Seismic2022

Application of diffraction imaging to fractured basement reservoirs

The Lancaster Field, Rona Ridge, West of Shetland, UK

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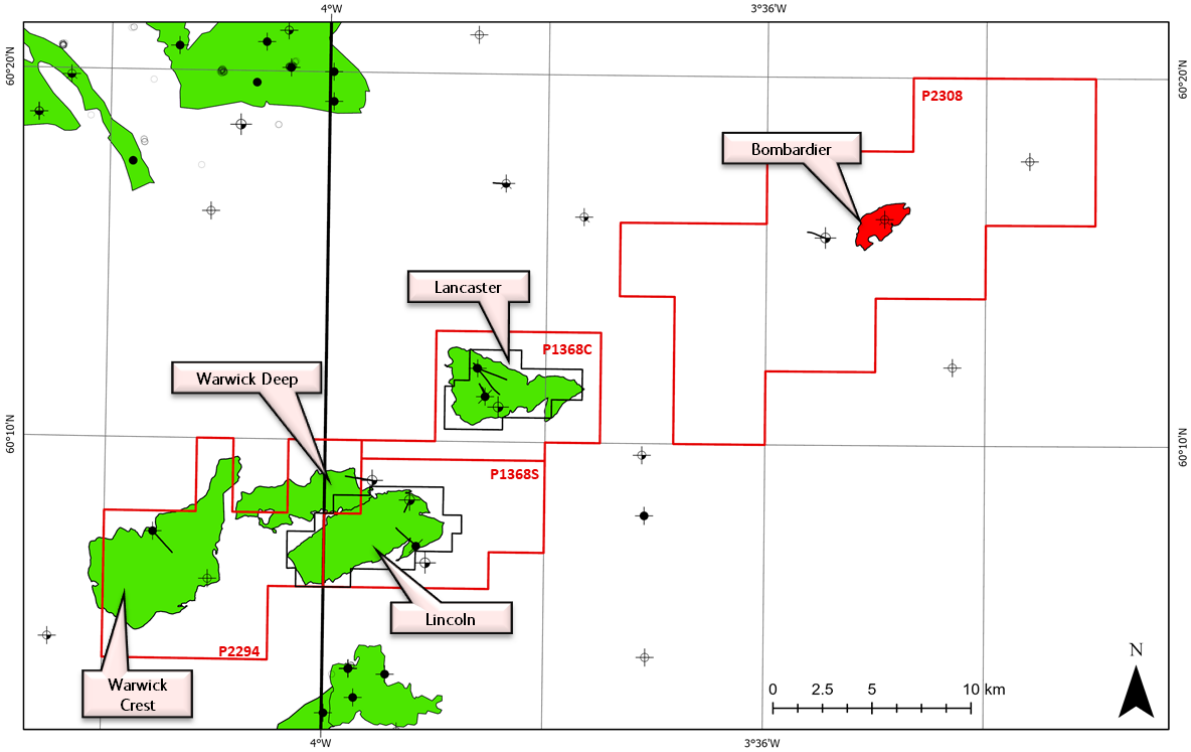
Outline

- Introduction
- Geological setting
- Diffraction imaging method
- Diffraction imaging of the fractured basement reservoir
- Conclusions

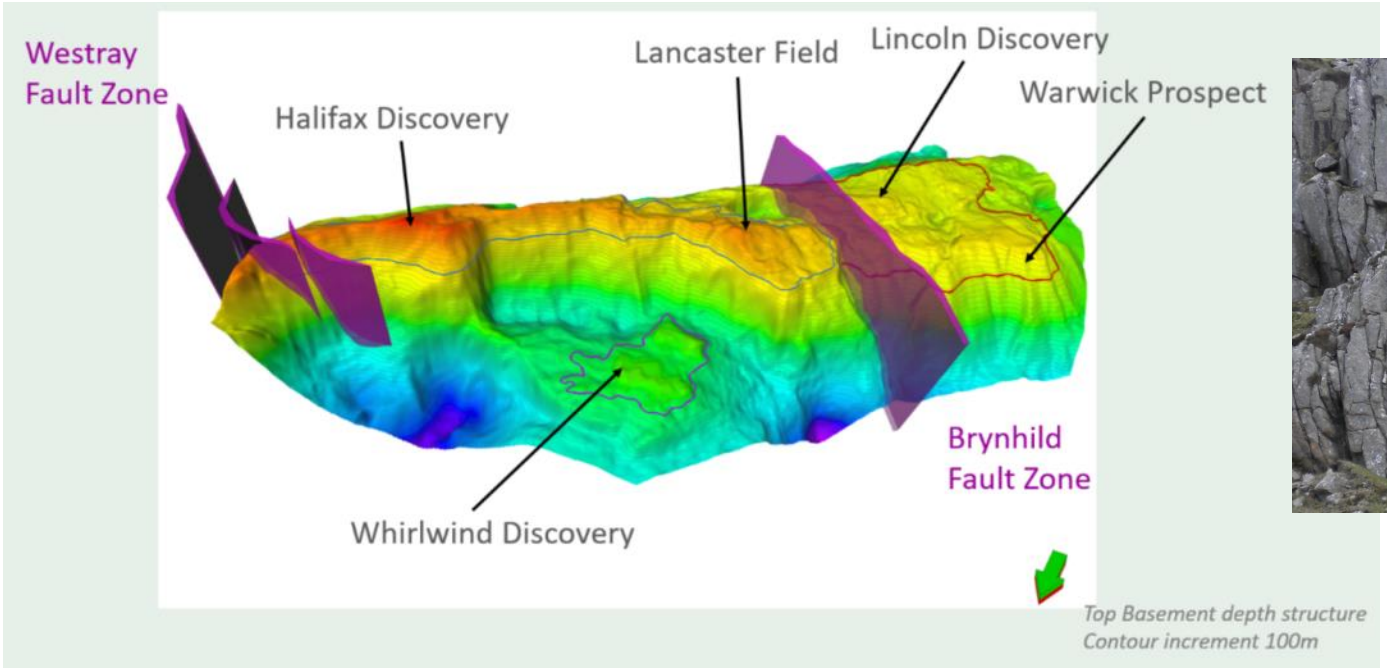
Introduction

Location map of study area



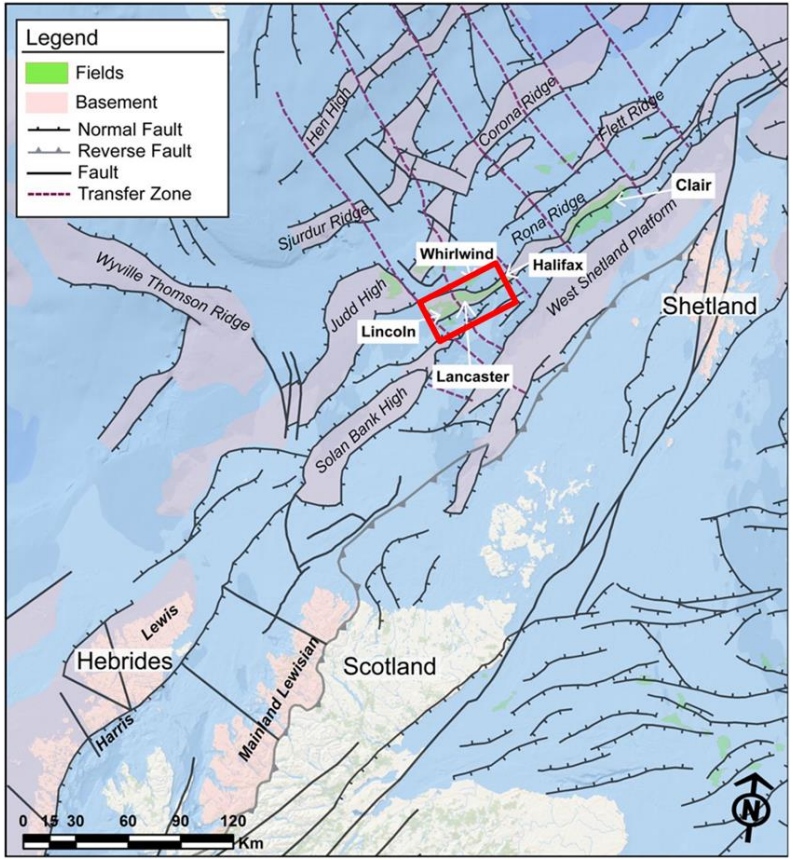
Introduction

Basement topography



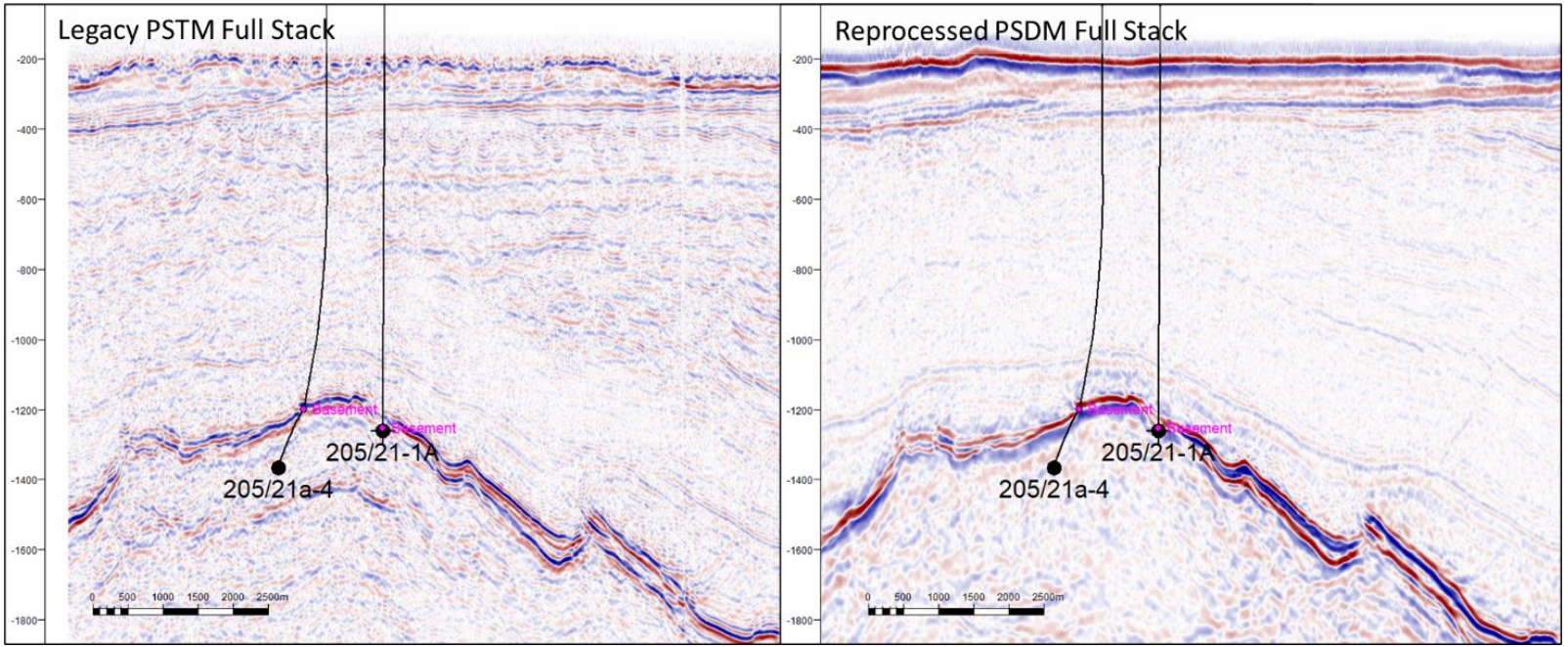
Fractured tonalite

Geological setting



Geological setting

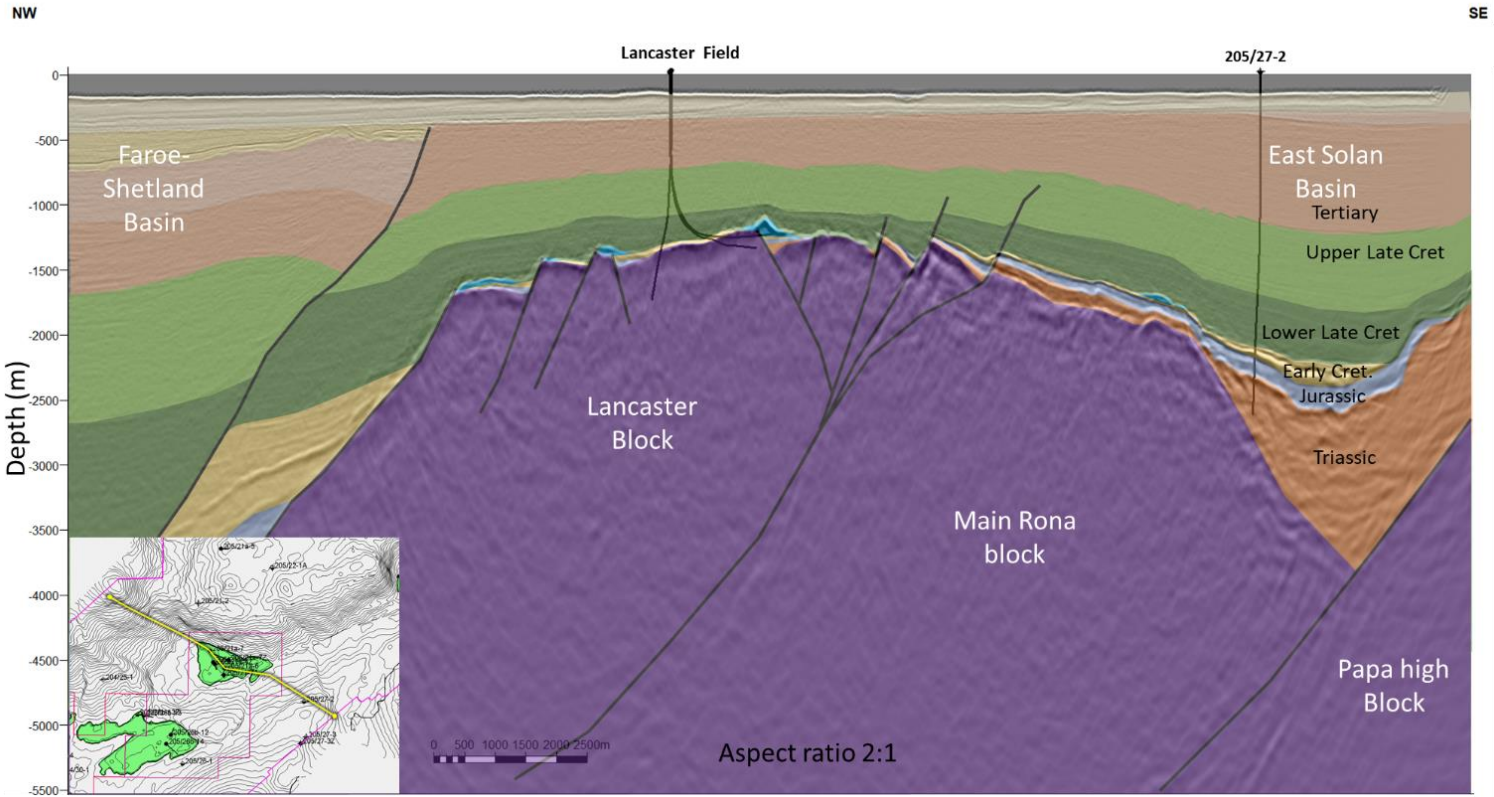
Seismic across the Lancaster field



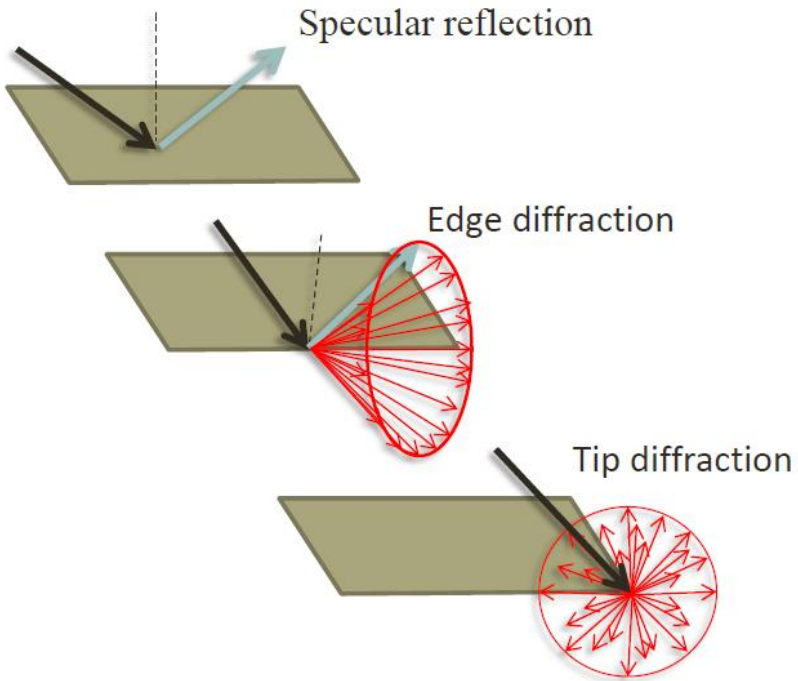
both legacy and reprocessing images are from other contractor

Geological setting

Regional structural geoseismic section of the Rona Ridge and the location of the Lancaster field



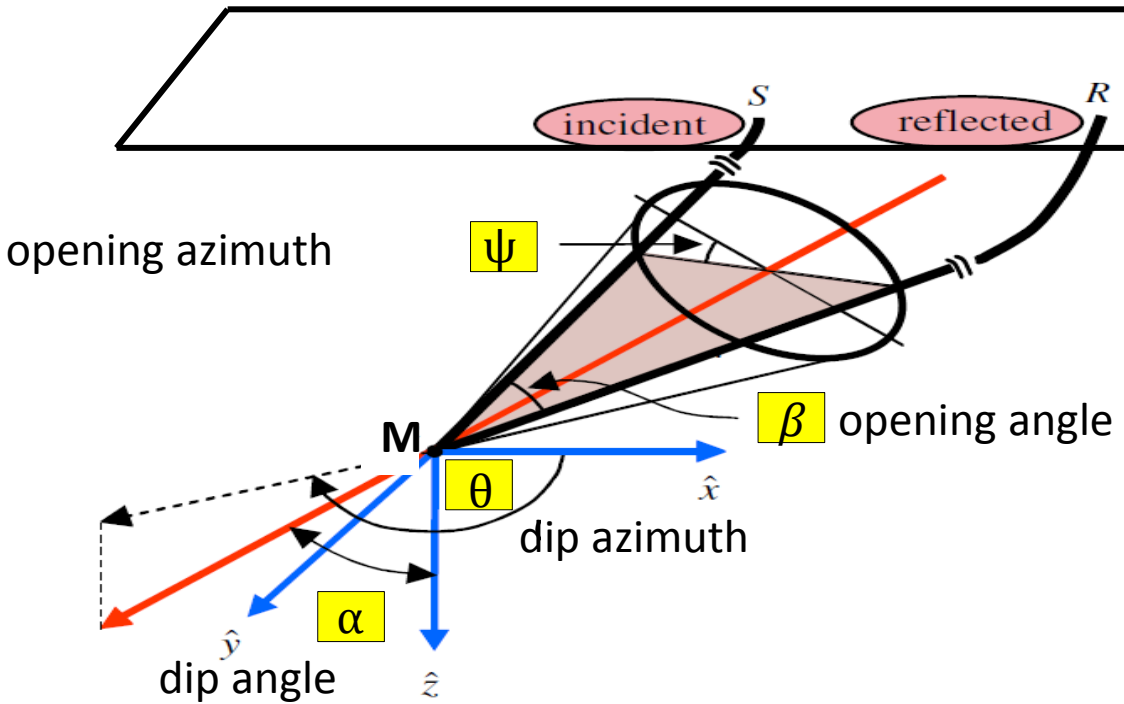
Diffraction imaging method



Diffractions are direct indicators of small scale heterogeneities in the subsurface. Tip or point diffractions are very weak in the area and main diffracted energy observed in the data are due to edge diffractors.

Diffraction imaging method

Depth Mapping in Local Angle Domain



$$U(S,R,t) \rightarrow I(M, \alpha_{dip}, \theta_{dip}, \beta_{open}, \psi_{open})$$

M is the subsurface image point, S and R are the source and receiver locations respectively,

$\alpha_{dip}, \theta_{dip}, \beta_{open}, \psi_{open}$

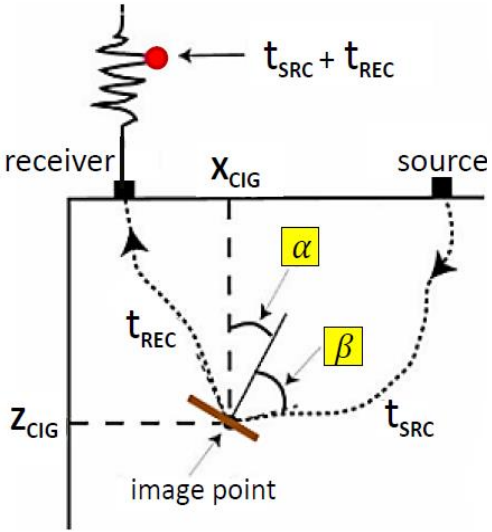
are four angles per subsurface point M.

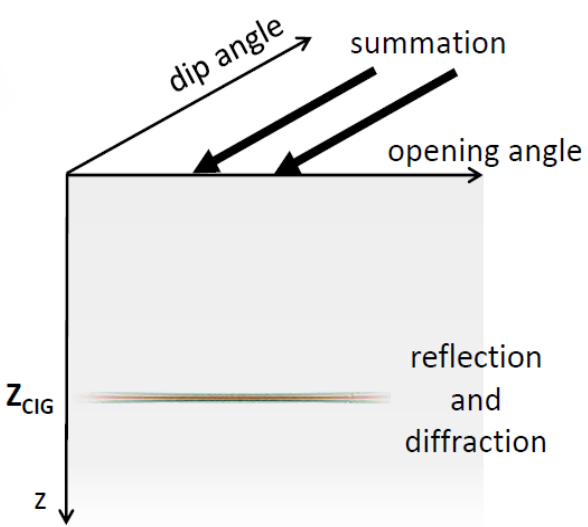
after Koren and Ravve 2011

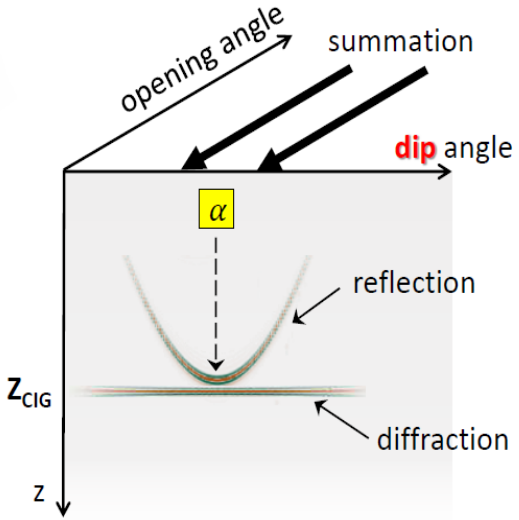
Diffraction imaging method

Reflection and Diffraction in Local Angle Domain

Migration Ray Scheme	Conventional Opening Angle CIG	Dip Angle CIG





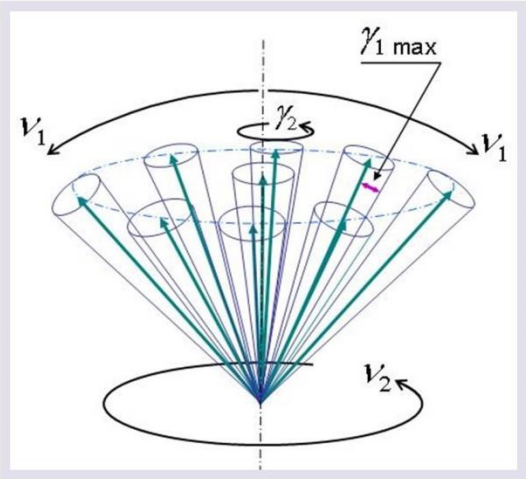


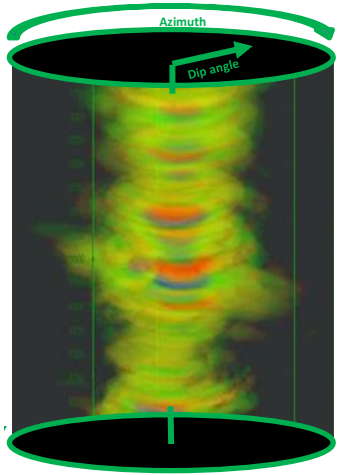
α = *dip angle*

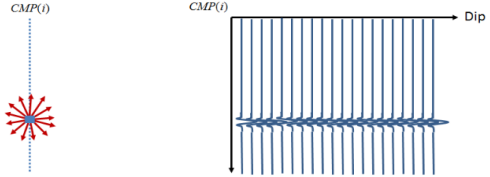
β = *opening angle*

Diffraction imaging method

Full-azimuth directional (dip) angle gathers contain directivity-dependent information at each subsurface point and optimal for the specular and diffraction energy separation

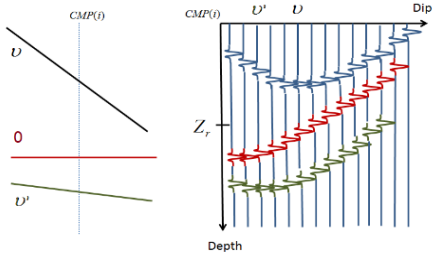






Diffraction pattern in Directional gather:

- Directional gathers shows the diffracted energy in all possible dips and all azimuths, keeping a constant depth as a function of the dip angle.
- In case of an edge diffractor, the geometry affects the distribution of the scattered energy with preferred azimuths.

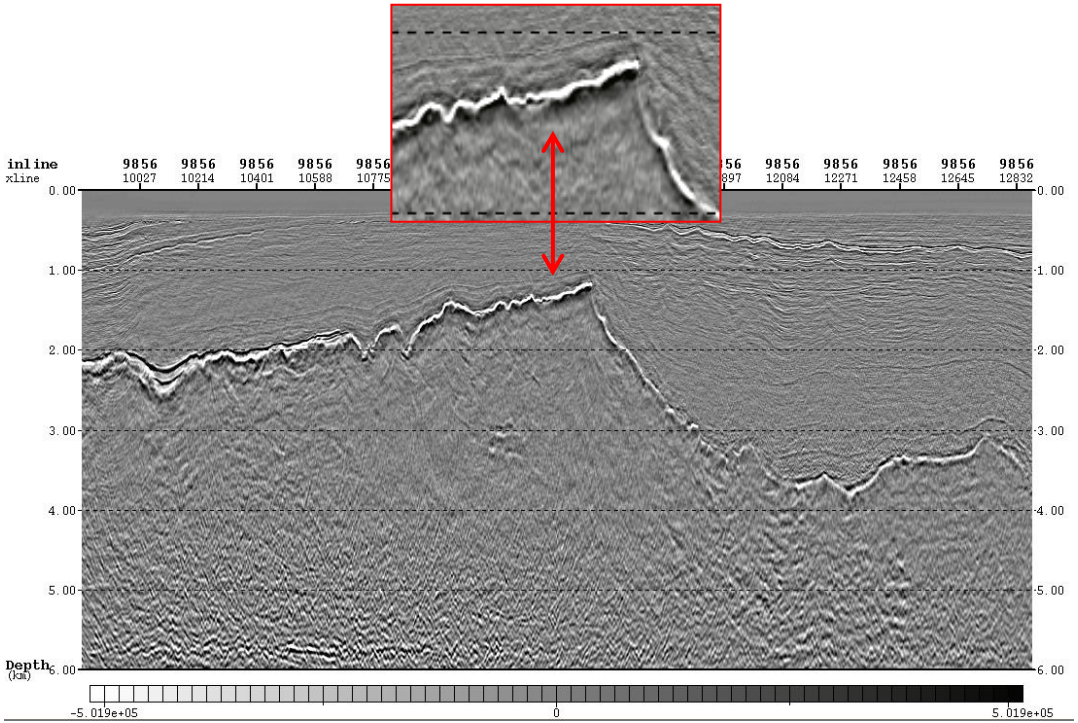


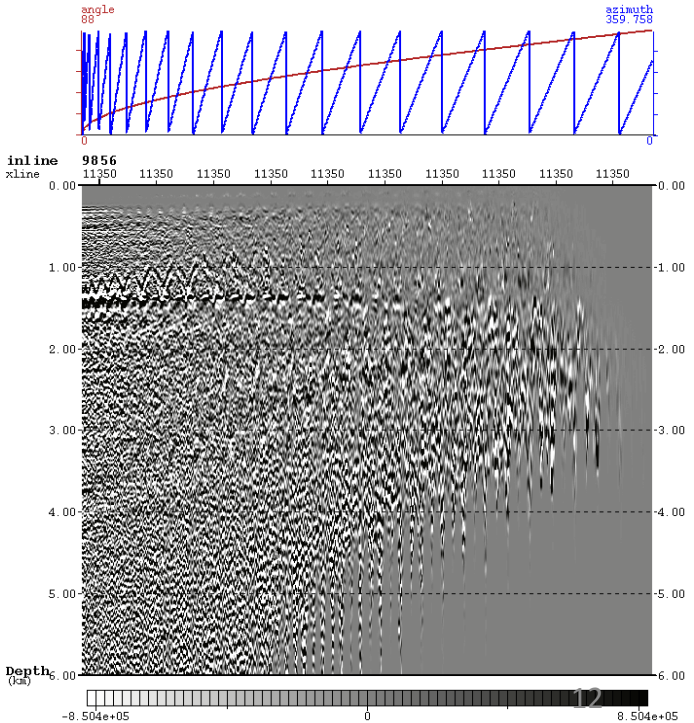
Reflection pattern in Directional gather:

- Curved shape (migration smile which is the projection from other CMP).
- The true dip is at the maximum curve depth.
- The curve fades at the edges.

Diffraction imaging method: Energy separation results

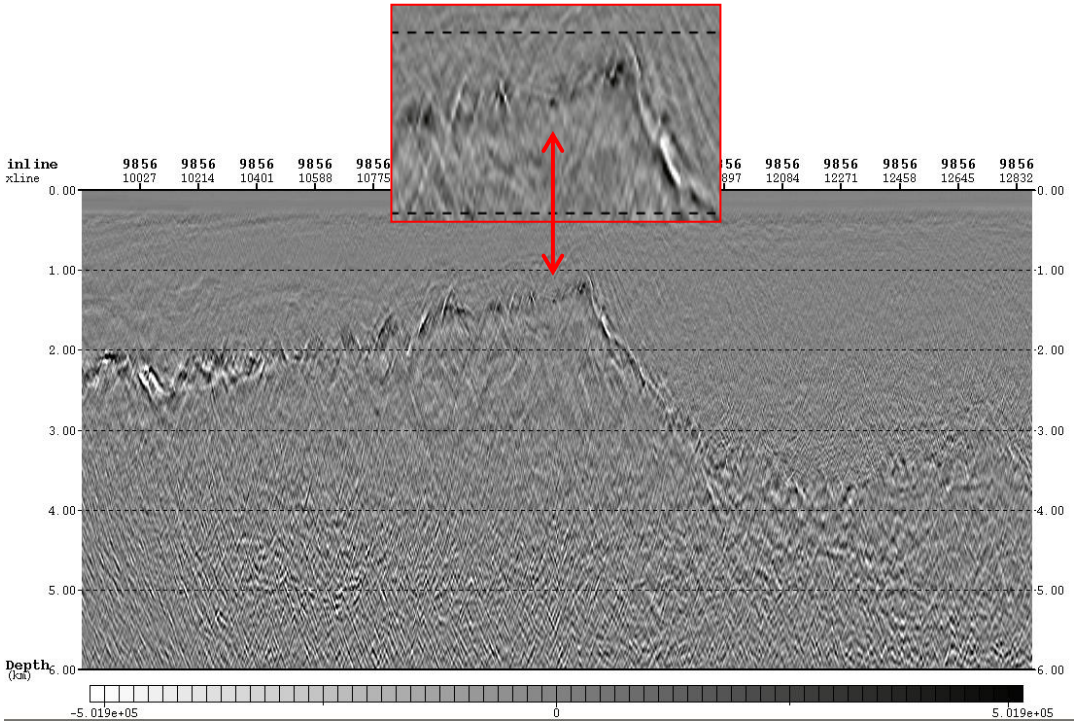
Gather & Section before reflection energy suppression

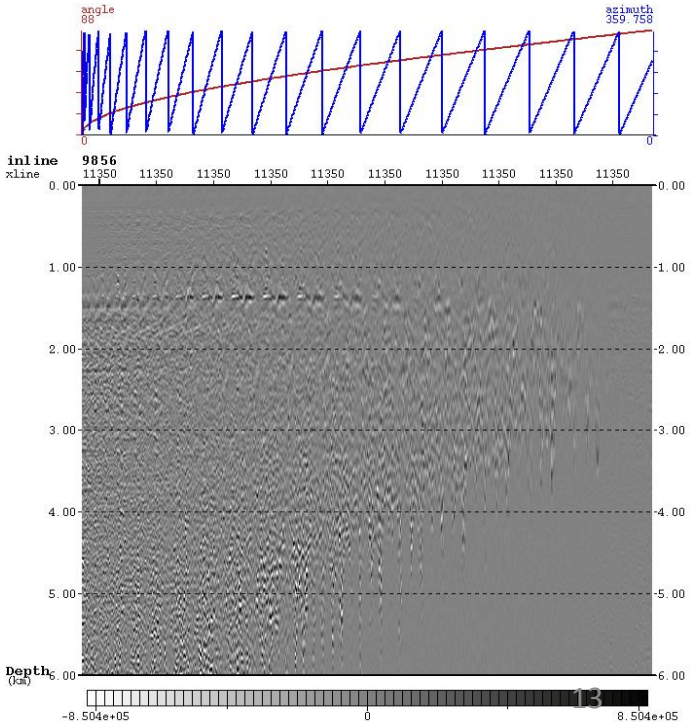




Diffraction imaging method: Energy separation results

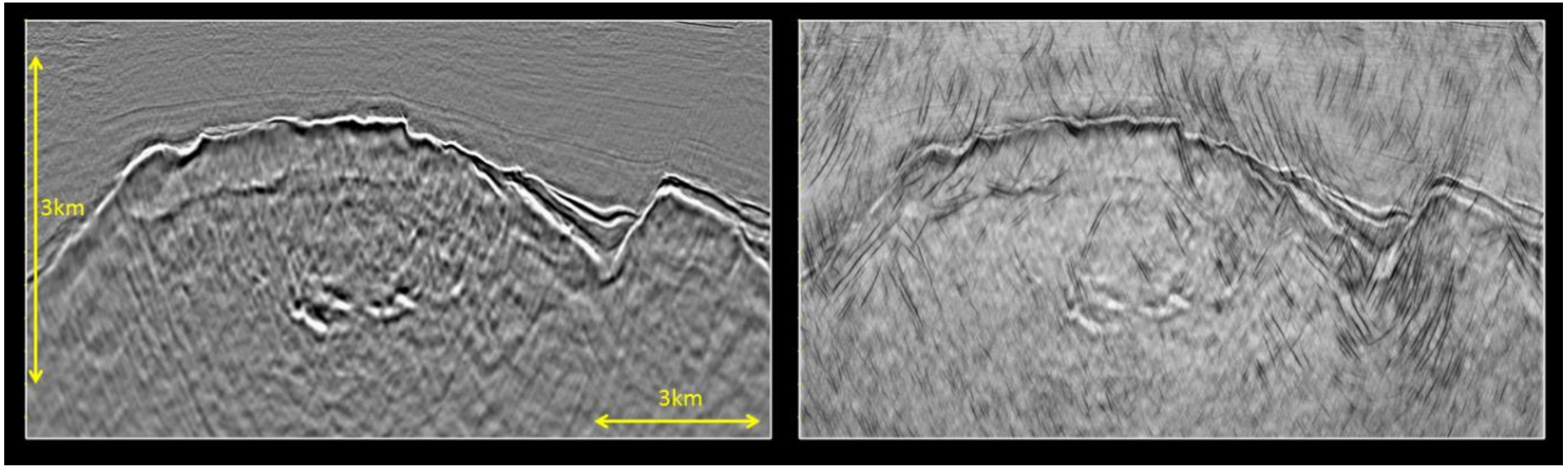
Gather & Section after reflection energy suppression





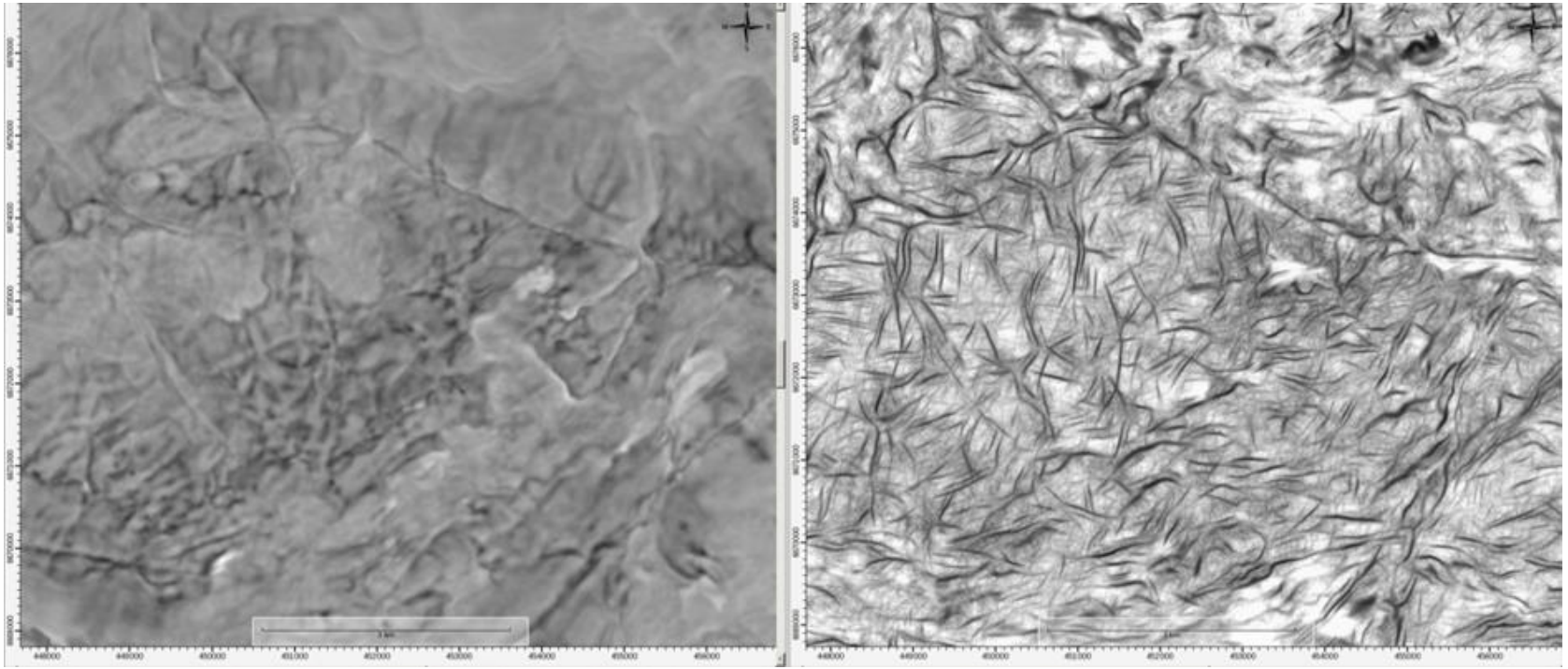
Diffraction imaging of the fractured basement reservoir

Seismic section with overlain diffraction image (DI)

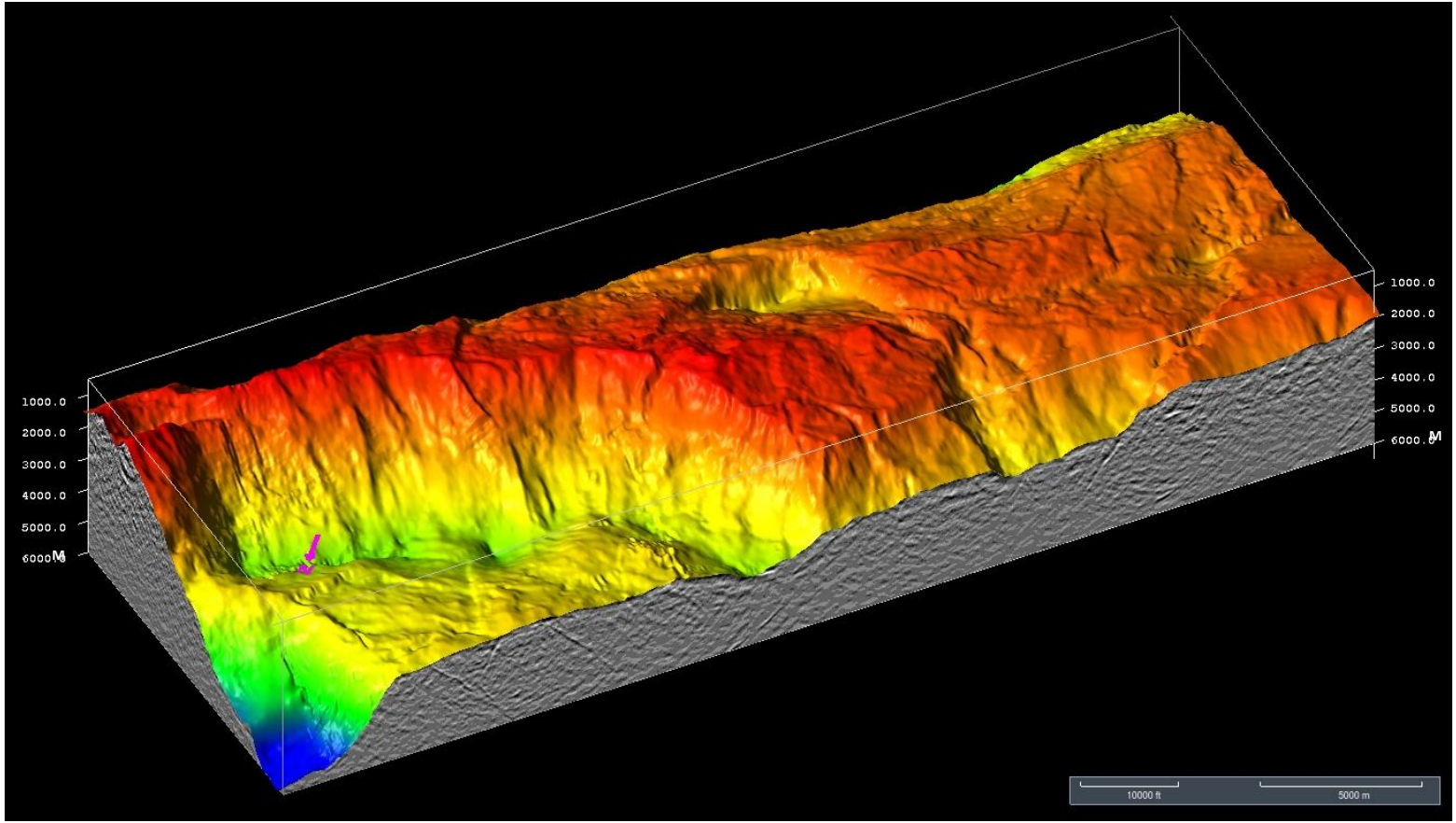


Diffraction imaging of the fractured basement reservoir

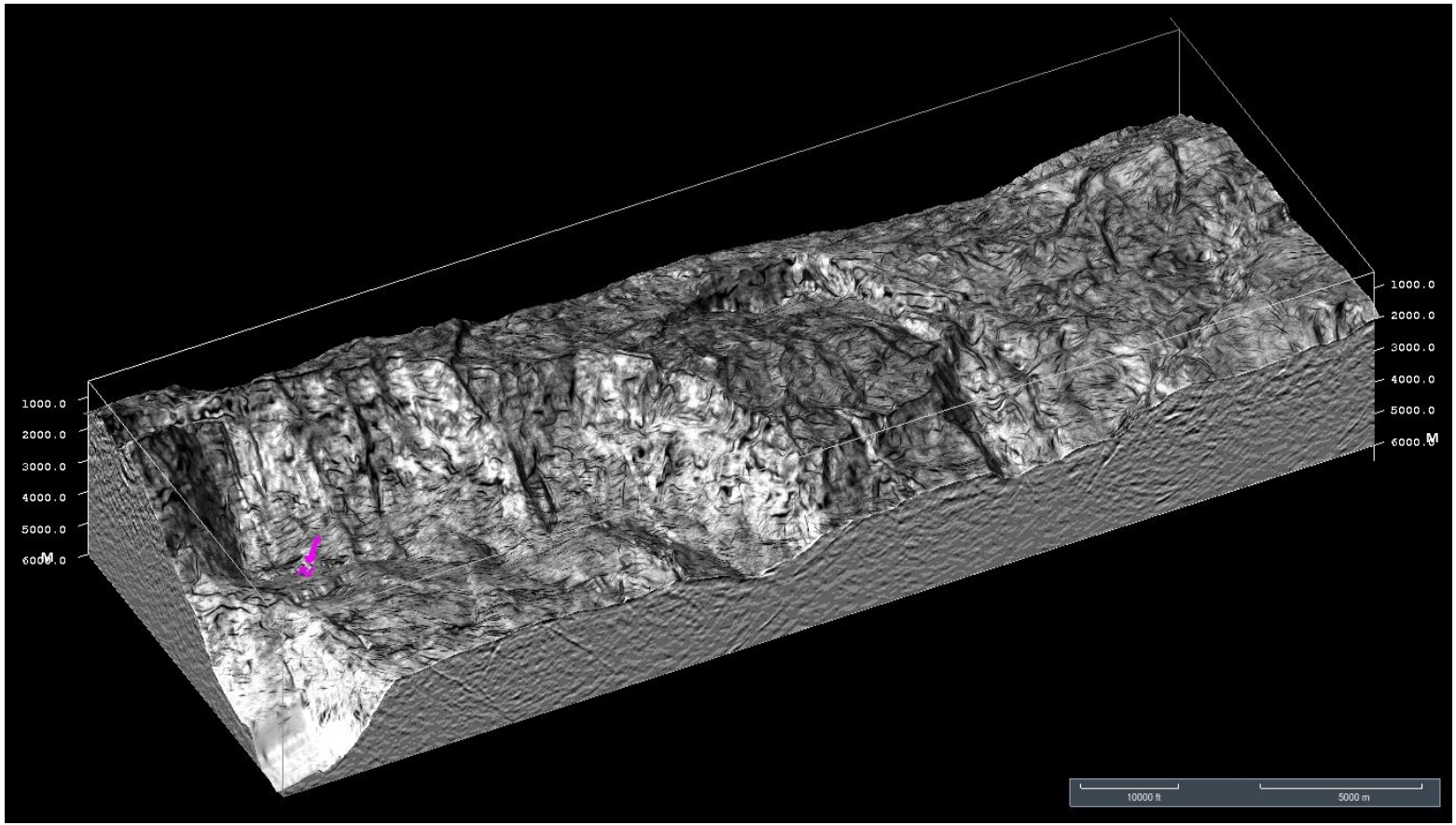
Geological DI patterns - PSDM and DI along top basement – amplitudes along horizon



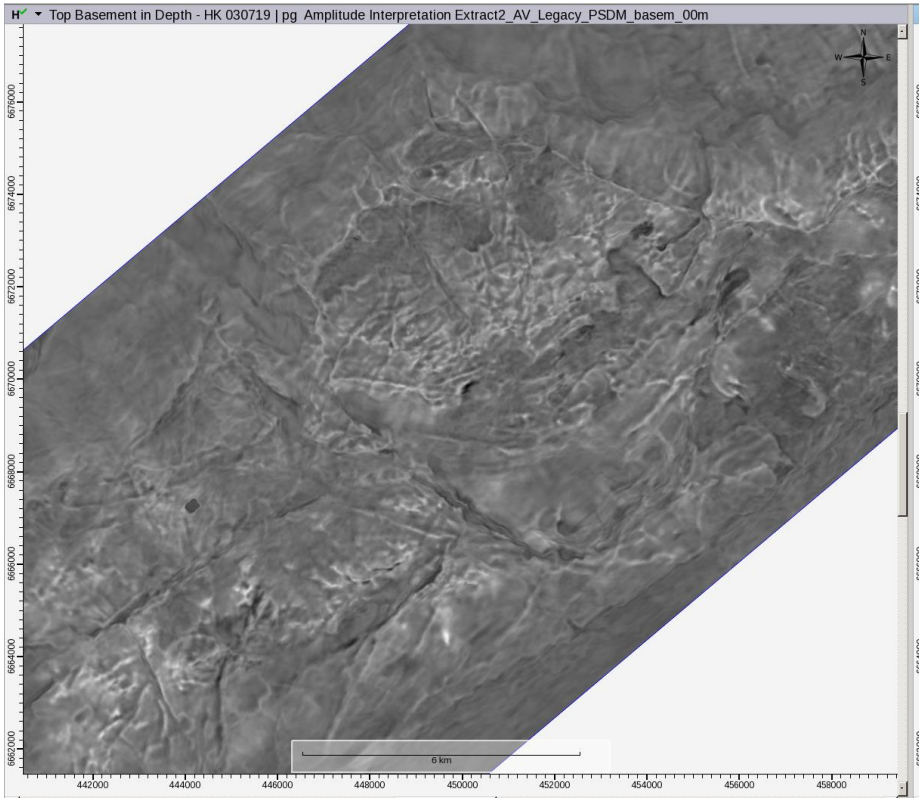
Basement Horizon Interpretation



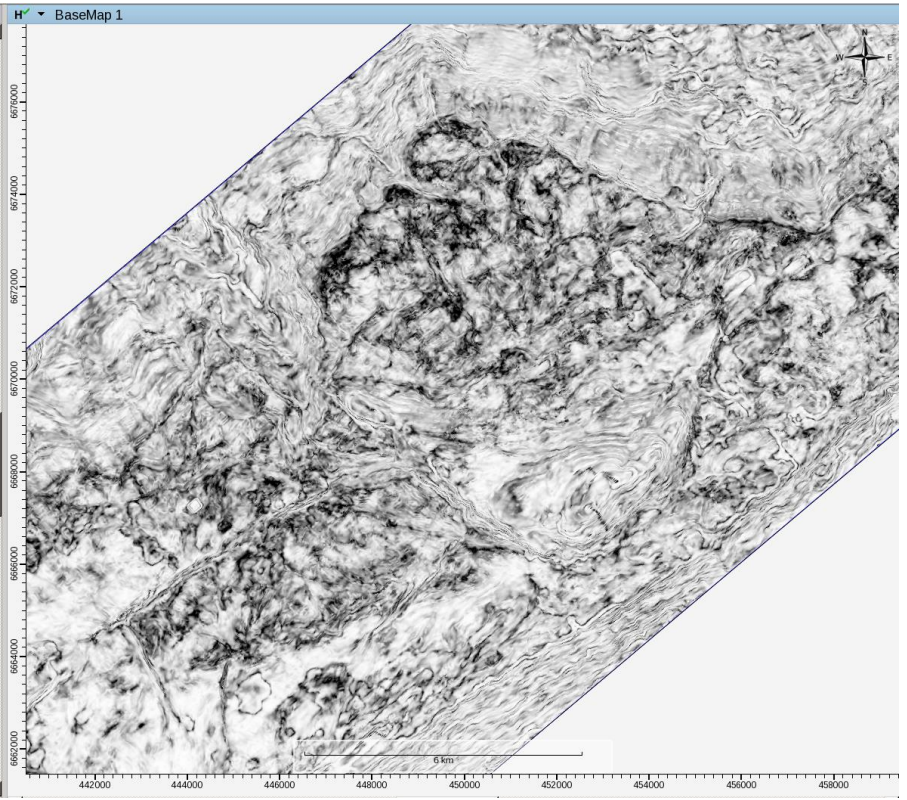
DI along Basement



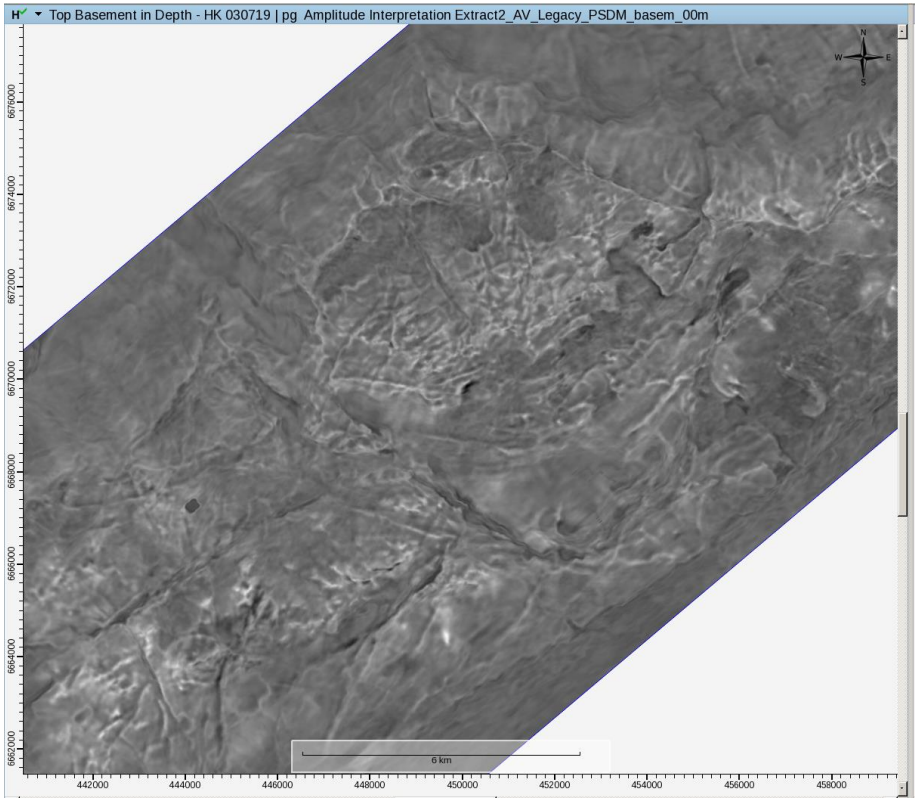
PSDM along basement



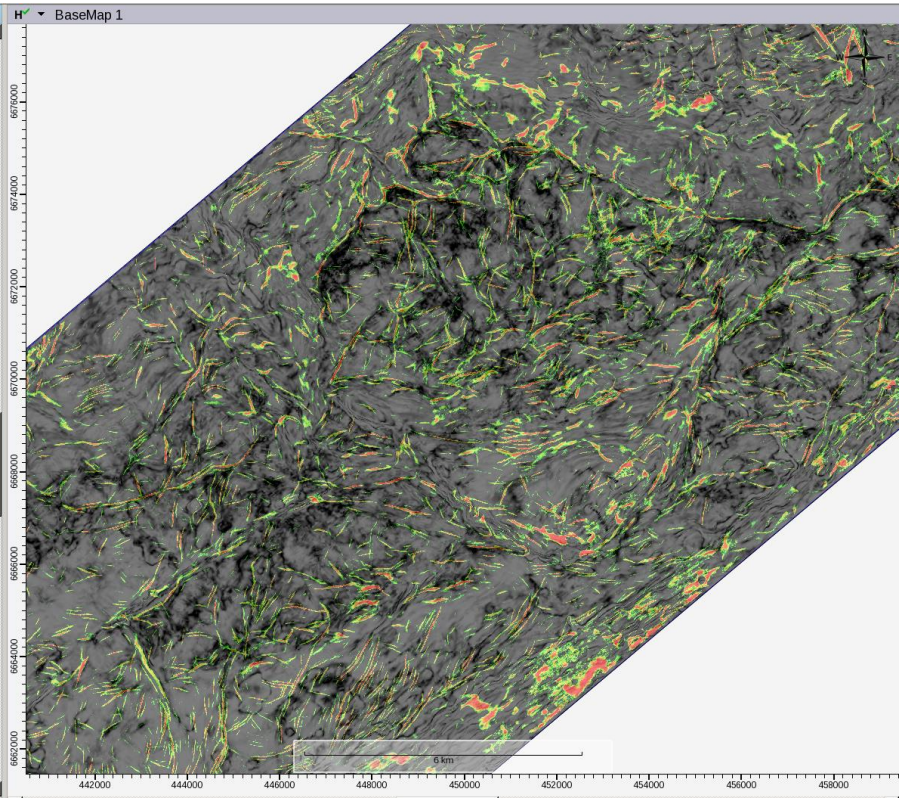
Coherency along basement



PSDM along basement

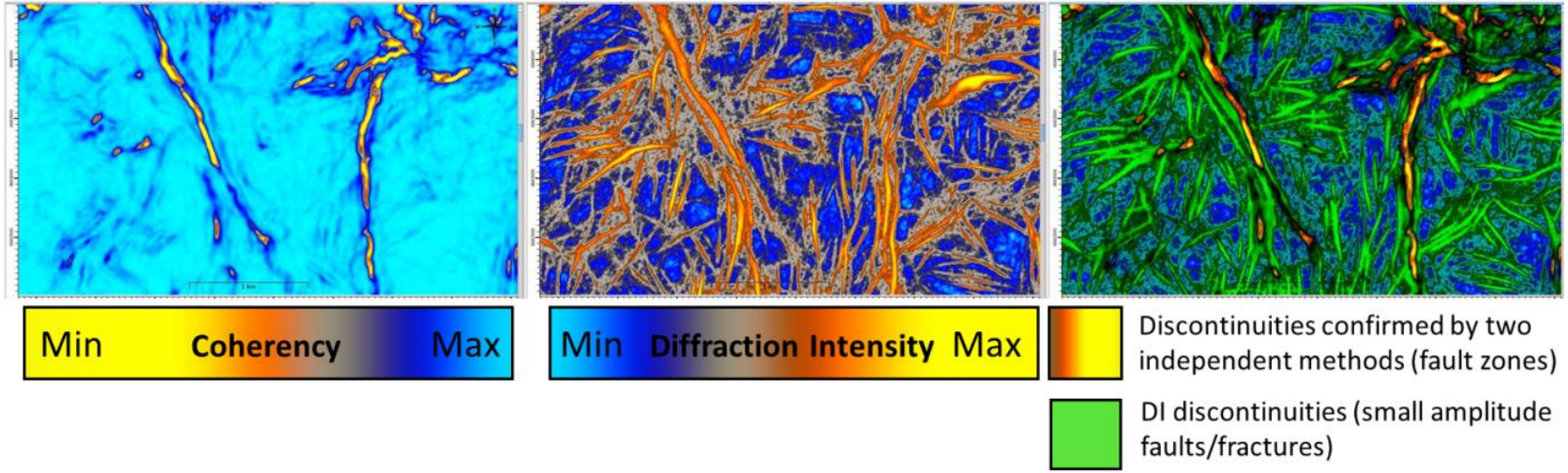


Coherency + DI along basement



Attributes along Top Basement

coherency (left) DI (centre) and an overlap of the two (right)

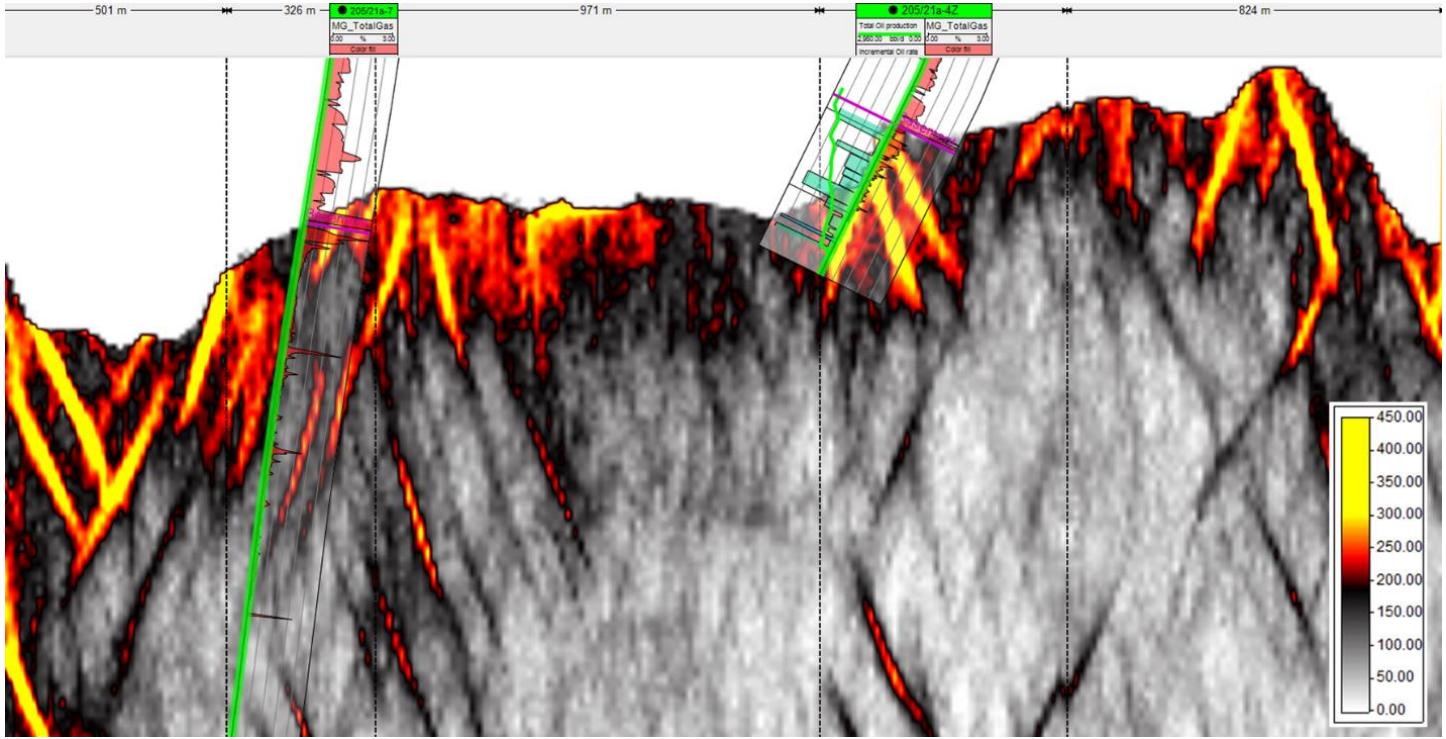


Production Logging Tool (PLT)

Correlation of PLT inflow zones with the Presence of Diffraction Image anomalies

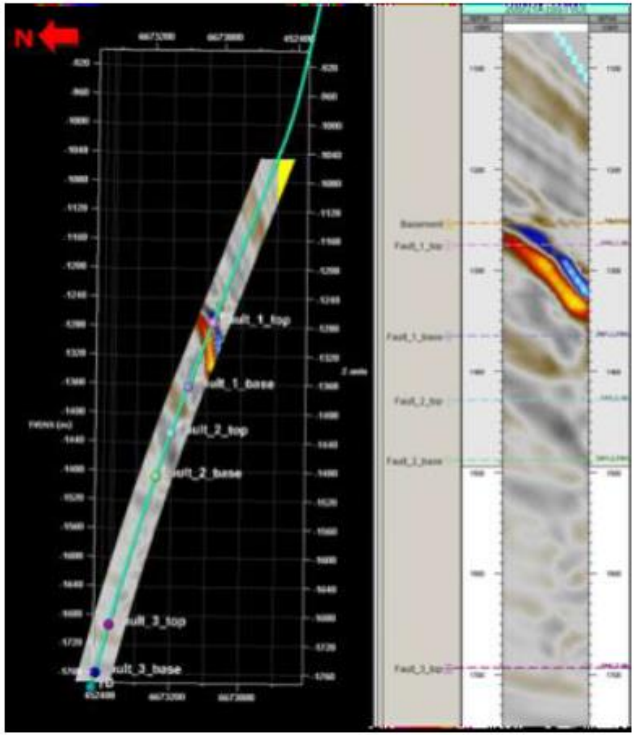
205/21a-7 no intra basement flow zones & no anomaly

205/21a-4z large anomaly & good flow

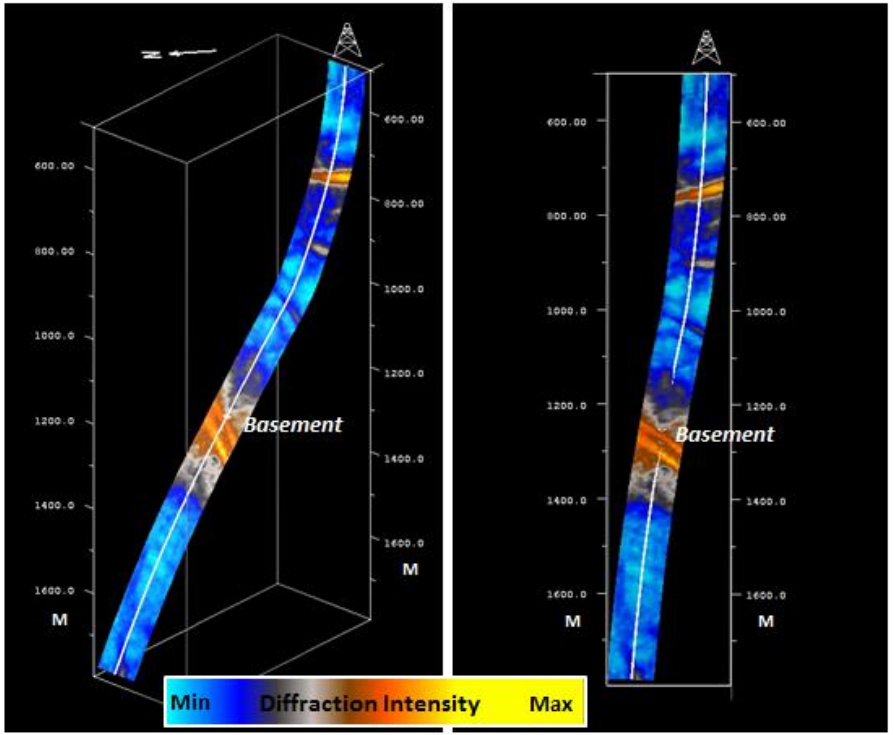


VSP fault vs DI fault in 205/21a-4 well traverse

VSP fault

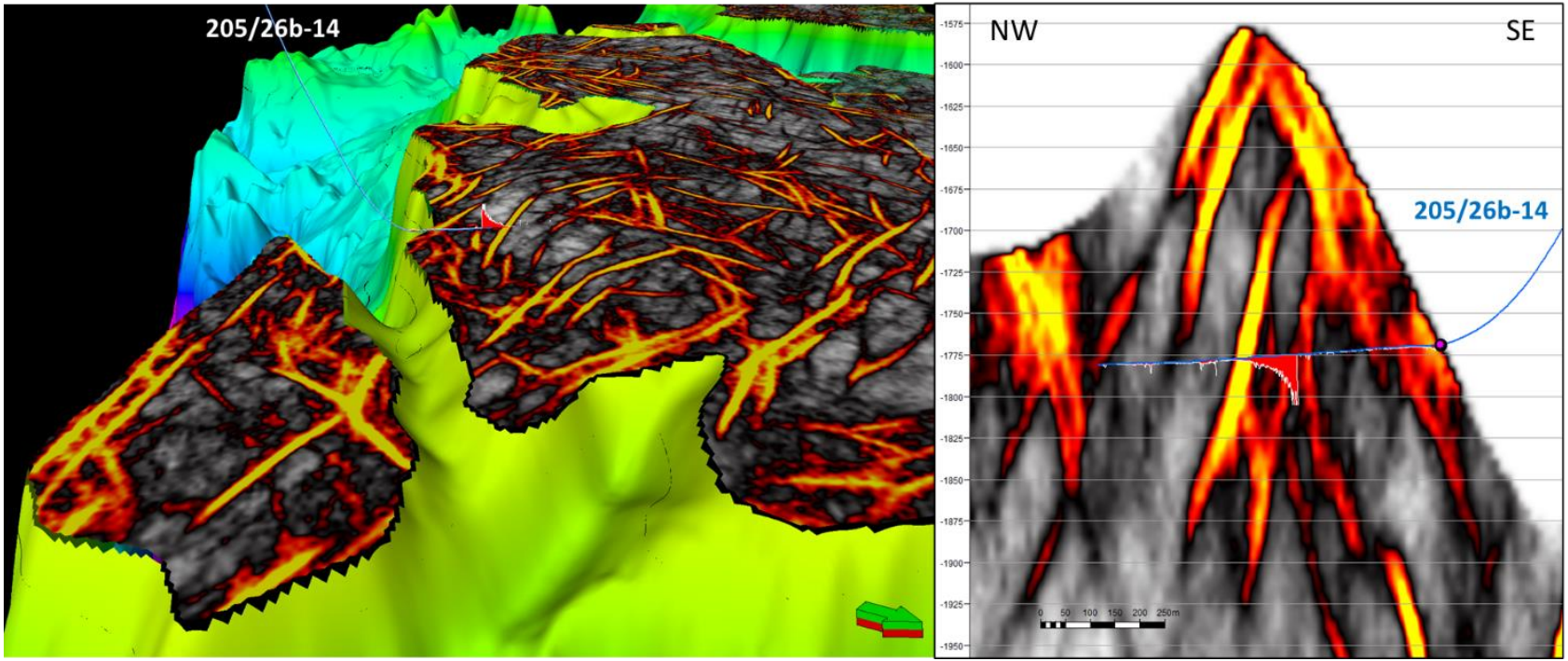


DI fault



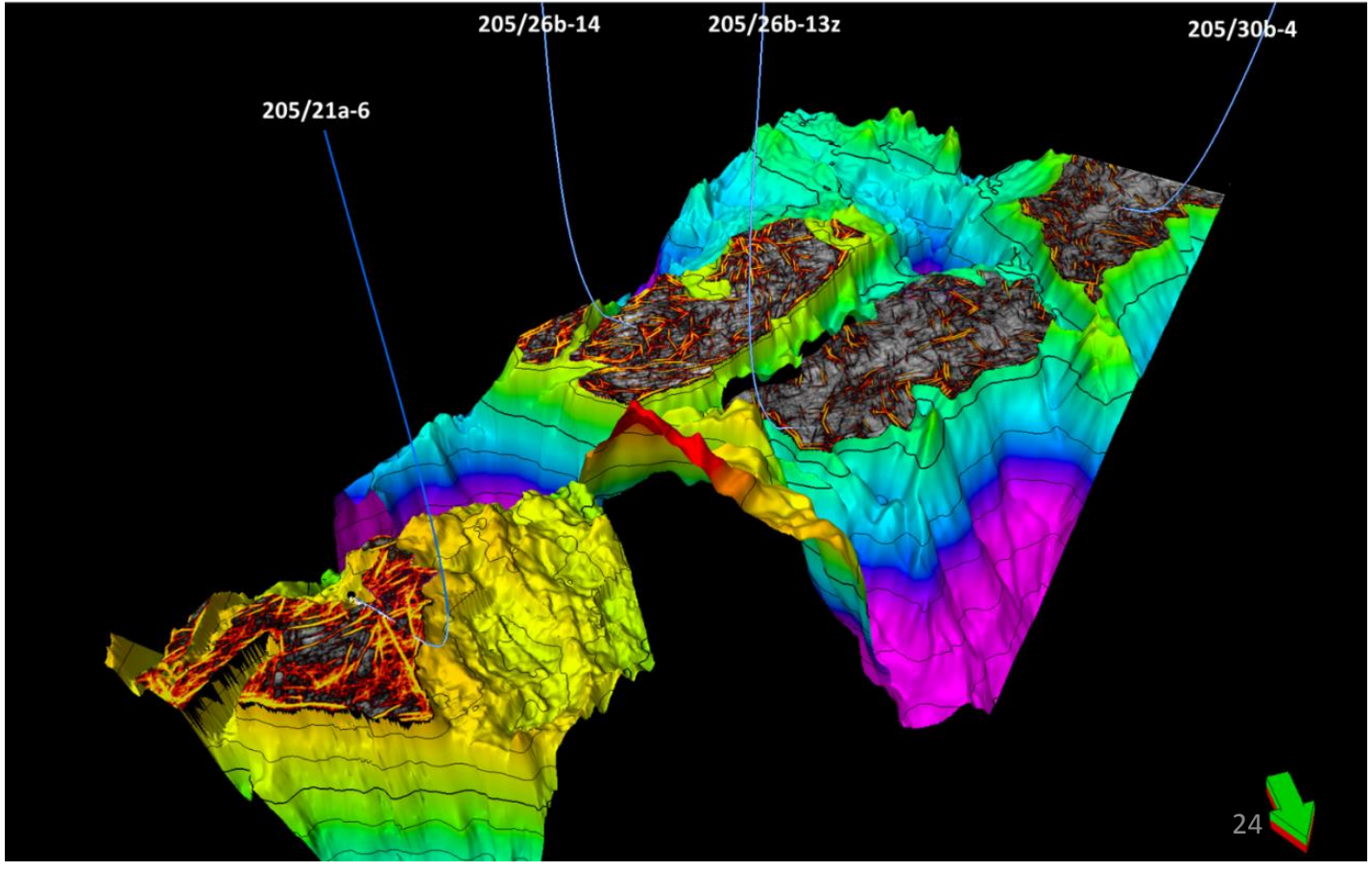
Diffraction imaging of the fractured basement reservoir

Use of the total Gas log to identify open fractures and inflow locations along a horizontal well



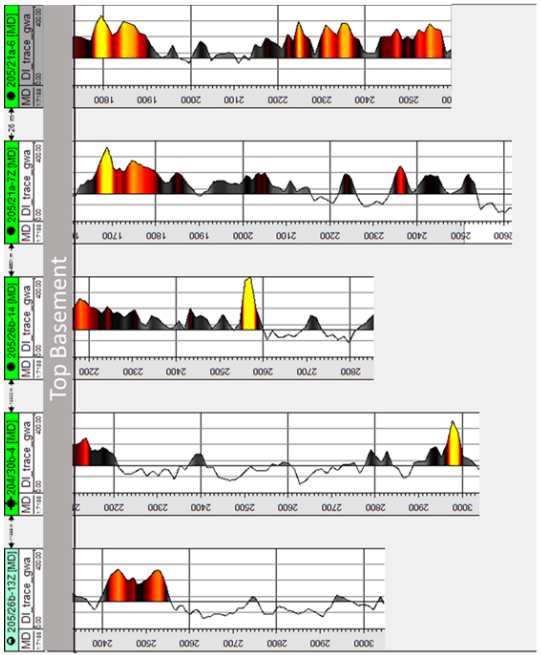
Diffraction imaging of the fractured basement reservoir

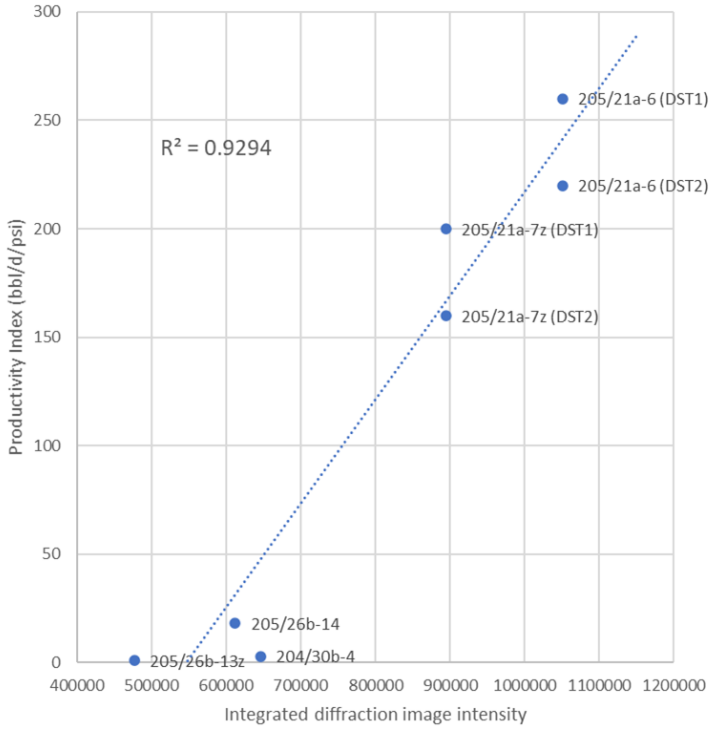
Basement depth surface with local structural crests removed to show DI depth slices locally extracted at the depth of the nearest horizontal well bore



Diffraction imaging of the fractured basement reservoir

Possible quantitative relationship between summed DI intensity along a well bore and the well's Productivity Index





Conclusions

- Analysis of the diffraction imaging volume alongside well data enhance the interpretational value of the seismic data.

- Diffraction imaging returns a higher resolution definition of subsurface discontinuities and reduces interpretational uncertainties.

- Diffraction pattern correlates very well with the observed production behaviours of the wells drilled to date - it will facilitate the placement of new wells and their trajectory design.

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