Using Diffraction Imaging for Prospect Evaluation in the Dutch Offshore

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WHEN YOU NEED TO BE SURE

Presentation content

- Setting the scene
- Diffraction Imaging – basic principles
- Case study
  - Fault interpretation
  - How can DI assist in well planning?
- Conclusions

Geological setting

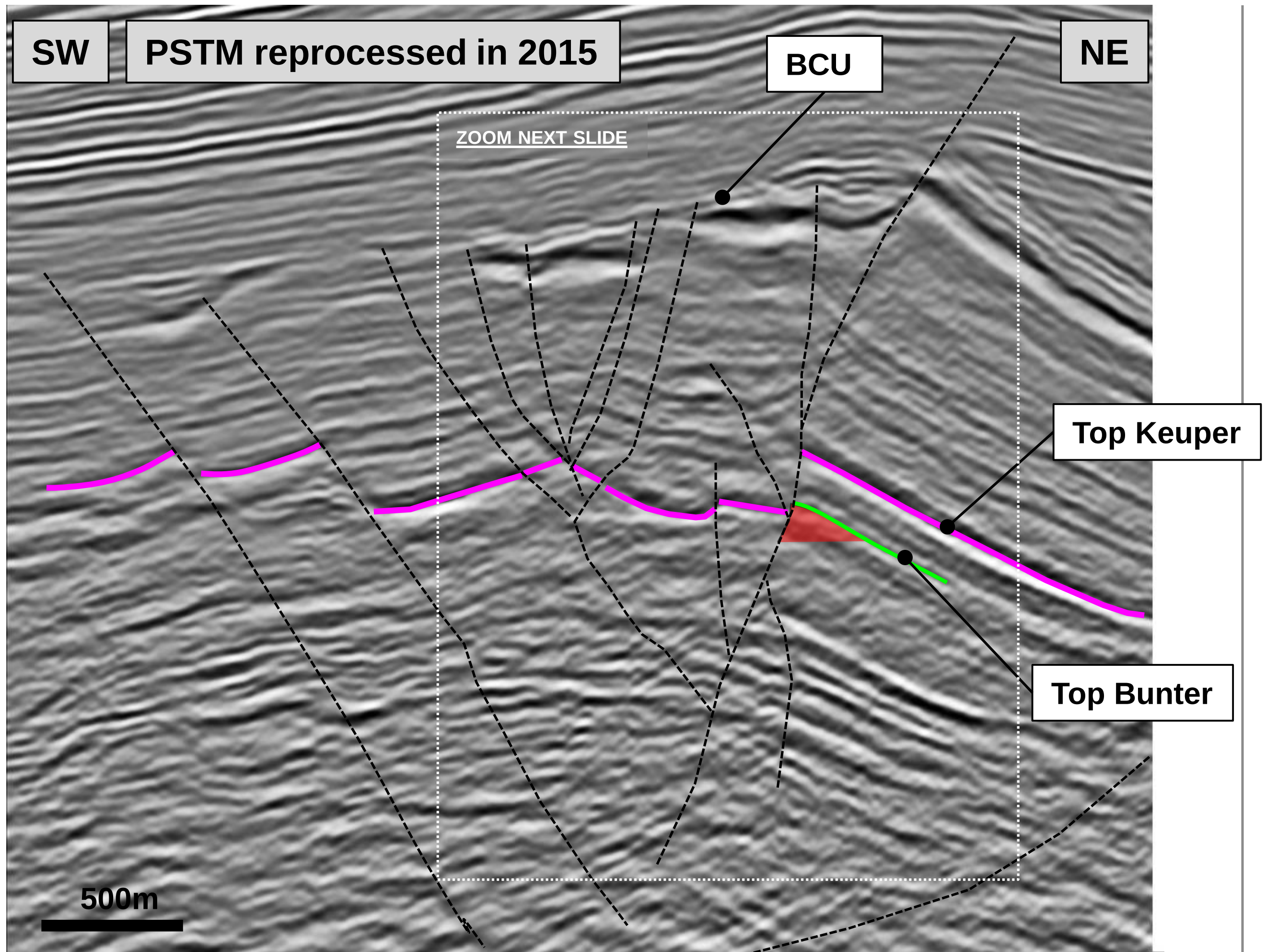
- Offshore Netherlands

General structural setting

- Rifting and subsequent inversion with strike-slip movements
- Flower structure
- Complex fault geometries

Field information

- Bunter reservoir / Gas
- 3-way dip closure
- NW-SE boundary fault



Black = AI increase

Fault interpretation (1/4)

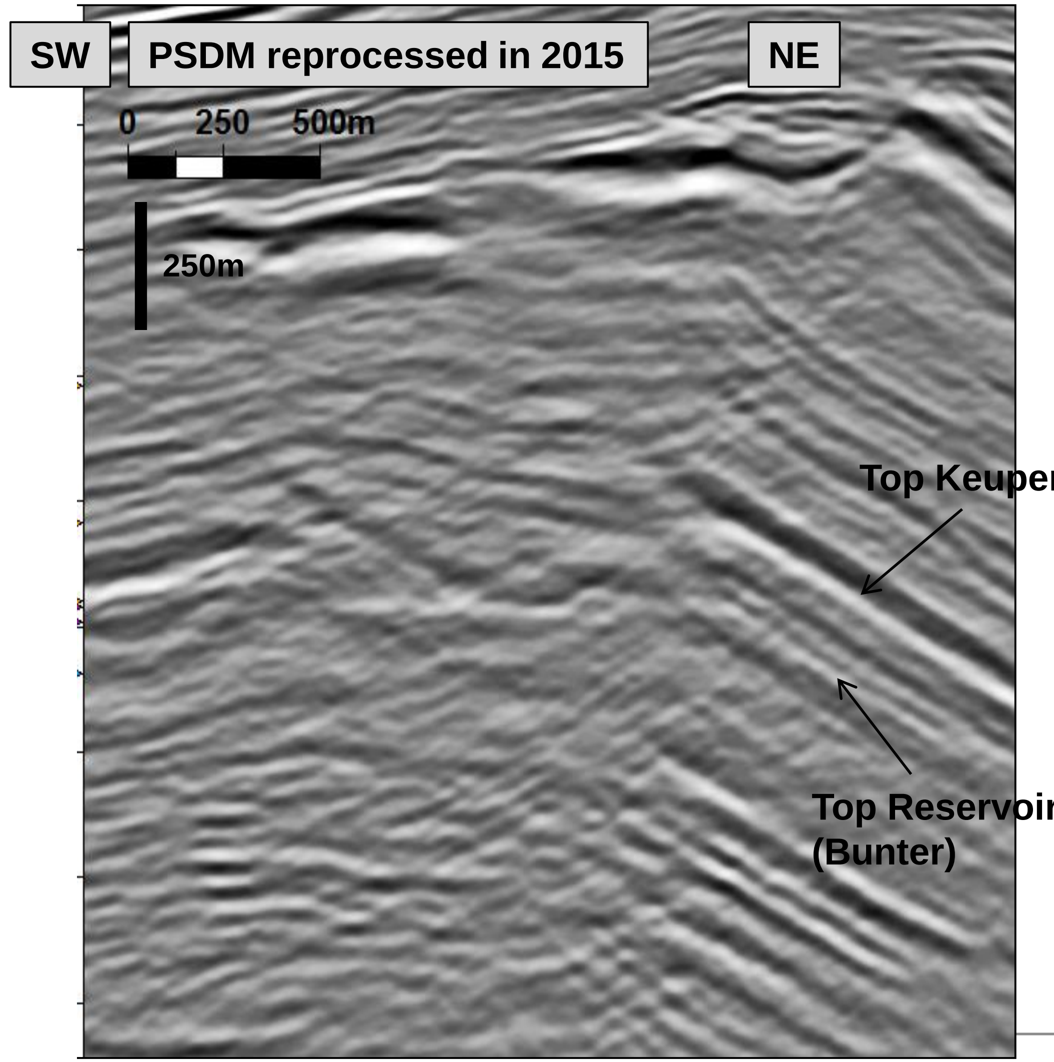
- Different sources of uncertainty:
  - Structural and imaging uncertainty

    What is the shape of the fault?

    The interpretation is affected by the structural complexity, seismic noise, smearing, attenuation with depth, etc.

  - Lateral resolution of the PSDM

    Fresnel zone (typically 50-75 m)



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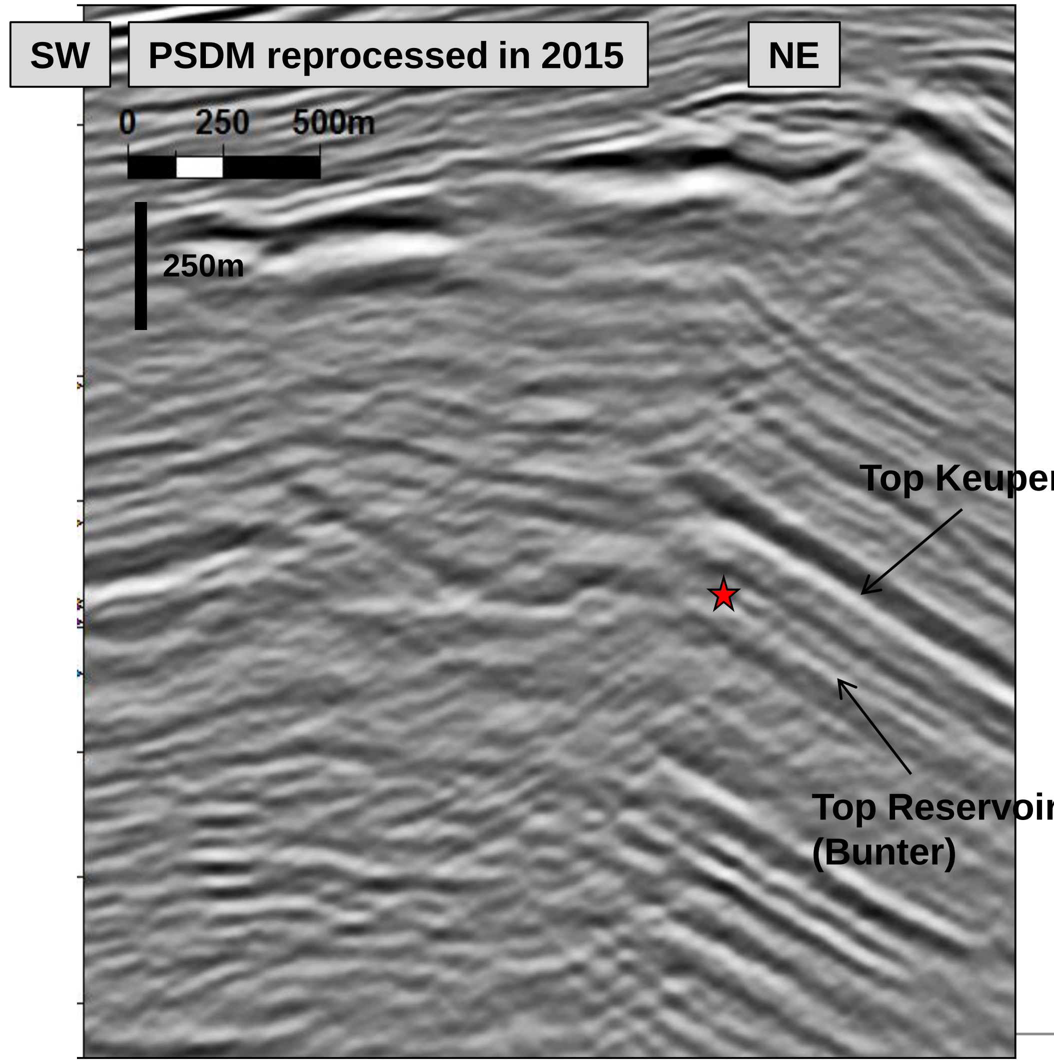

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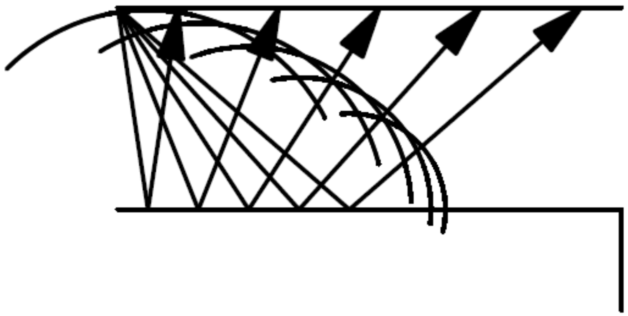
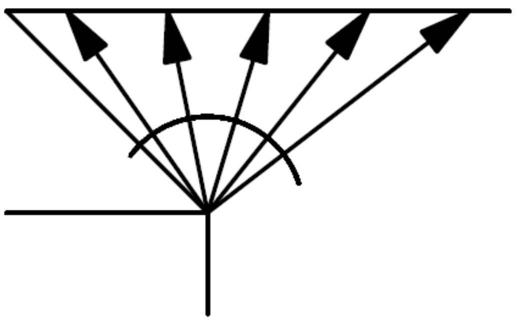
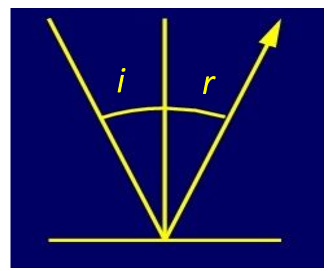
Diffraction Imaging – what is it? (1/2)

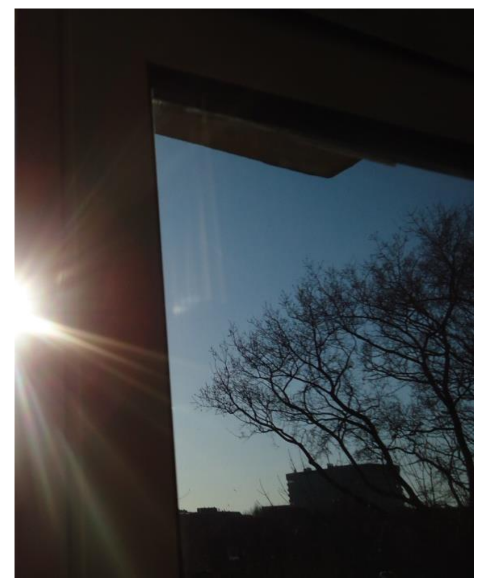




- **What is diffraction?**
  - Reflections satisfy Snell's law
  - Diffractions do not



Snell's law: $i = r$



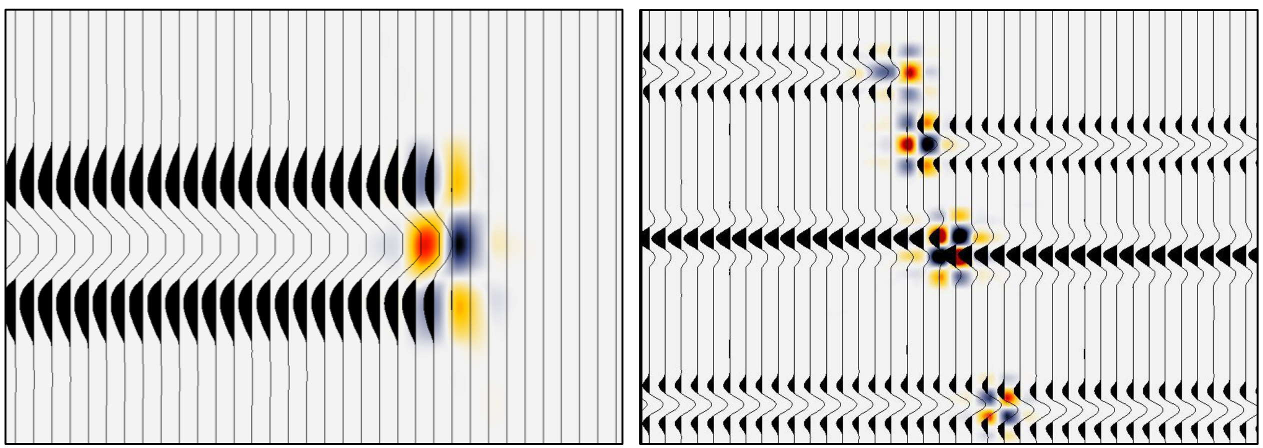
<u>Diffraction:</u>
The process by which a beam of waves is spread out as a result of passing through a narrow aperture or across an edge.

Diffraction Imaging – what is it? (2/2)

- Diffractions are created at discontinuities:
  - Edges (result in lines)
  - Tips (result in points)
- In the subsurface, such discontinuities can reveal:
  - Faults
  - Pinch-outs
  - Contacts, etc…
- Diffractions are imaged as multi-poles

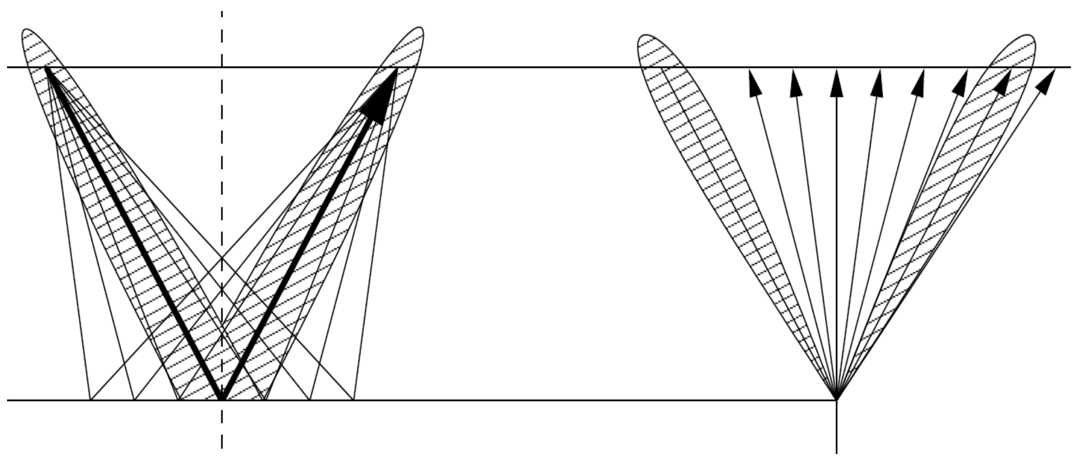
Wiggles:
Reflections

Colour:
Diffraction multi-poles



Diffraction Imaging – lateral resolution (1/2)

- Improved lateral positioning
  - The position of discontinuities is better defined with Diffraction Imaging:
    - Zero-width Fresnel zone (at diffraction depth)
    - No tuning limitations as with specular reflections (next slide)
- Superior illumination



<u>Specular reflection + Fresnel zone</u>

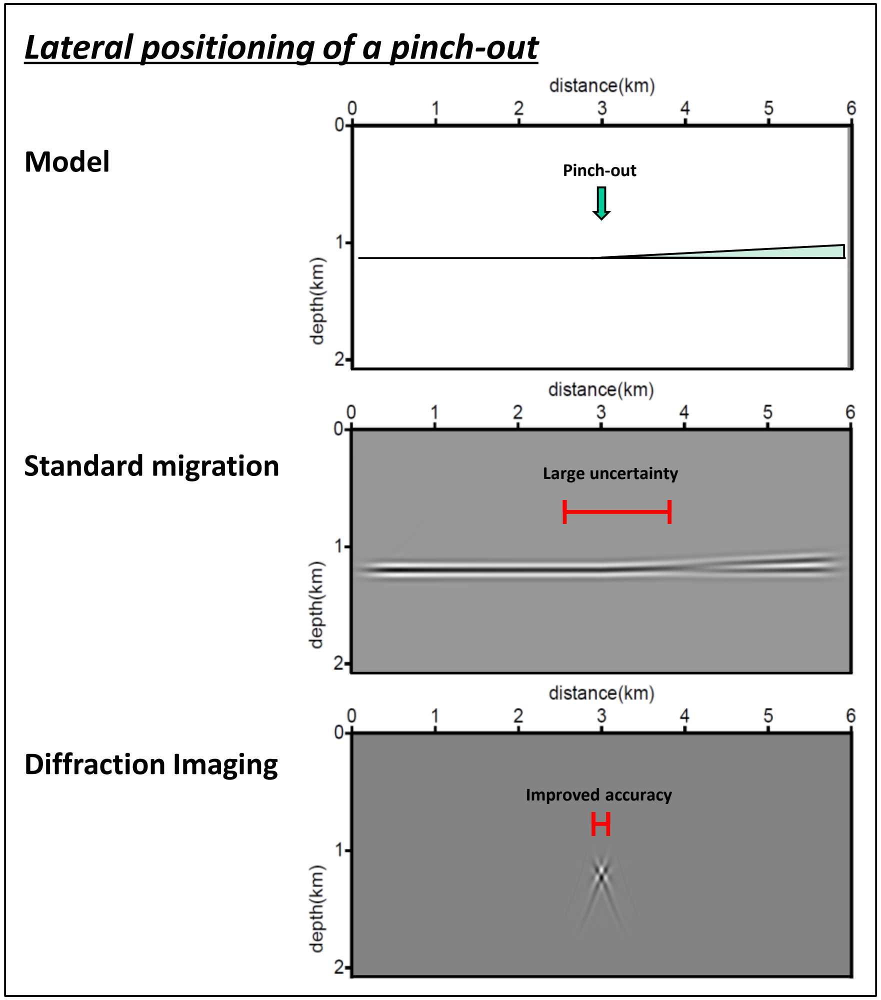
- Smearing of detail
- Depends on mirror orientation

<u>Diffraction + Fresnel zone</u>

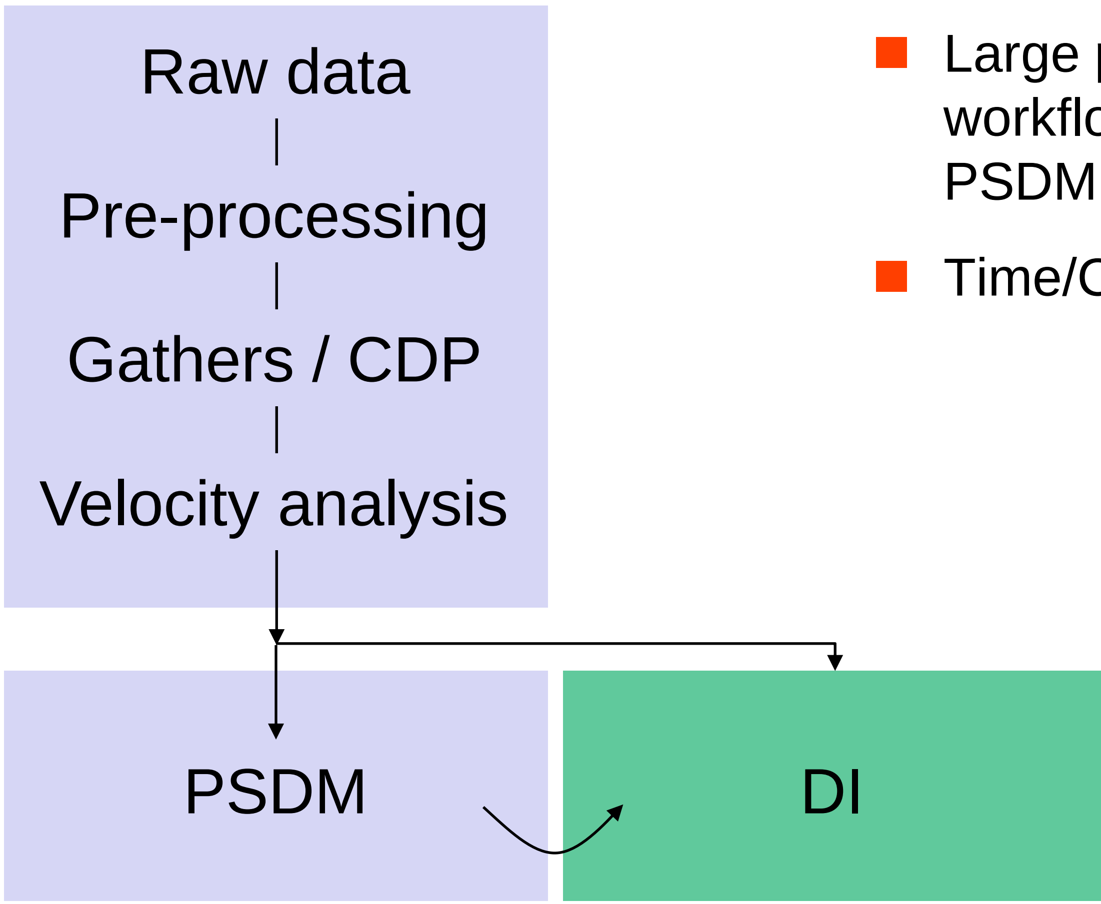
- No smearing (zero-width Fresnel zone)
- No mirror (superior illumination)

Diffraction Imaging – lateral resolution (2/2)

- Reflection tuning might limit the imaging of discontinuities
- In such cases, Diffraction Imaging can help identify with more precision:
  - Pinch-outs
  - Fluid contact features



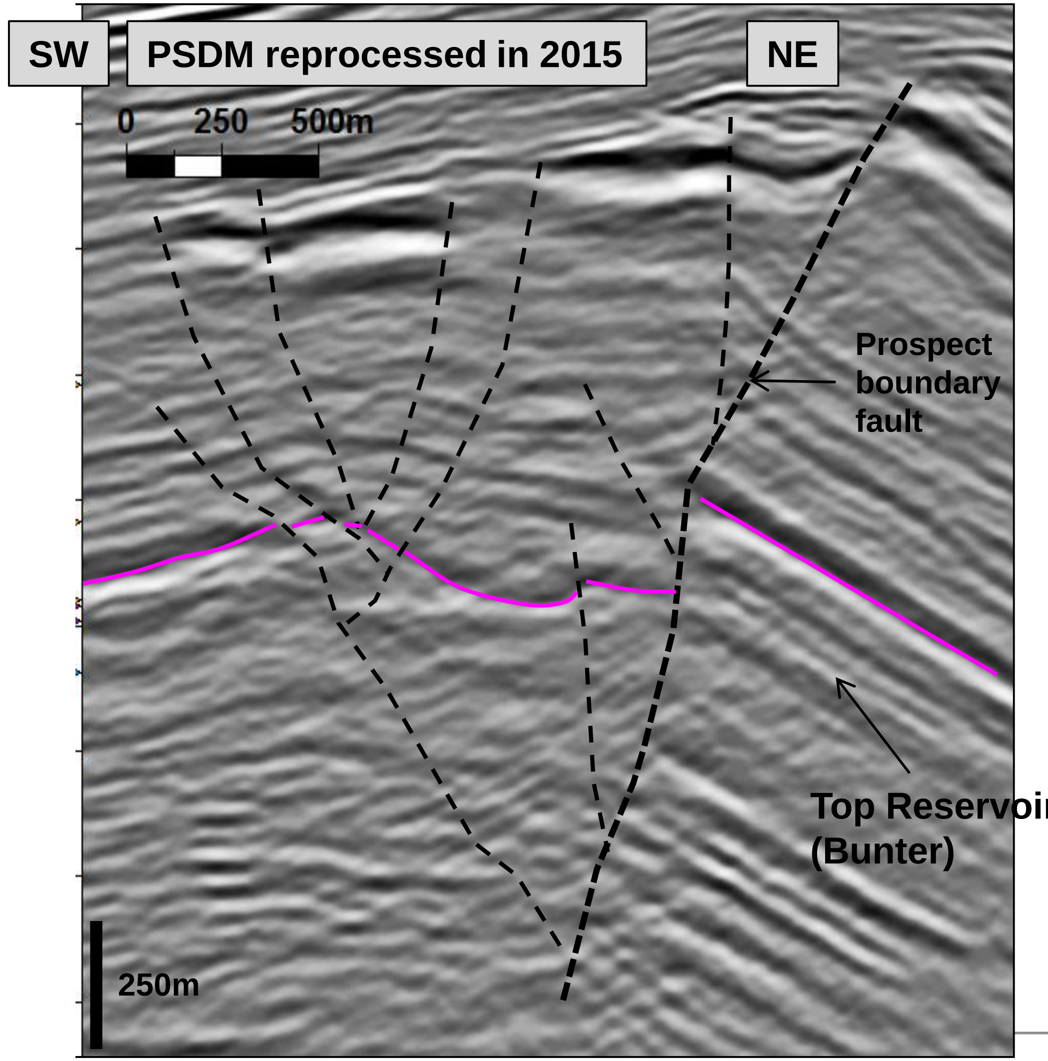
Processing workflow



- Large part of DI processing workflow is shared with PSDM processing
- Time/Cost effective

Fault interpretation (1/4)

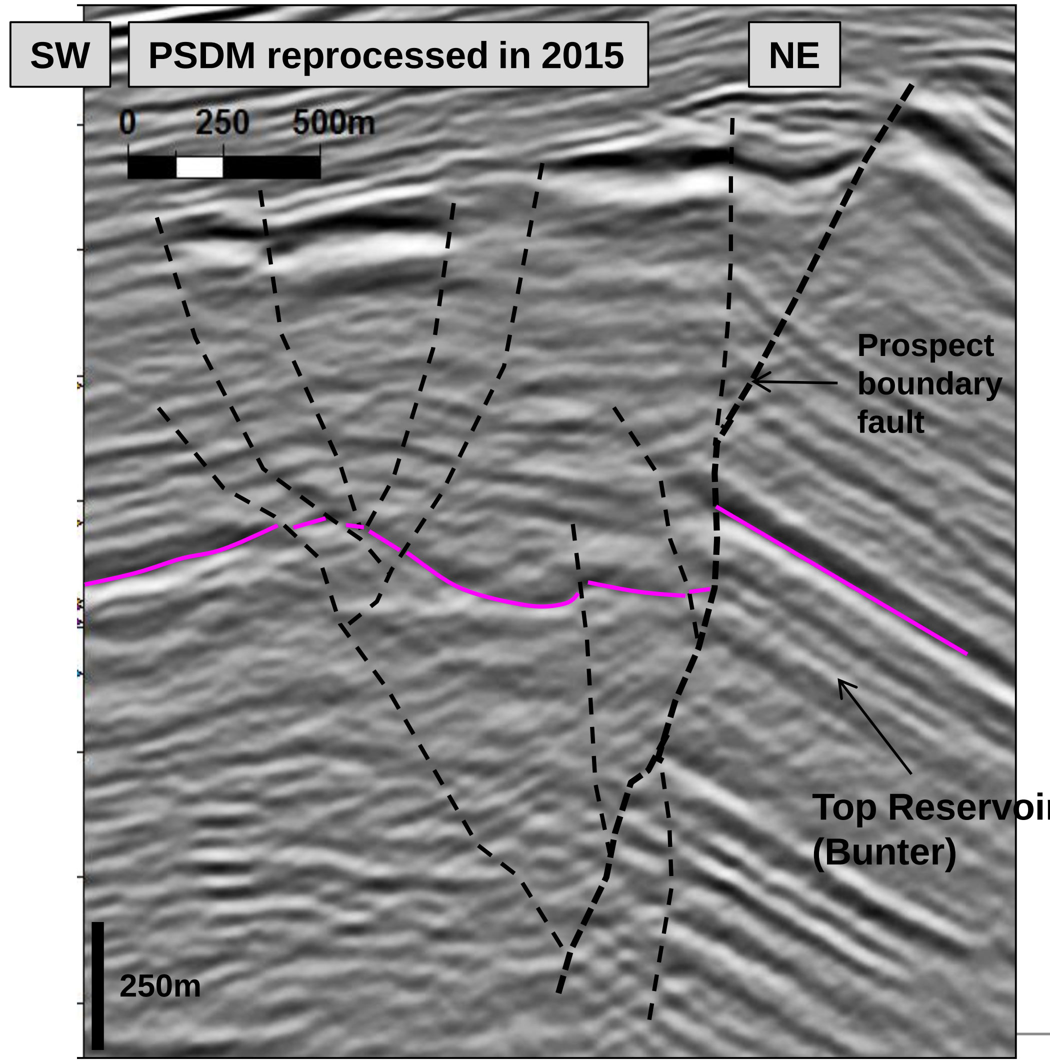
- Before drilling, there was a large uncertainty regarding the position of the prospect boundary fault
- Alternative interpretations:
  - ***Mid case***
  - *Conservative case*
  - *Upside case*



Black = AI increase

Fault interpretation (2/4)

- Before drilling, there was a large uncertainty regarding the position of the prospect boundary fault
- Alternative interpretations:
  - *Mid case*
  - ***Conservative case***
  - *Upside case*



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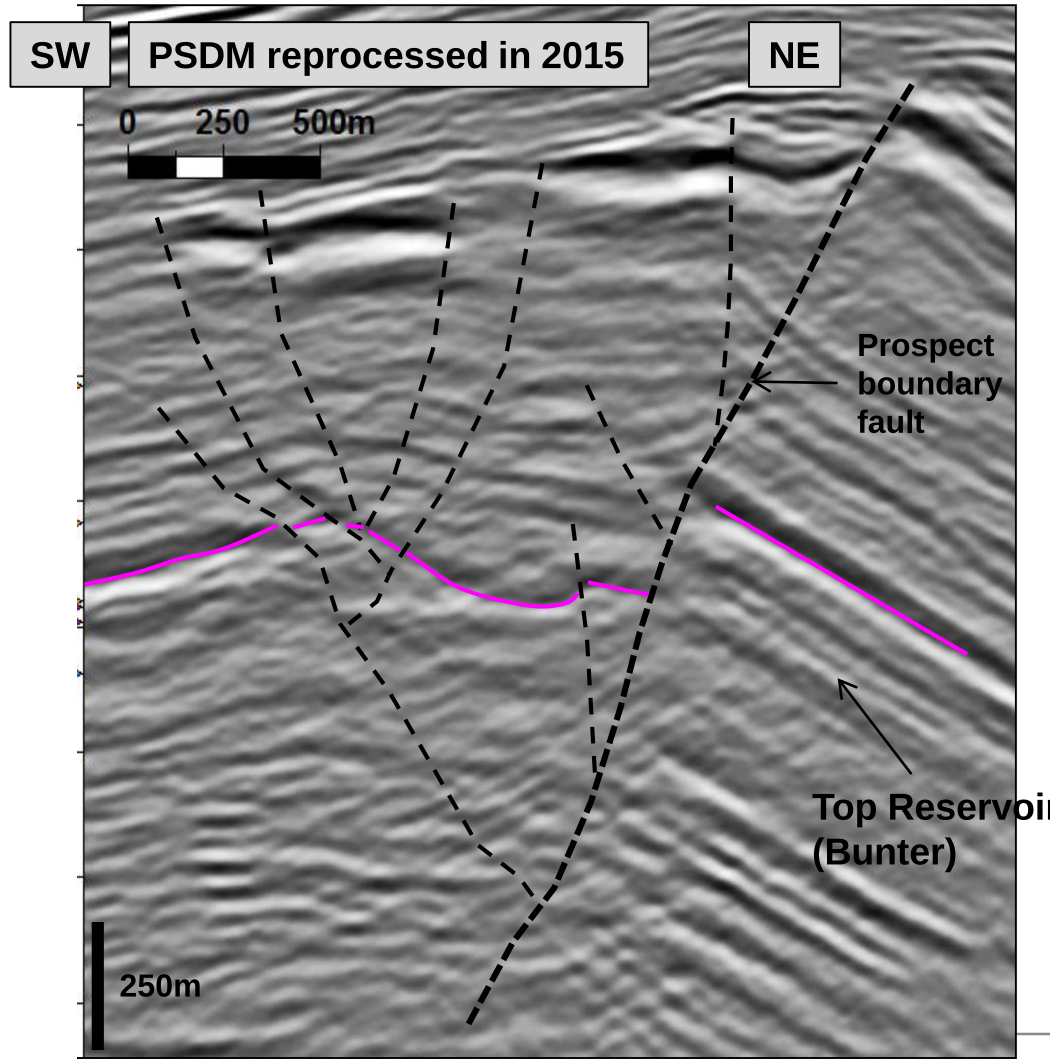
Fault interpretation (3/4)

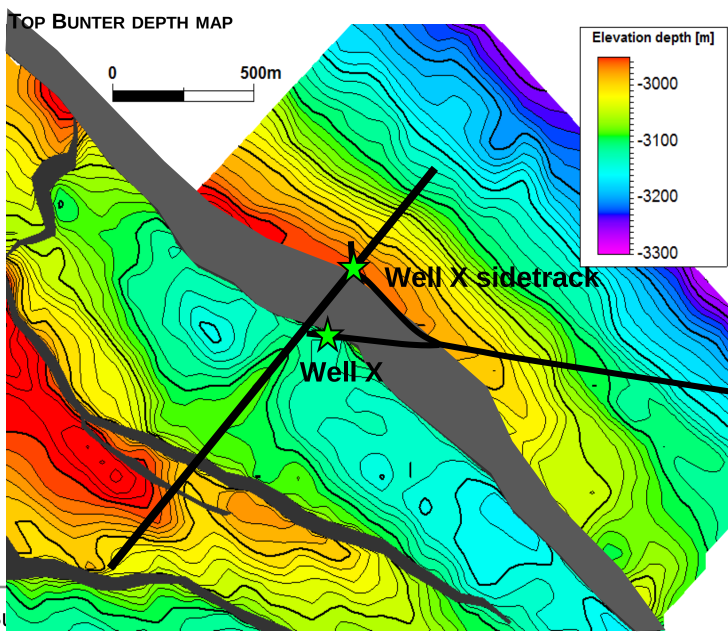
- Before drilling, there was a large uncertainty regarding the position of the prospect boundary fault
- Alternative interpretations:
  - *Mid case*
  - *Conservative case*
  - ***Upside case***

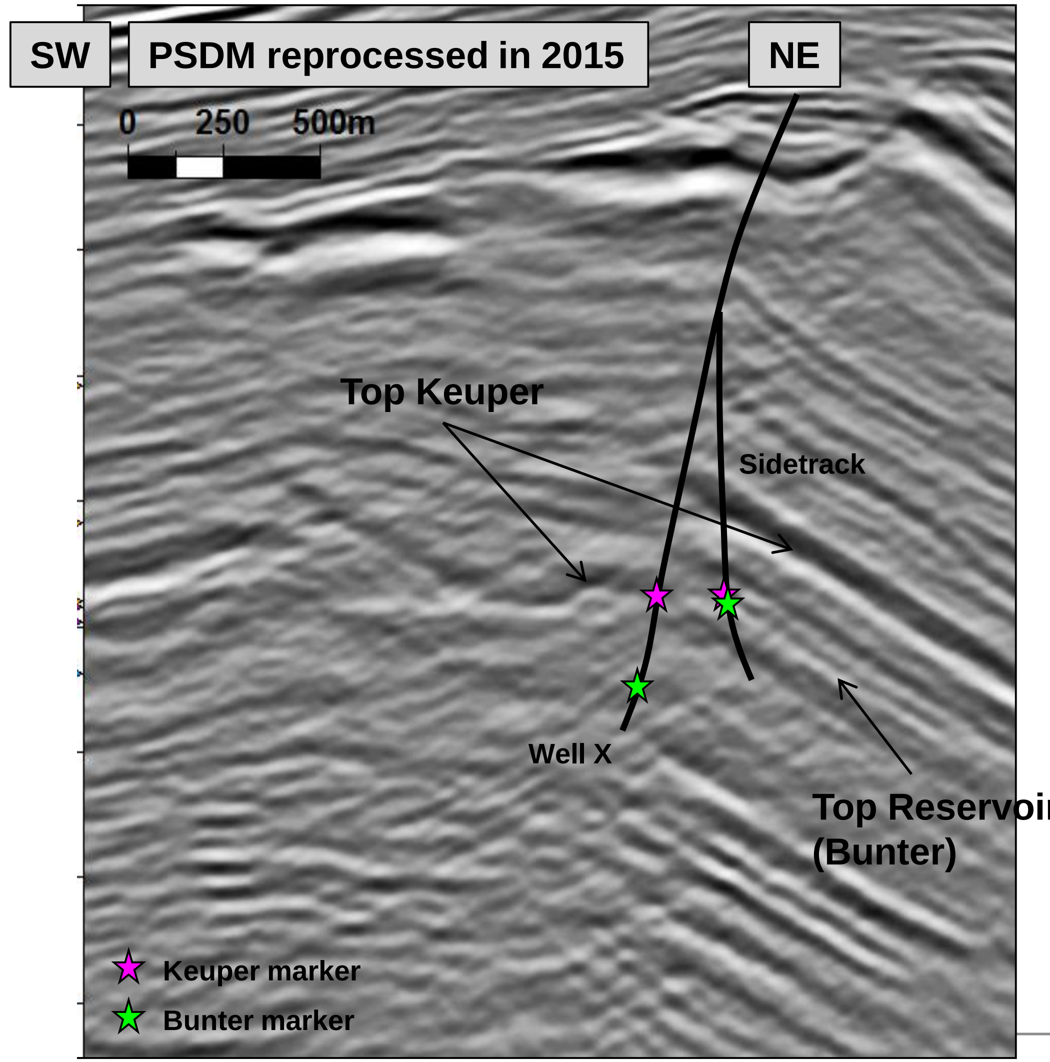


Black = AI increase

Fault interpretation (4/4)

- Two wells have been drilled:
  - Well X
    - Reached the downthrown block
  - Sidetrack
    - Successfully reached the reservoir
    - Pinpointed the fault, which is found in a more easterly position than suggested by PSDM





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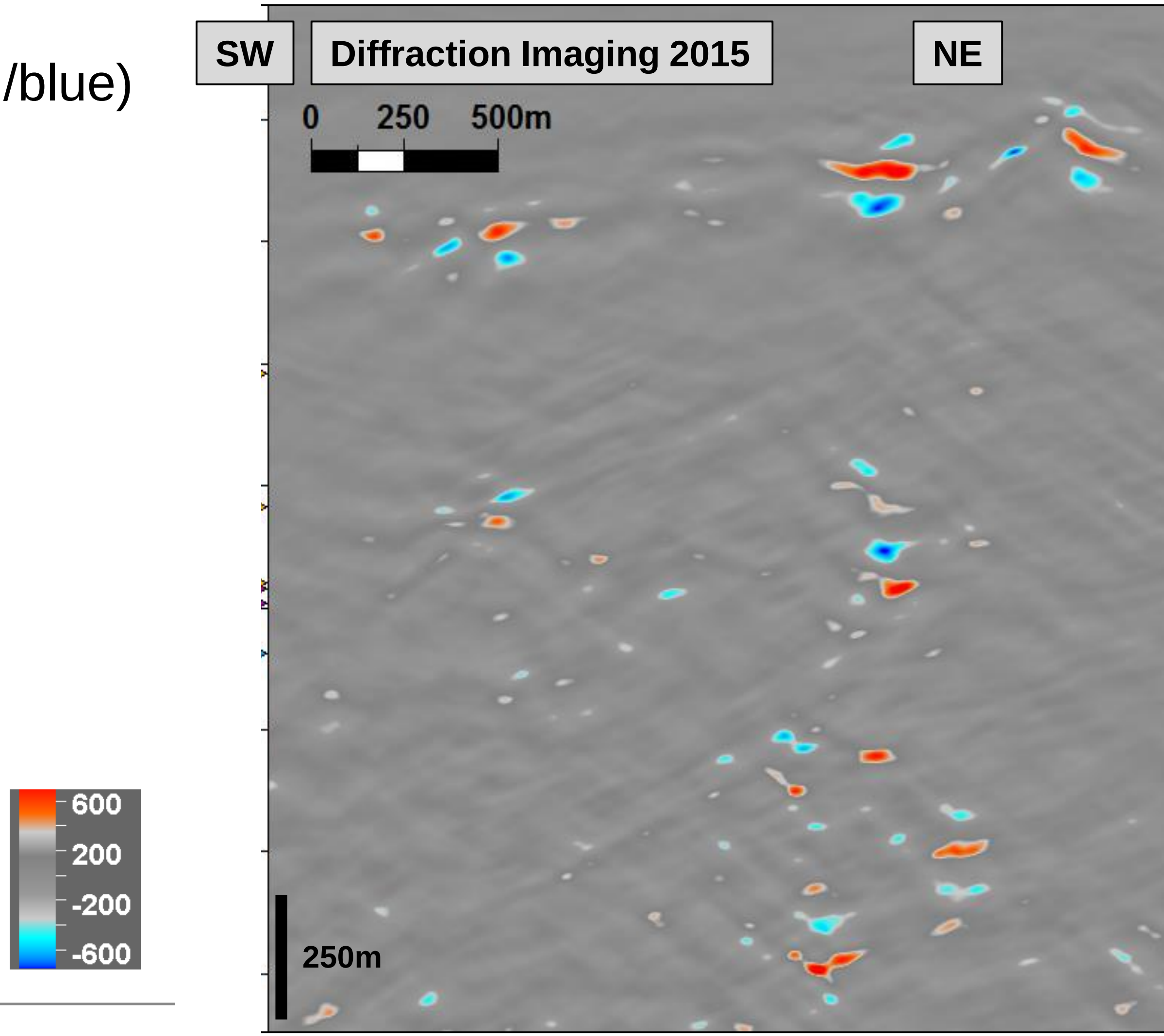
Diffraction Imaging

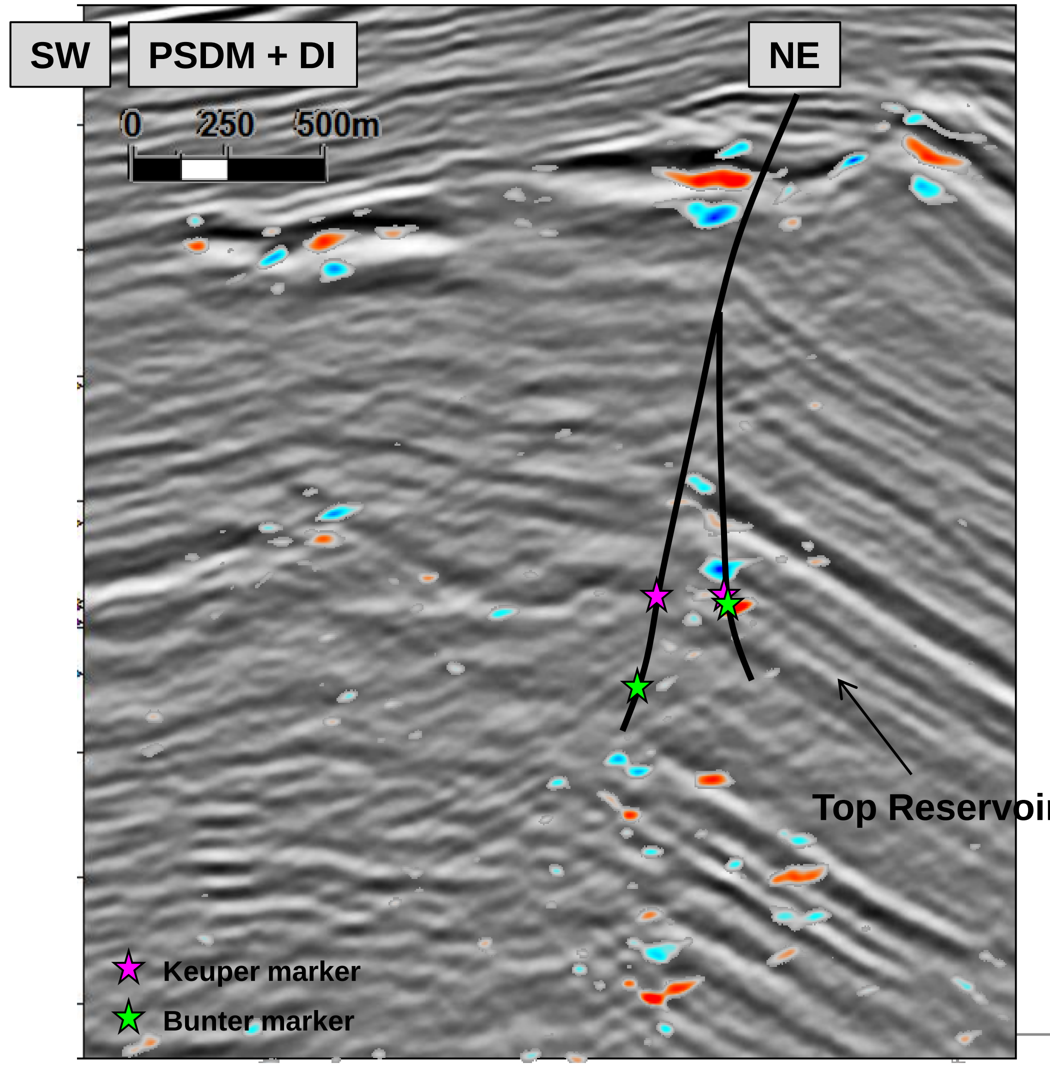
- Diffraction poles (red/blue) at discontinuities
- Strong diffractivity at reservoir level



Red = positive; Blue = negative

Diffraction Imaging – overlay

- DI in agreement with well data
- **This case study permits to validate the correct position of diffraction poles with well data**



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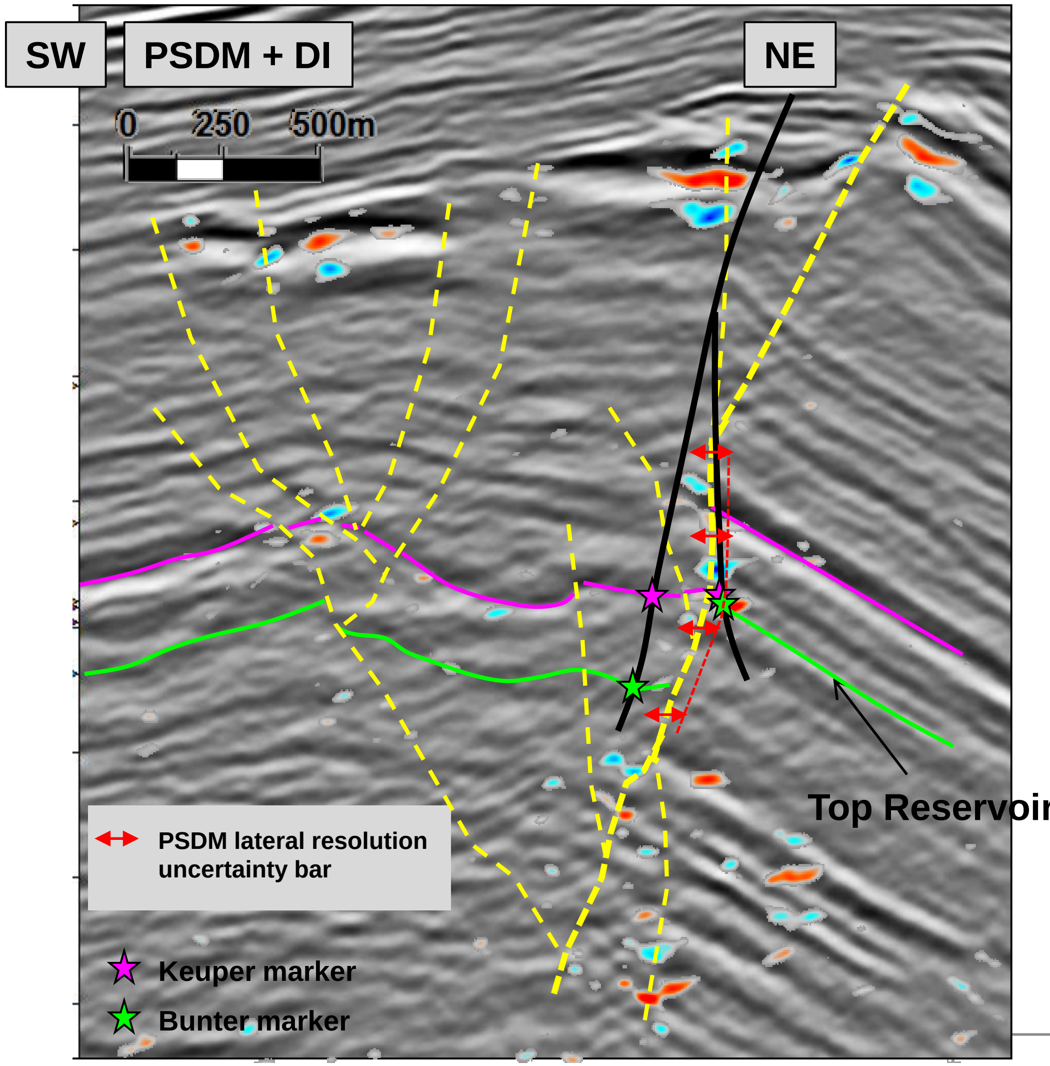
Diffraction Imaging – interpretation

- The use of DI permits to adjust the fault interpretation
- Final fault position on the outer edge of the Fresnel zone of the conservative scenario

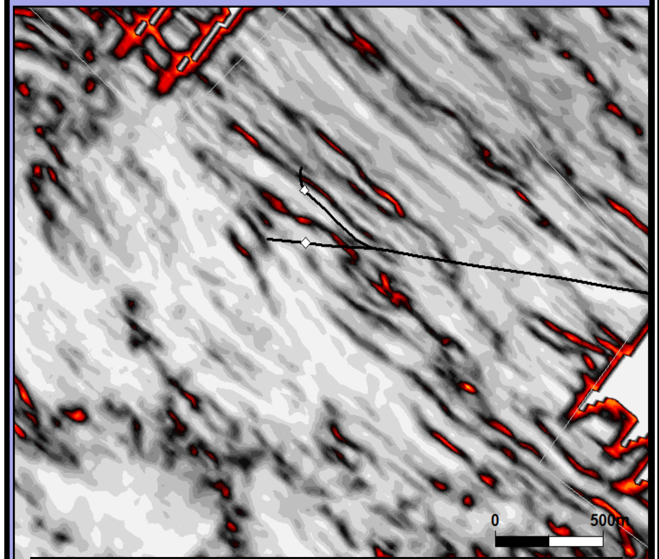


Red = positive; Blue = negative

Attribute extractions

PSDM attribute

Variance – depth slice

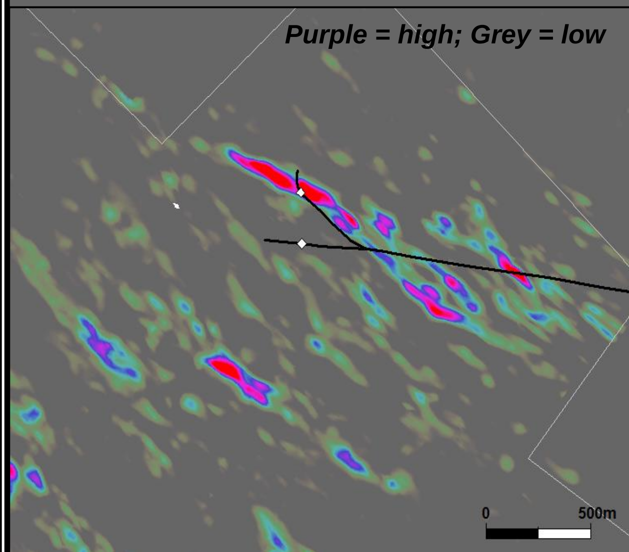


- Various discontinuities observed
- Local PSDM imprints similar to faults

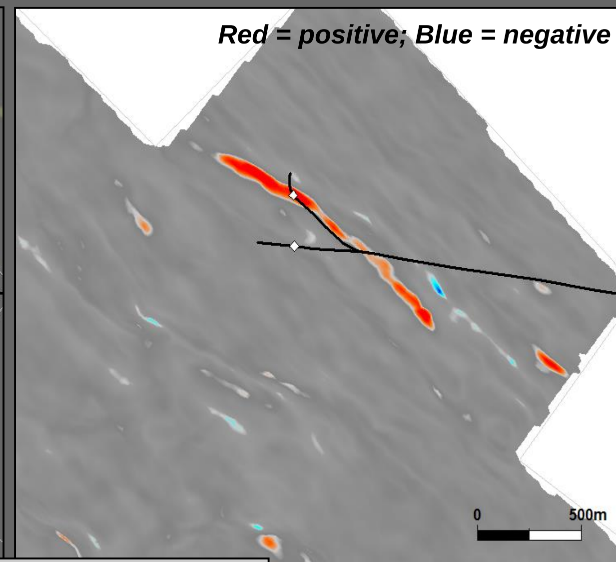
→ **Does not allow accurate fault positioning**

Diffraction Imaging attributes

Maximum magnitude – depth slice +/-70m



Amplitude – extracted @ top reservoir

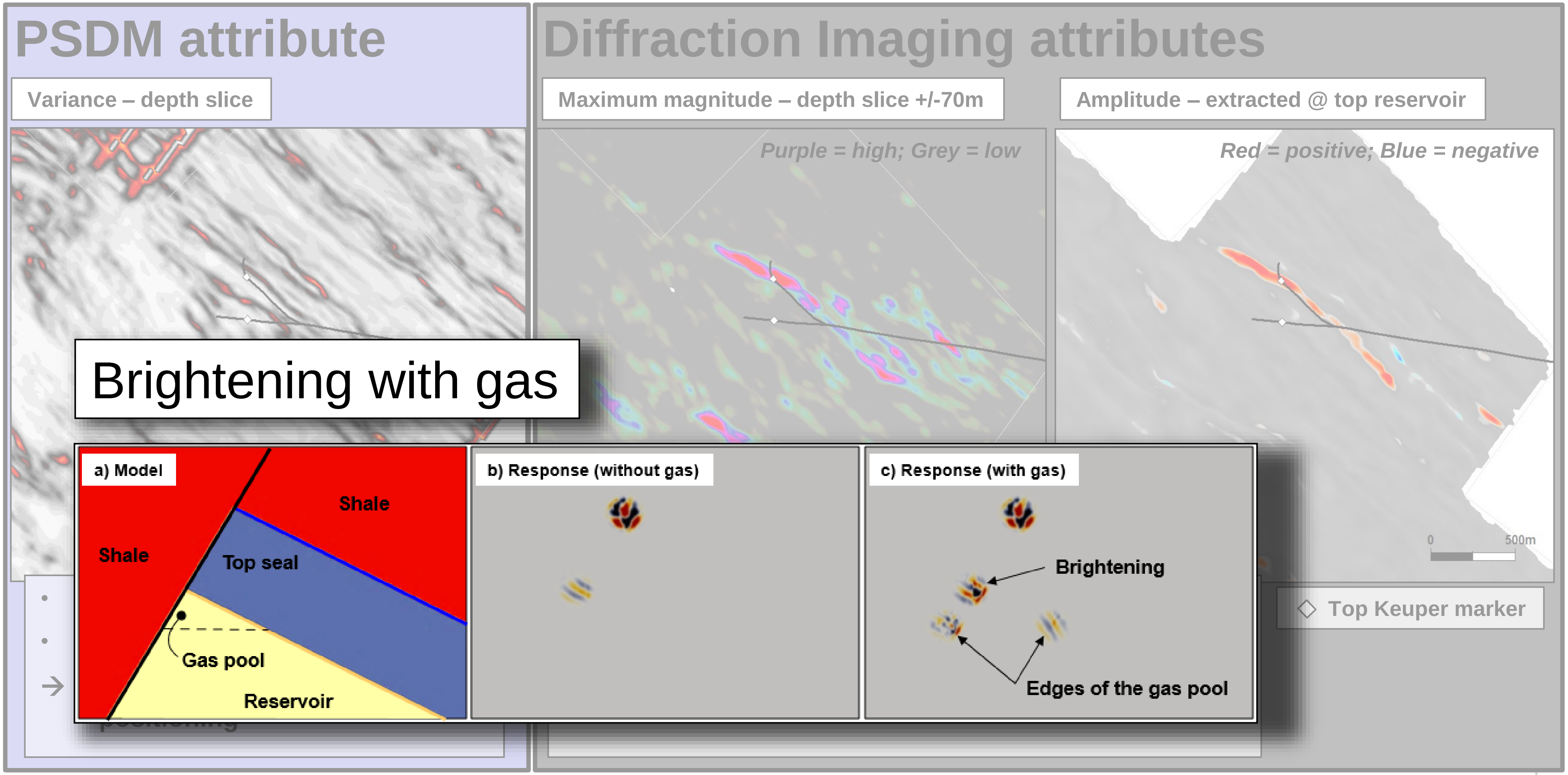


◇ **Top Keuper marker**

- The shape of the fault is revealed by the DI attributes
- The fault location is in agreement with the well data

→ **Improved fault positioning**

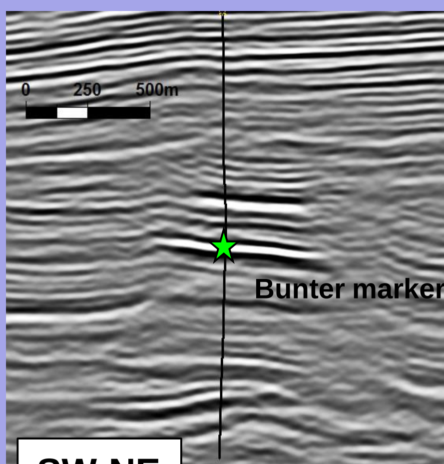
Attribute extractions

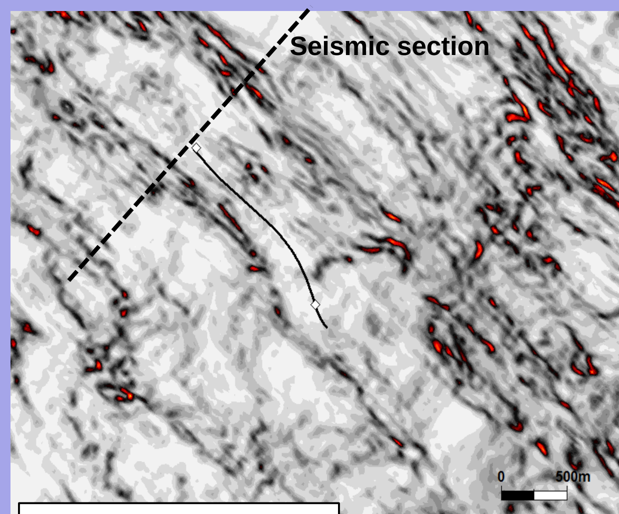


Adjacent field

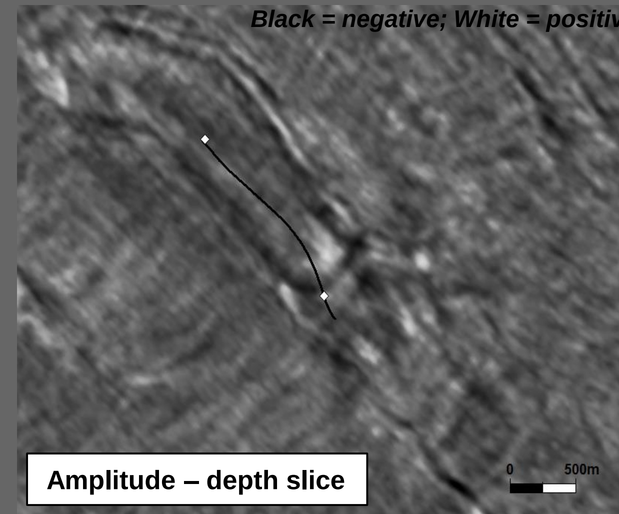
- Attributes from an adjacent field show similarly the improved fault definition using Diffraction Imaging

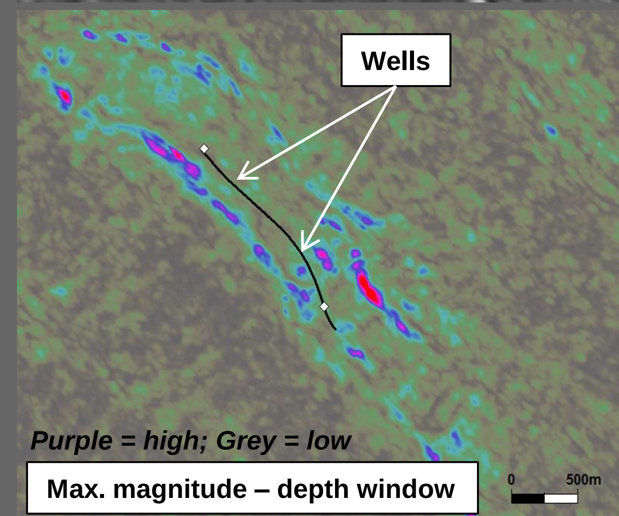
PSDM section and attribute





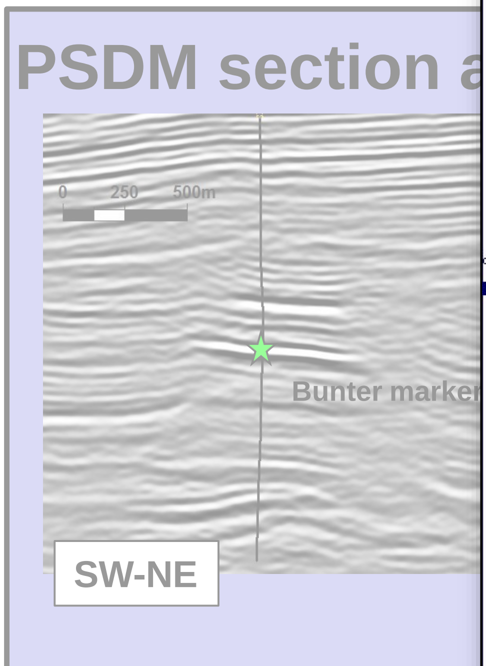
DI attributes



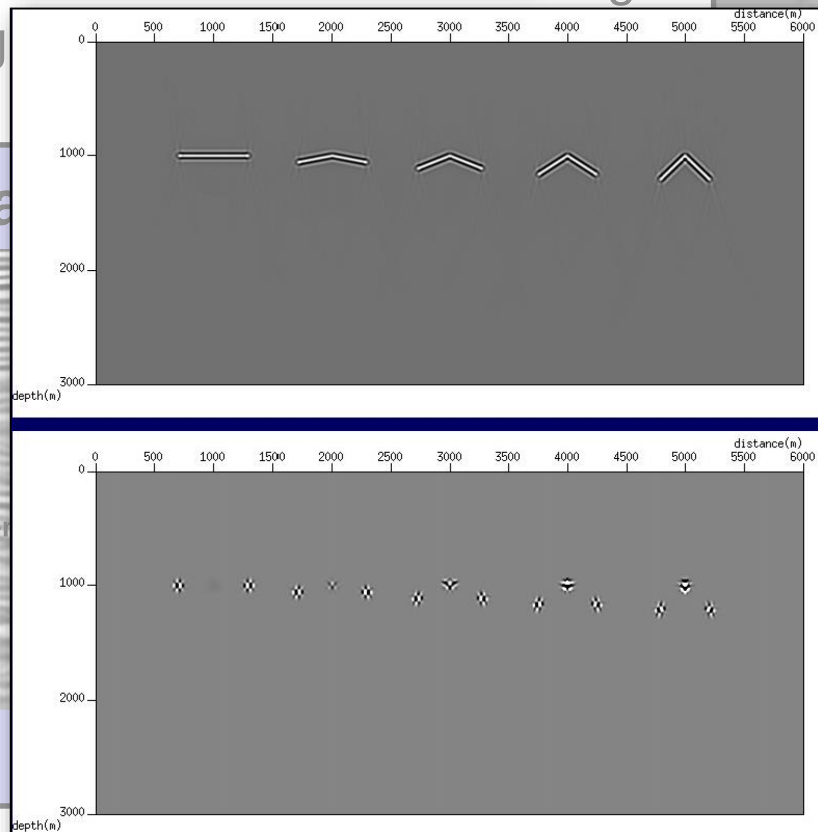


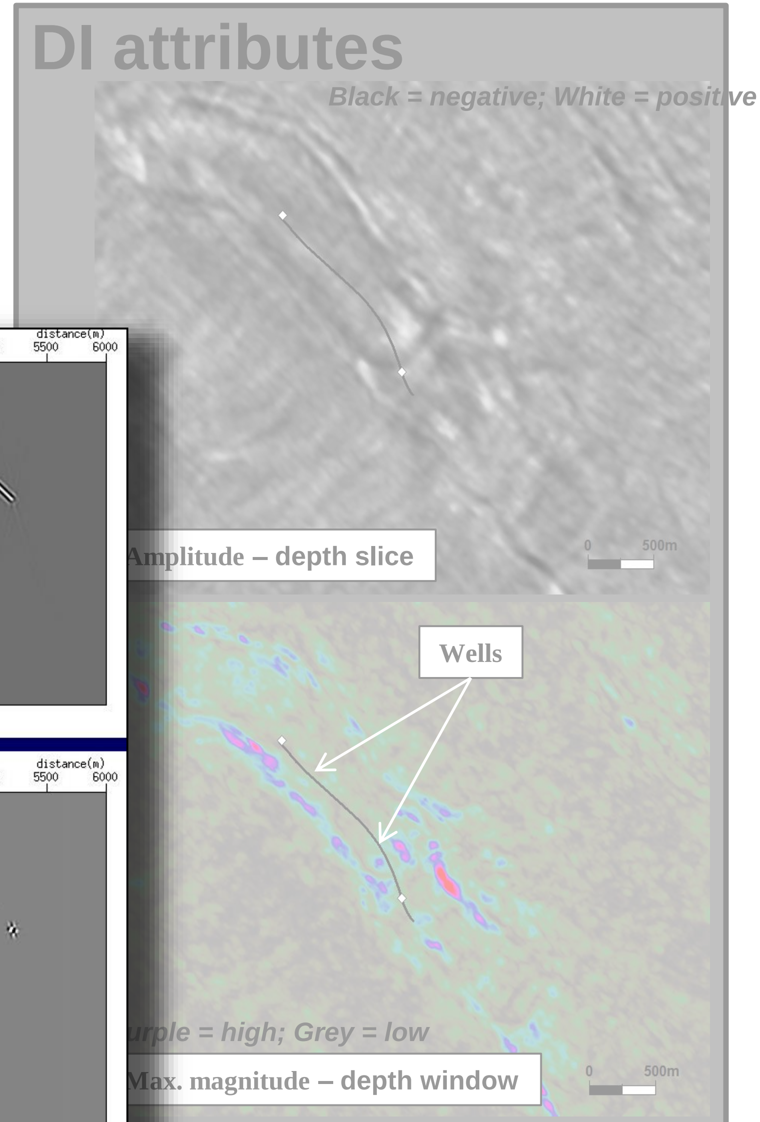
Adjacent field

- Attributes from a
  similarly the improved fault definition using
  Diffraction Imag



Angularity effect





Conclusions

1. Diffraction Imaging allows locating the position of faults with an improved accuracy compared to reflection data
   - Validation through the case study
2. Diffraction Imaging is a valuable complementary source of information for seismic interpretation
   - Fault positioning
   - Positioning of well targets
   - Delineation of field edges
   - Reduction of drilling risk for narrow fault-bounded prospects