

Developing integrated amplitude driven solutions for pore content prediction through effective collaboration

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Outline of presentation



- Today's challenges for Exploration in the Southern North Sea

- Collaboration projects examples
 - Fluid contacts beyond Flat-spots
 - Seismic interpretation in four dimensions
 - Gassmann modeling for solid pore fill

- Conclusions
 - Turning ideas into practical solutions

Today's challenges for Exploration in the Southern North Sea ...



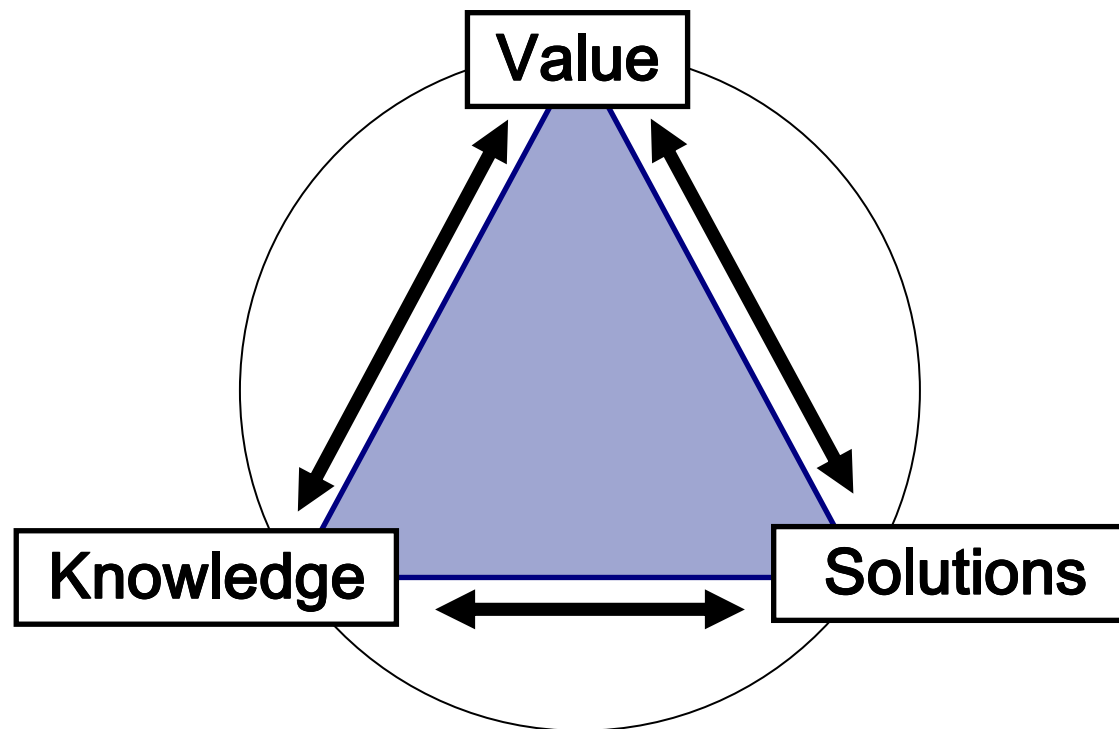
- Mature area
 - The obvious has been found
 - Look for the subtle traps and new plays
 - New ways needed to combine and analyze data
- Decreasing prospect size
 - De-risking critical to justify **the** exploration well
 - The exploration well might be the sole producer
- Shorter turn-around time
 - License periods decreased
 - More data to analyze in less time
- New opportunities require new tools

... are ideal for an effective, flexible operator

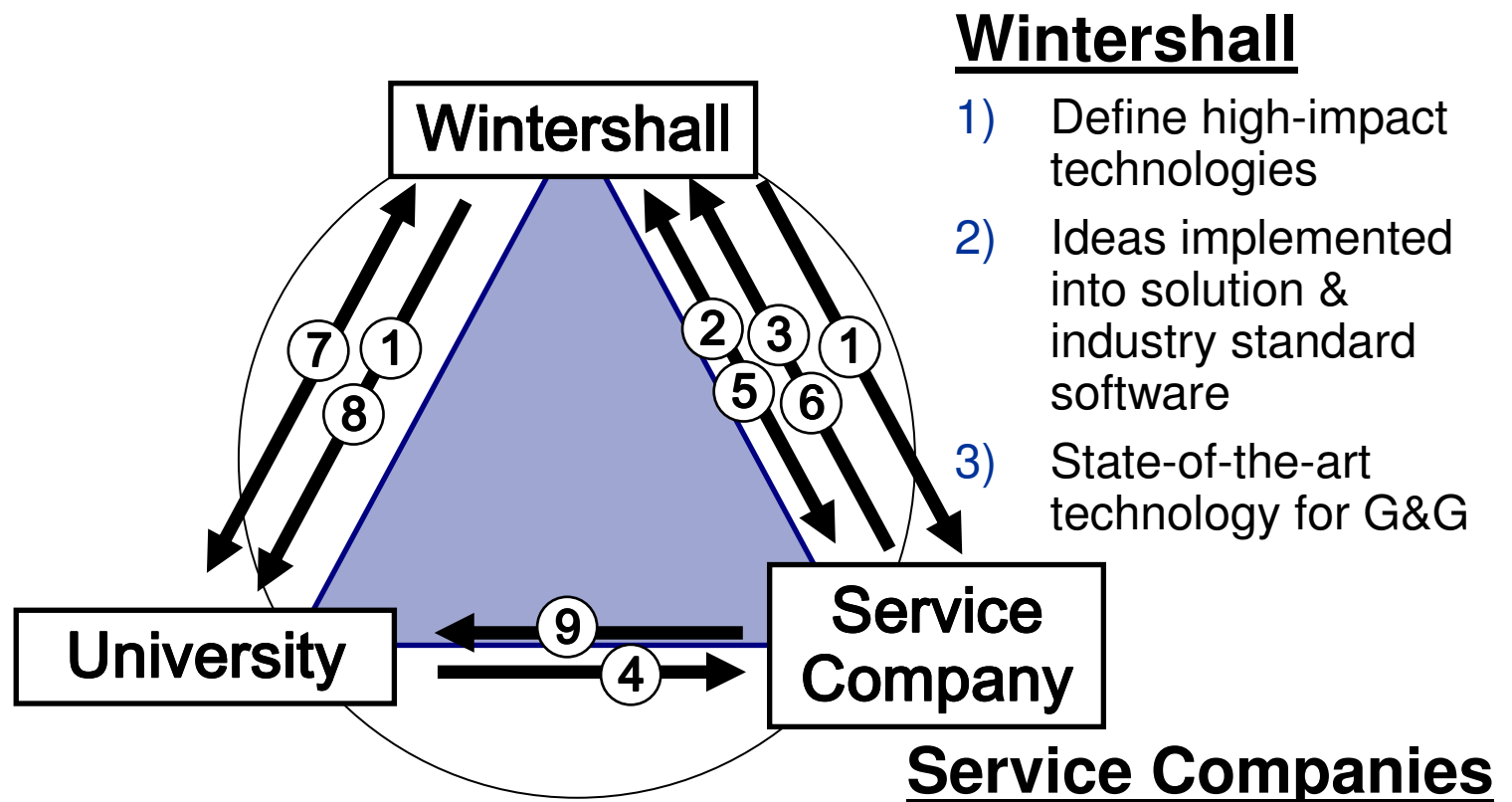


- Wintershall has a compact and flexible organization
 - Quick reaction to opportunities
 - Direct match between practical challenges and technological possibilities
 - ... but no in-house R & D
- Technology development through partnerships
 - Turn ideas into working solutions
 - Solutions implemented in mainstream software
 - Short lead time and cost-effective
 - High-tech solutions available to all G&G staff

Collaboration towards innovation



Collaboration towards innovation



- 1) Define high-impact technologies
- 2) Ideas implemented into solution & industry standard software
- 3) State-of-the-art technology for G&G

University

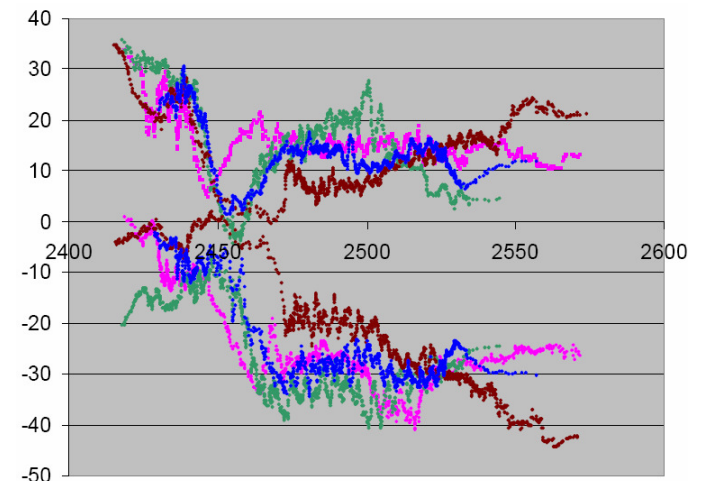
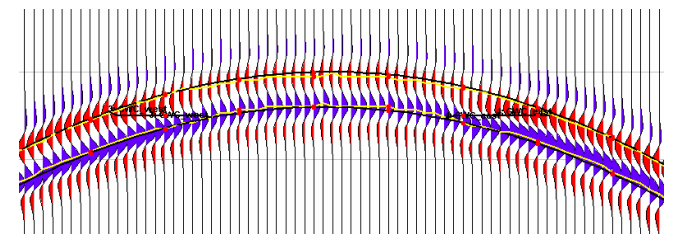
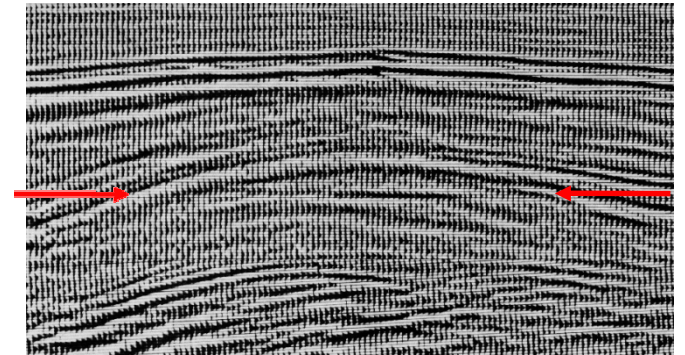
- 7) Intellect & environment to mature ideas into technology
- 8) Real Data problems for students
- 9) Access to industry standard tools

- 4) Platform to convert technology into practical solutions
- 5) Demand driven development
- 6) Support for tools

Fluid contacts beyond Flat-spots

Innovative use of an old idea

- Flat-spots are a 'known' DHI in the SNS
- Structure-conformable amplitude effects along top reservoir
- Cross-plot seismic amplitudes against depth
- Apply this concept to seismic data



Amplitude extraction in combination with seismic modeling as a guide for determining the depth of the free water level – a case study, H.B. de Haan, R.J. Arts and N.G. Neele, 63rd EAGE 2001 ⁷

Fluid contacts beyond Flat-spots

Partnership to 3D integrated tool



■ Wintershall



- Need for 3D integrated amplitude approaches
- Verify very subtle flat-spots
- Provide test-cases for maturation

■ Leeds University

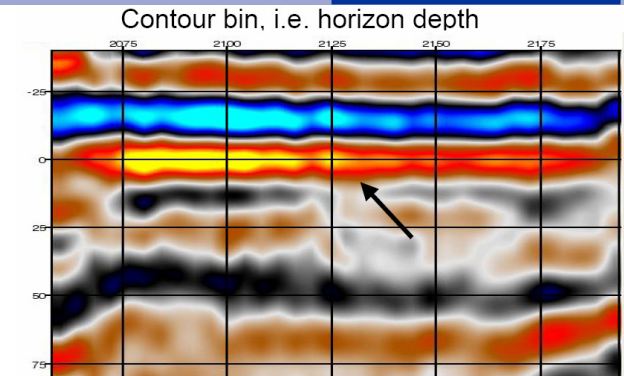


- Fine-tune theory, application, and implementation
- Extend into pre-stack domain

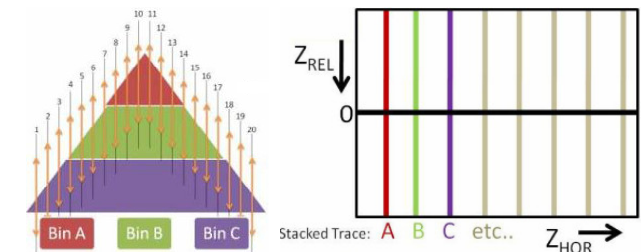
■ dGB Earth Sciences



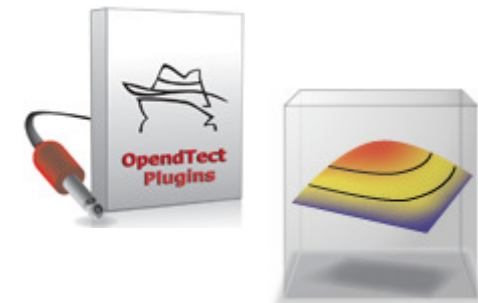
- Implement as 3D solution
- Industry standard package & software support



Use of spatial, frequency and curvature attributes for reservoir, fluid and contact predictions; W. Flierman, J.G. van der Weide, A. Wever – Wintershall Noordzee B.V., F. Brouwer, A. Huck – dGB Earth Sciences B.V.

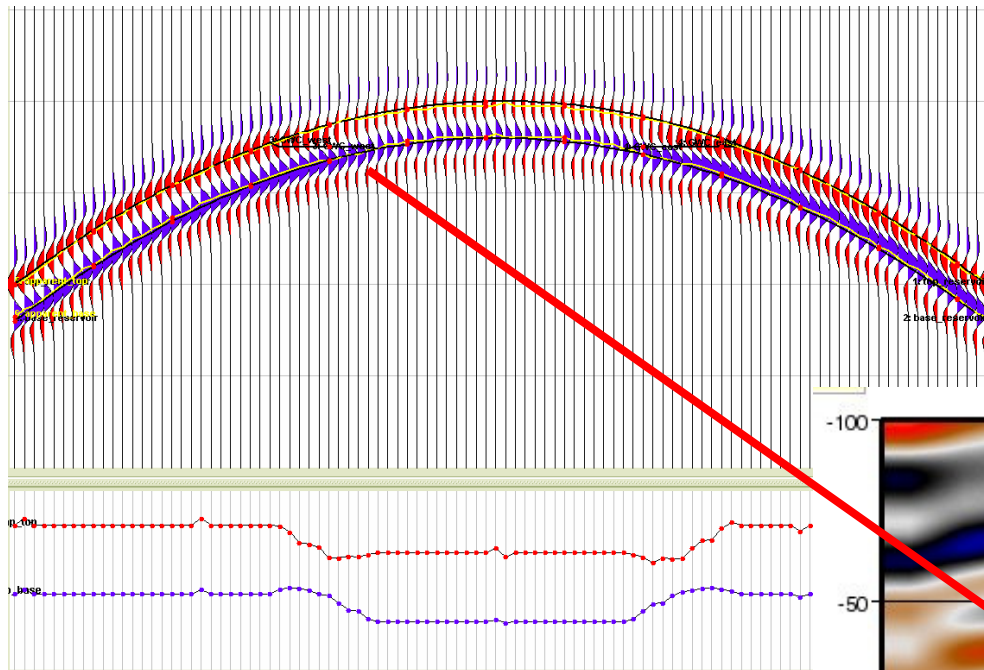


"Extending the common contour binning technique into the pre-stack domain", M Chandler, MSc thesis Leeds University, 2008

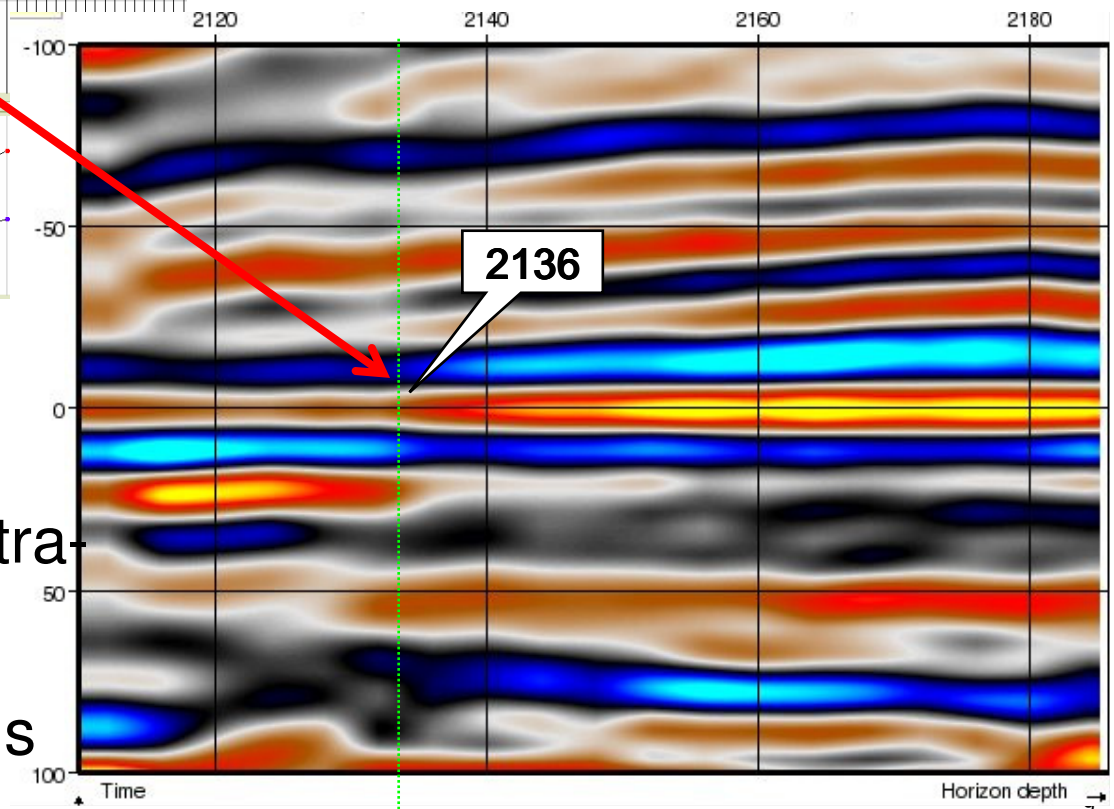


Fluid contacts beyond Flat-spots

Post-stack CCB over tested structure



- Amplitude dim-spot
- Overburden imprint
- Flat-spot depending on reservoir thickness

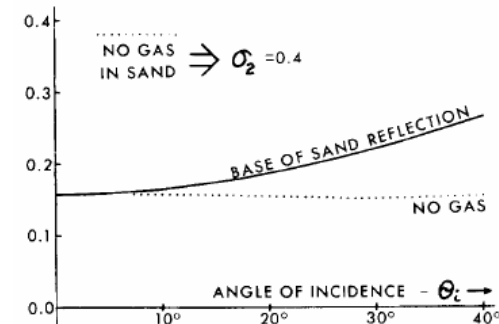


- CCB averages-out overburden effect
- Suppresses effects of intra-reservoir faults
- In total 1875 bin positions

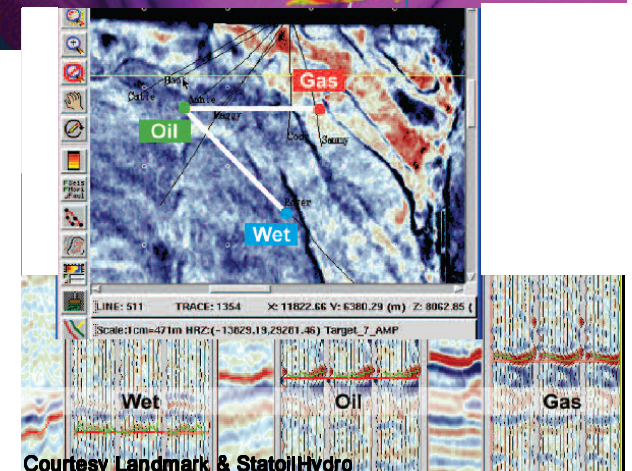
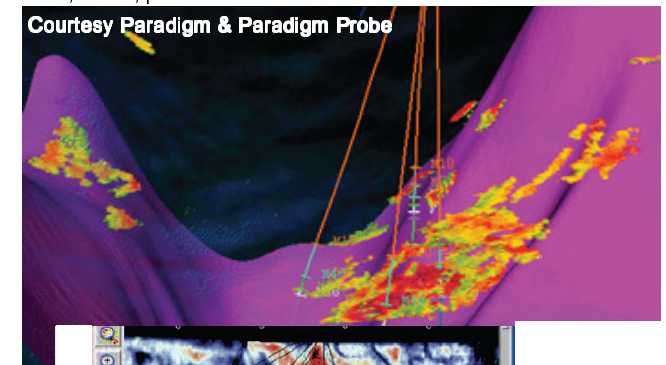
Seismic interpretation in 4 dimensions

Interpretive & 3D use of Pre-stack seismic

- AVO is mature technology
- Increased compute power enables 3D visualization of large data-sets
- Interactive screening, investigation, interpretation of pre-stack data for AVO
- Requires dedicated tools
 - Single platform solution
 - 3D integration for effective data analysis and verification



Plane-wave reflection coefficients for gas sands at nonnormal angles of incidence, W.J. Ostrander, Geophysics Vol 49, no 10, p1637-1648



Seismic interpretation in 4 dimensions

Parties to tackle visualisation & data amount



■ Wintershall



- Offset data provides realisations of the earth
- Density (gas) effect

■ IKON Science



- Modelling offset effects
- Interface to Petrel

■ Headwave

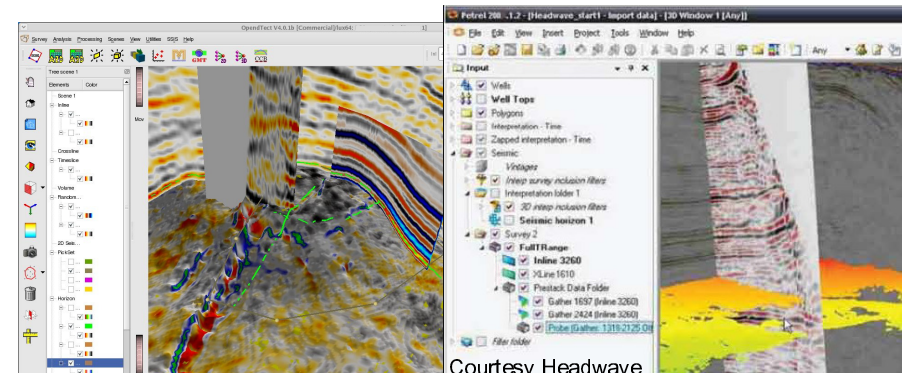


- 3D visualisation in Petrel

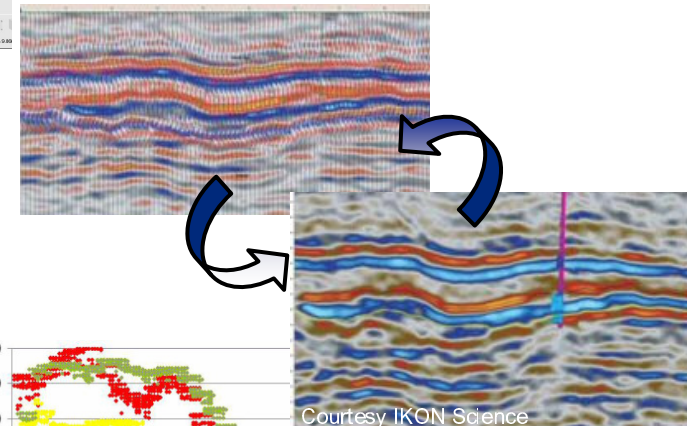
■ dGB Earth Sciences



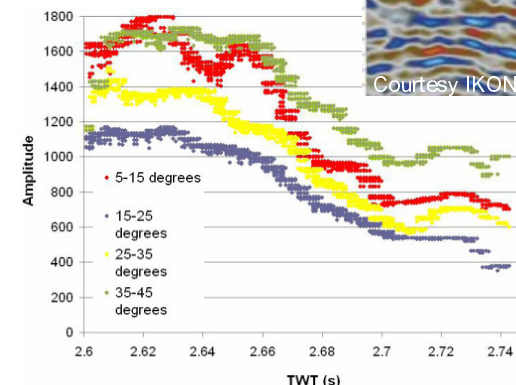
- Powerful integrated tools
- Pre-stack CCB



Courtesy Headwave



Courtesy IKON Science



"Extending the common contour binning technique into the pre-stack domain", M Chandler, MSc thesis Leeds University, 2008

Seismic interpretation in 4 dimensions

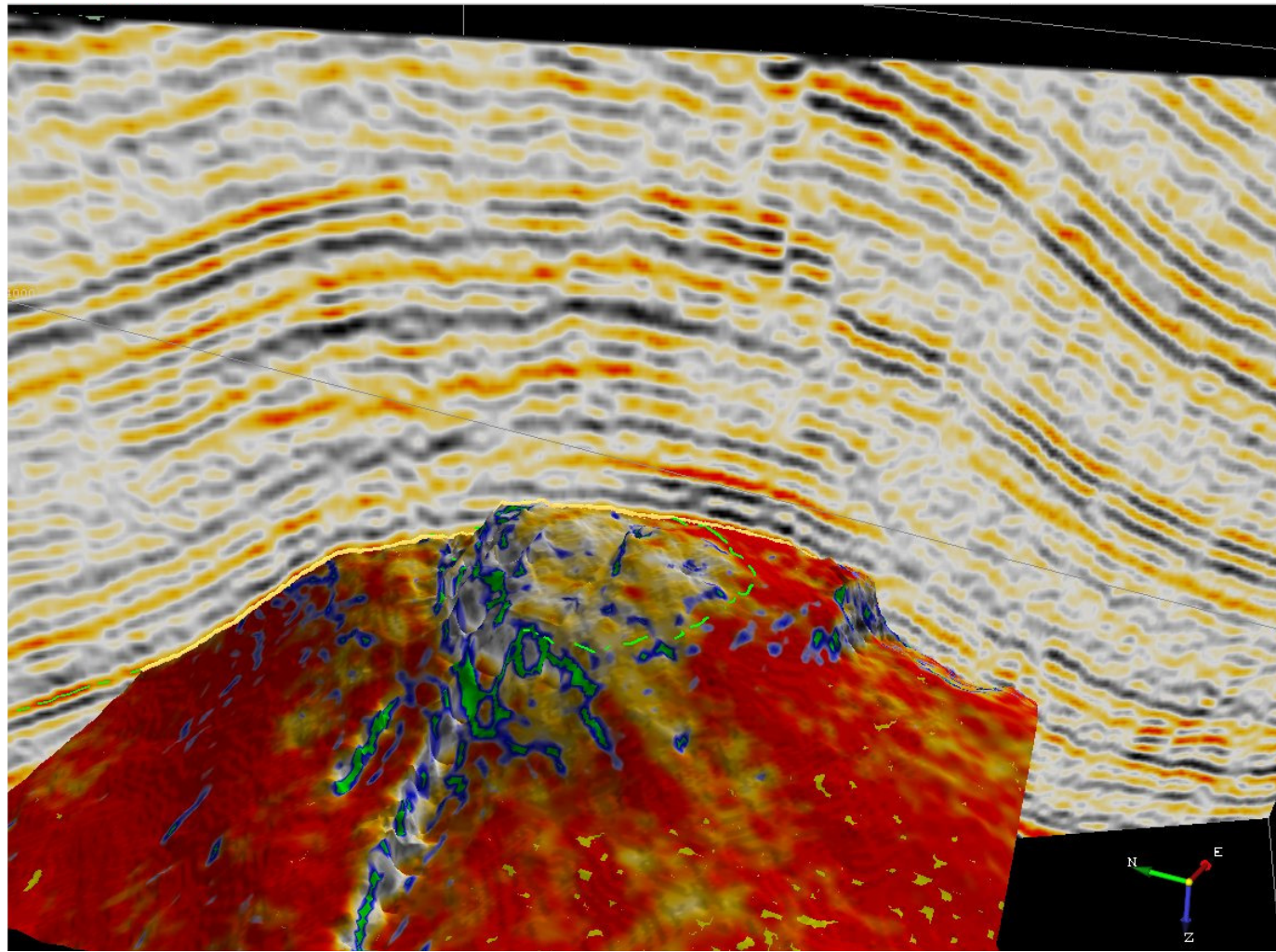
Workflow for pre-stack data evaluation



- 1) Structural (stack) interpretation
- 2) Modeling of seismic response
- 3) Stack CCB on structures
- 4) Offset-evaluation using partial-stacks
- 5) Pre-stack CCB on (prospective) structures
- 6) (Amplitude) analysis of gathers
- 7) 3D integration

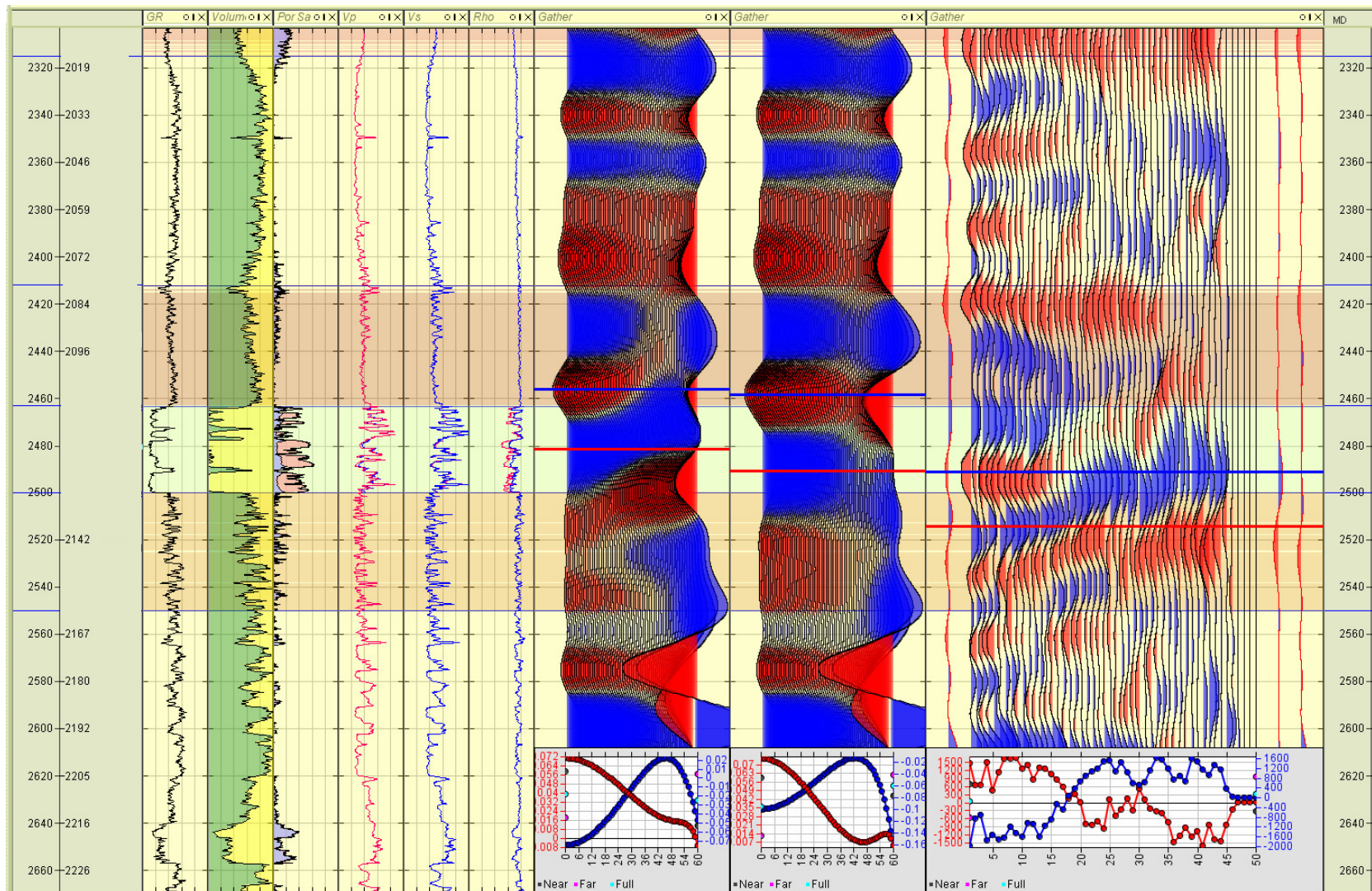
Seismic interpretation in 4 dimensions

1) Structural (stack) interpretation



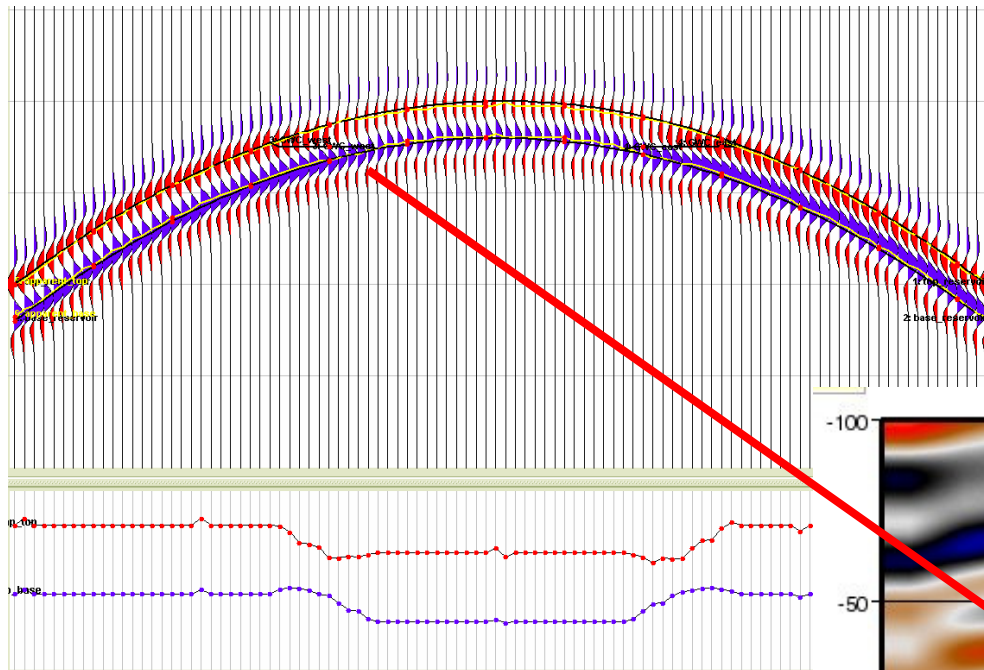
Seismic interpretation in 4 dimensions

2) Modeling of seismic response

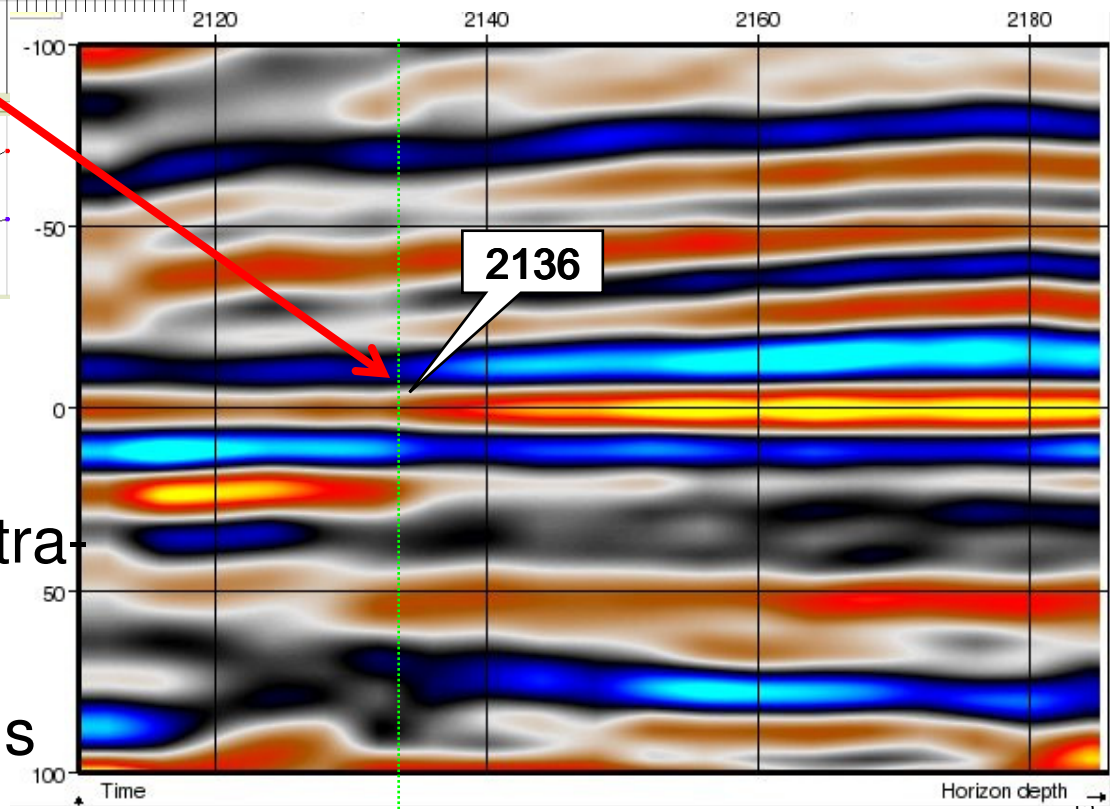


Fluid contacts beyond Flat-spots

3) Post-stack CCB over tested structure



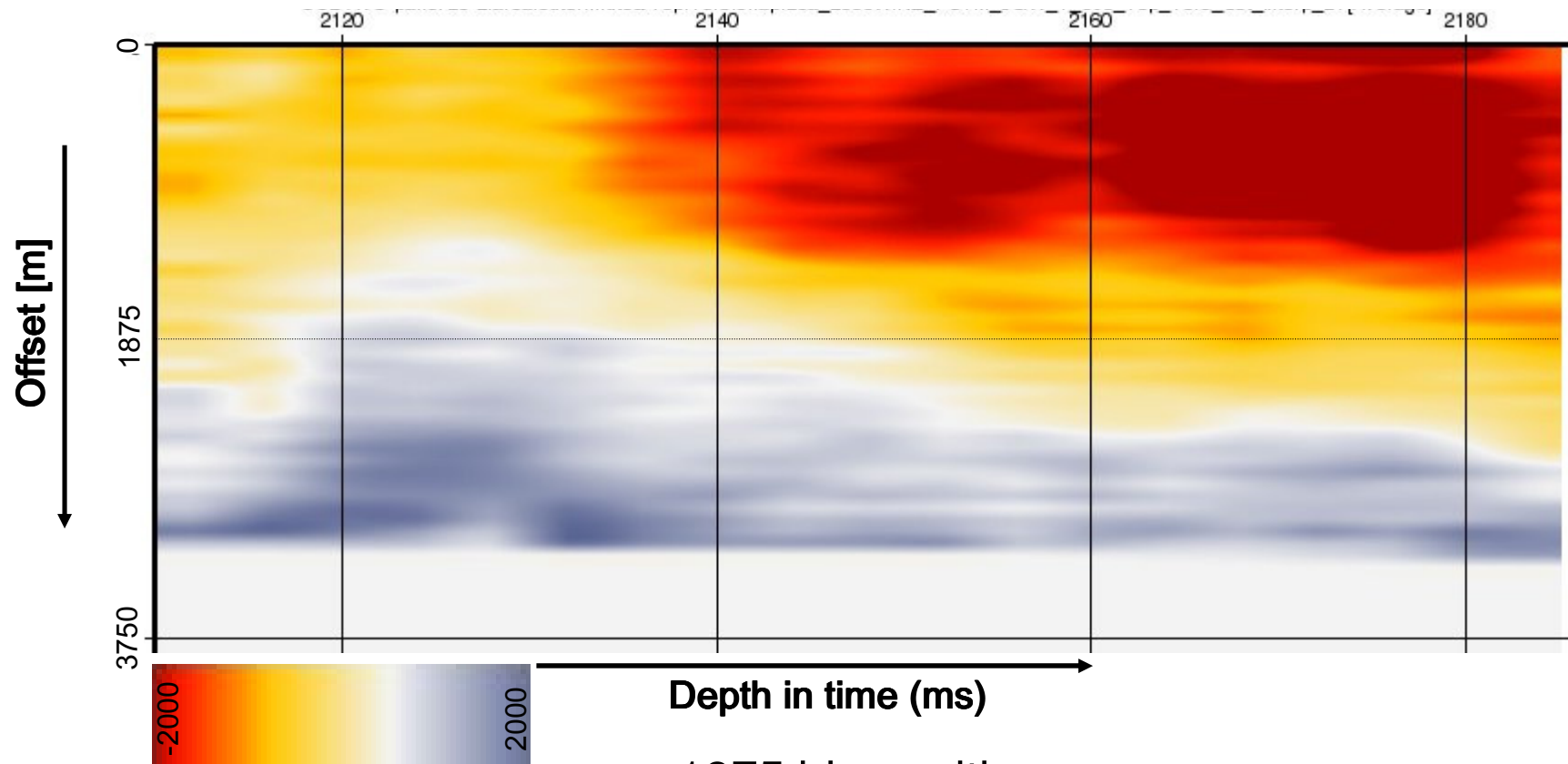
- Amplitude dim-spot
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- CCB averages-out overburden effect
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- In total 1875 bin positions

Seismic interpretation in 4 dimensions

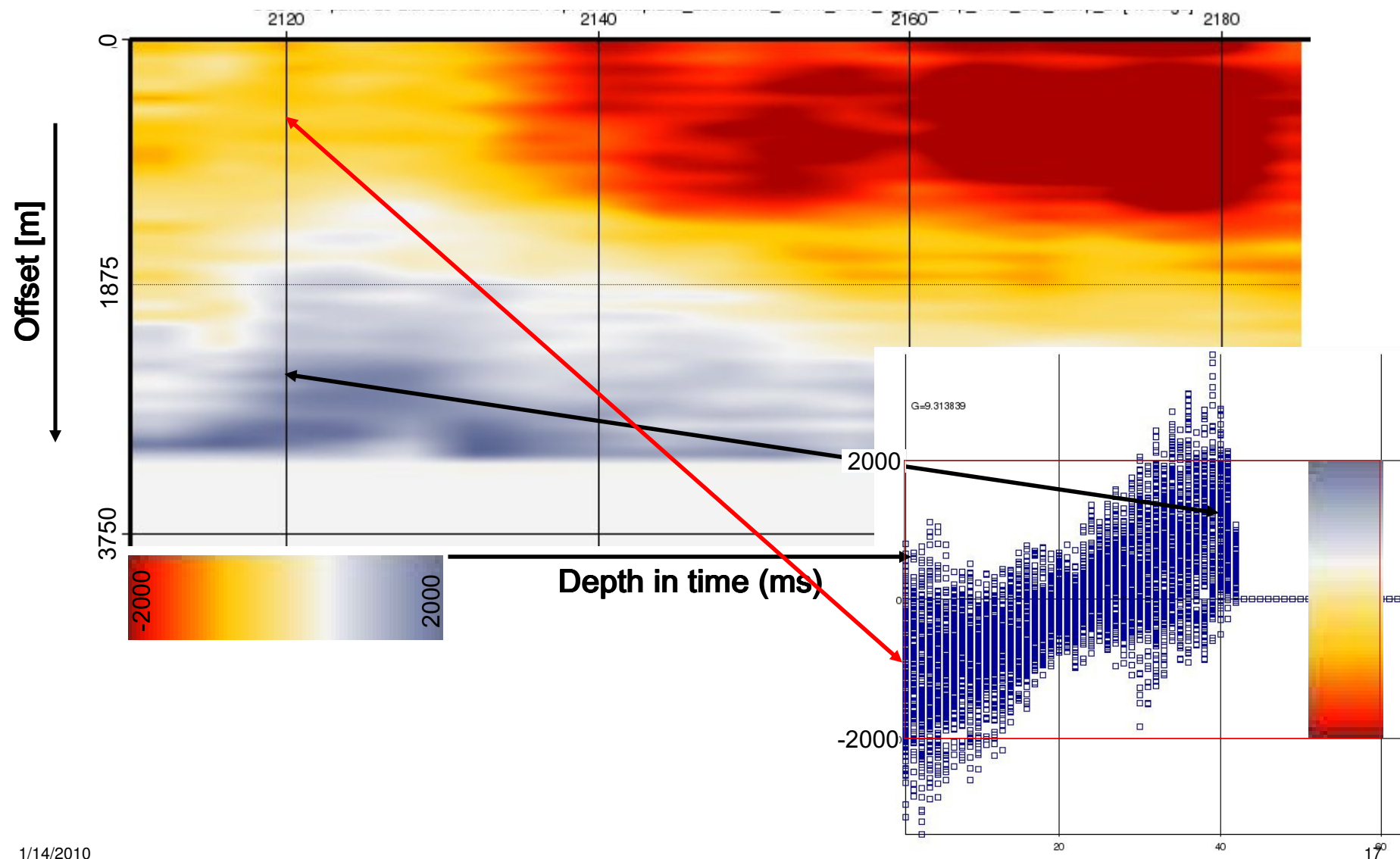
5) Pre-stack CCB



- 1875 bin positions
- Nominal fold of 80
- In total 152.000 traces

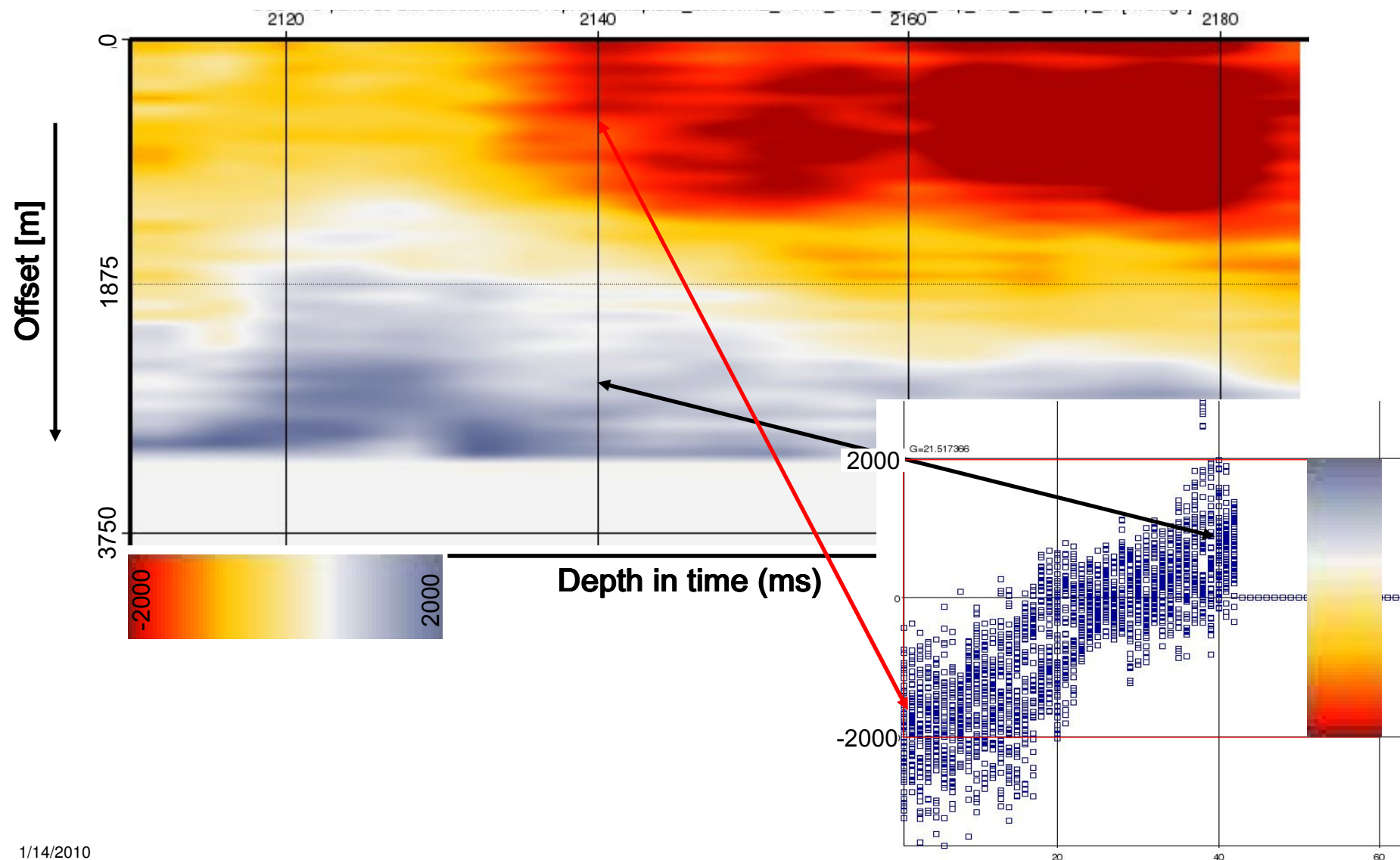
Seismic interpretation in 4 dimensions

5 & 6) Pre-stack CCB



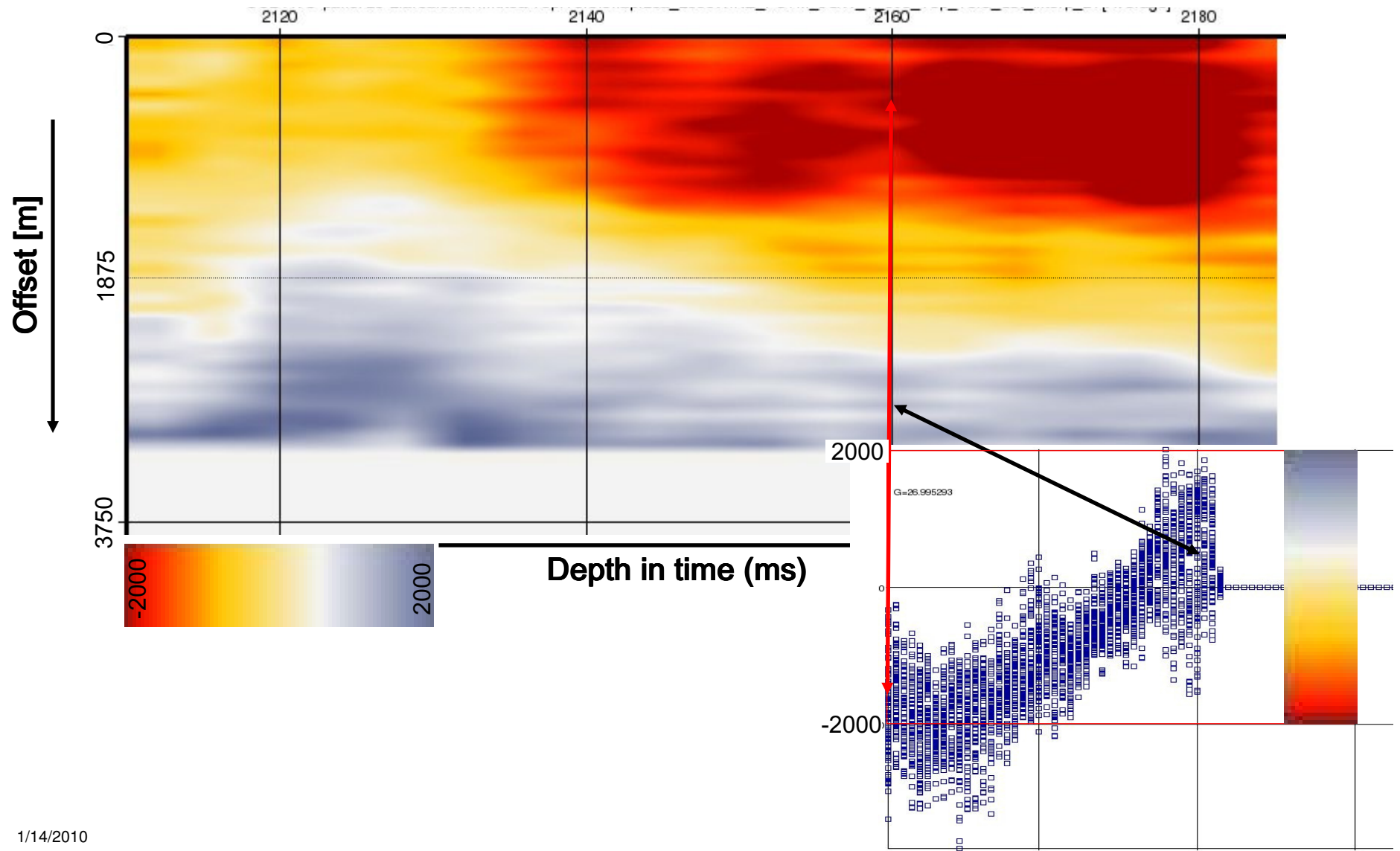
Seismic interpretation in 4 dimensions

5 & 6) Pre-stack CCB



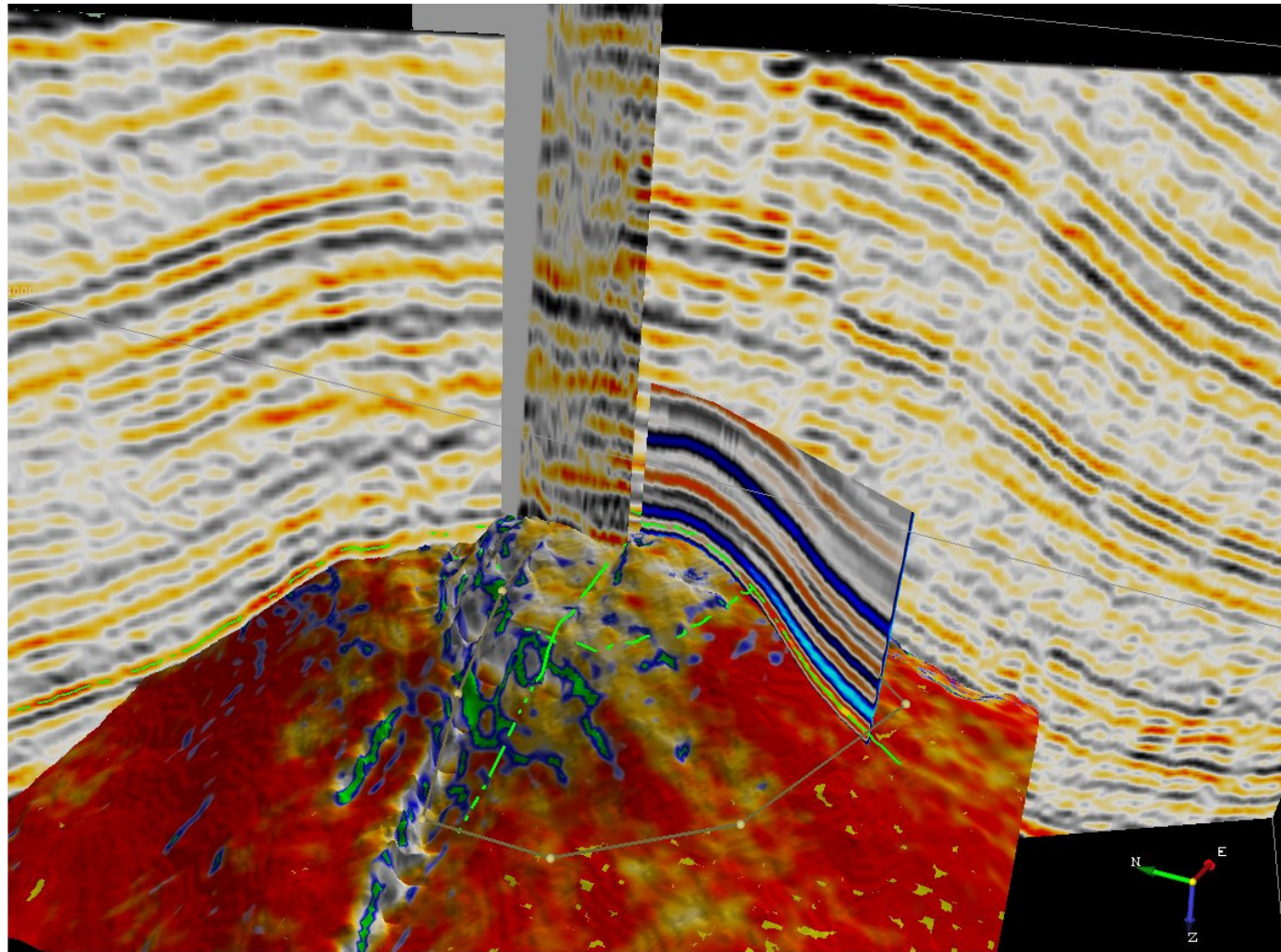
Seismic interpretation in 4 dimensions

5 & 6) Pre-stack CCB



Seismic interpretation in 4 dimensions

7) 3D integration



Gassmann modelling for solid pore fill

New developments based on classic theory

- Classic Gassmann
 - Water – gas – oil substitution
 - No shear forces for pore-fill

$$K_{sat} = K_{dry} + \frac{\left(1 - \frac{K_{dry}}{K_0}\right)^2}{\frac{\phi}{K_f} + \frac{1-\phi}{K_0} - \frac{K_{dry}}{K_0^2}}$$

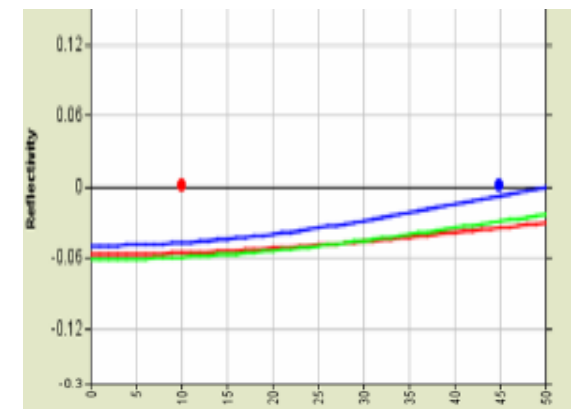
Gassmann, F. [1951] Elastic waves through a packing of spheres. *Geophysics*, 16, 673-685.

- Extended Gassmann
 - Covers for shear forces of pore and fill
 - Developed for heavy and bituminous oils

$$K_{sat}^{*-1} = K_{dry}^{-1} - \frac{(K_{dry}^{-1} - K_{gr}^{-1})^2}{\phi(K_{if}^{-1} - K_{\phi}^{-1}) + (K_{dry}^{-1} - K_{gr}^{-1})}$$

Ciz, R., and Shapiro, S.A. [2008] Generalization of Gassmann equations for porous media saturated with a solid material. *Geophysics*, 72, A75-A79

- Applied to Salt-Plugged Bunter



I. Pacek [2009] Extended Gassmann approach to pore-fill substitution for salt and fluids, calibrated on Triassic Sandstone Reservoirs in the Southern North Sea. MSc thesis TU Delft

Gassmann modelling for solid pore fill

Partnership towards seismic – synthetic loop



■ Wintershall



- Reservoir risk for prospects close to salt domes
- Assessment of potential needs quantitative approach

■ IKON Science



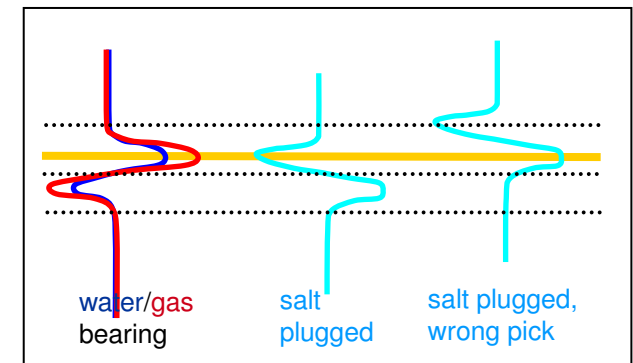
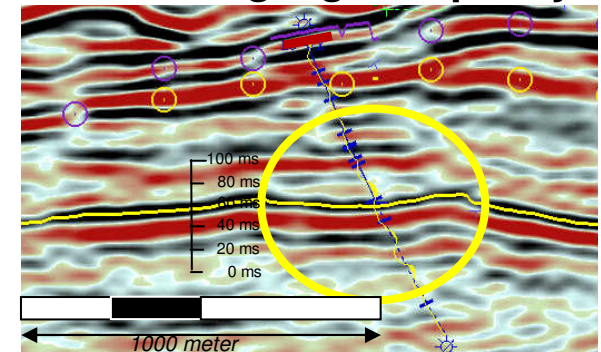
- Seismic & rock physics modeling solutions
- Ability to handle pre-stack seismic

■ TU Delft

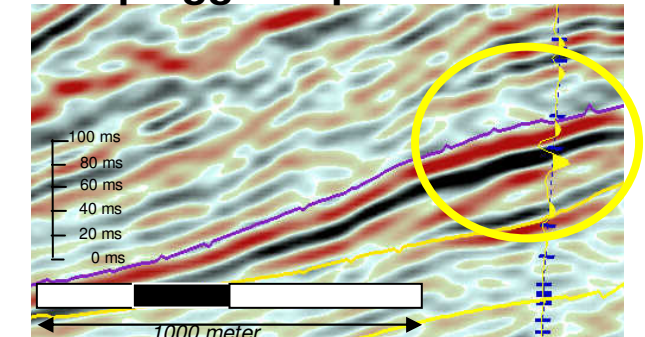


- AVO & modeling expertise

Gas bearing – good quality

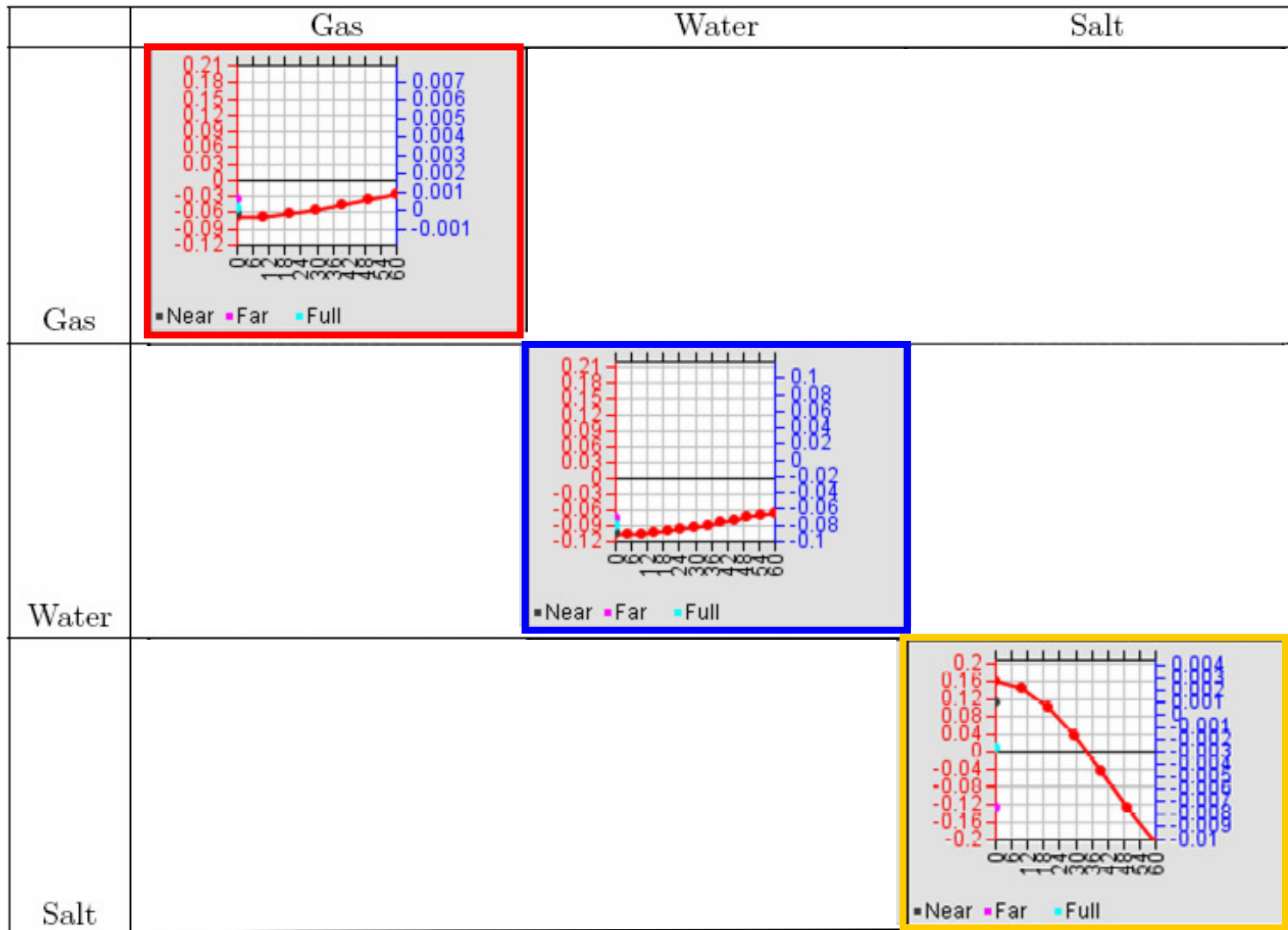


Salt plugged – poor reservoir



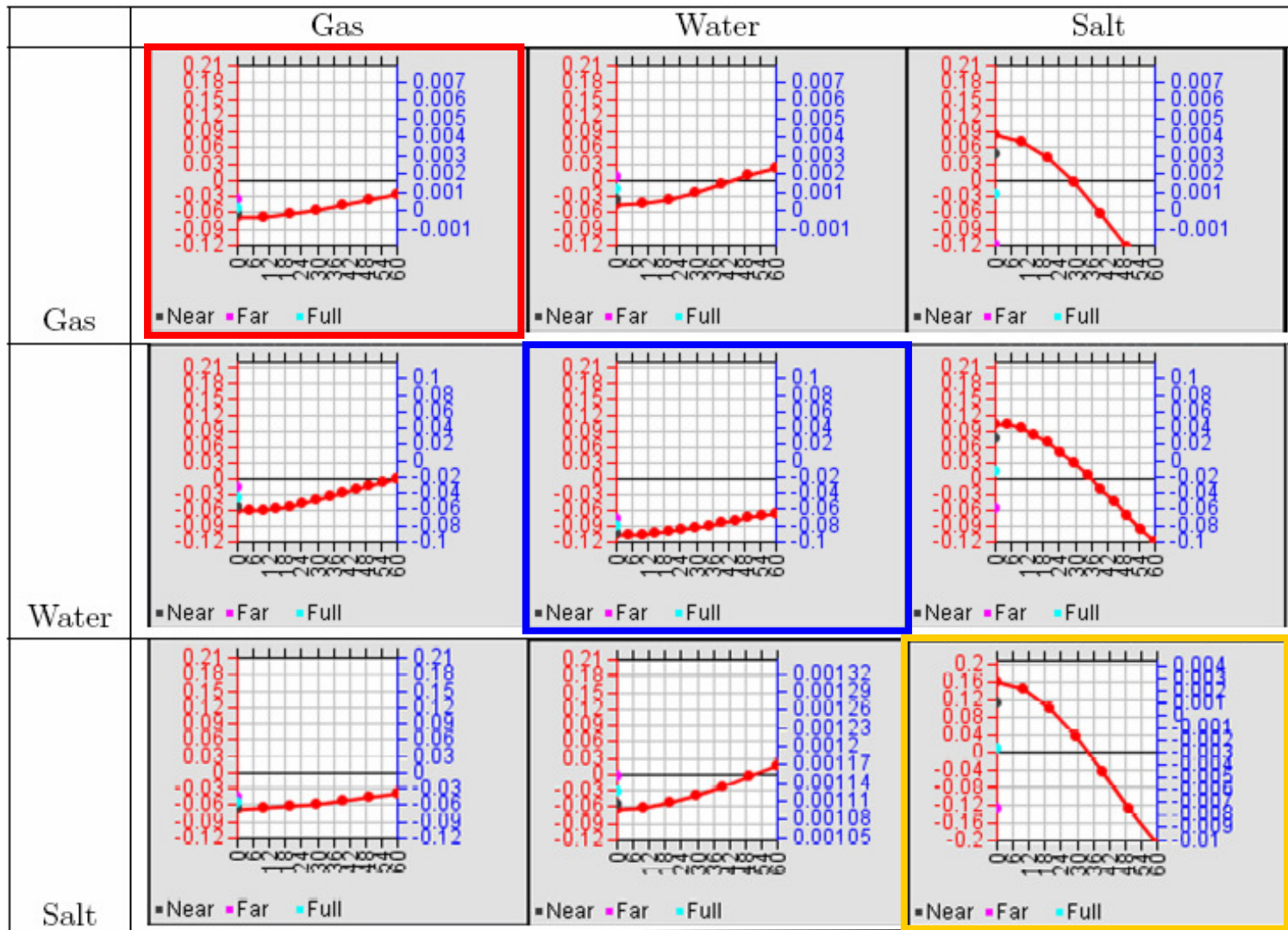
Gassmann modelling for solid pore fill

Modelled vs. real AVO behaviour



Gassmann modelling for solid pore fill

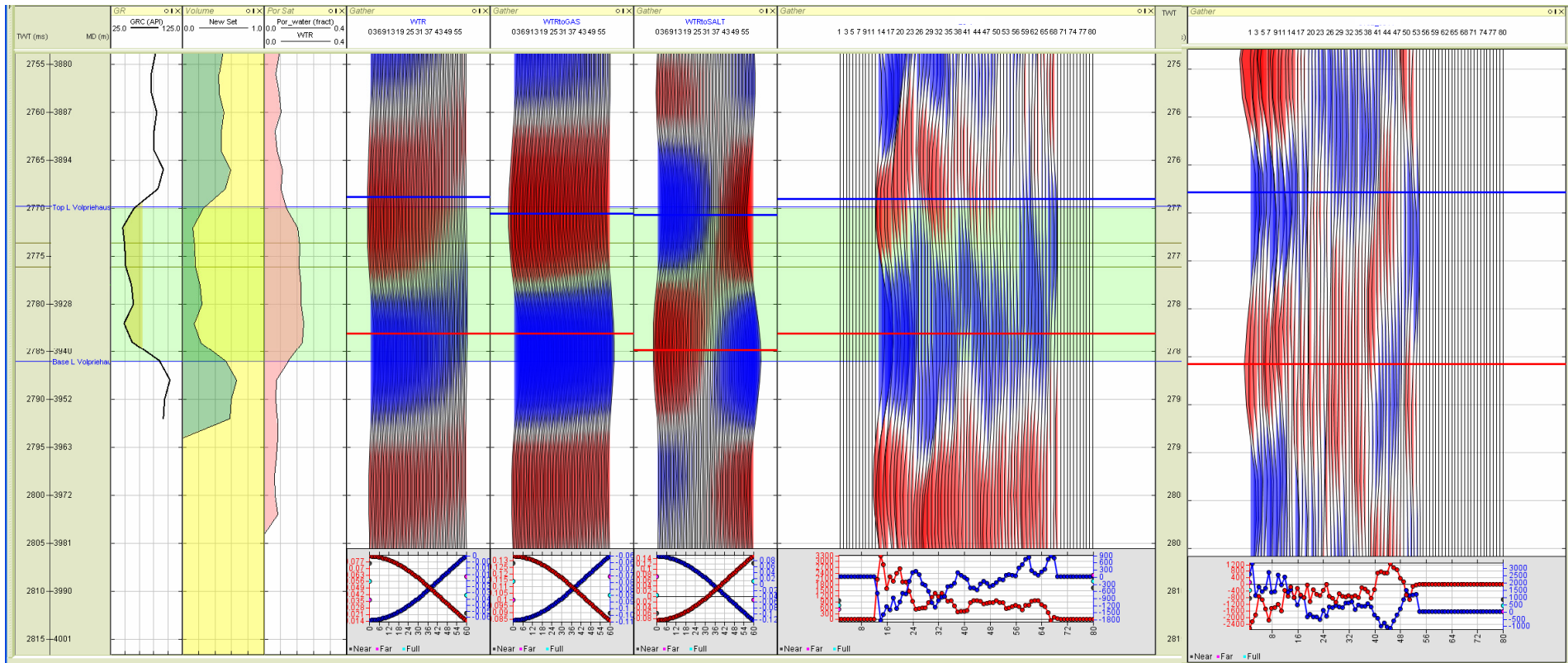
Modelled vs. real AVO behaviour



Gassmann modelling for solid pore fill

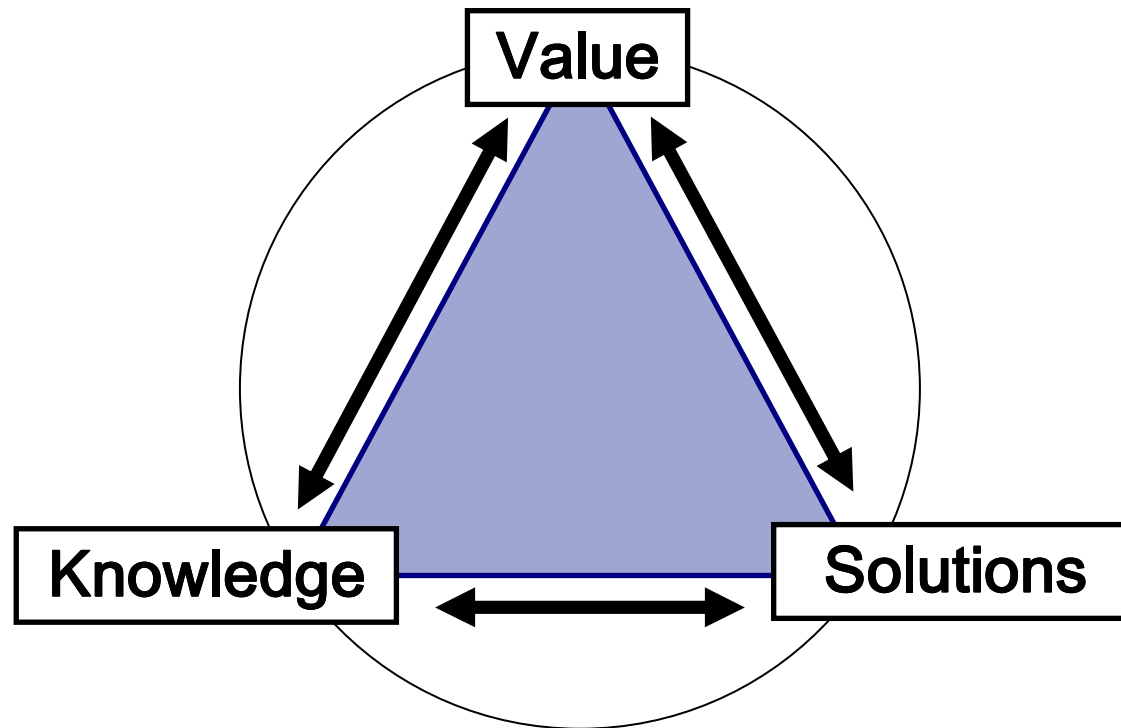
Proof of Concept for Salt Substitution

water-bearing well water gas salt water-bearing well salt-plugged well



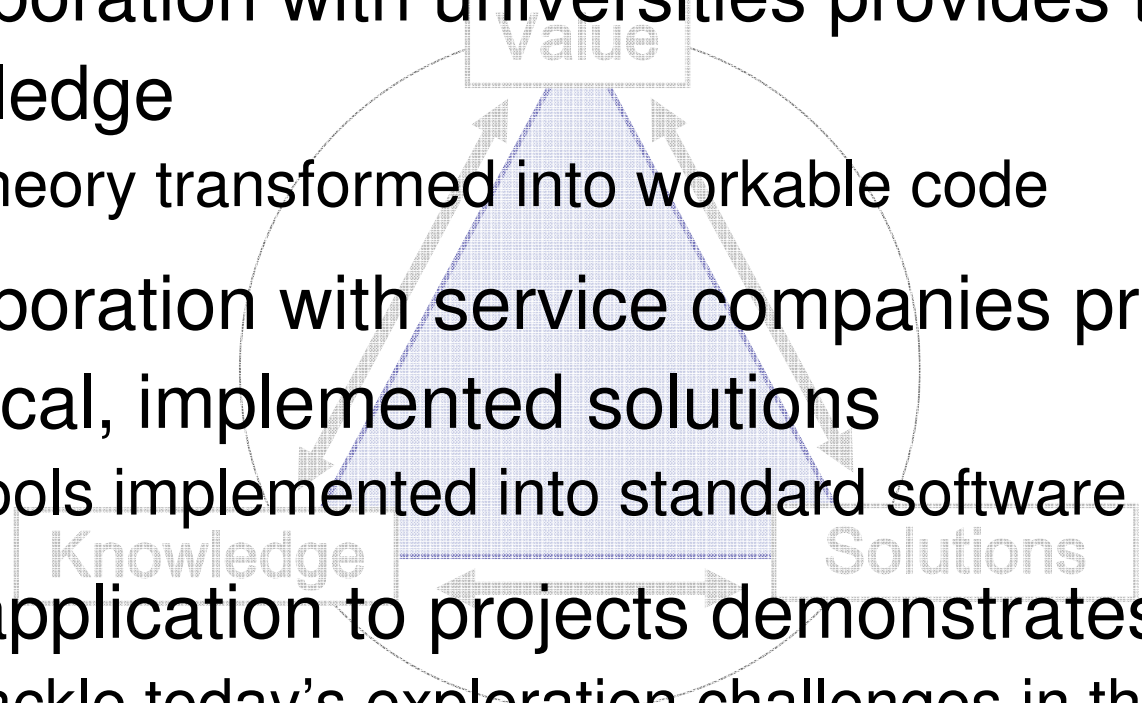
- Synthetic from original well data matches seismic
- Salt-substituted synthetic matches seismic at salt-plugged well location

Conclusions: turning ideas into practical solutions



Conclusions: turning ideas into practical solutions

- Collaboration with universities provides the new knowledge
 - Theory transformed into workable code
- Collaboration with service companies provides practical, implemented solutions
 - Tools implemented into standard software
- The application to projects demonstrates the value
 - Tackle today's exploration challenges in the SNS
- **Wintershall widely uses this concept to turn ideas into practical solutions**



Partners in blocks and projects are kindly acknowledged



Thank you for your attention

&

are there any questions???