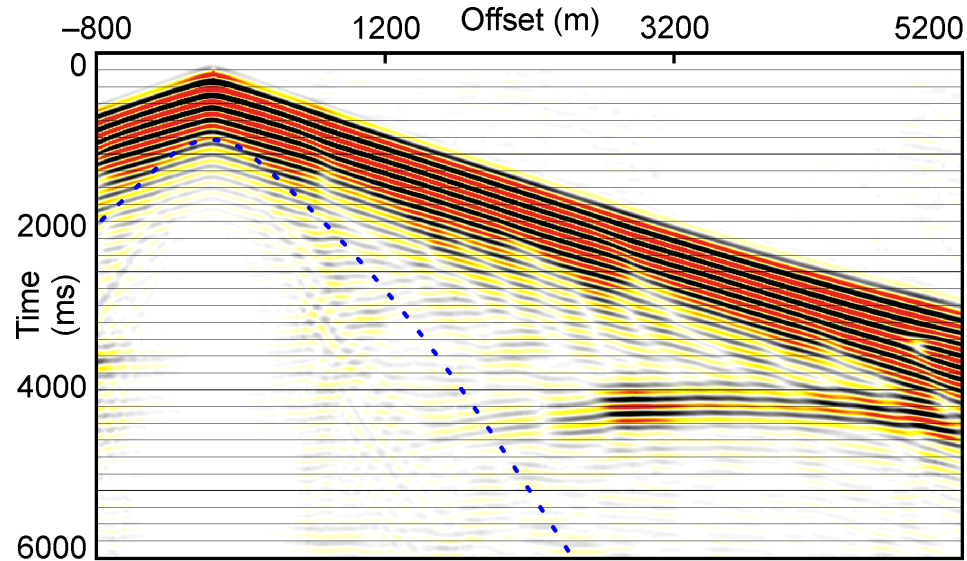


VTI, maximum Epsilon = 20%, maximum Delta = 8%

Inversion parameters

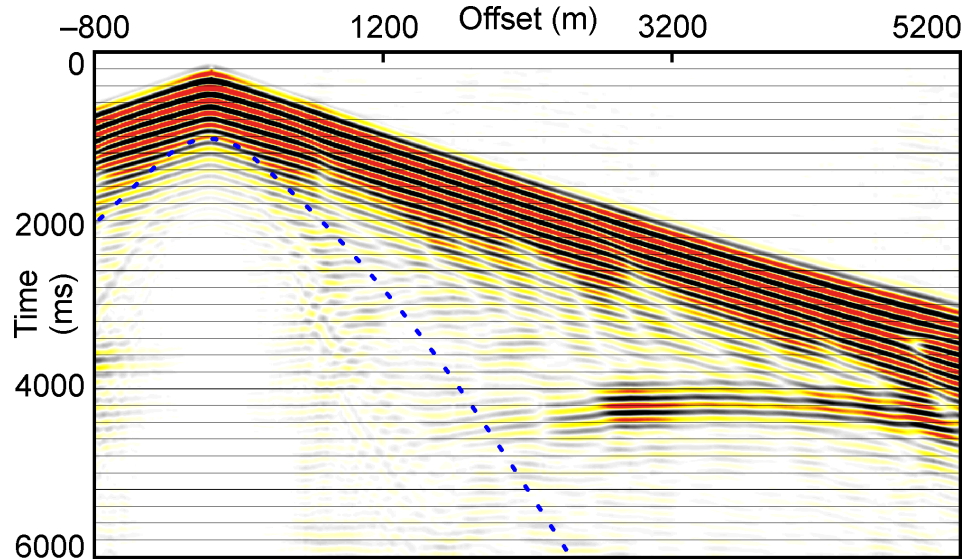
- Time domain, acoustic 3D, VTI anisotropy
- Hydrophones only → include ghosts and multiples
- Apply reciprocity
- 6000 → 1440 sources
- 80 sources per iteration
- Six frequency bands from 3 → 6.5 Hz
- 18 iterations per frequency
- Each source used once per frequency
- Amplitude equalisation
- Conjugate gradients
- Approximate diagonal Hessian

Field data

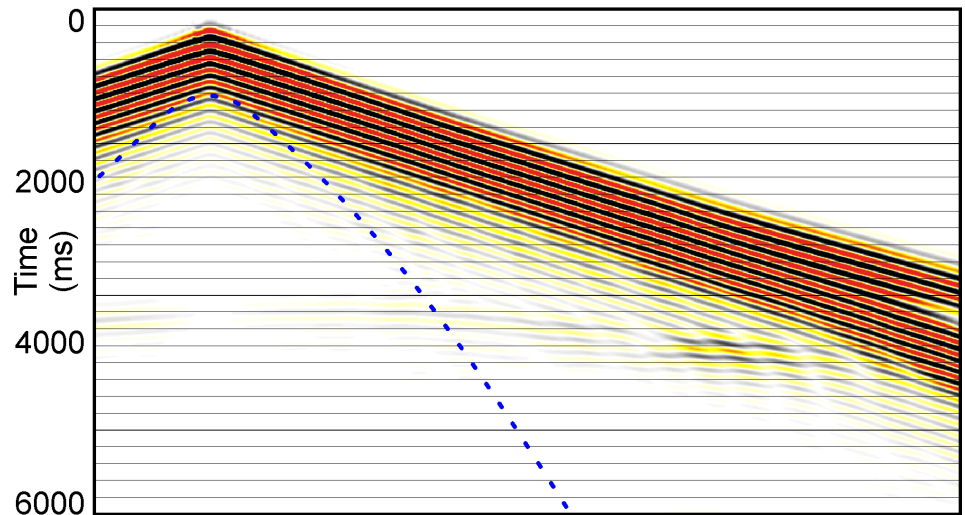


Start model

Field data

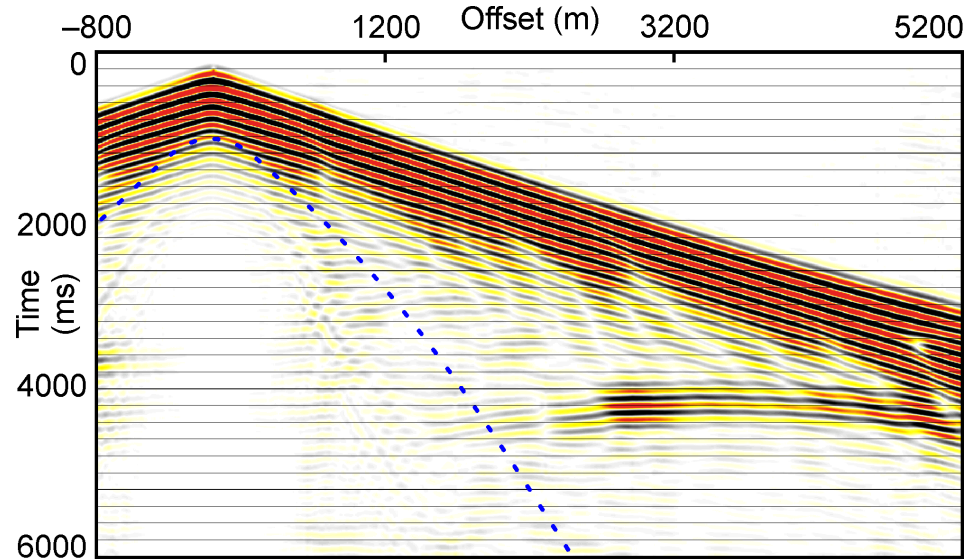


Start model data

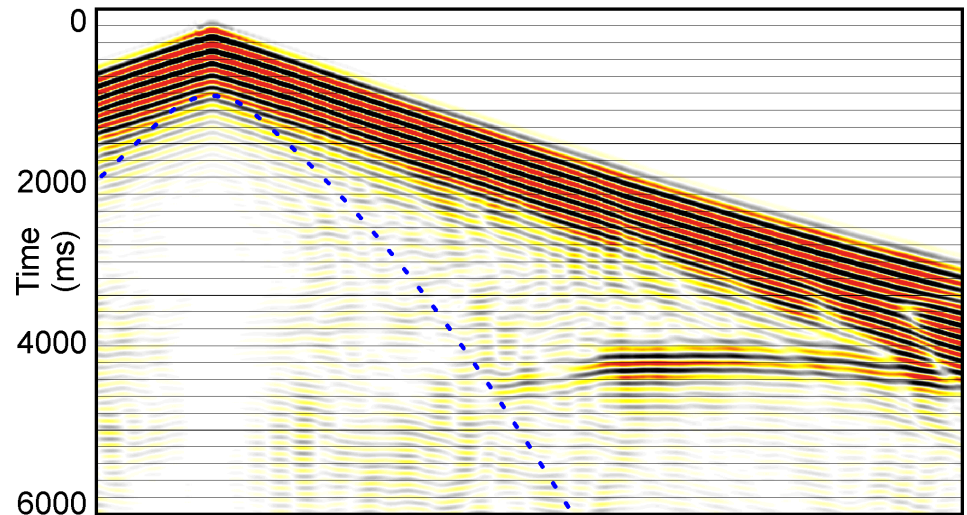


FWI model

Field data

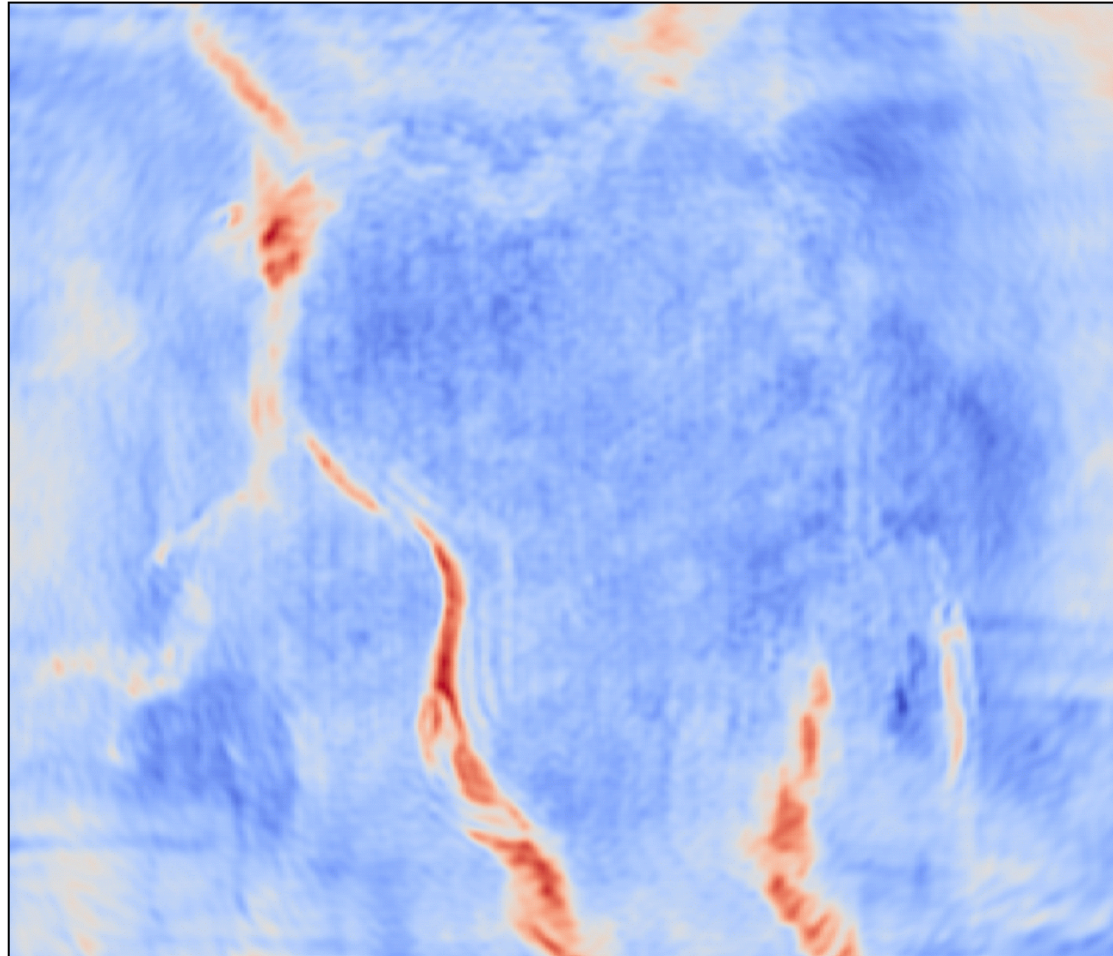
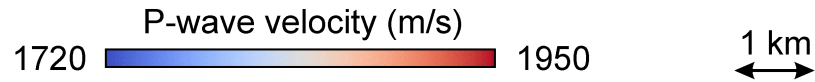


FWI model data



FWI results

from homogeneous
start model

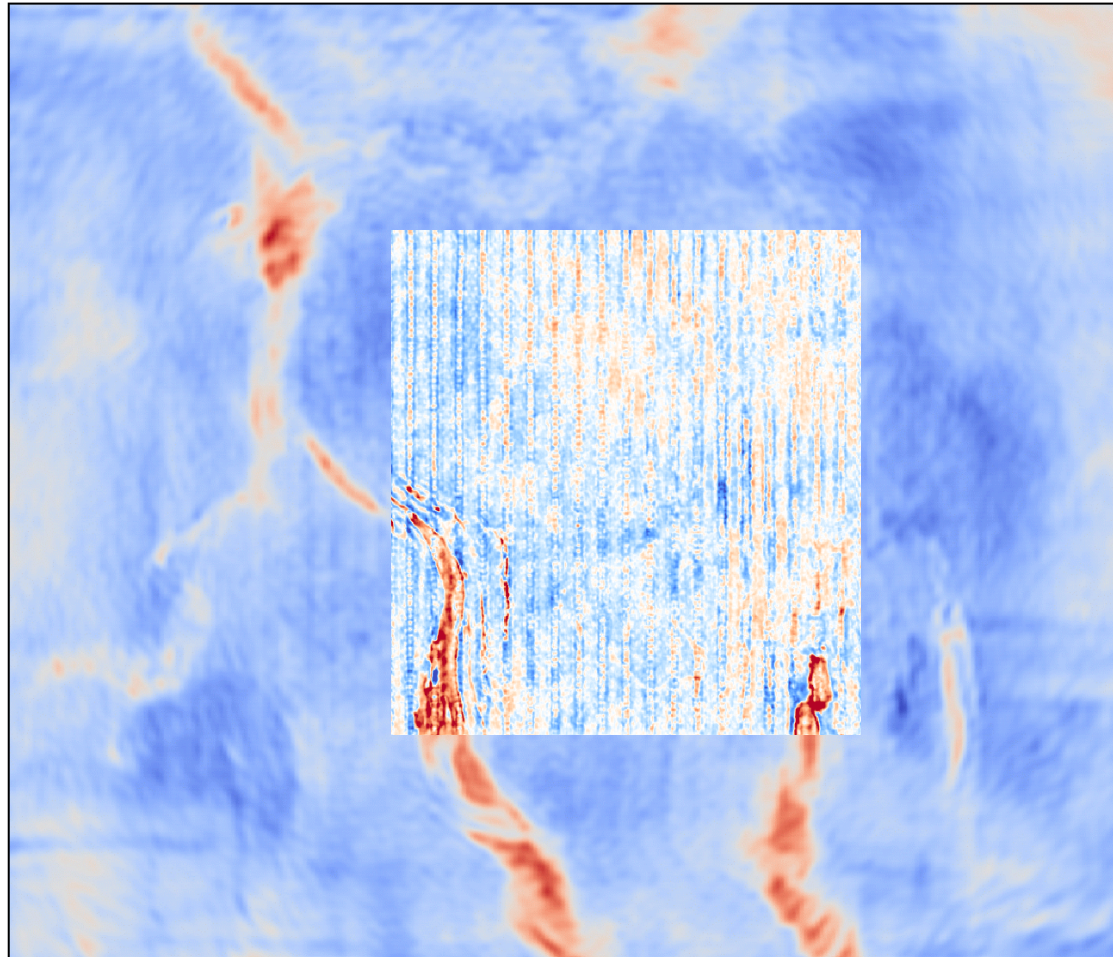


250 m depth

horizontal
depth slice

FWI results + original PSDM

from homogeneous
start model

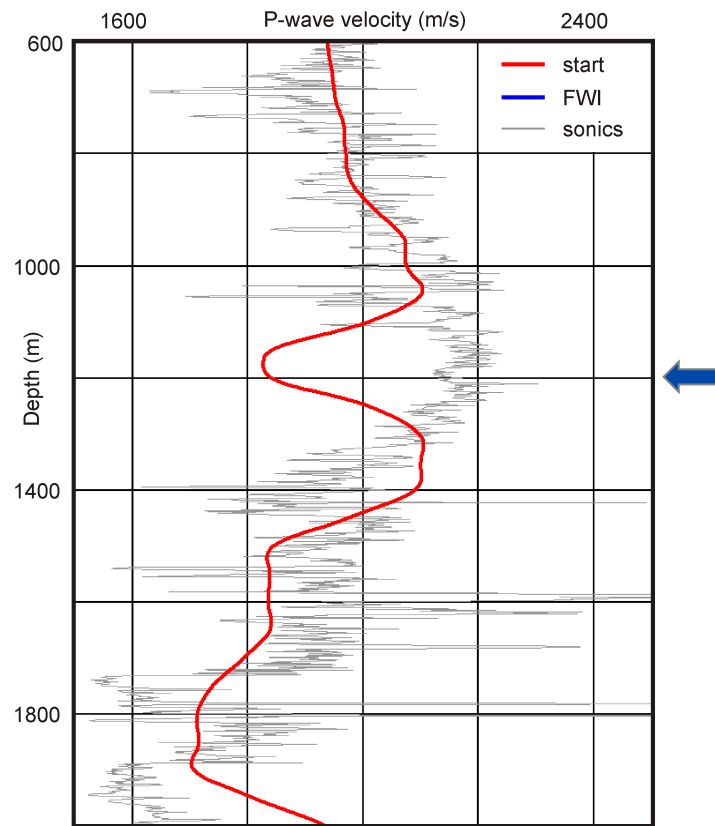
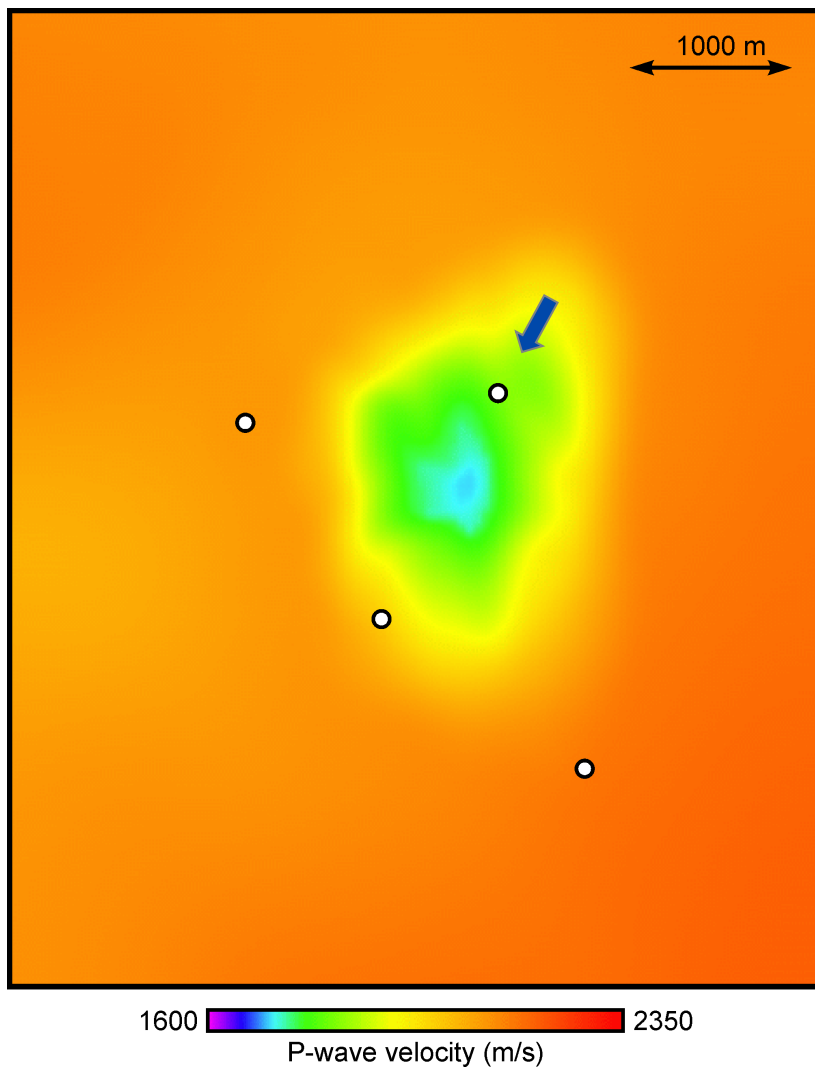


250 m depth

horizontal
depth slice

Starting model

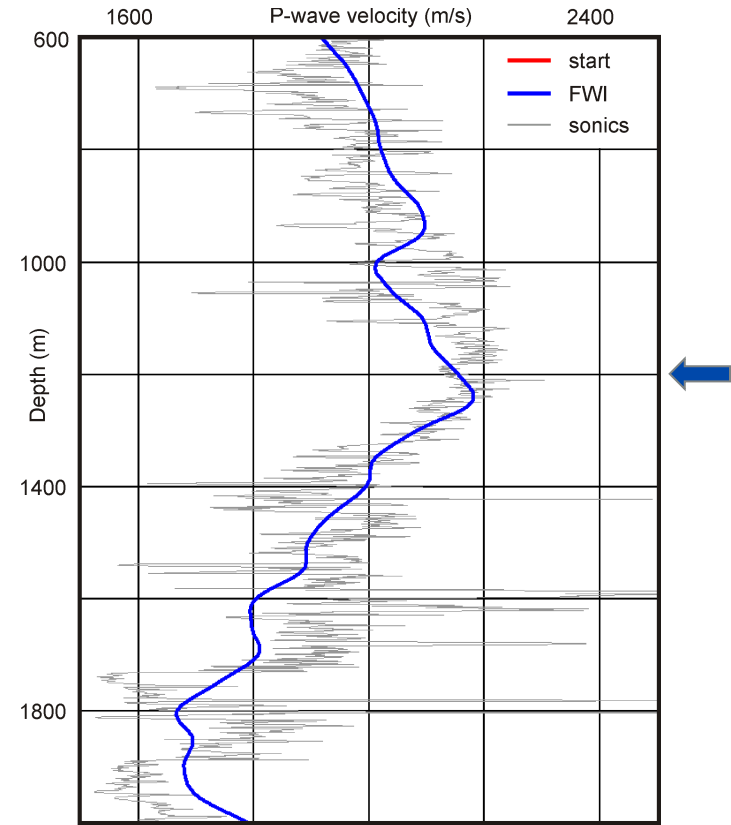
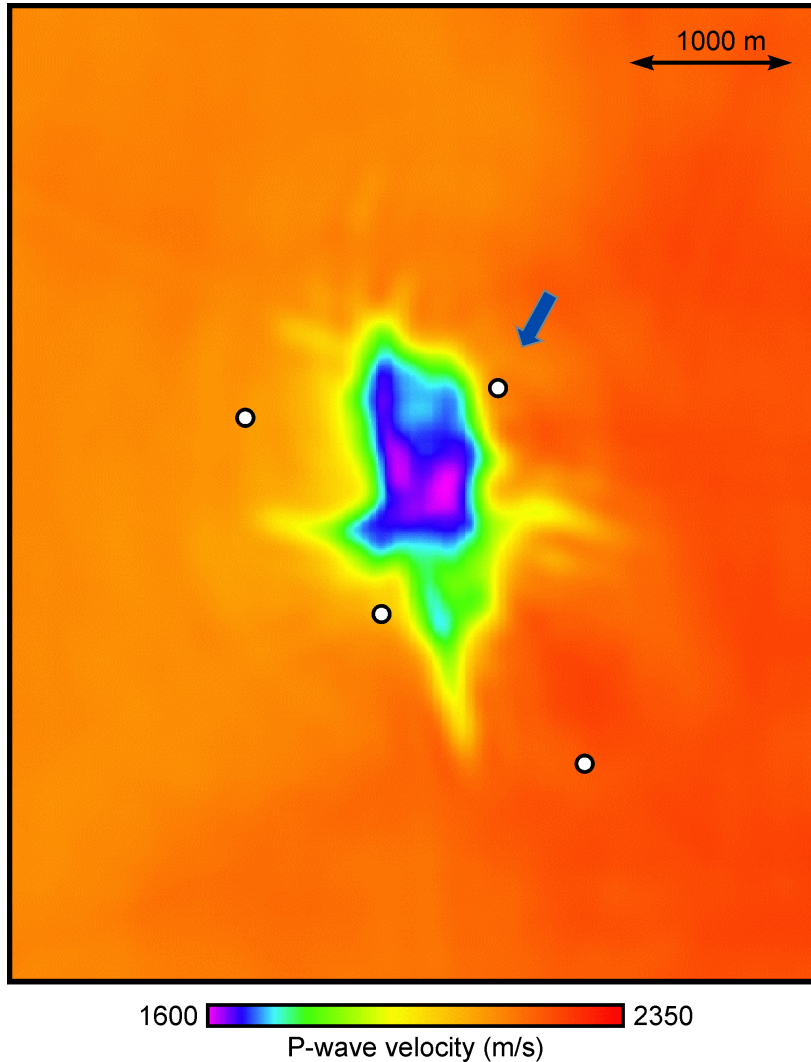
1200 m
depth



well log

FWI model

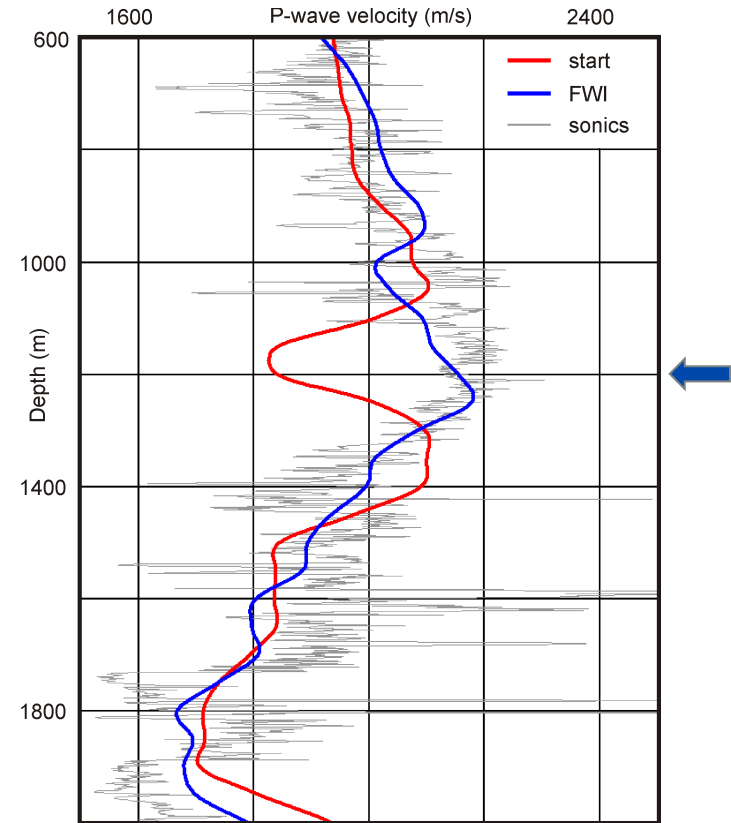
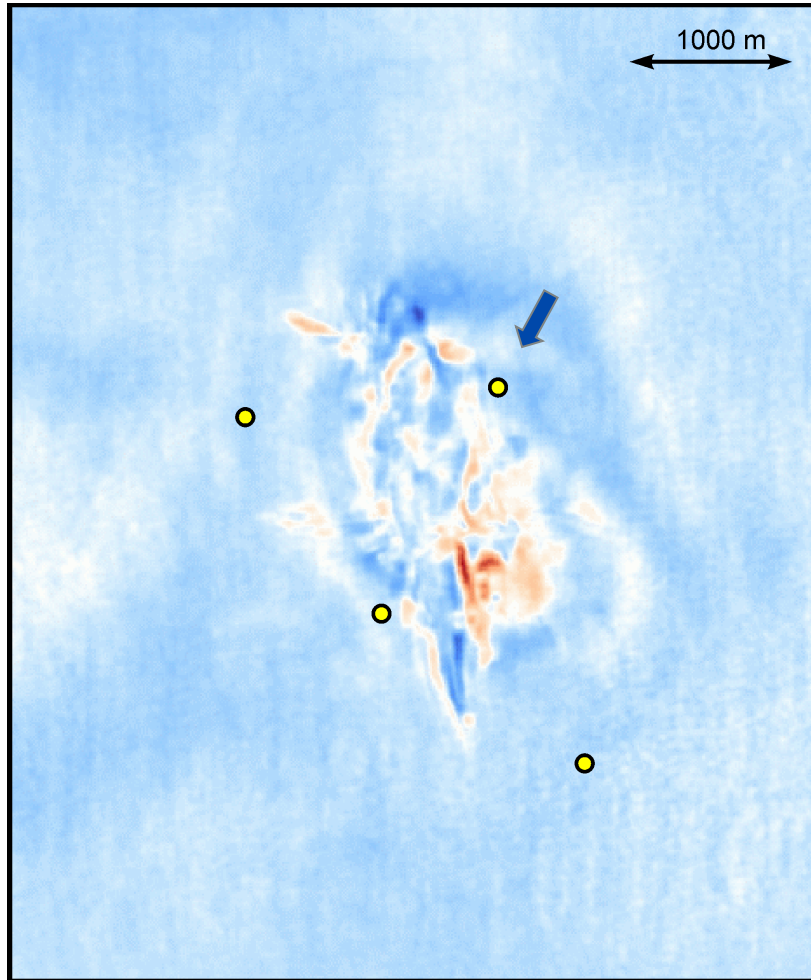
1200 m
depth



well log

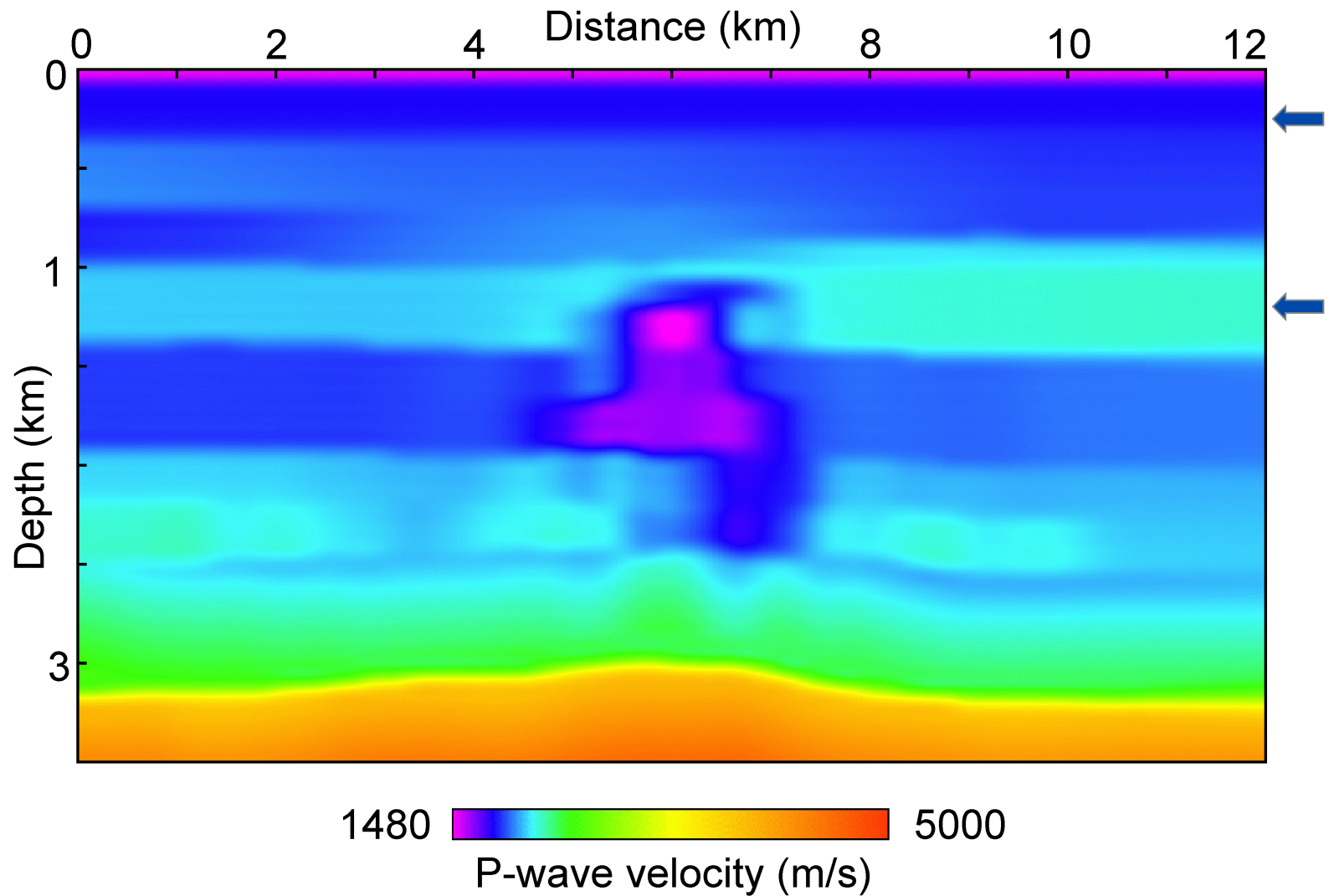
PSDM

1200 m
depth

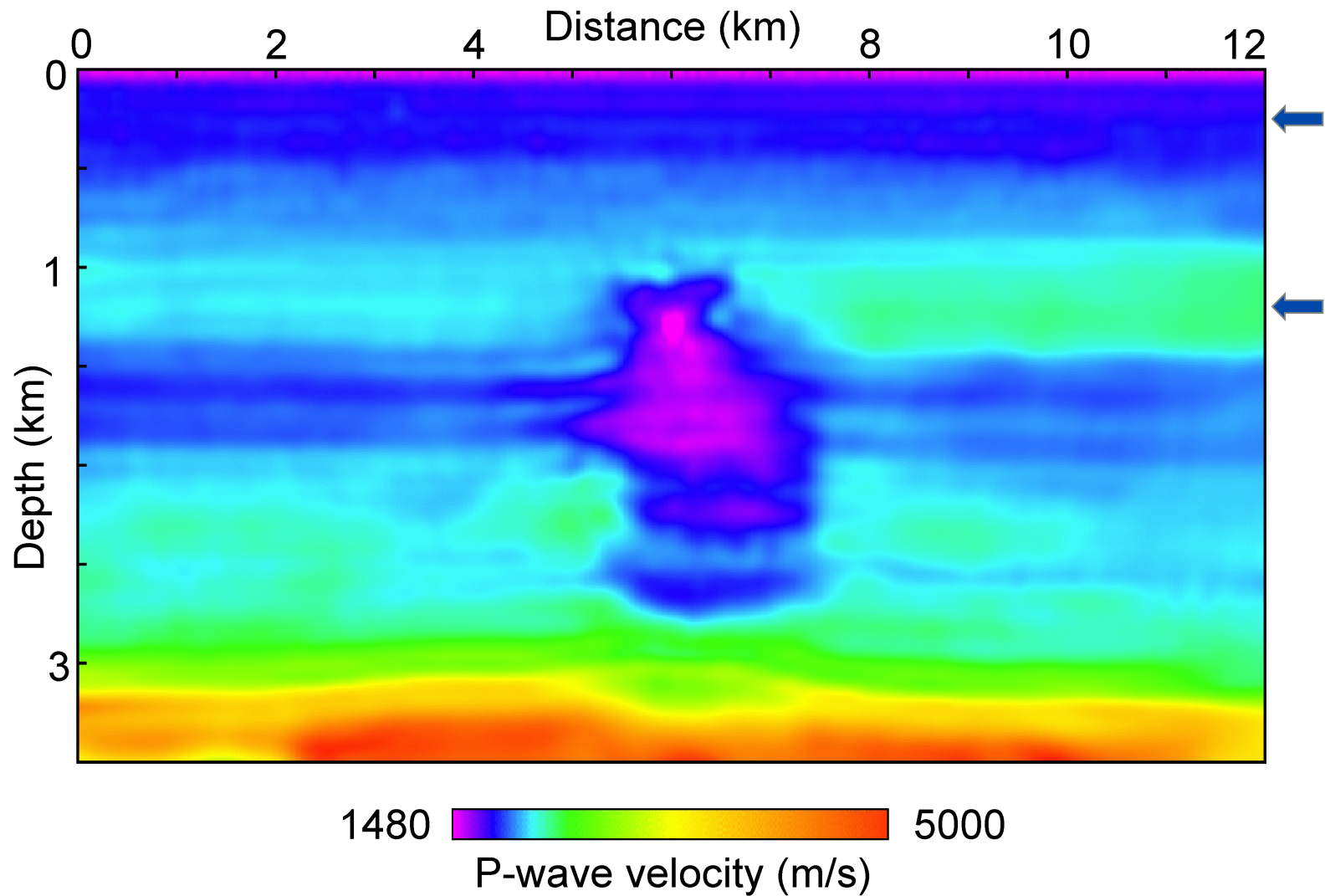


well log

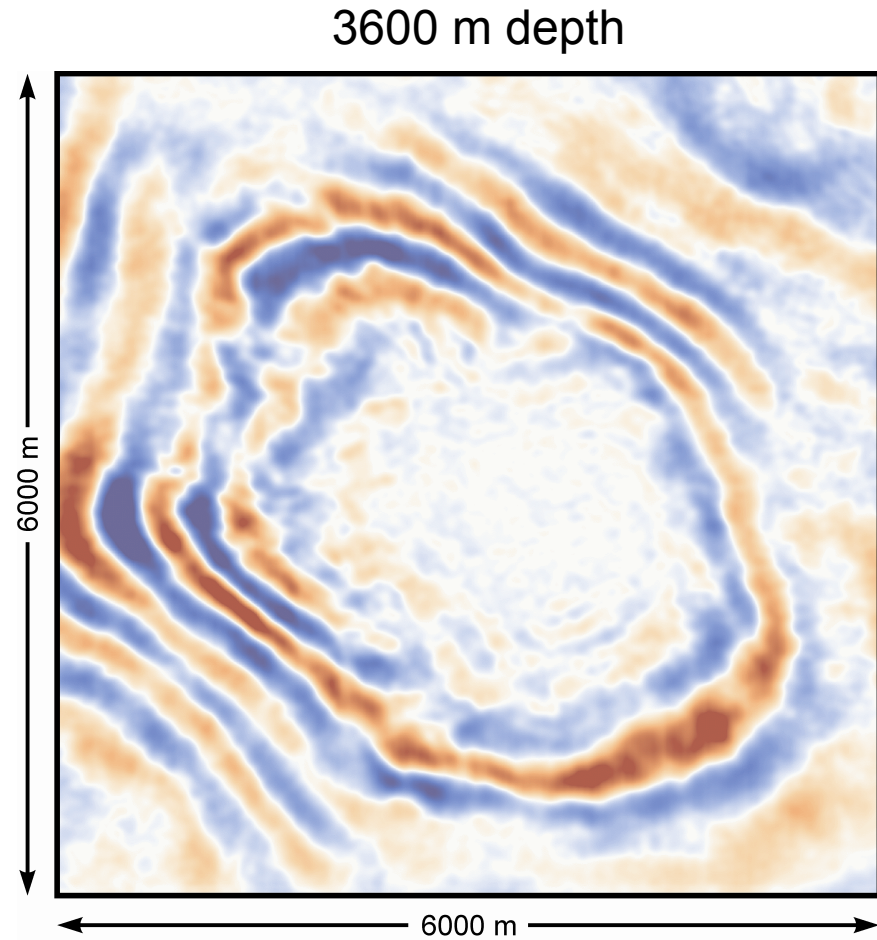
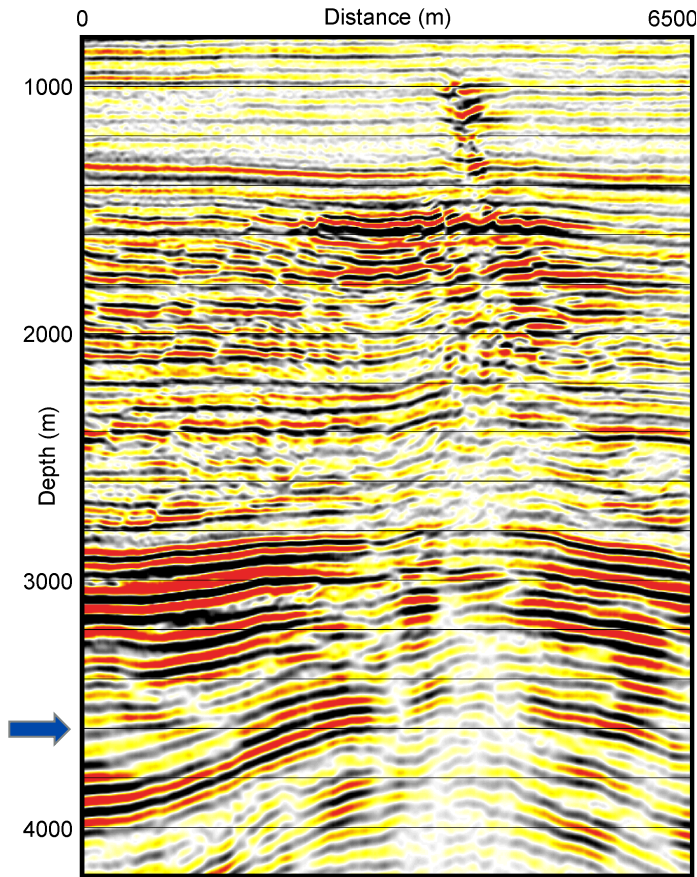
Starting model



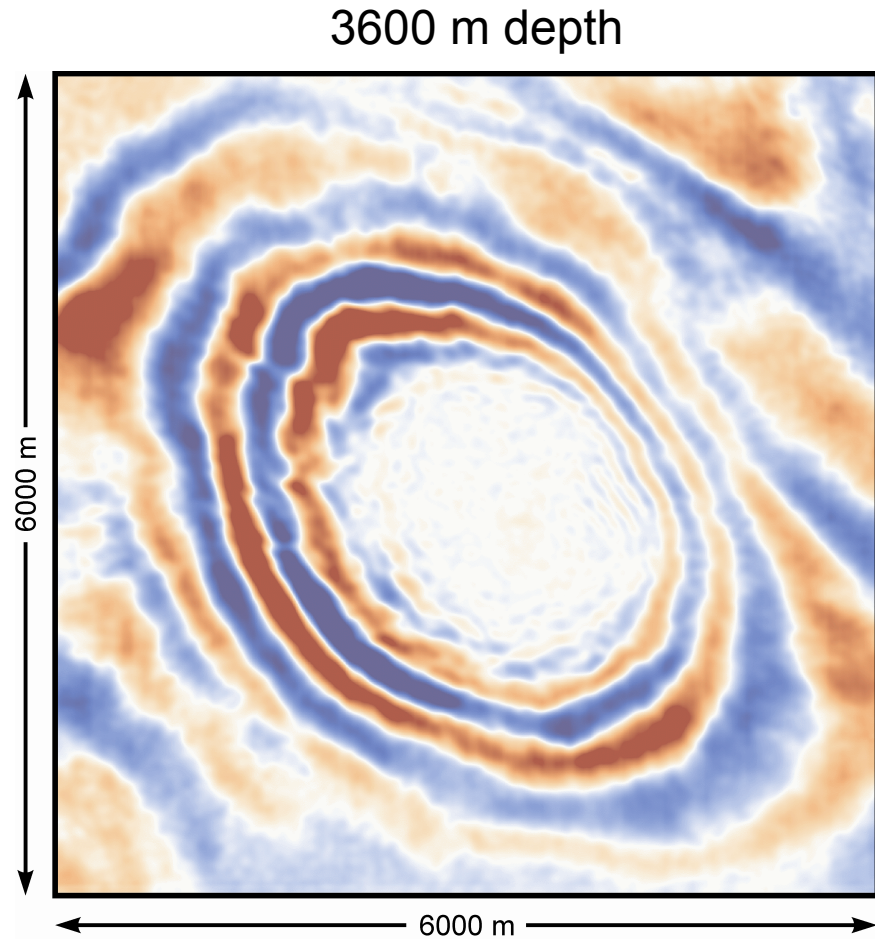
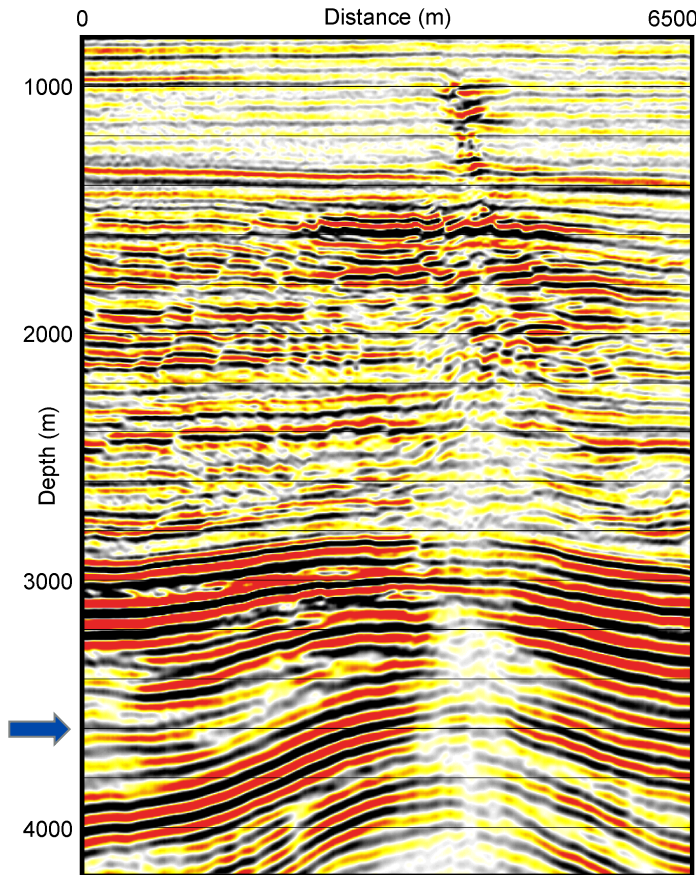
FWI model



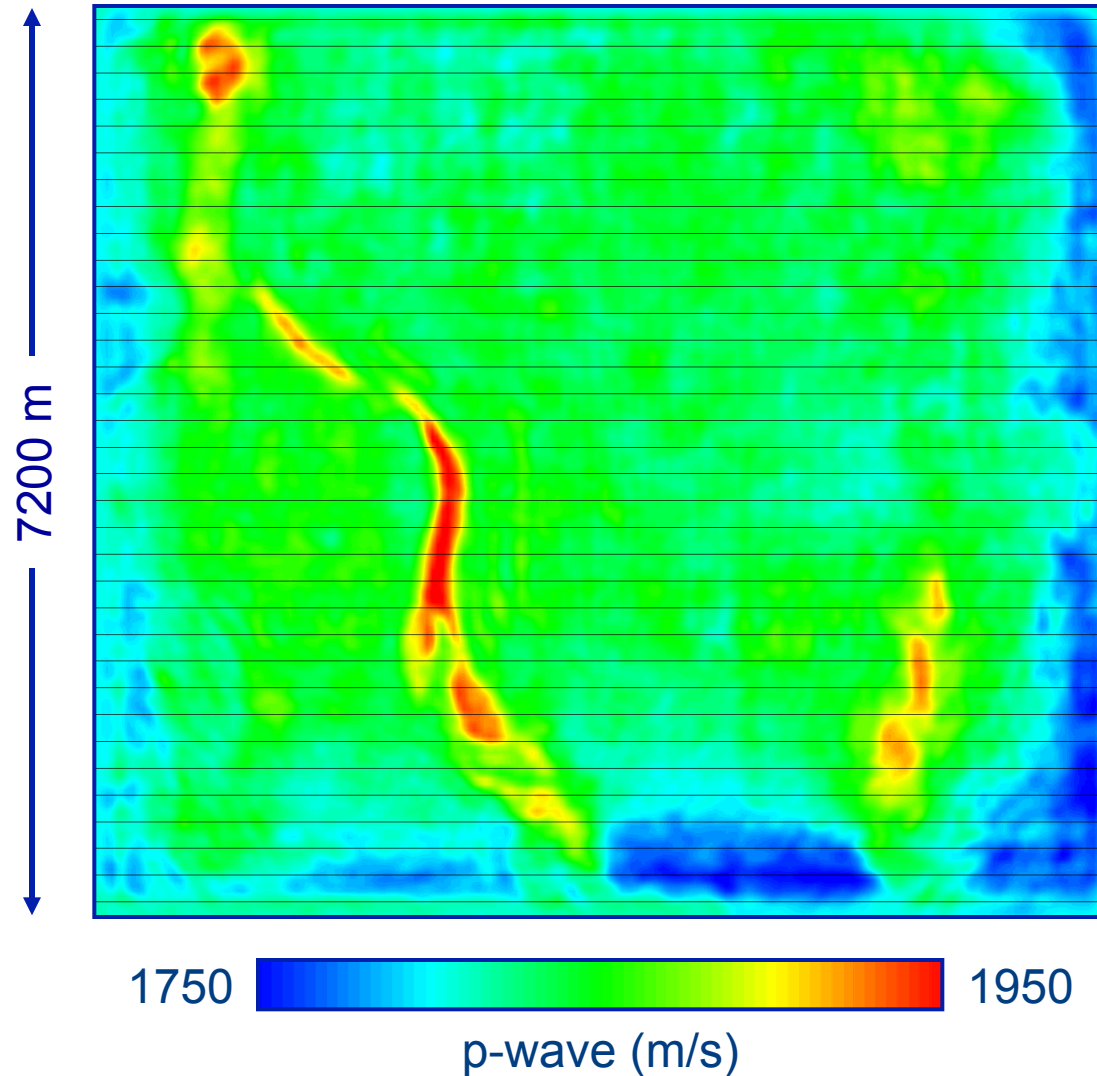
RTM with starting model



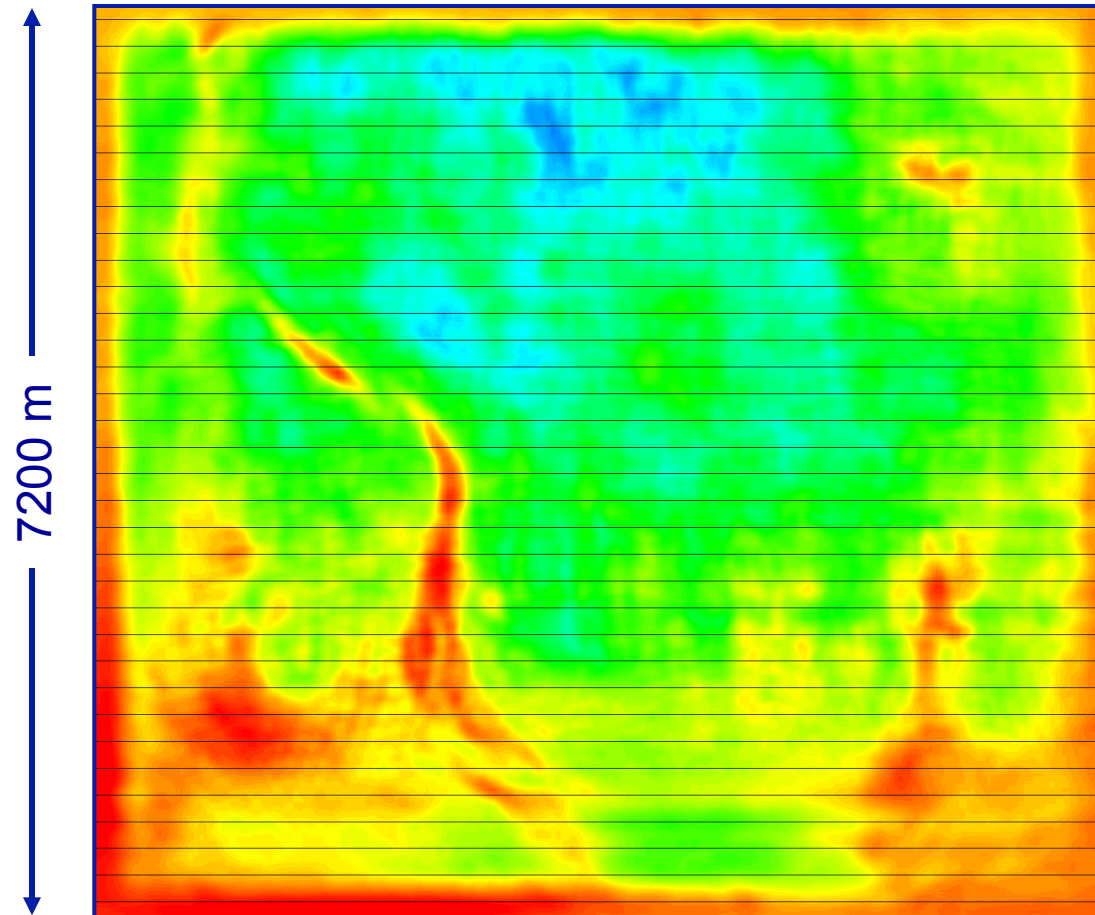
RTM with FWI model



Elastic FWI: P-wave



Elastic FWI: S-wave



250 m depth

Conclusions

3D FWI

- significant changes at reservoir level
- works well on appropriate data
- not expensive (500 cores for 60 hours)

- Anisotropy was essential
- Careful QC and QA is essential
- Elastic FWI is possible (but expensive)

Acknowledgements

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