Dynamic GeoScience

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ikon Science

OPTIMISE SUCCESS THROUGH SCIENCE

Agenda

1. **Ikon Science**
   Where we are now

2. **Geoscience 2012**
   A motion picture

3. **Rock physics, AVO and Inversion**
   Simply rocks

4. **Hydrodynamics & Seismic Attributes**
   rocks + pressure + fluids

3. **Time-Lapse & Real Time**
   rocks + pressures + fluids + time

4. **Geomechanics**
   pressure, fluids + time + stress

5. **Summary Thoughts**

Global Rocks, Fluids and Pressures

Global clients

ikon Science

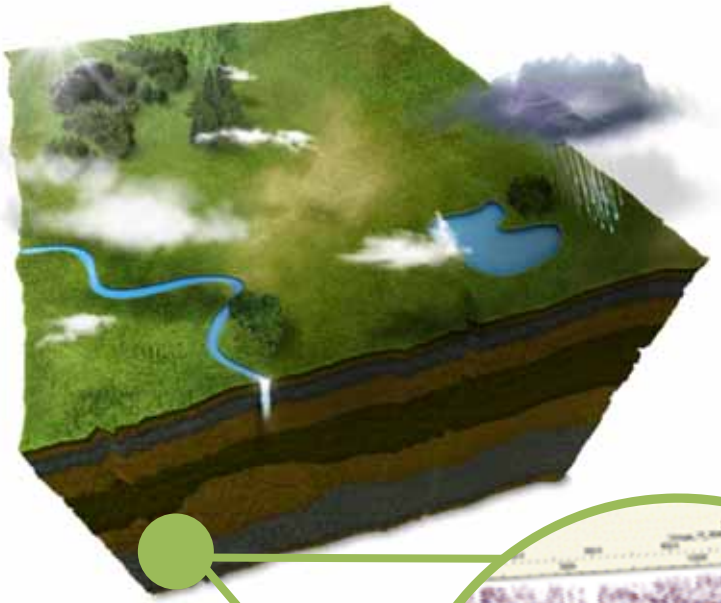
Major oil companies



National Oil Companies

Mids & Independents

What do we all want to know & see?



1. What fluid do we have?
   (Oil/Gas/Water?)

2. Where is it / what is it in?

3. How will it behave?

The digital data explosion....

2MP

10MP

20MP

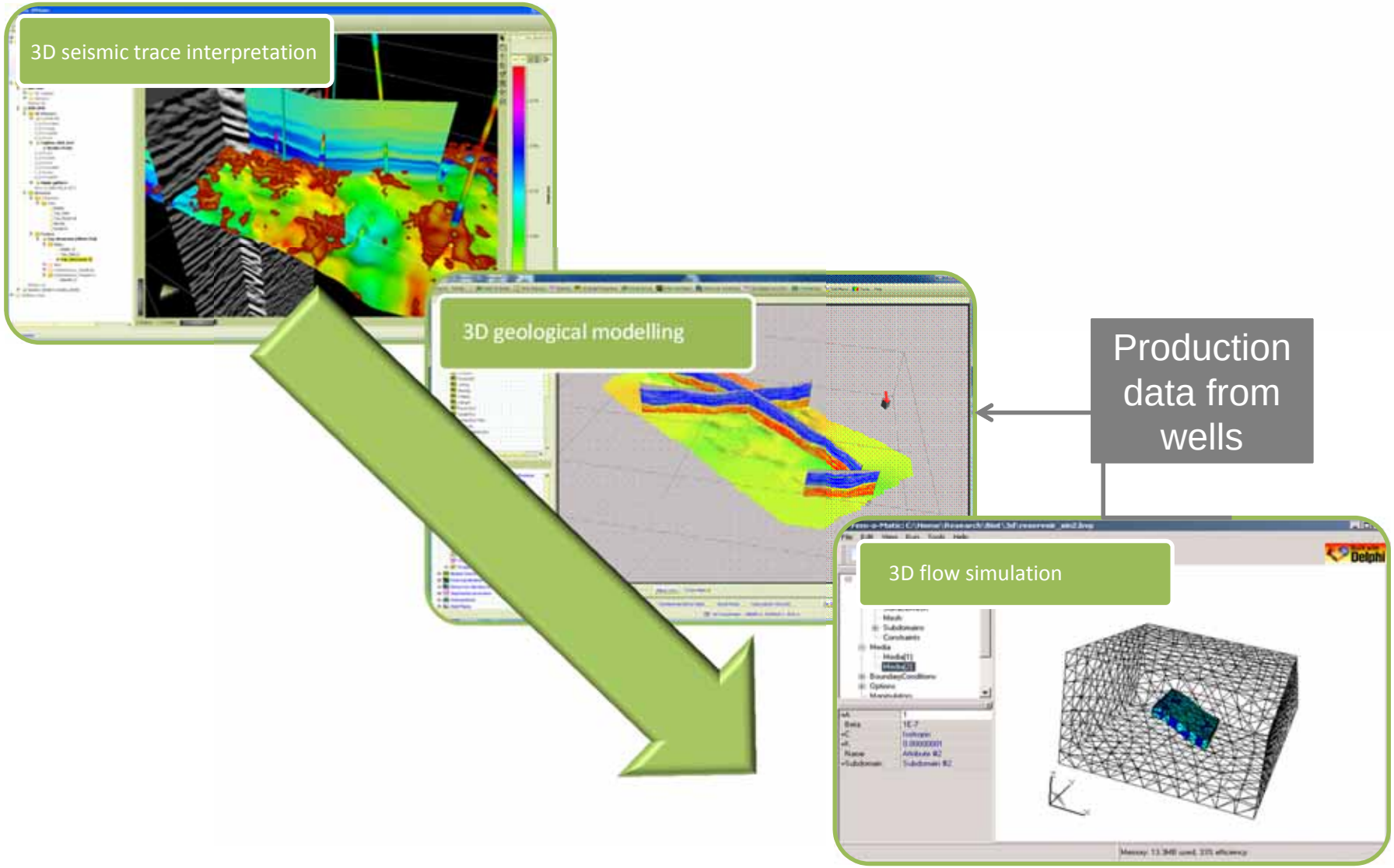
10 Years of Technology

Standard X-Ray 2001

MRI Scan 2011

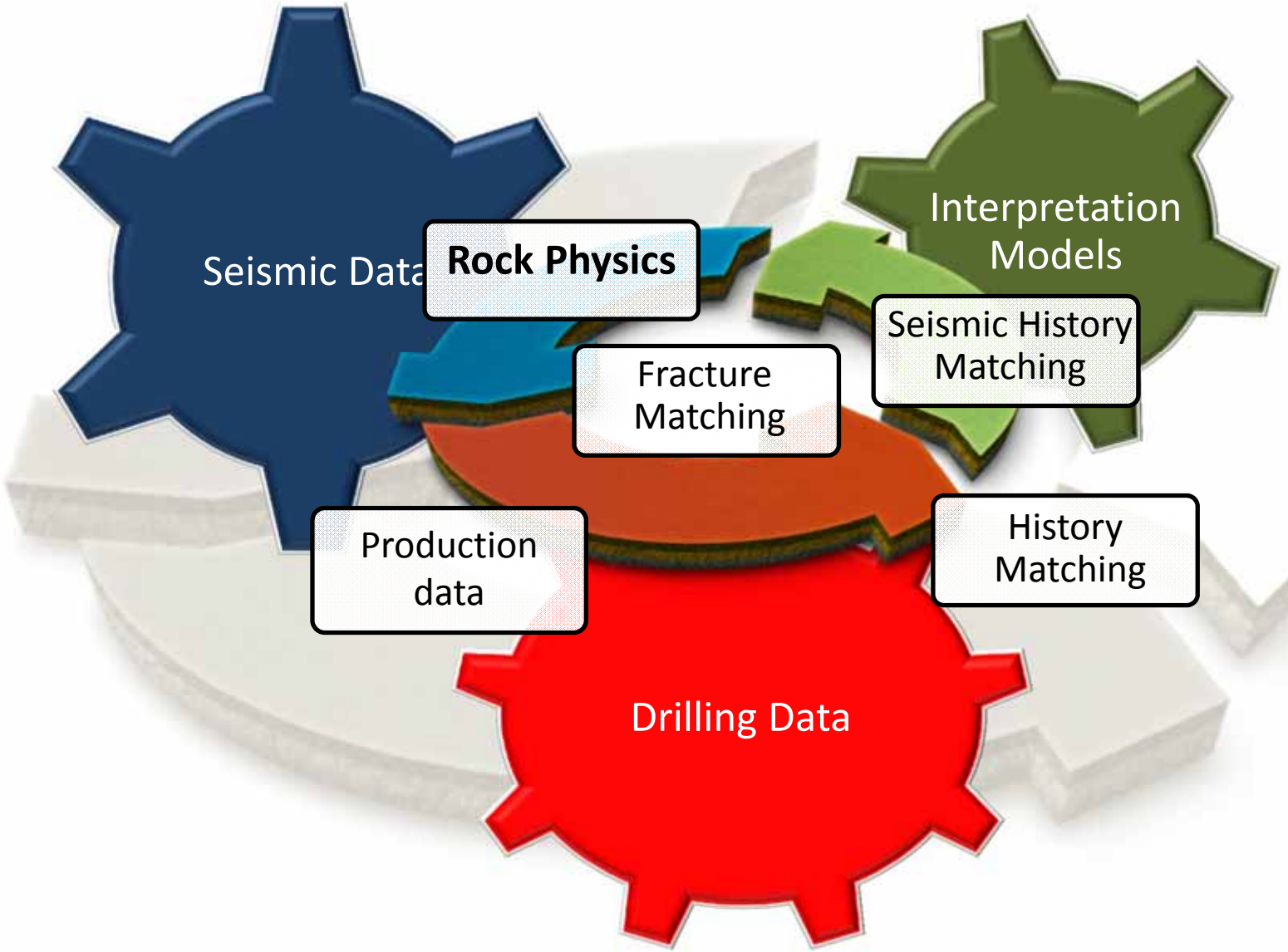
The 3D highway - recent past

Properties predicted on ‘qualitative ’ models



The 3D highway - now

Predictions built on QI - input from real data



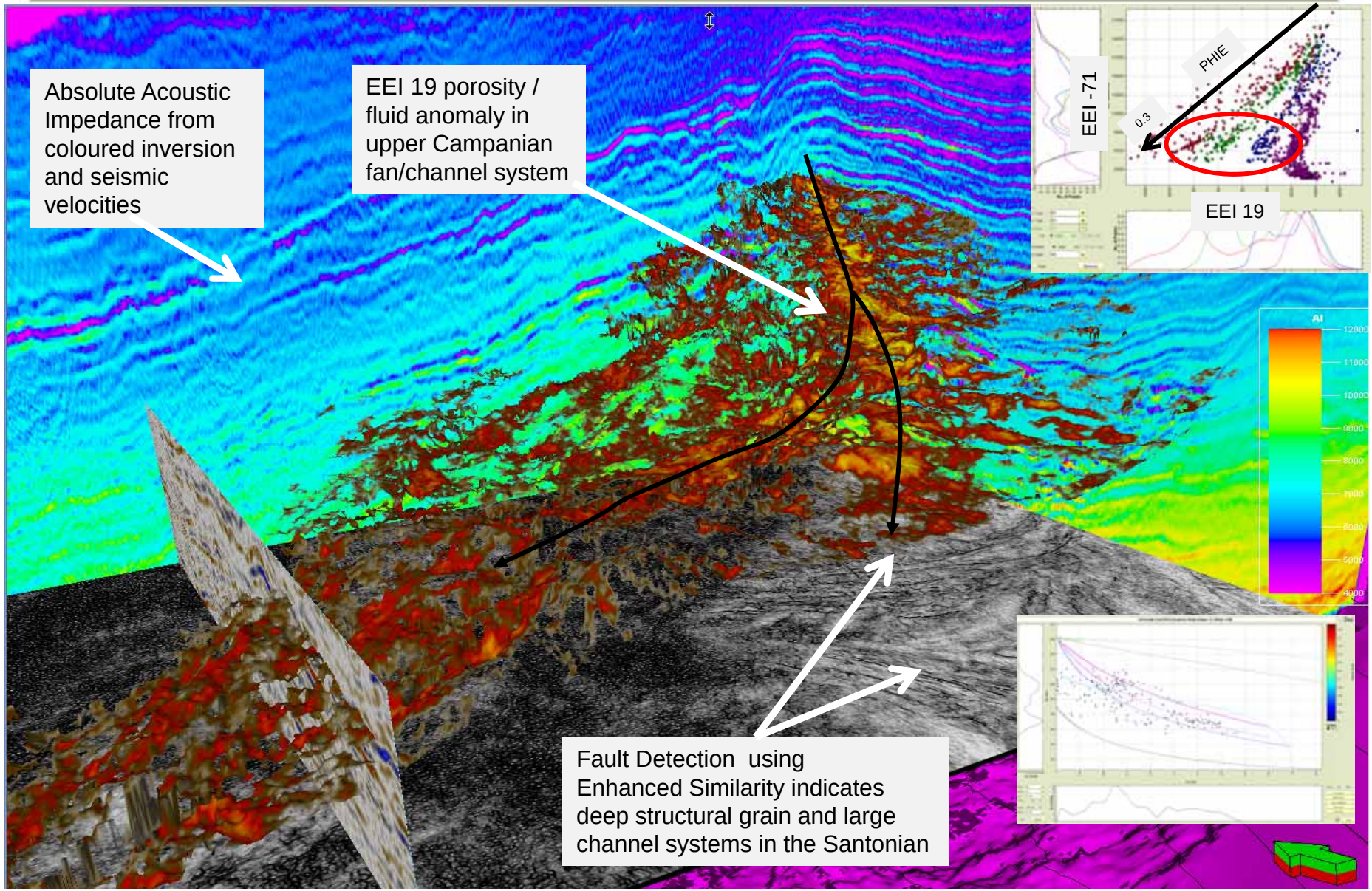
Dynamic Geoscience Example 1.

1. Rock Physics, AVO and Inversion

All Very Obscure ... ???

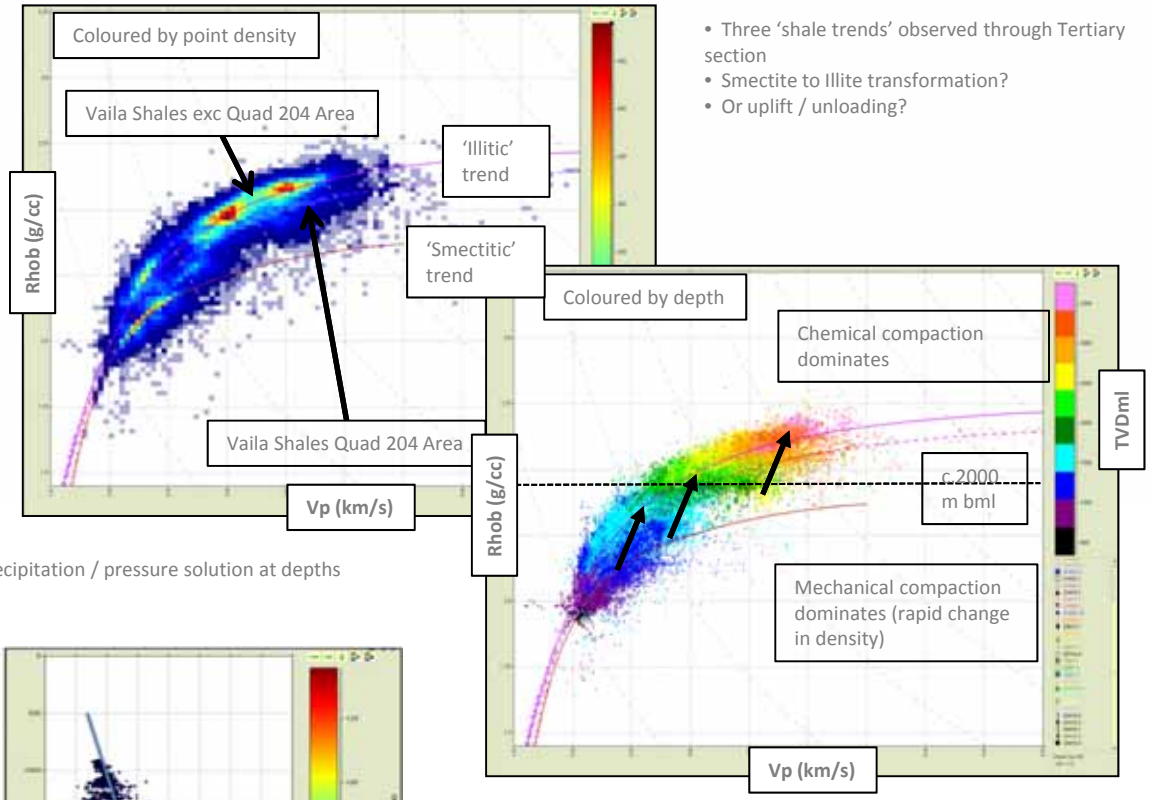
Or, All Very Obvious?

AVO Inversion
West African Campanian

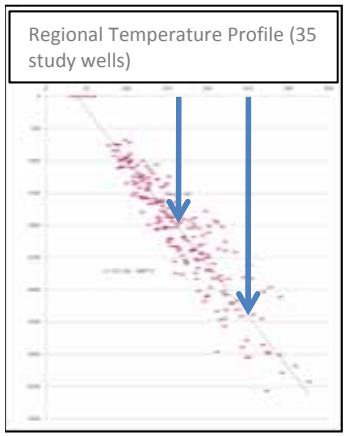


WOS :- Impact of basin history on rock properties

Temperature control on shale diagenesis and corresponding rock properties have an impact on seismic behaviour



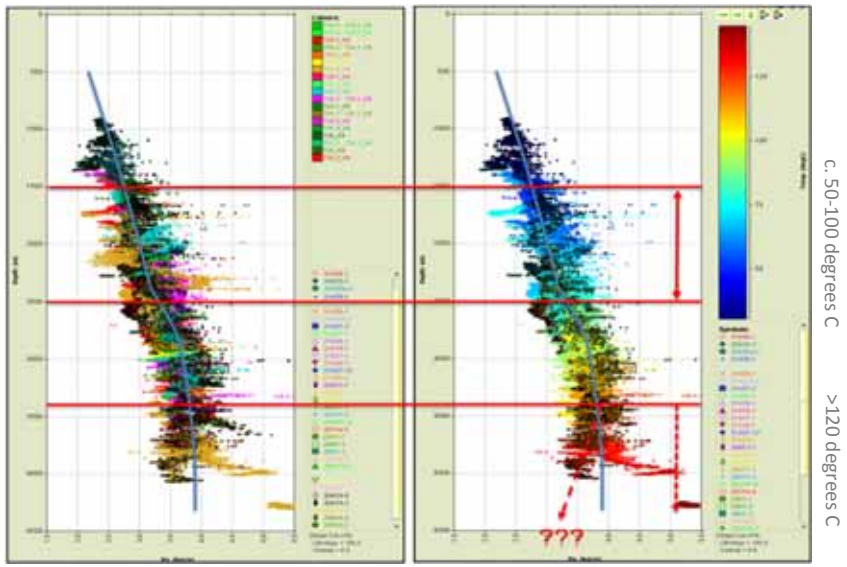
- Three 'shale trends' observed through Tertiary section
- Smectite to Illite transformation?
- Or uplift / unloading?



~70 C at 2km

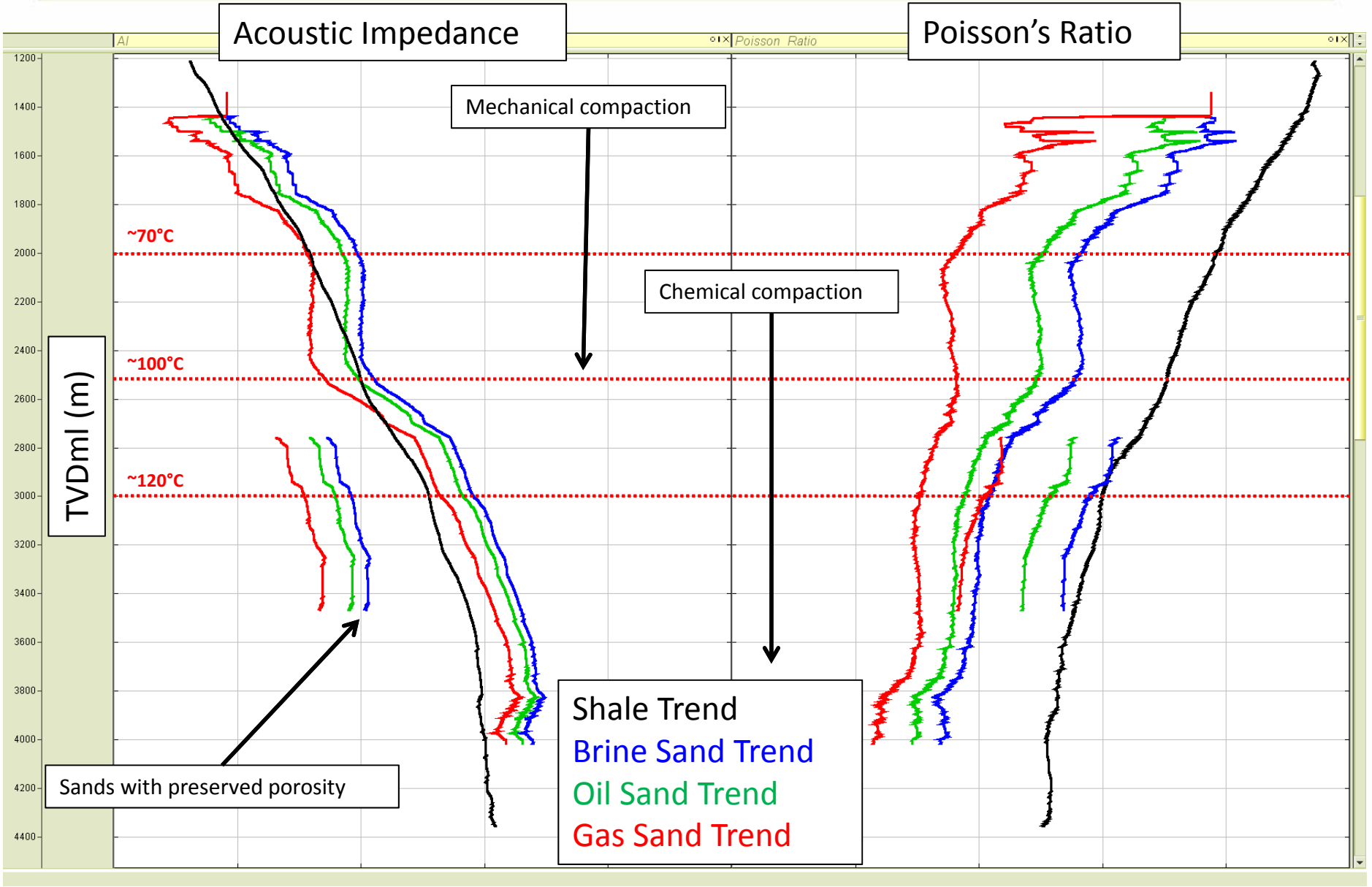
~120 C at 3.5km

Onset of clay transformation and quartz precipitation / pressure solution at depths >2000m bml?

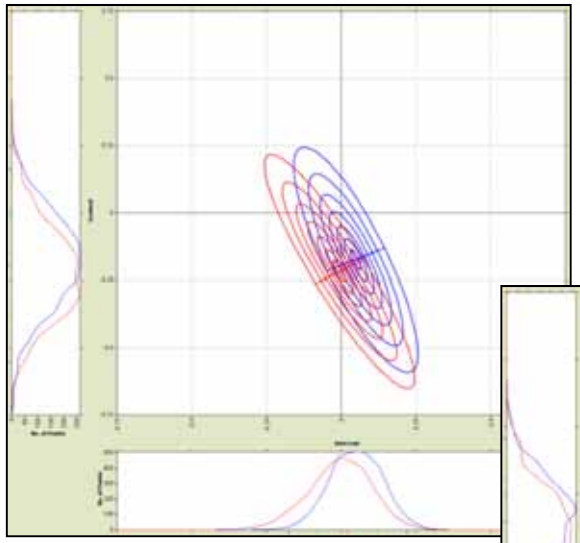


70-100 °C – Smectite to Illite transformation,
Quartz cementation and retardation of mechanical compaction process

Mechanical & Chemical Compaction

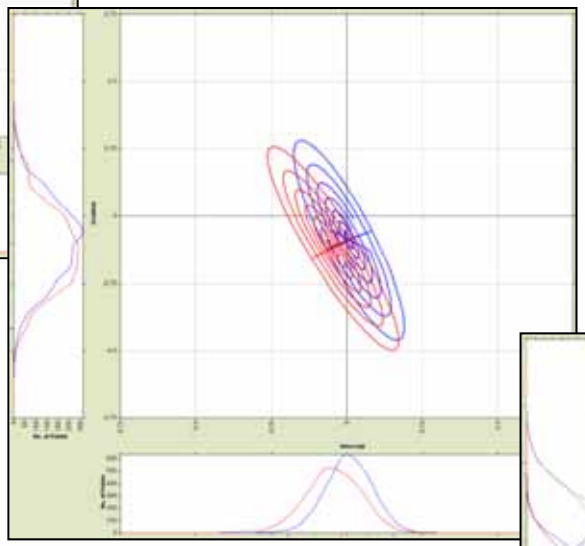


AVO models which better reflect the geology



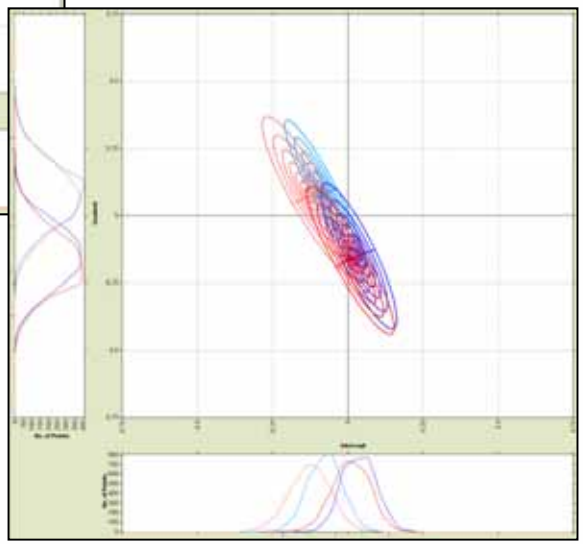
2000m bml

- Wet Sands ‘hard’ Class I AVO
- Gas Sands transparent to ‘soft’ Class II AVO



2500m bml

- Wet Sands transparent weak class II AVO
- Gas Sands ‘soft’ Class II-III AVO



3000m bml

- Low Porosity Wet Sands ‘hard’ class I AVO
- Low Porosity Gas Sands transparent to ‘soft’ Class II AVO
- High Porosity Wet Sands ‘soft’ class IV AVO
- High Porosity Gas Sands ‘soft’ (but bright!) Class IV AVO

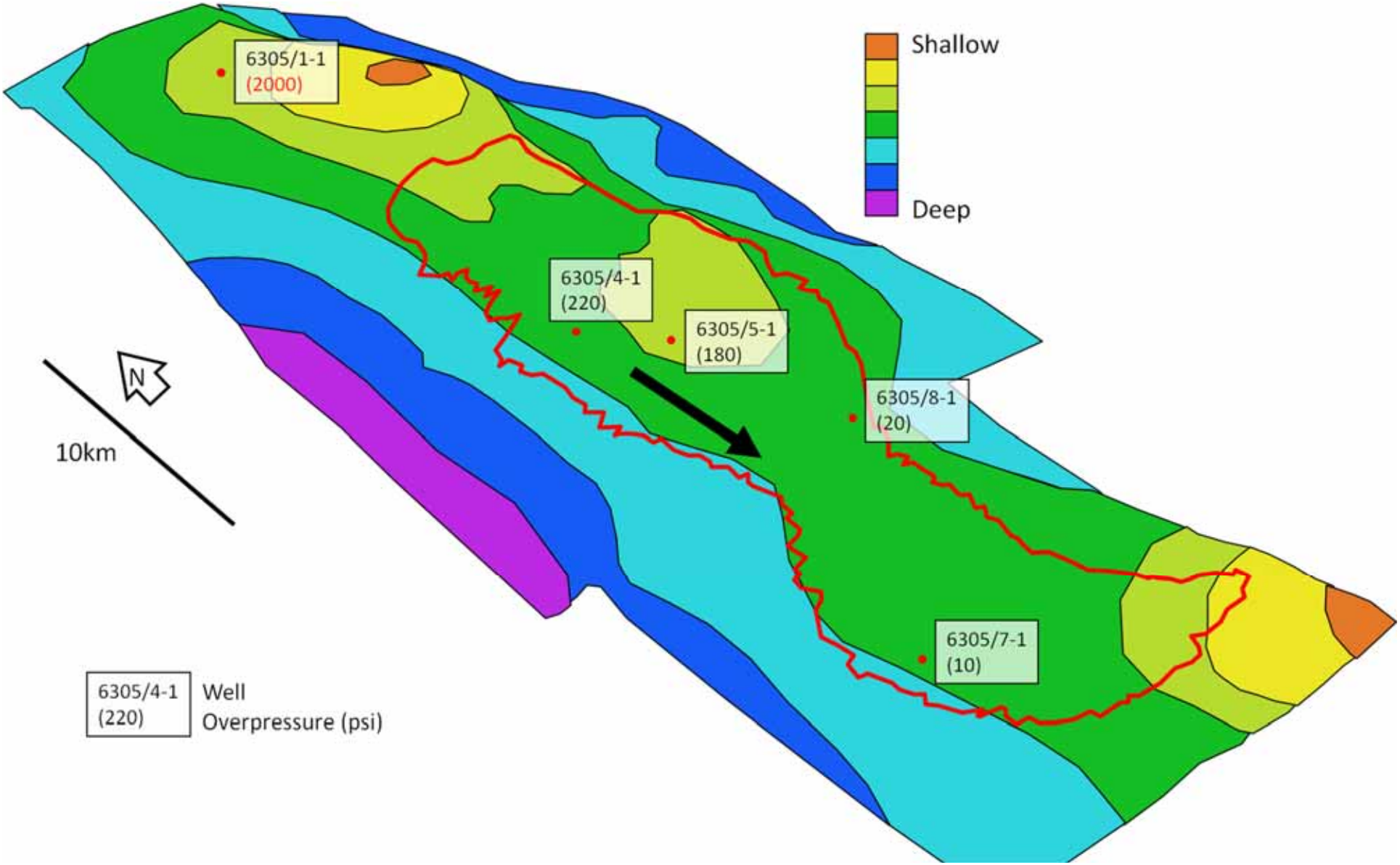
Dynamic Geoscience Example 2.

Hydrodynamics & Seismic Attributes

The interactions of rocks + pressure and fluids

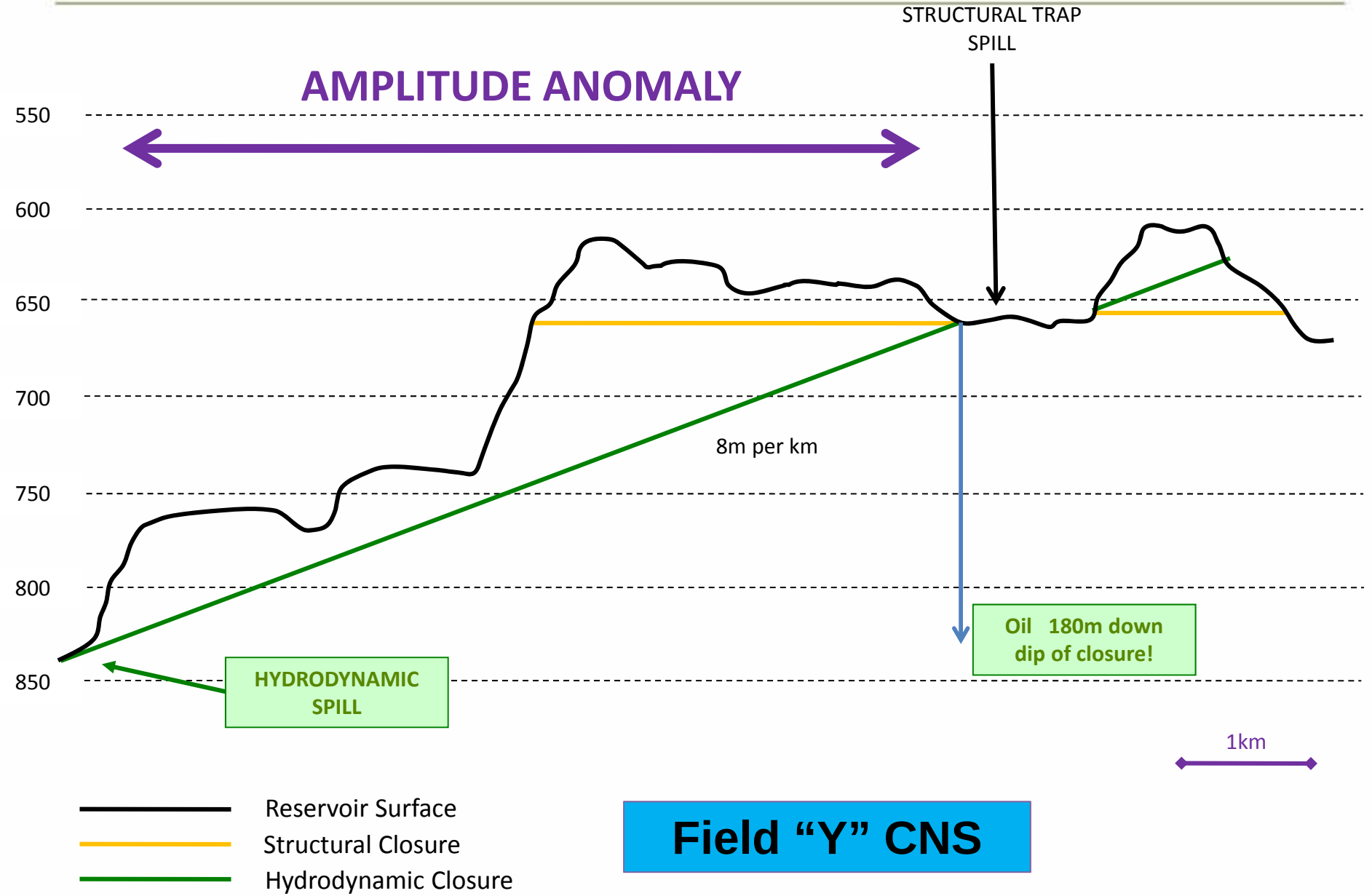
The regional informs the local

The Ormen Lange Field
Offshore Norway



A Tell-Tale Tilt....

Predicted through regional knowledge

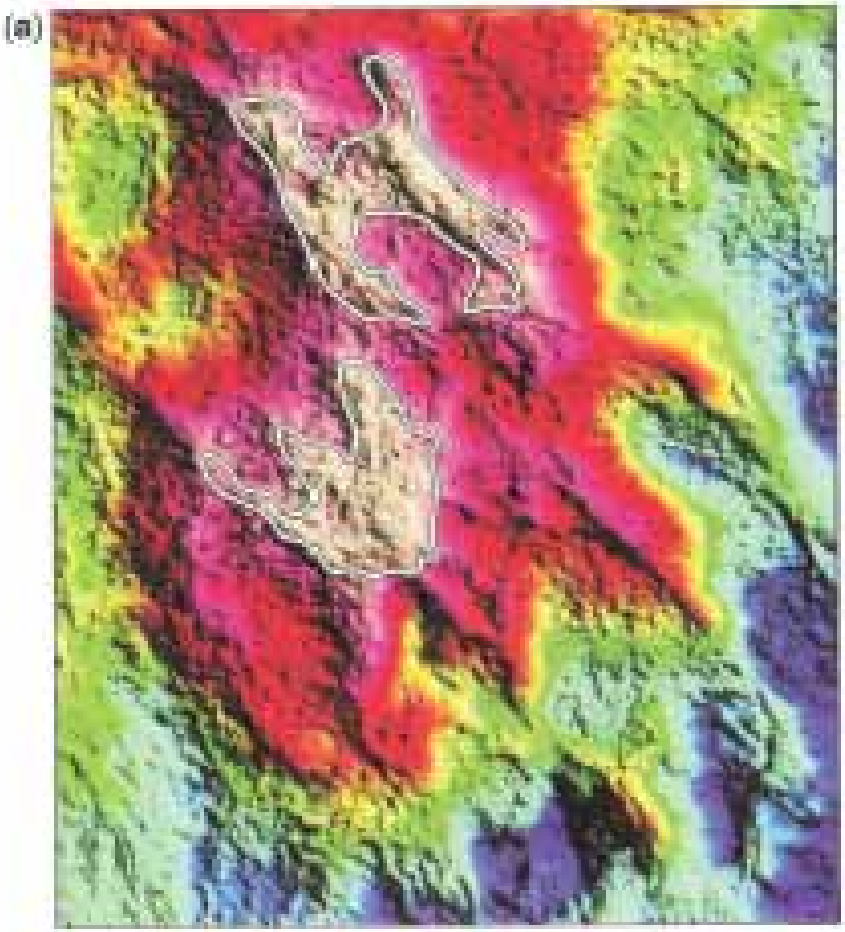


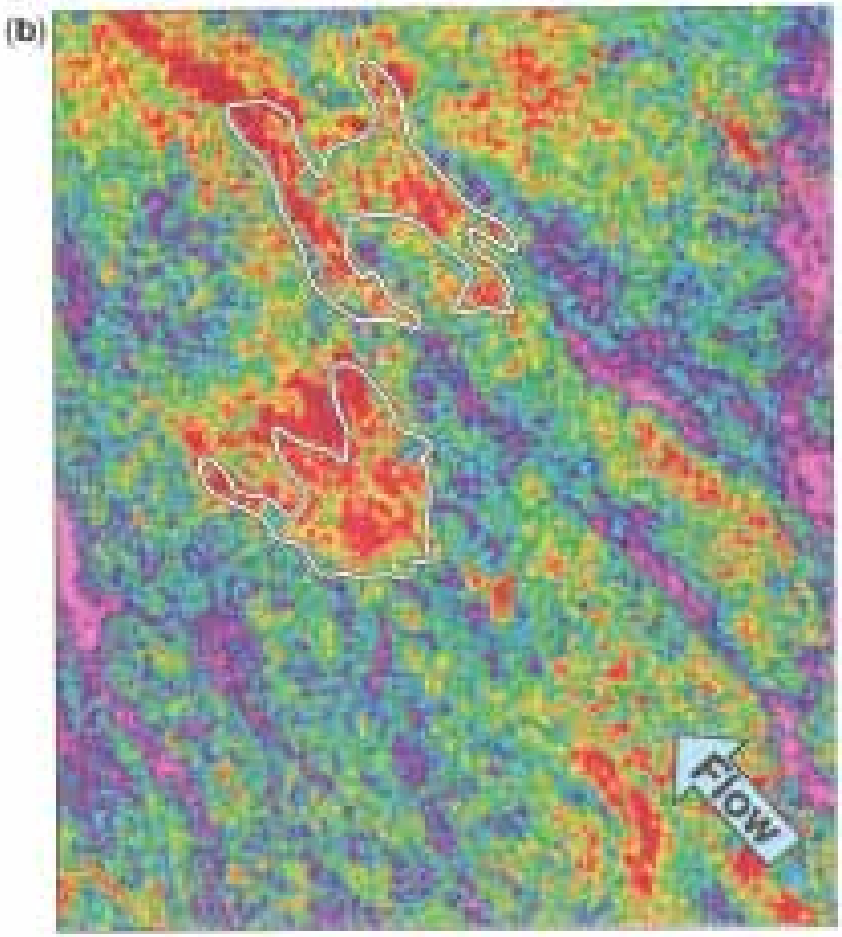
Field "Y" CNS

Hydrodynamics At Montrose Field

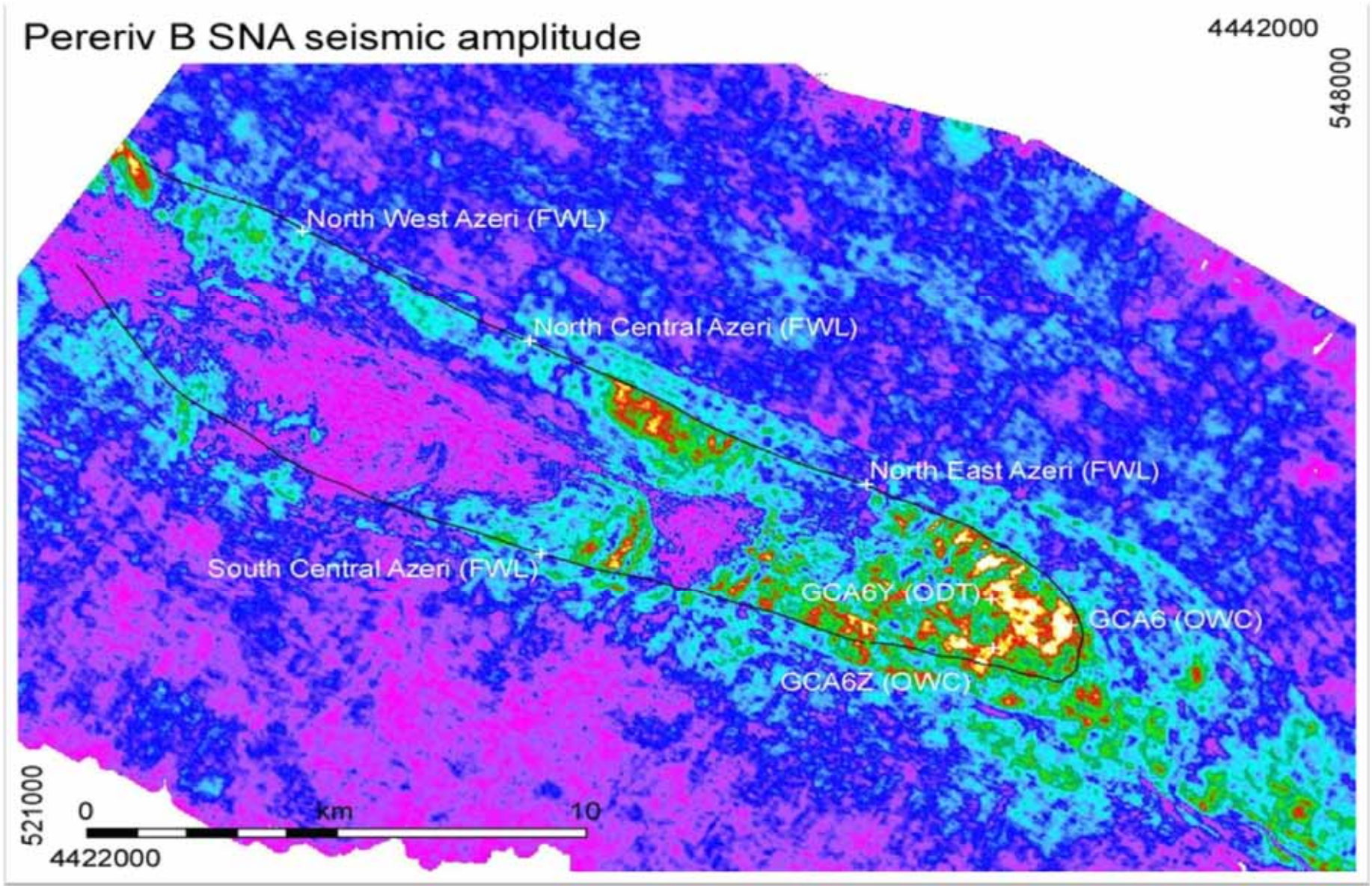
Structure

Calibrated fluid attribute





After Hugh Denis


Pereriv B SNA seismic amplitude
4442000
548000
North West Azeri (FWL)
North Central Azeri (FWL)
North East Azeri (FWL)
South Central Azeri (FWL)
GCA6Y (ODT)
GCA6 (OWC)
GCA6Z (OWC)
521000
0
km
10
4422000

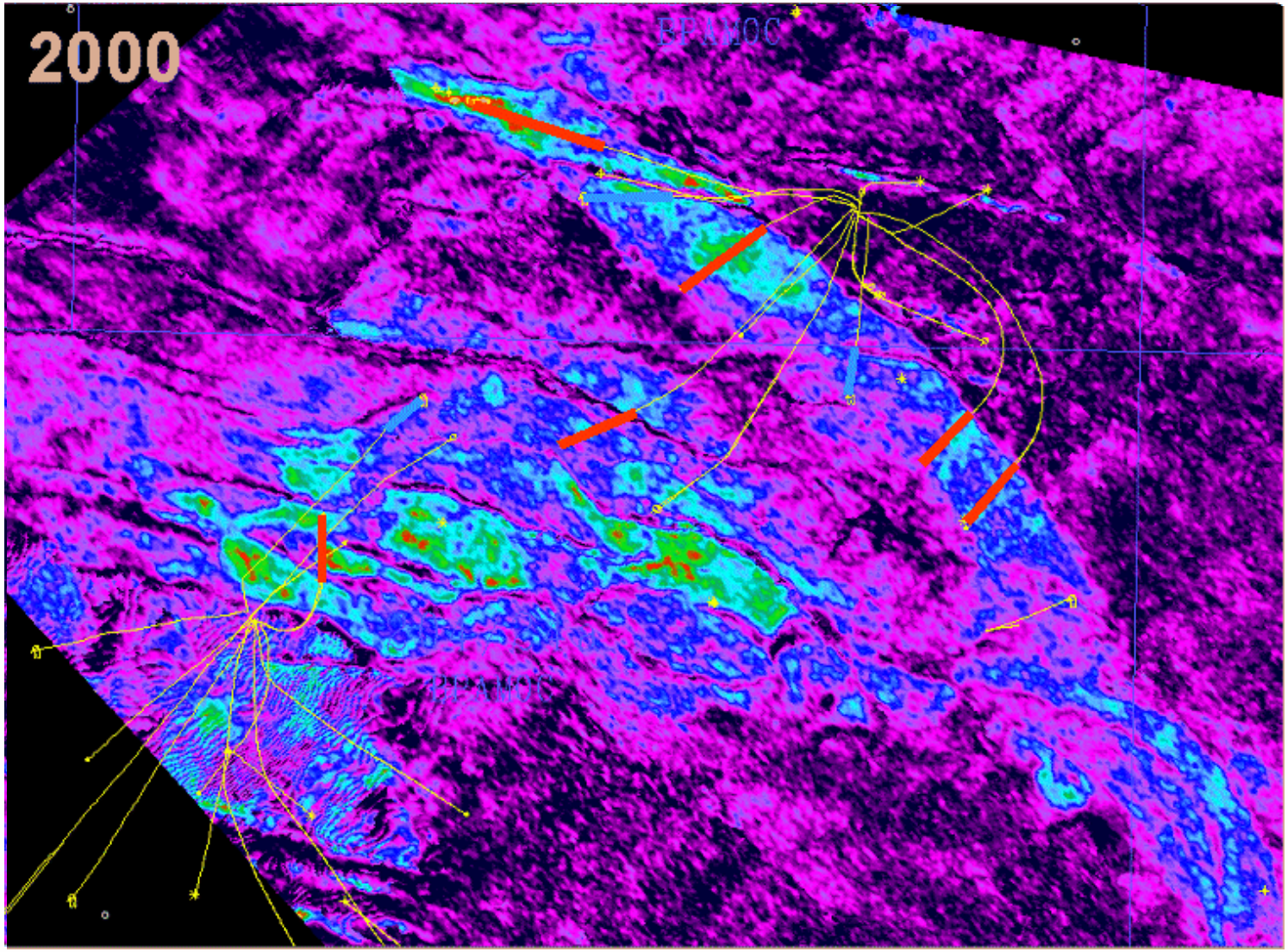
Dynamic Geoscience Example 3

Time-Lapse => Reservoir Monitoring

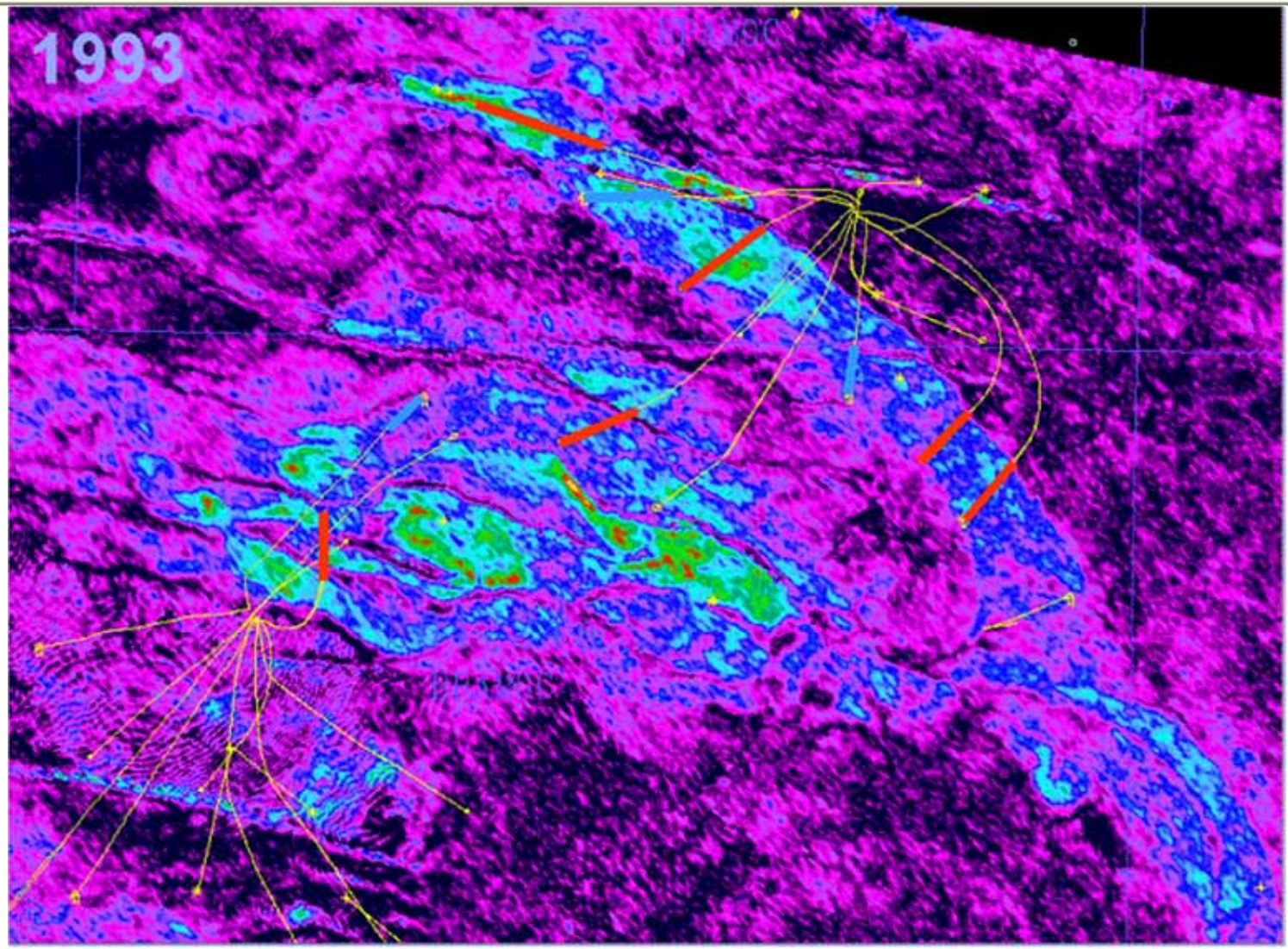
A look at the rocks & the fluids interacting with pressure and time

& well, we can't do a dynamic science presentation without mentioning Time-Lapse !

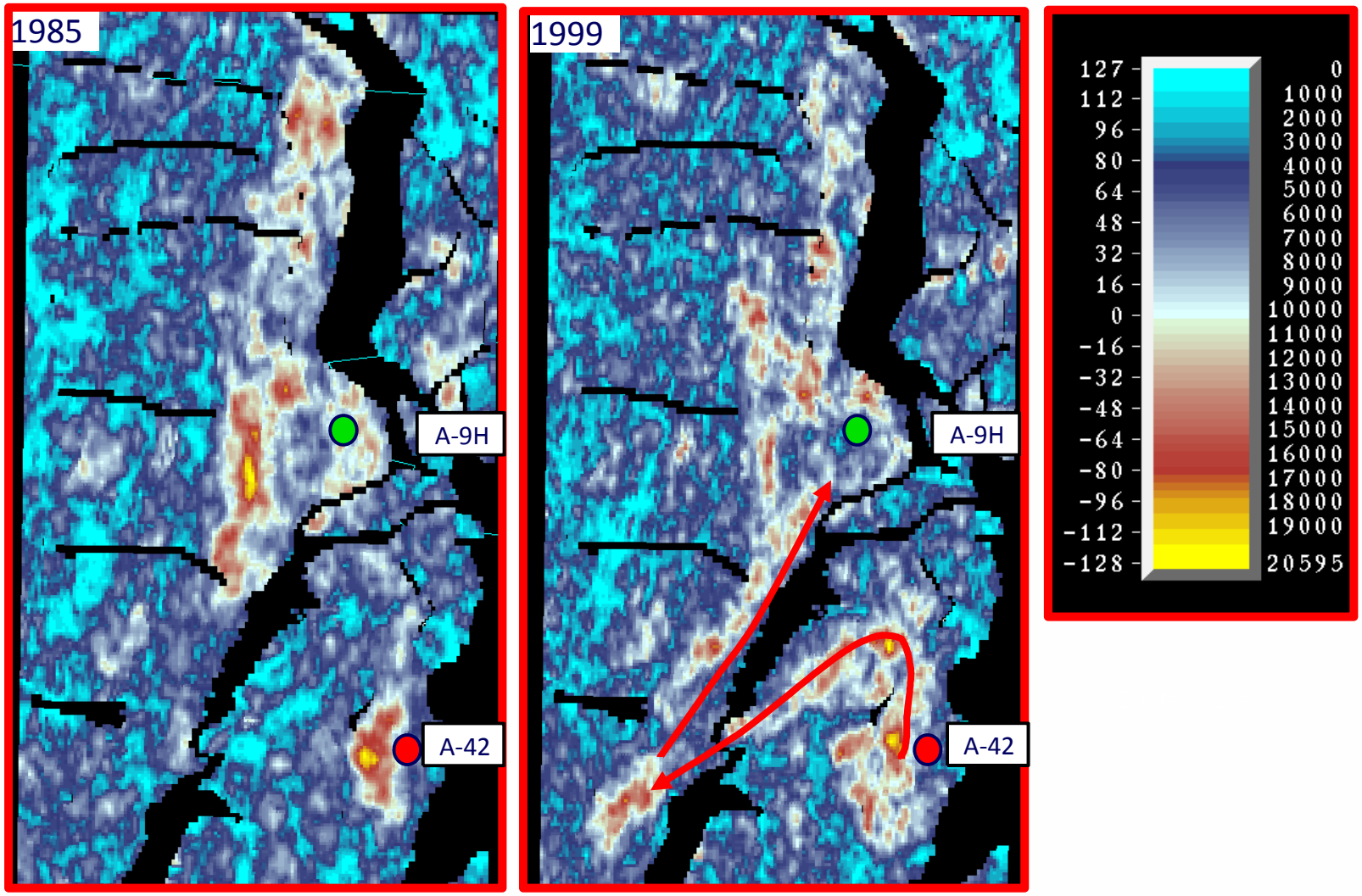
Foinaven, UK North Sea



Foinaven, UK North Sea

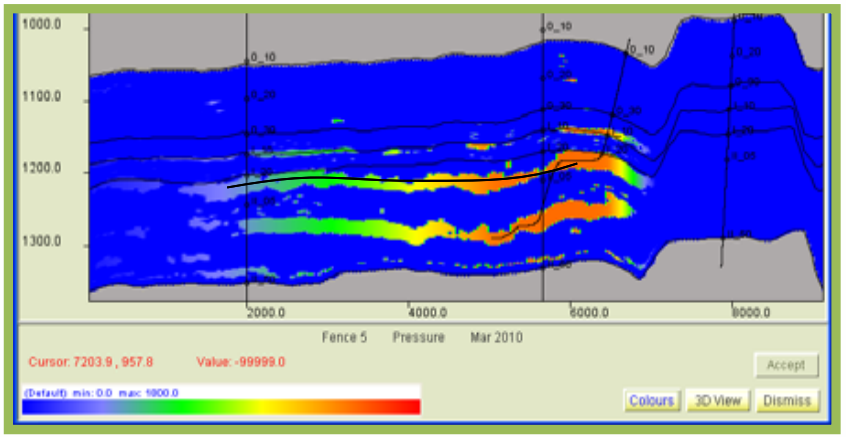


Time-lapse example – Gullfaks Gas Injector

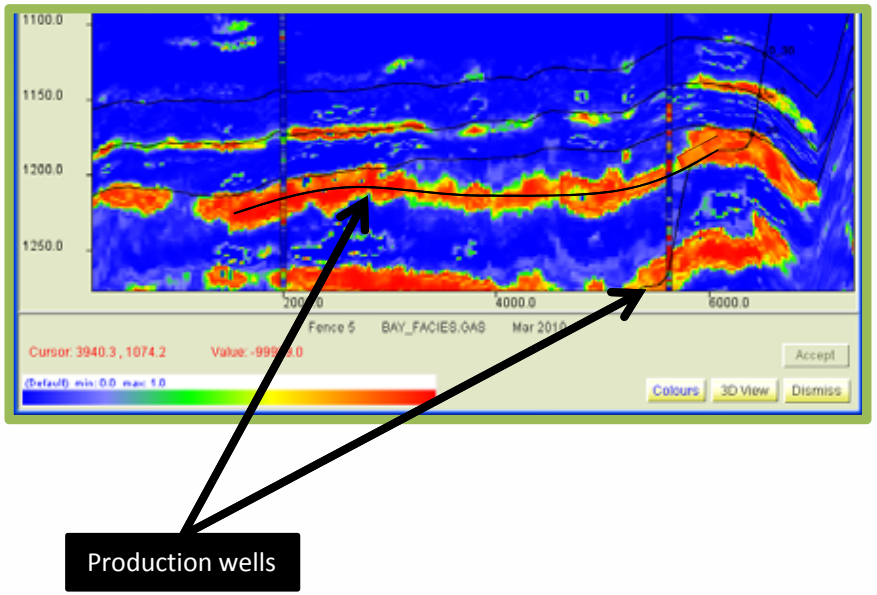


Time-Lapse Pressure change

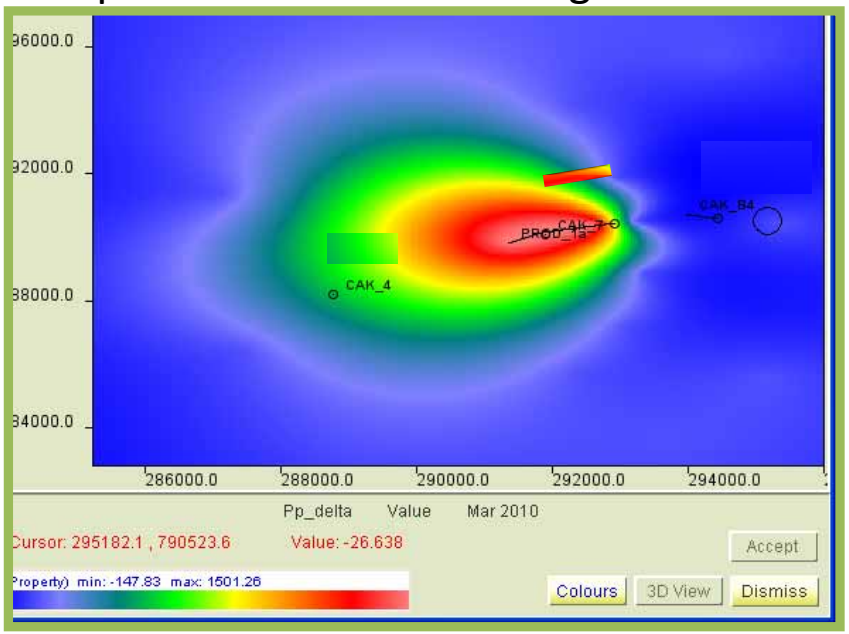
X-Section Pressure Perturbation



High Phie Gas Sand



Map View of Pressure Change

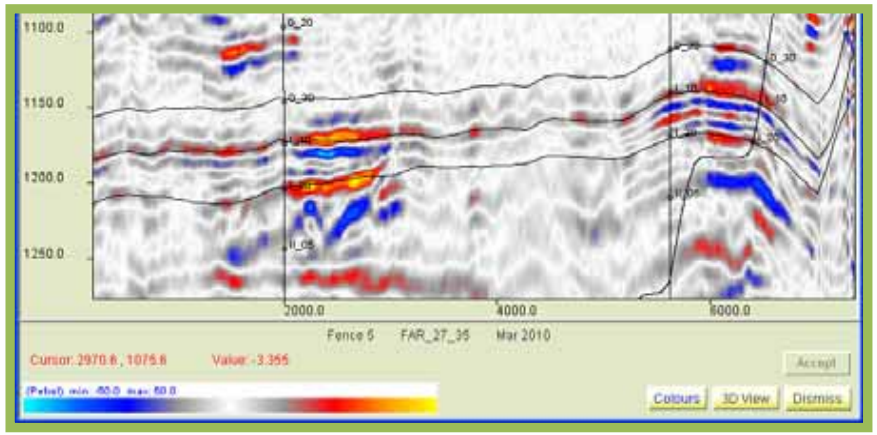


Pseudo production wells were created to represent the location of local pressure effects due to production.

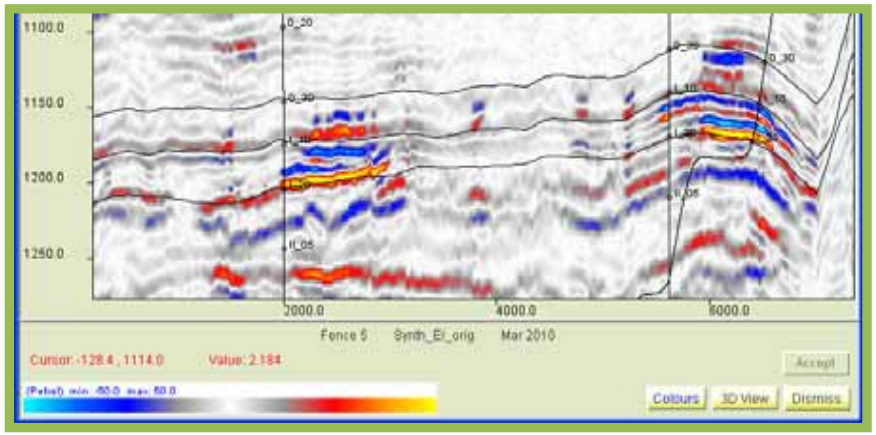
Pore Pressure changes are modelled input.

Time-Lapse Pressure change

Original Far Stack Seismic



Pre-production Far Stack Synthetic

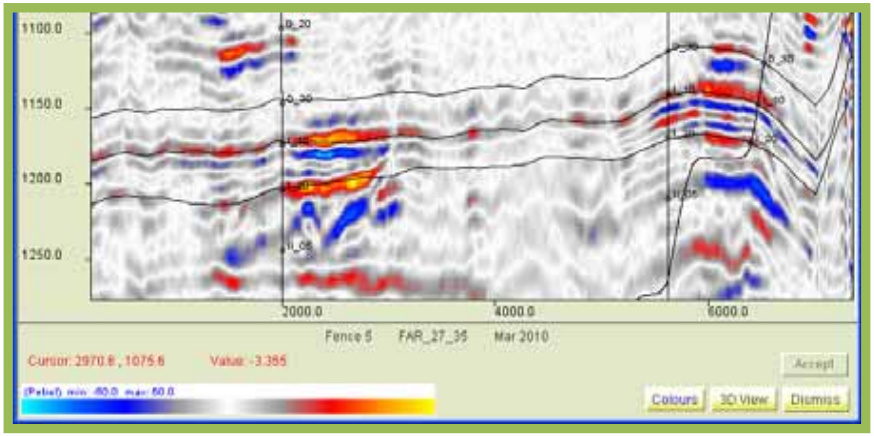


The Far stack has been inverted to produce EI from the far stack seismic.
Re-convolving the EI with the Far stack wavelet is shown here.

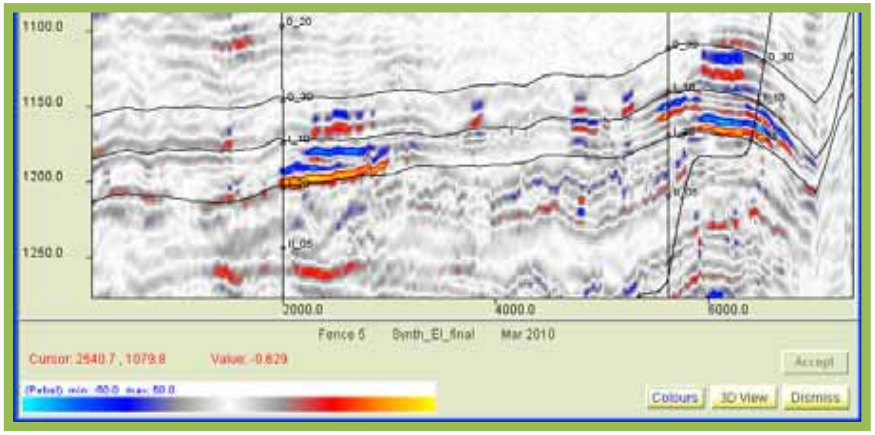
Semi-Synthetic is similar to the original seismic, thus supports a good inversion.

Time-Lapse Pressure change

Original Far Stack Seismic



Post Production Far Stack Synthetic

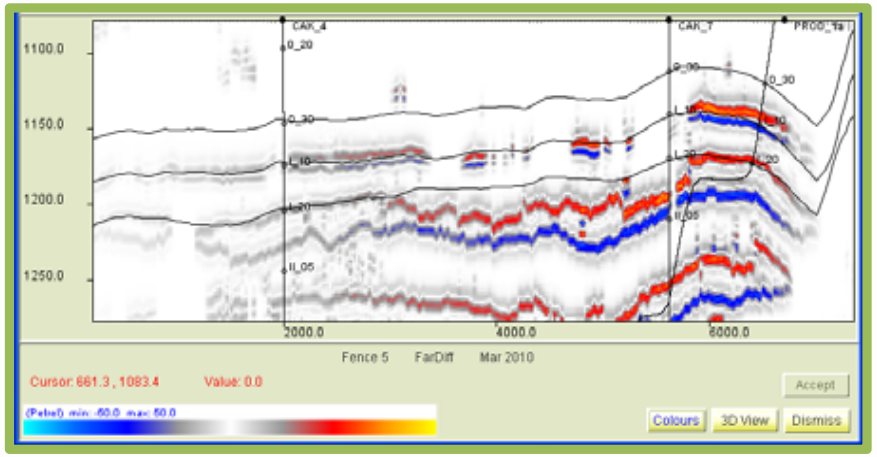


The Far stack has been de-convolved using a inversion operator to produce EI from the far stack seismic.

This has then had the pressure perturbed within the model, with a knock on effect of changing the EI.

The modified (perturbed EI) is then re-convolved with the far stack wavelet.

Far Stack Synthetic % Difference



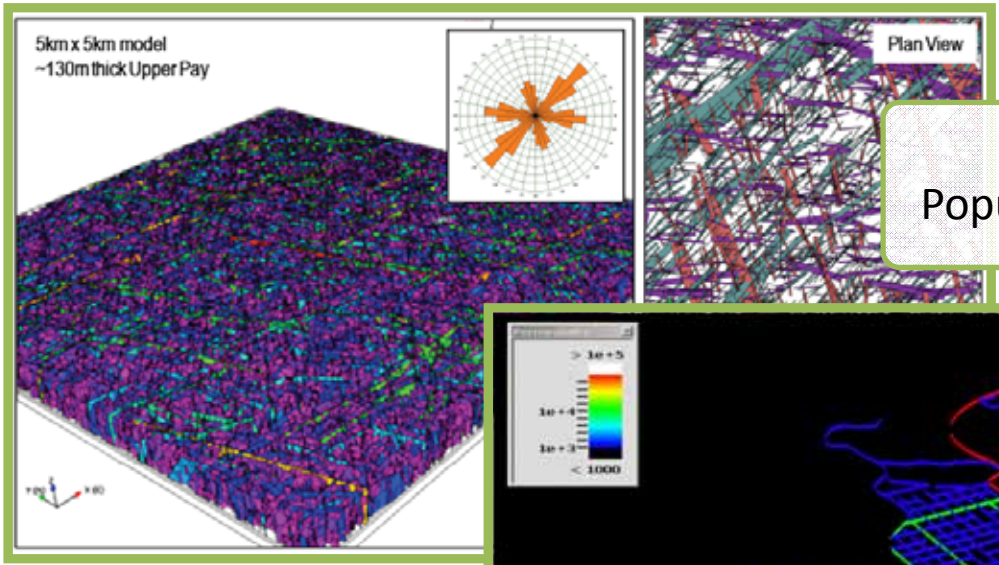
Dynamic Geoscience - Example 4

Geomechanics

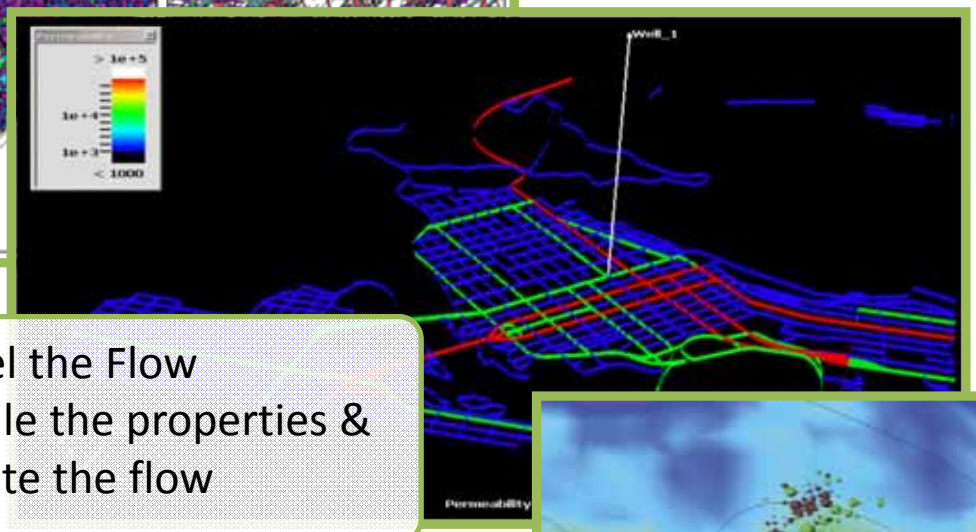
Stress impacts on rocks, pressure, fluids and time

Real data plus models – an interesting future for unconventional plays and storage

Workflow for the Pressure & Stress Dependent Fracture network



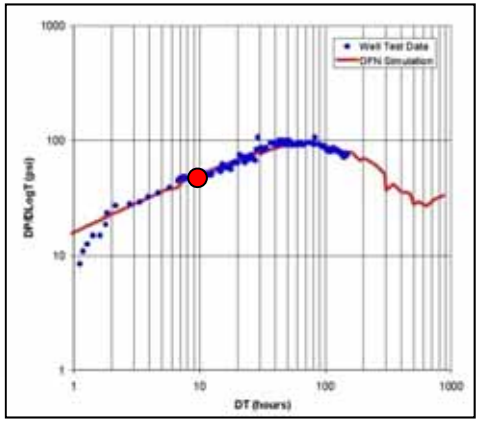
1. Model the Geology
Populate a DFN using all available data

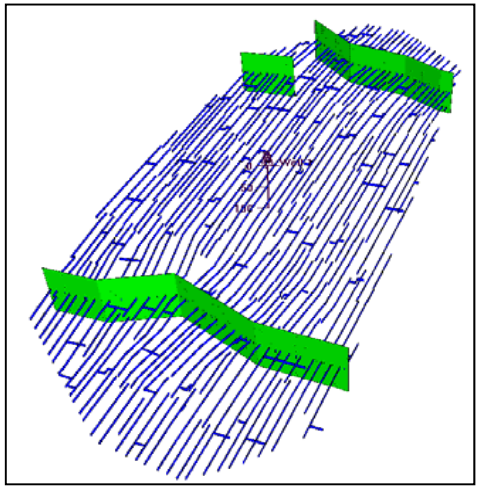


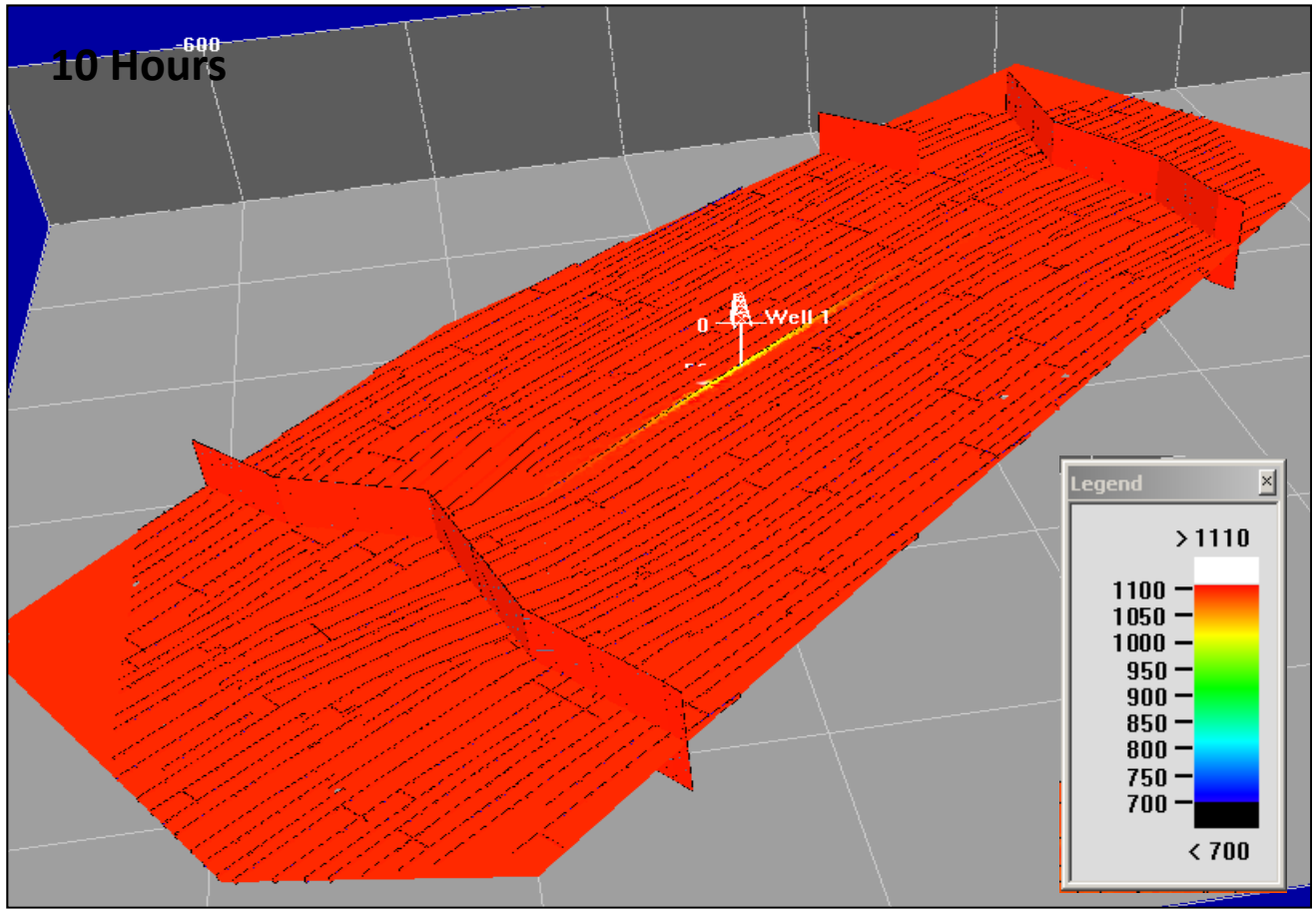
2. Model the Flow
Dynamically upscale the properties & simulate the flow

3. Calibrate
Through Seismic History Matching & Frac Matching

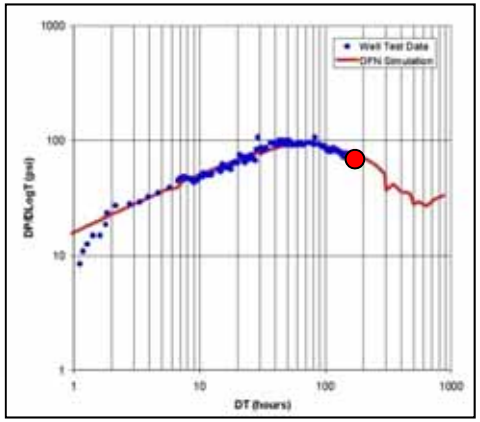
Tight Carbonate Reservoir, Awali Field, Bahrain – Model the Flow

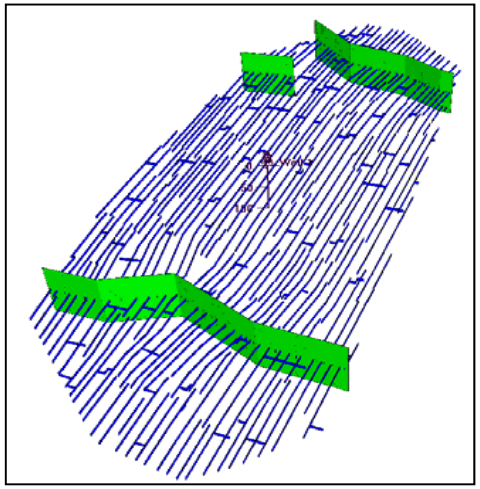


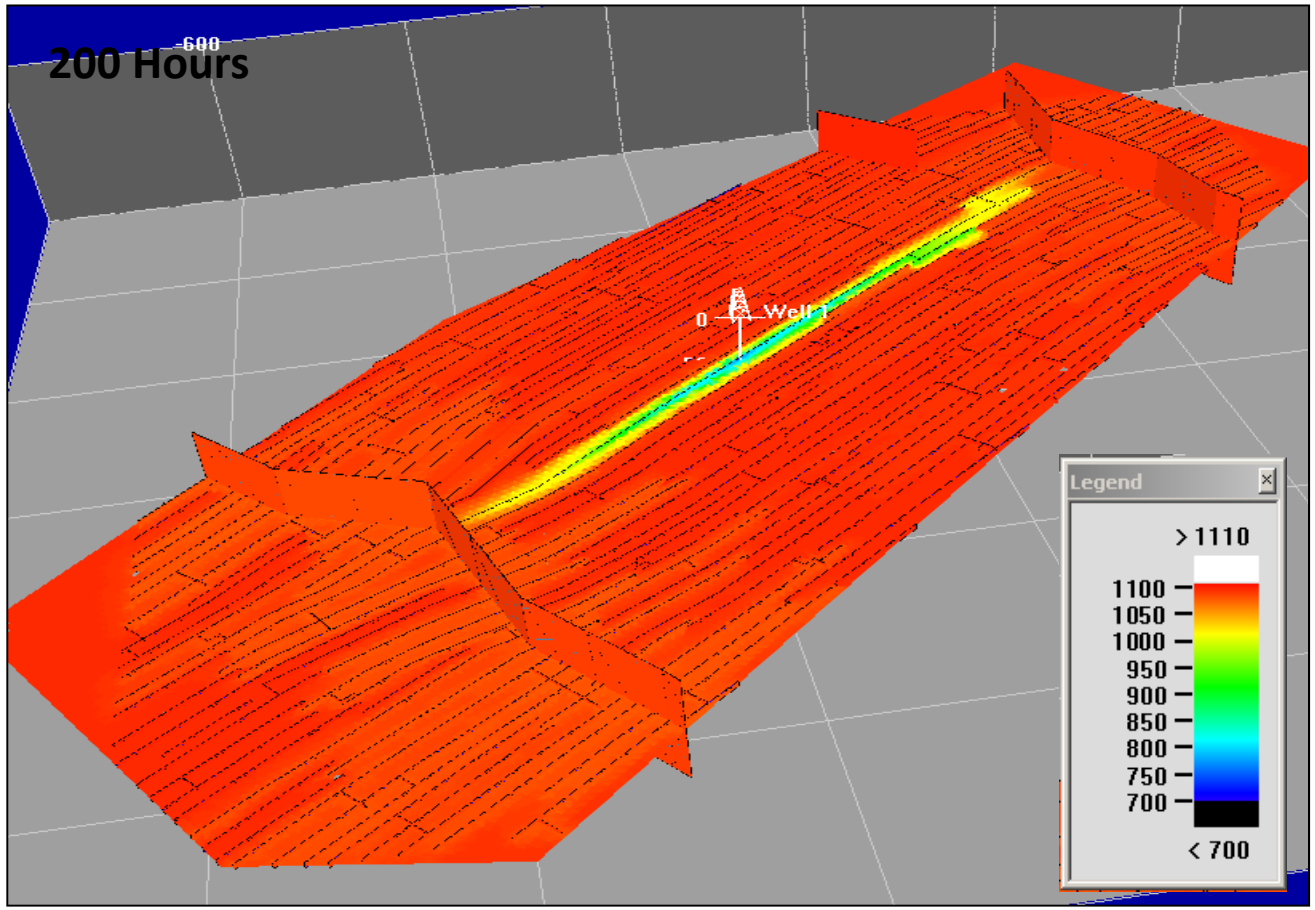




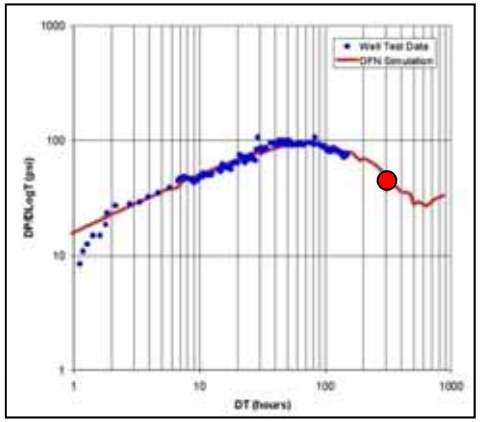
Tight Carbonate Reservoir, Awali Field, Bahrain – Model the Flow

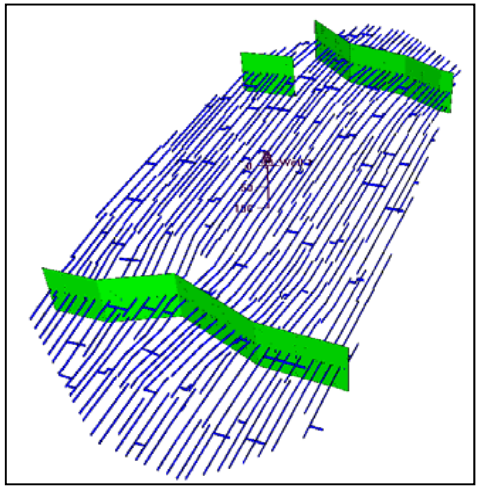


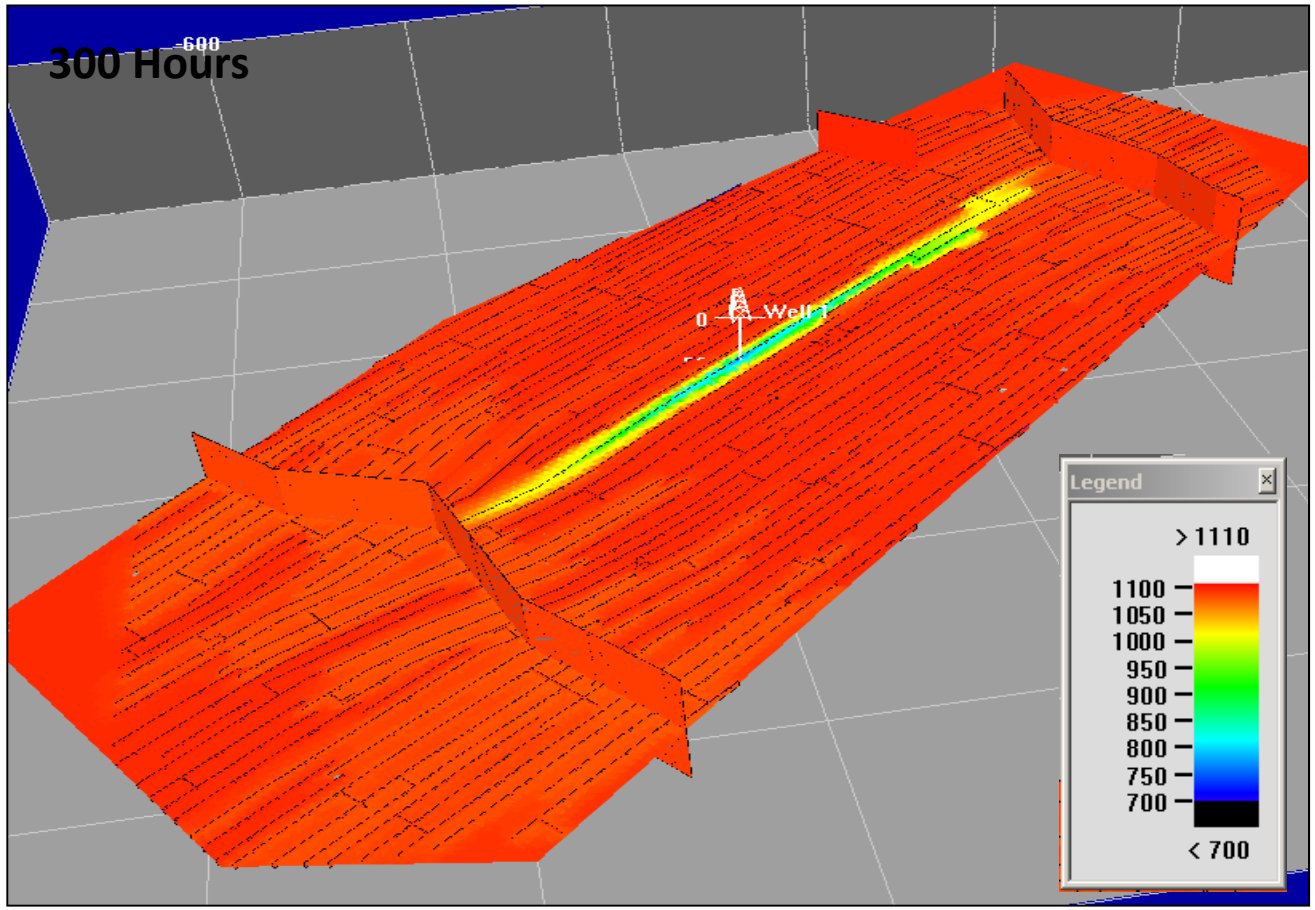




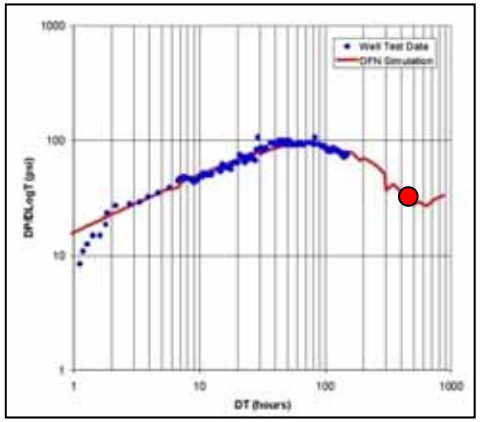
Tight Carbonate Reservoir, Awali Field, Bahrain – Model the Flow

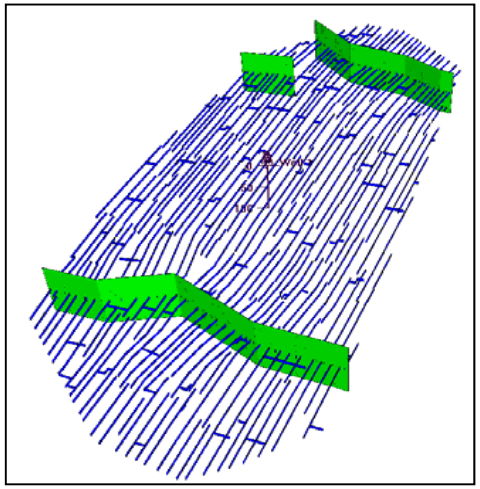


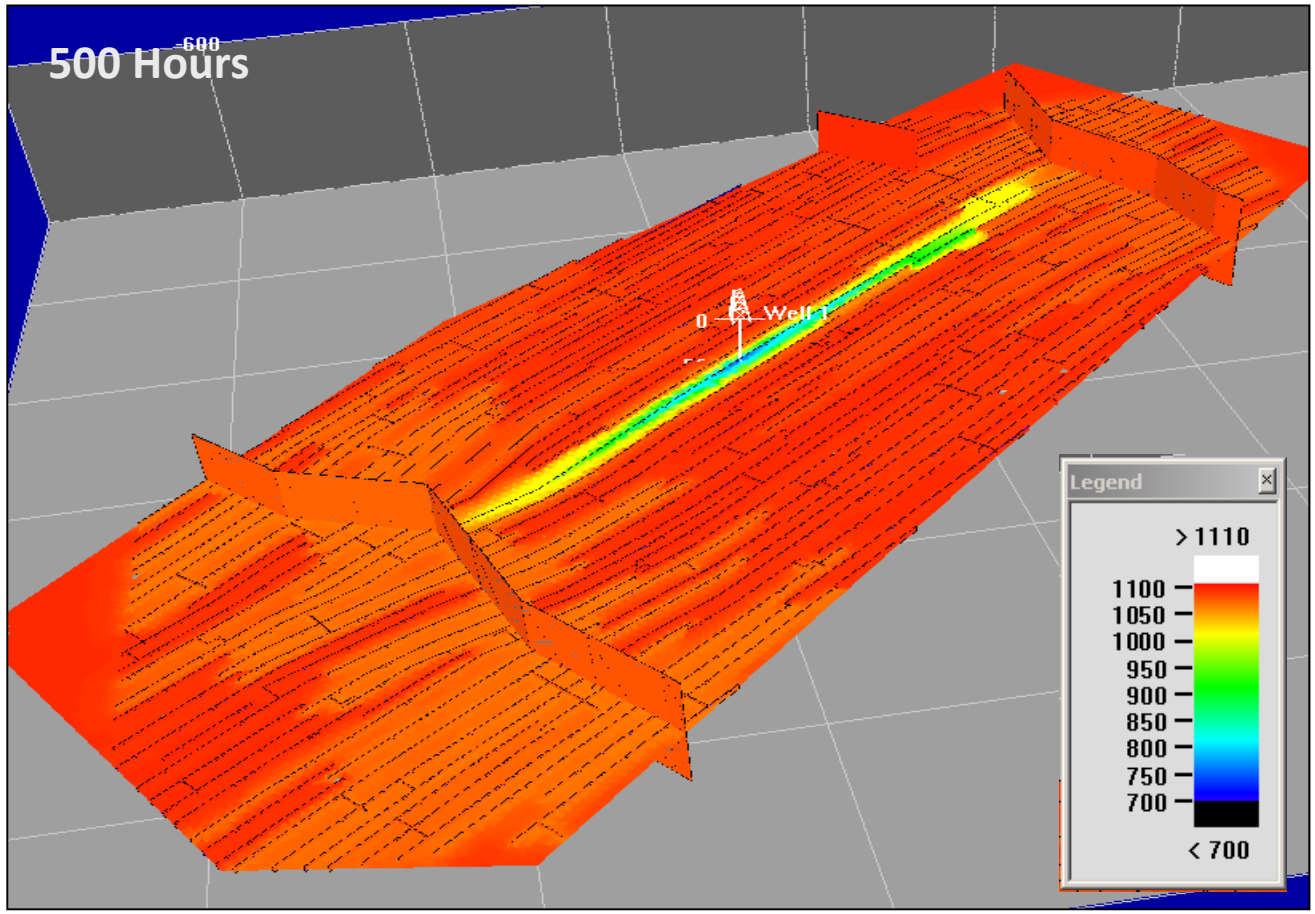




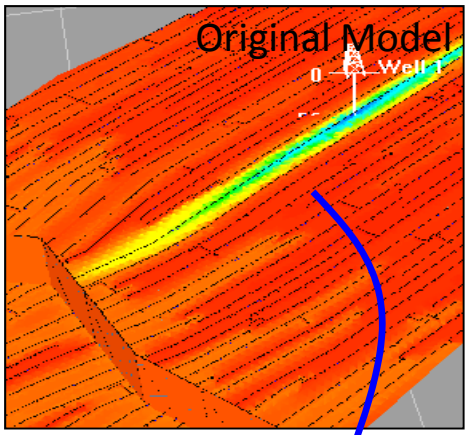
Tight Carbonate Reservoir, Awali Field, Bahrain – Model the Flow

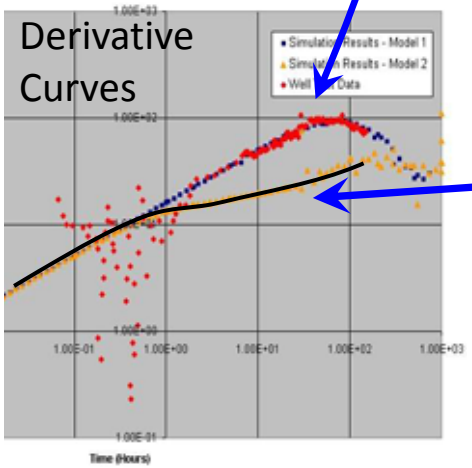


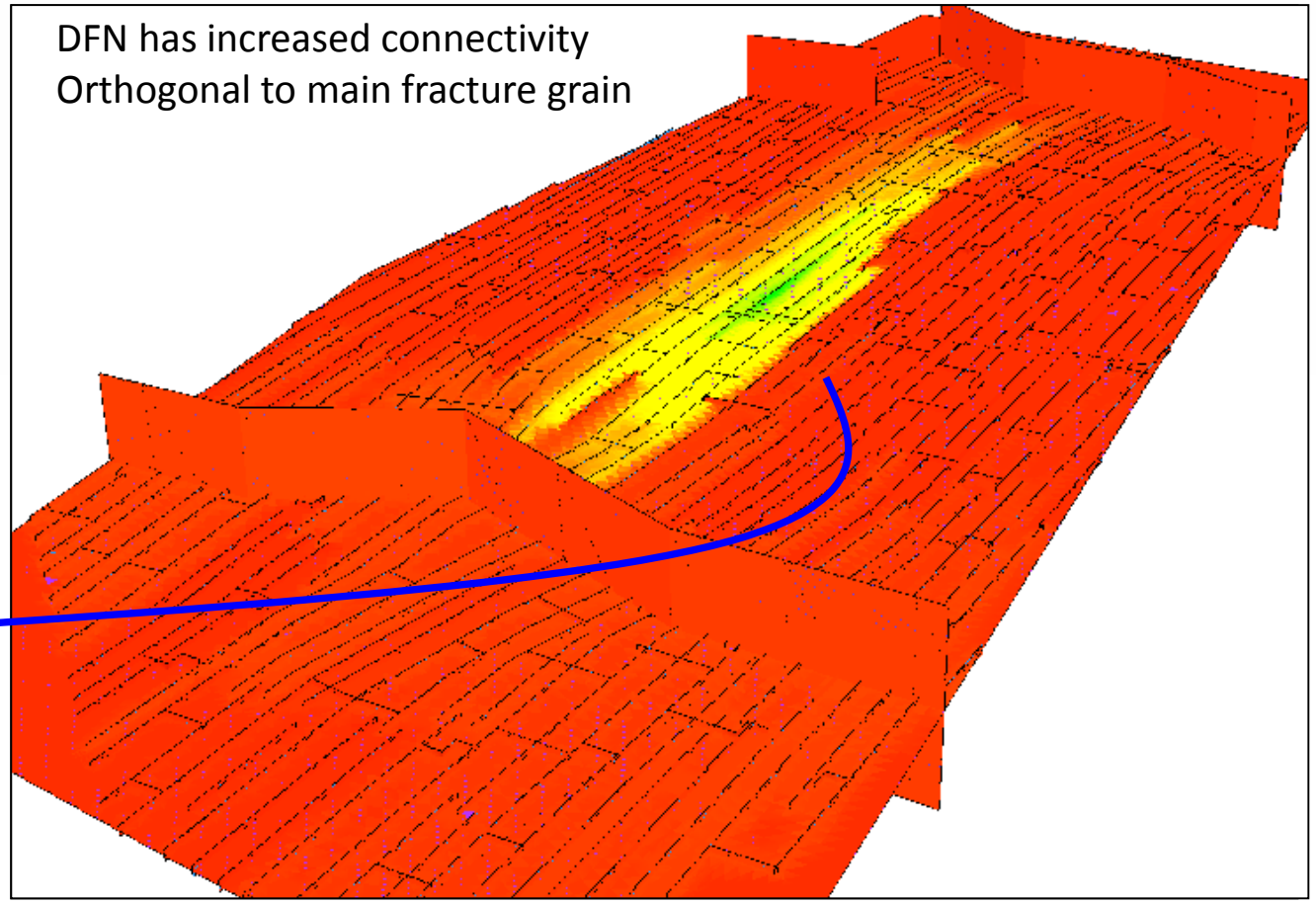




Tight Carbonate Reservoir, Awali Field, Bahrain – Getting it wrong







Summary of Positive trends

1. Quantitative Interpretation is increasingly useful for revealing Geology and Engineering

2. Some signs that our culture for thinking more holistically is improving.

3. There is a wealth of available technology & even more in R+D that can be integrated

4. Results can produce a virtuous cycle

Summary of Positive trends

1. **There is increased understanding of geology for certain plays:-**
   - Rock responses/ geochemistry/ fluid responses
   - Geopressure
   - Geomechanics/stress

   Aided by better data quality + increased data quantity + technology

2. **A Learning Culture**

'Learning' organisations allow better prediction and investigation of reservoir properties through both heuristic (trial & error) and theoretical methods.

3. **Available Technology, R&D**

More interactive and integrated science in the software platforms allows data & models to be integrated and tested.

4. **Results can produce a virtuous circle**

   Better prediction means = drilling success = more confidence investment and usage
   e.g. Transform margin plays (oil)
   East Africa (gas and oil)

We can expect a lot more to come in these areas

Reality Check

Ongoing scope for improvement:-

- Most onshore
- Most pre salt
- Most Unconventionals
- Most Carbonates ....

Barriers:-

- Technical – understanding rock properties and their expression
- Data – quality, type and quantity
- Cultural – education, organisation and behaviours

Any Questions?

Thank you

ikon Science