Examples of multi-azimuth imaging and some thoughts on how to analyse the potential uplift

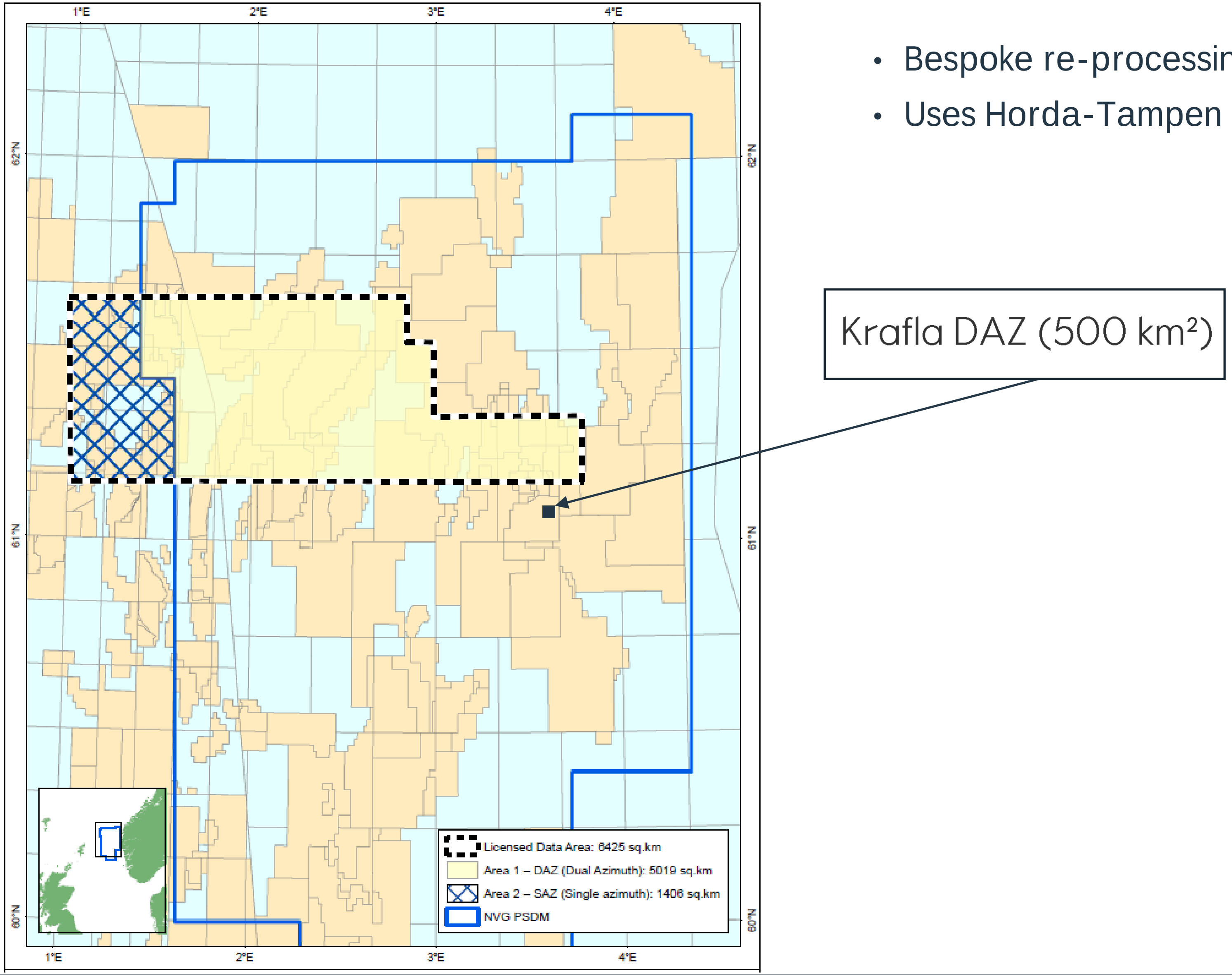
7th June 2022

Mark Rhodes
Leading Advisor Seismic Data Quality in Exploration
Equinor

Agenda

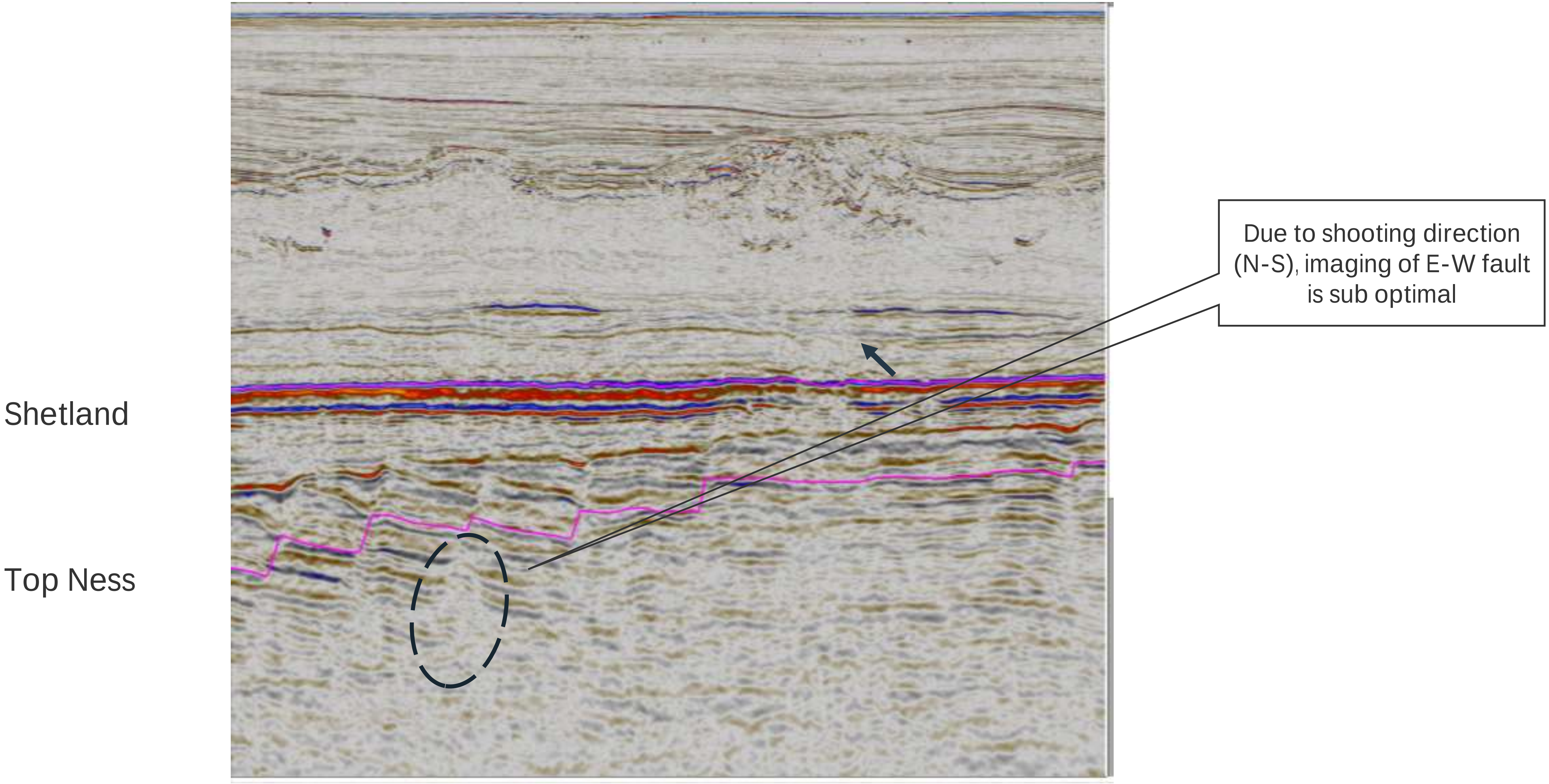
- Krafla DAZ reprocessing
- Gullfaks DAZ reprocessing
- Full azimuth offset coverage - DAZ v MAZ
- GeoX MAZ data quality comparison
- Martin Linge MAZ interpretation comparison
- Suggestions on how to find out if MAZ is a possibility and if it adds value

Krafla DAZ reprocessing



- Bespoke re-processing effort and velocity model build
- Uses Horda-Tampen CGG16001 and NVG05

Horda-Tampen single azimuth, CGG16001, Az = 0



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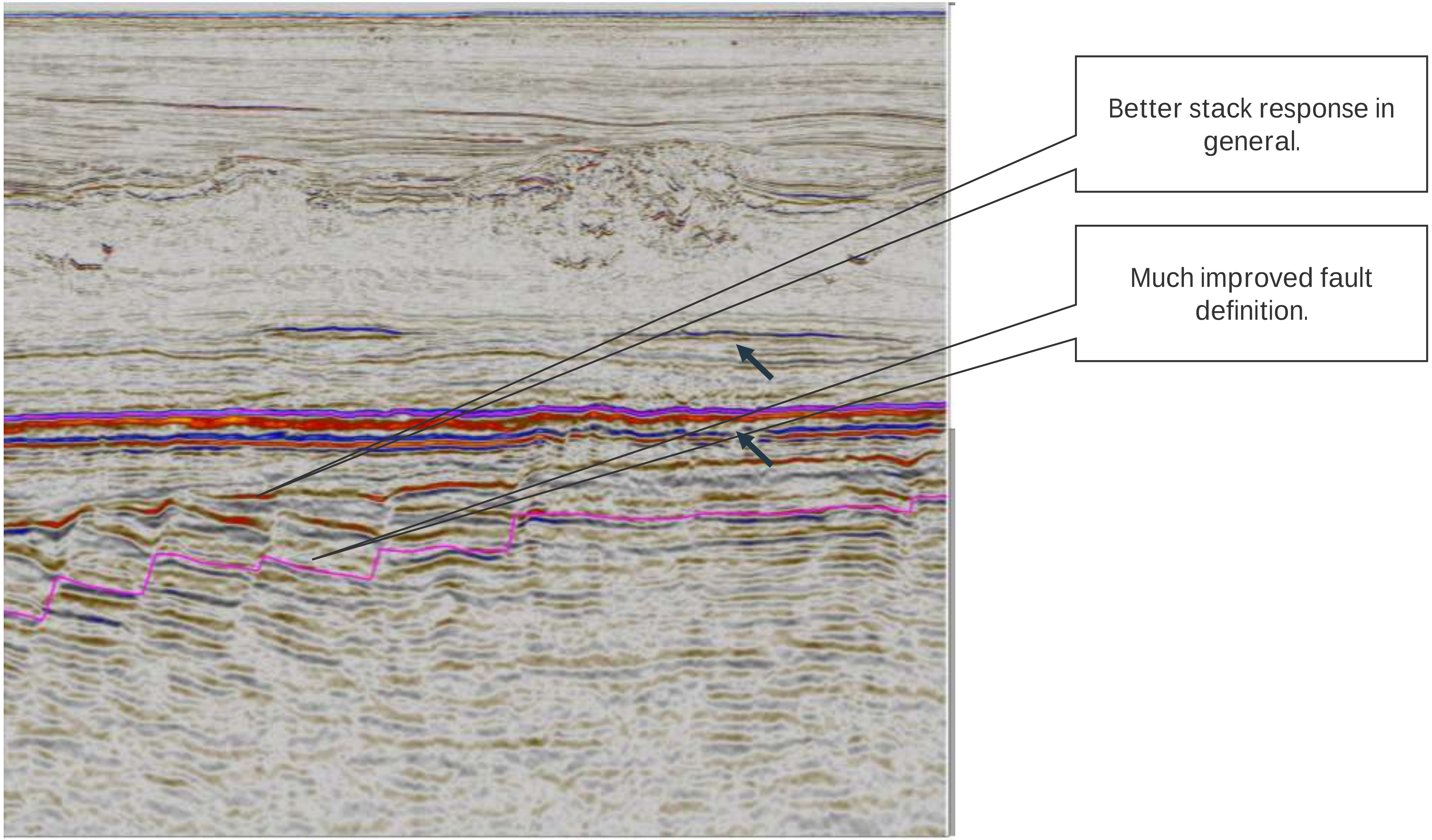
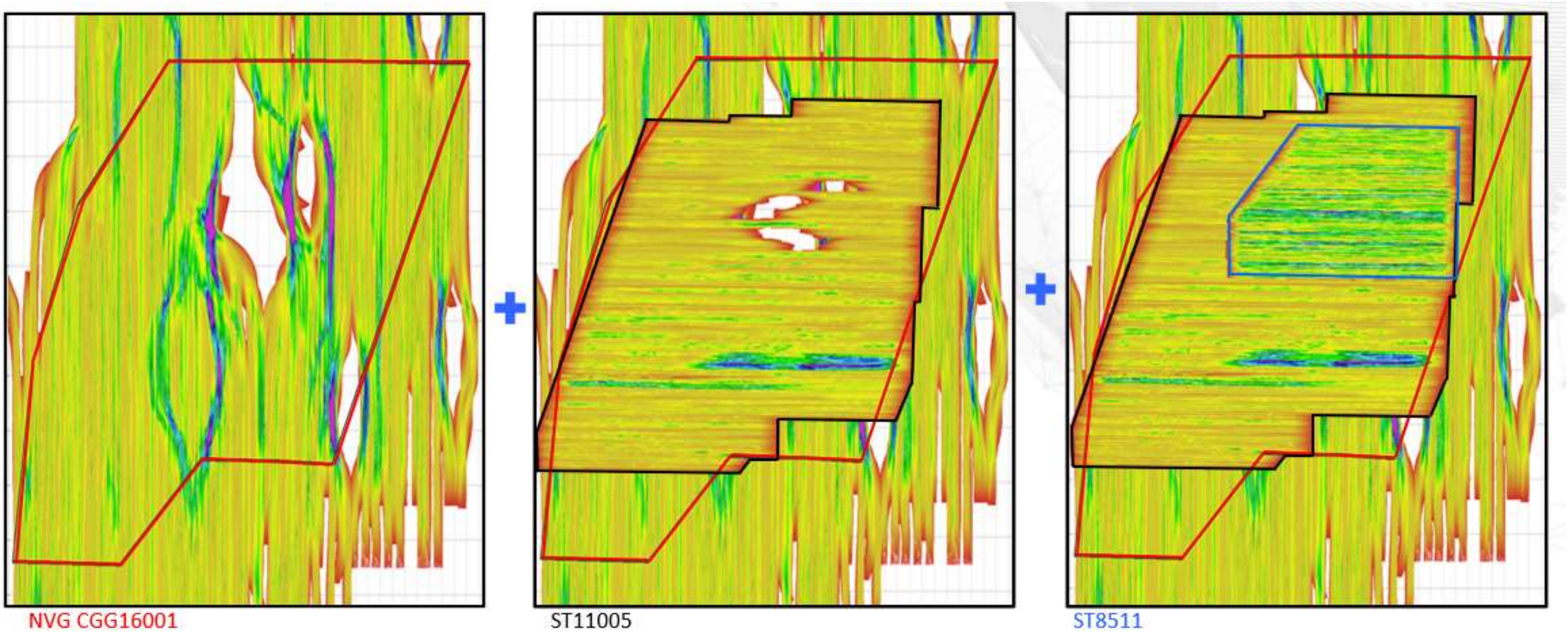
Krafla DAZ, CGG16001+NVG05 PGS, Az = 0, Az = 113

Each survey was migrated separately and combined via weighted stack



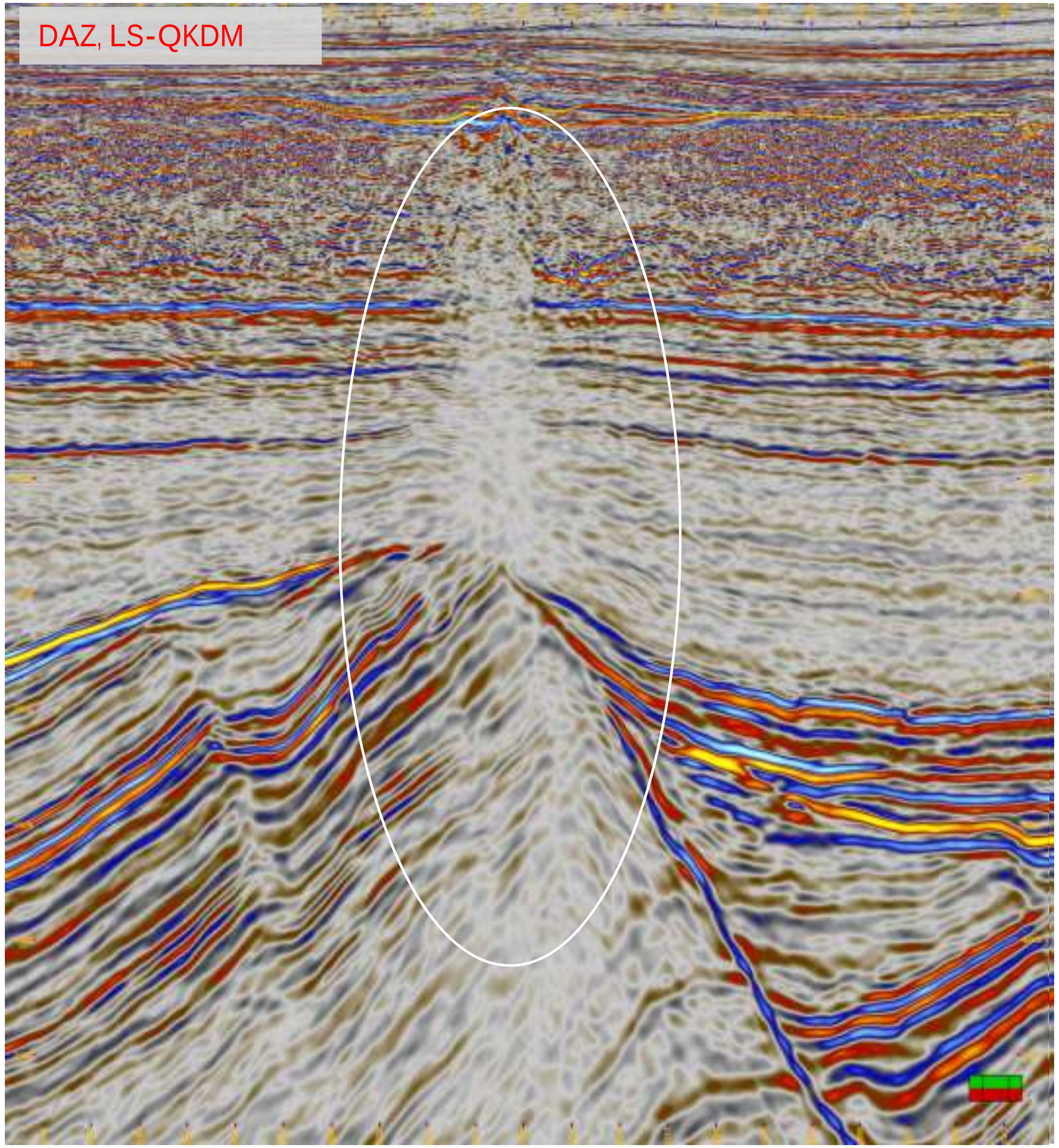
Gullfaks Dual Azimuth

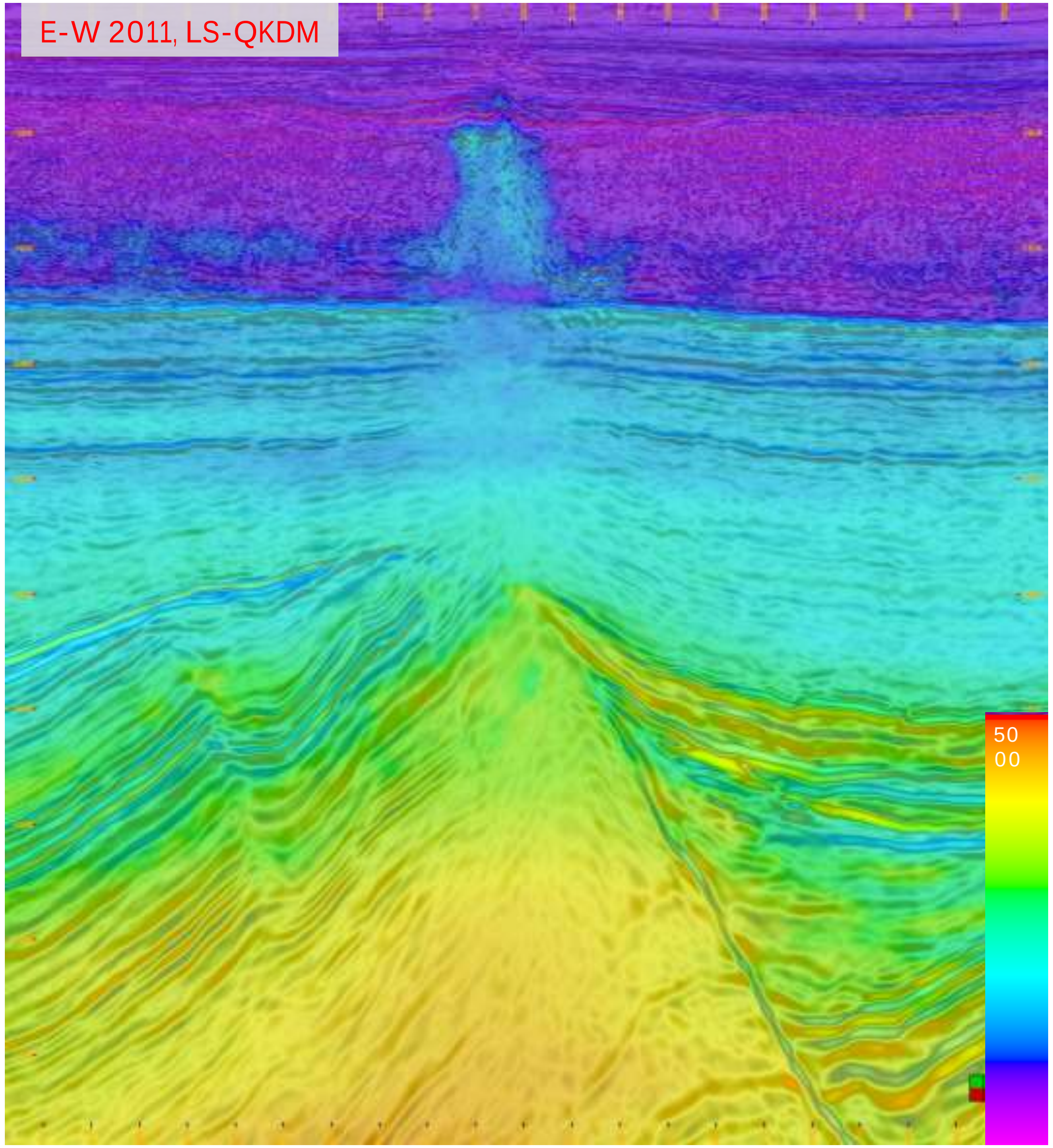


Dual Azimuth only valid where the CGG16 and ST11 overlap

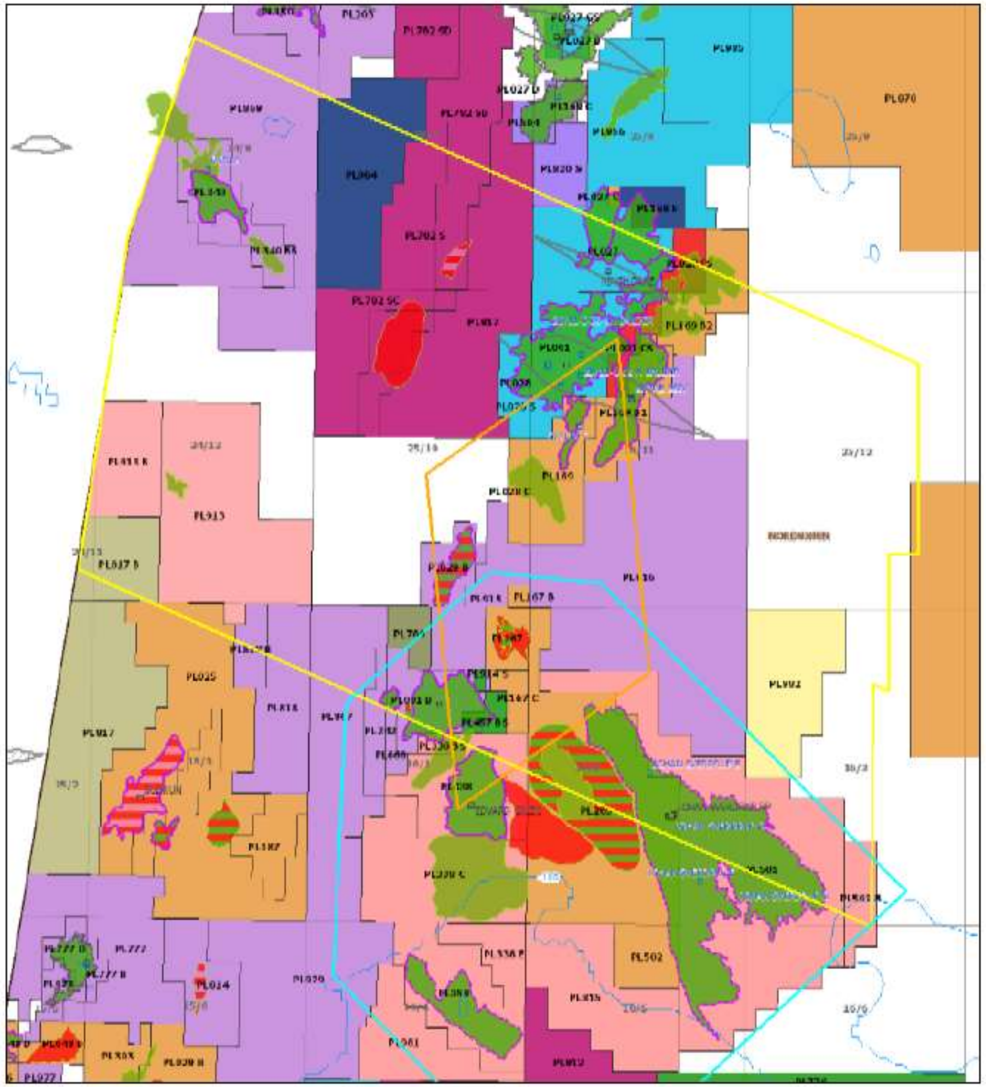
ST85 used to fill rig holes

Gullfaks DAZ Example

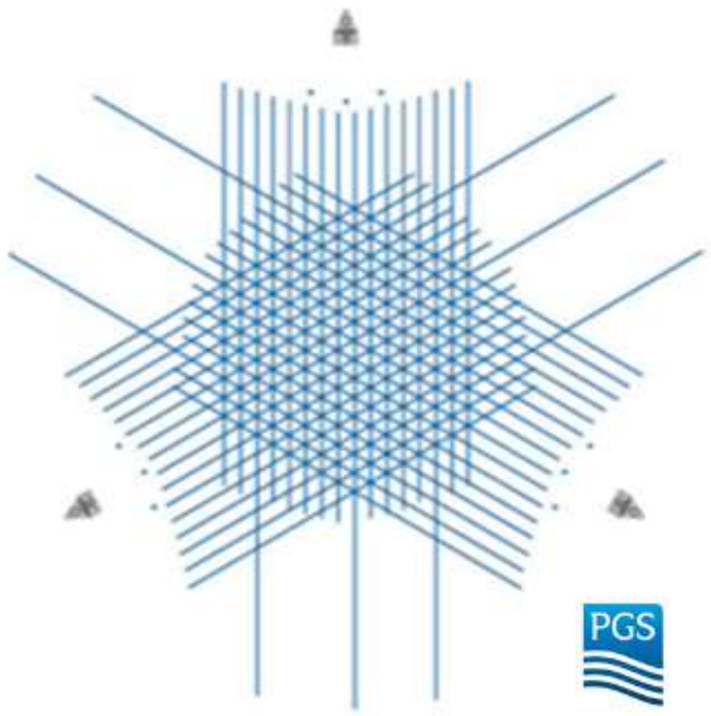




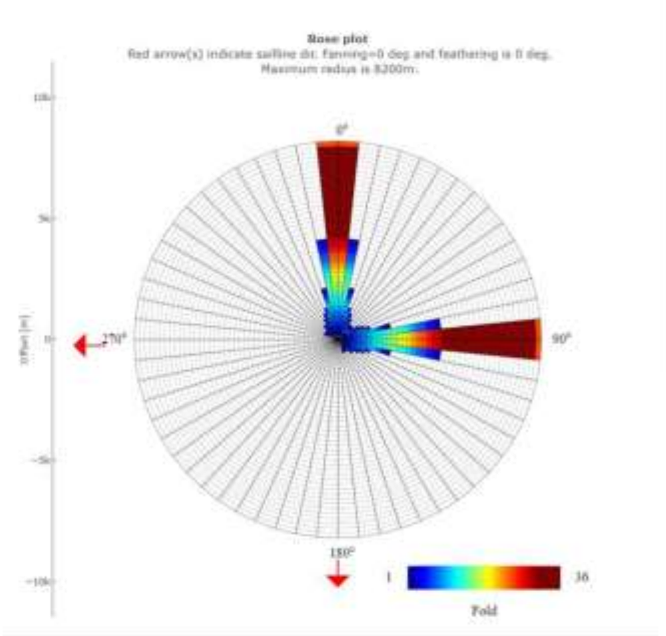
GeoX location map and surveys

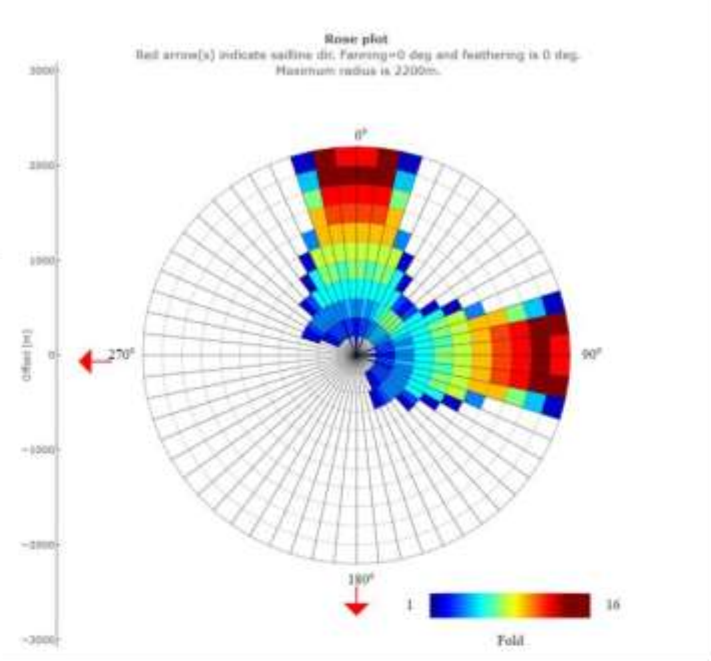


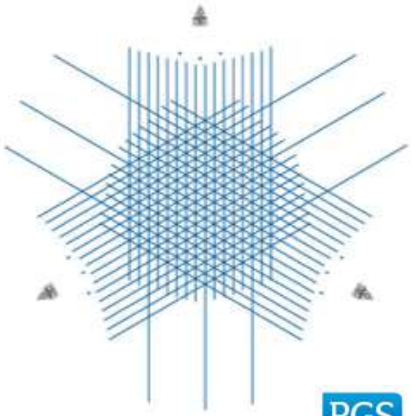
Area of Interest 545 sq km (orange)
MC3D-SVG11 (PGS15917) (yellow)
LN0902 (southern part) (blue)



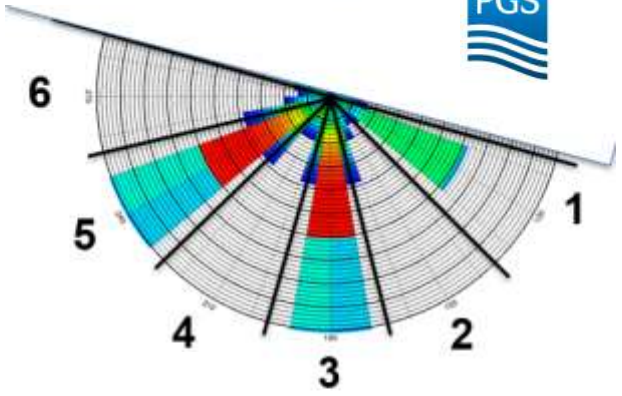
Dual Azimuth v Triple Azimuth Offset Distribution



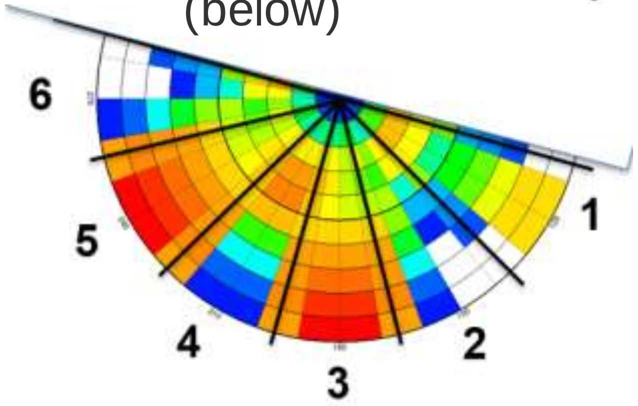


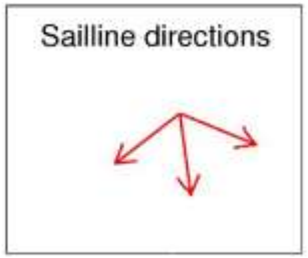


- 114 deg -> SVG11
- 144 deg
- 174 deg -> GeoX AZ1
- 204 deg
- 234 deg -> GeoX AZ2
- 264 deg



Rose diagram:
Offset inc. 200m
Offset zoom 10000 (right) / 2000m (below)





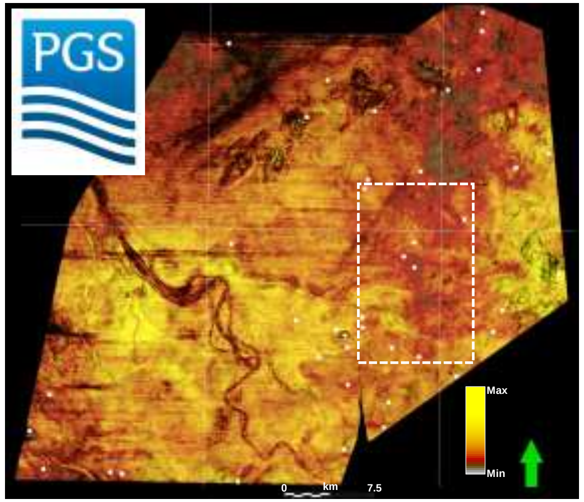
GeoX - Shallow amplitudes – MAZ versus single azimuths

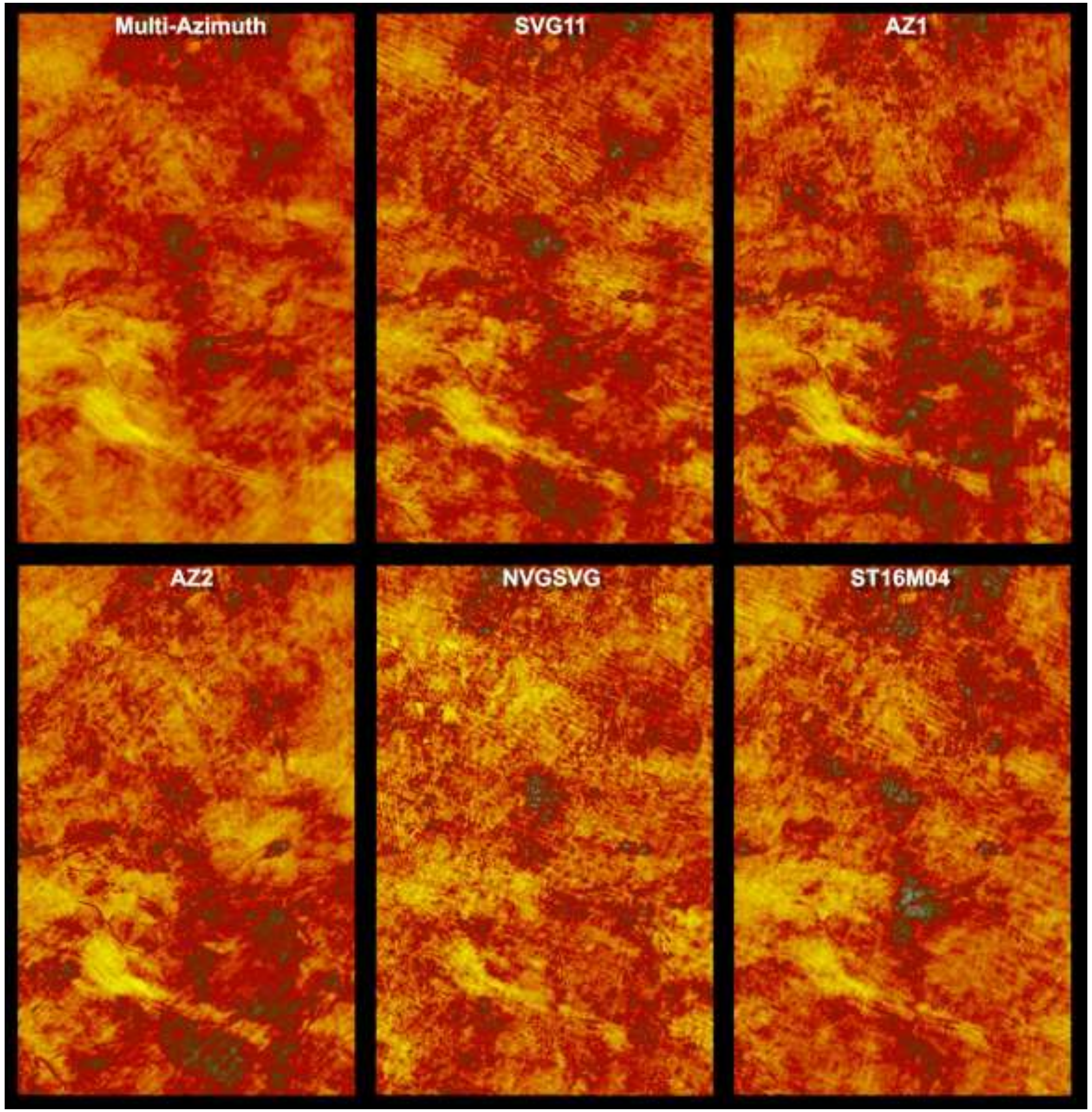
Comparing amplitudes at internal Utsira event:

- The best image is the Mutli-azimuth. Of the three input azimuths (SVG11, AZ1 and AZ2), AZ1 is the best
- The vintage surveys are of poorer quality; particularly the NVGSVG survey

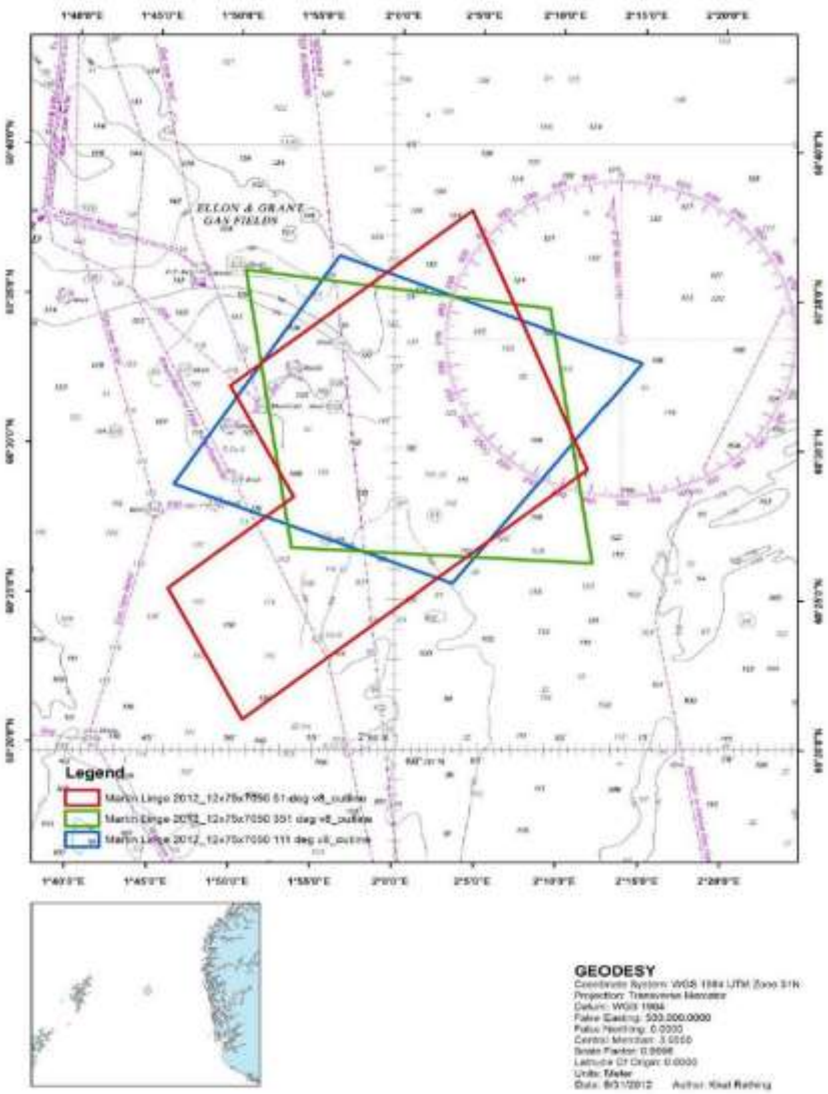
Survey & Interpretability / Quality

MAZ	SVG11	AZ1	AZ2	NVGSVG	ST16M04
Very good	Good	Good	Good	Poor	Good



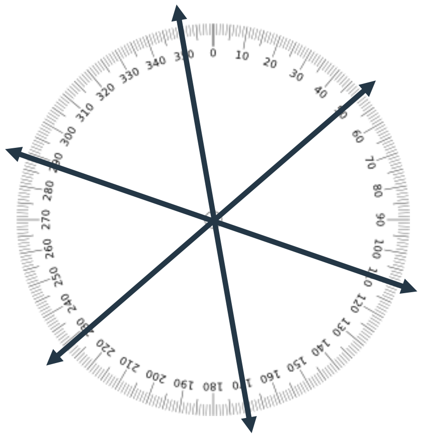


Martin Linge – the need to interpret all azimuths

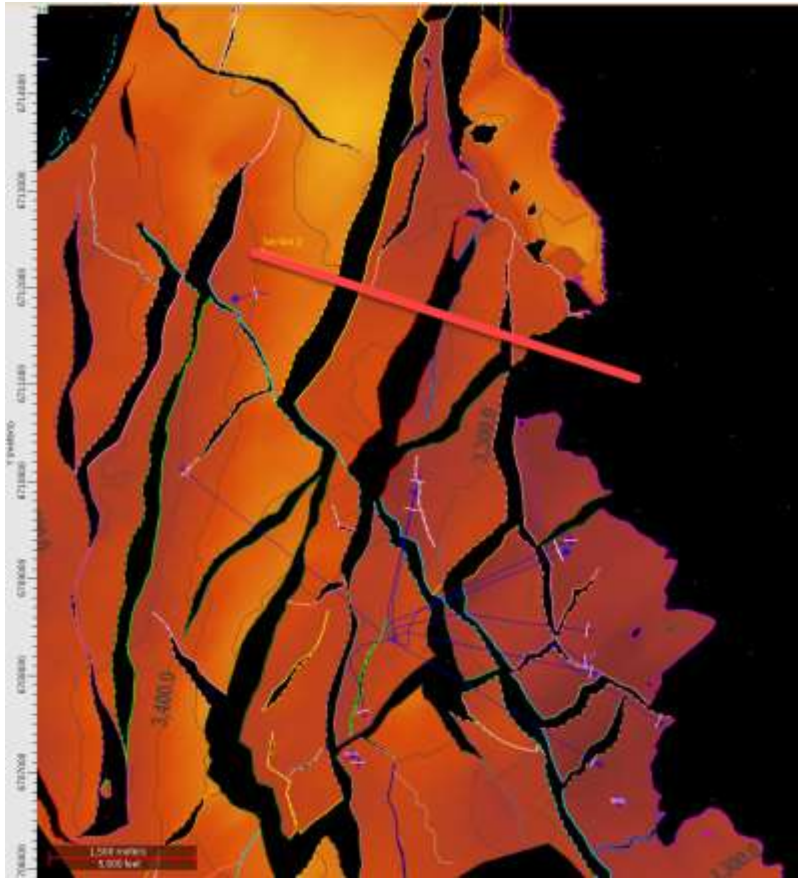


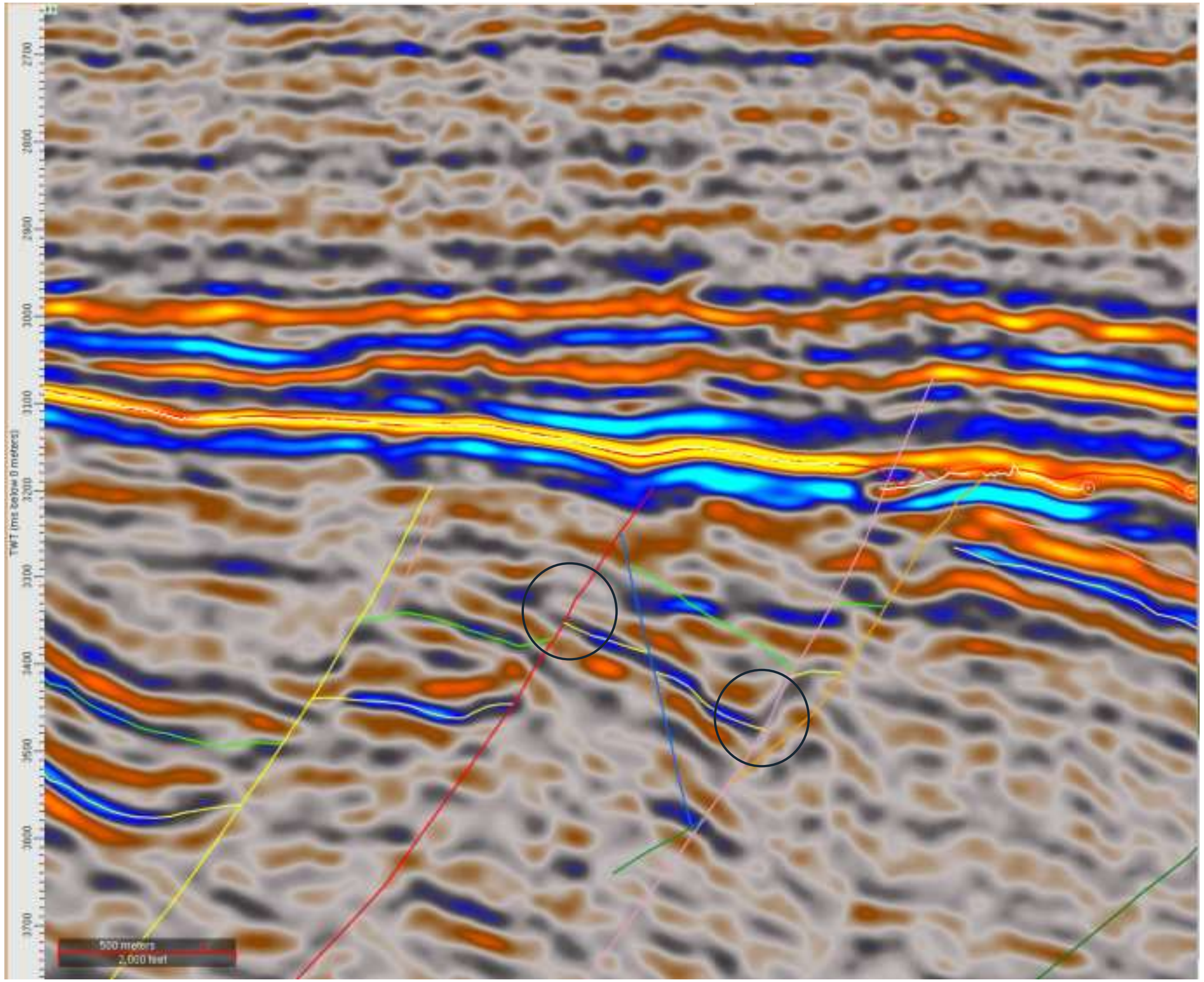
- 3 azimuths acquired
- Azimuths for fault intrerpretation are not what you expect
  - In some cases best fault and reservoir definition from data parallel to the fault

Herja Nord



Seismic section: West → East
Seismic cube: TO1301MLERQ18-Near MAZ





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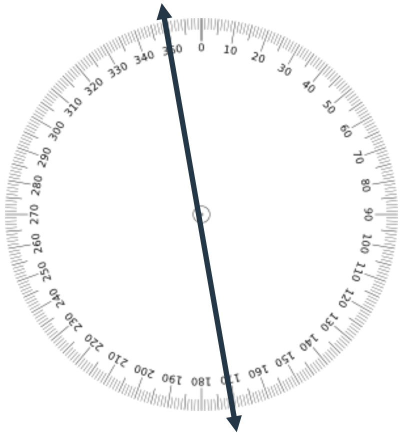
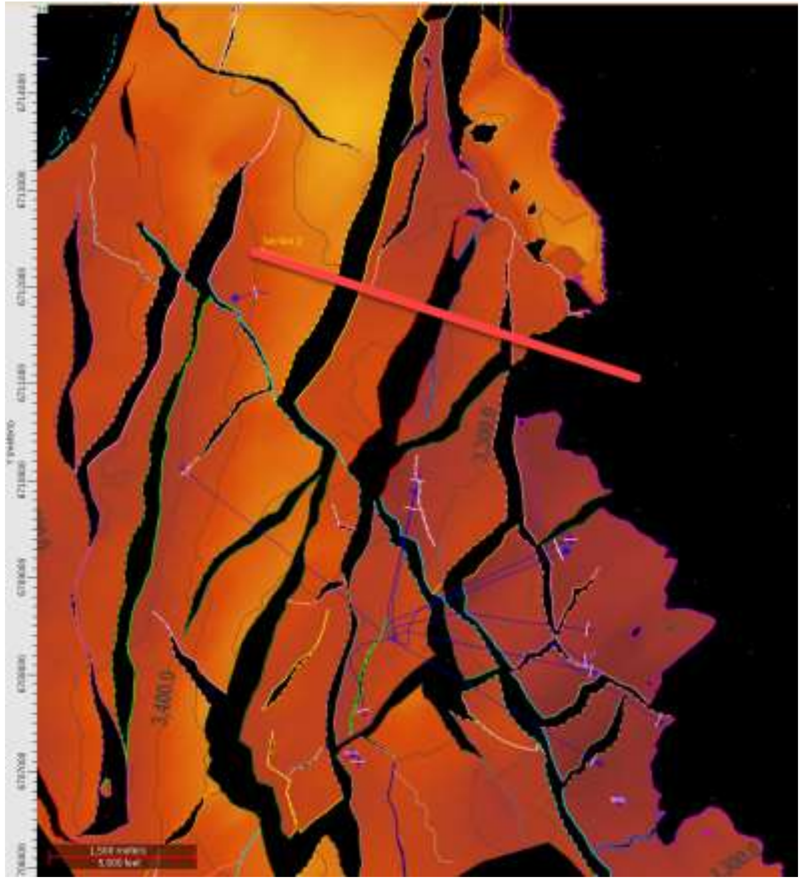
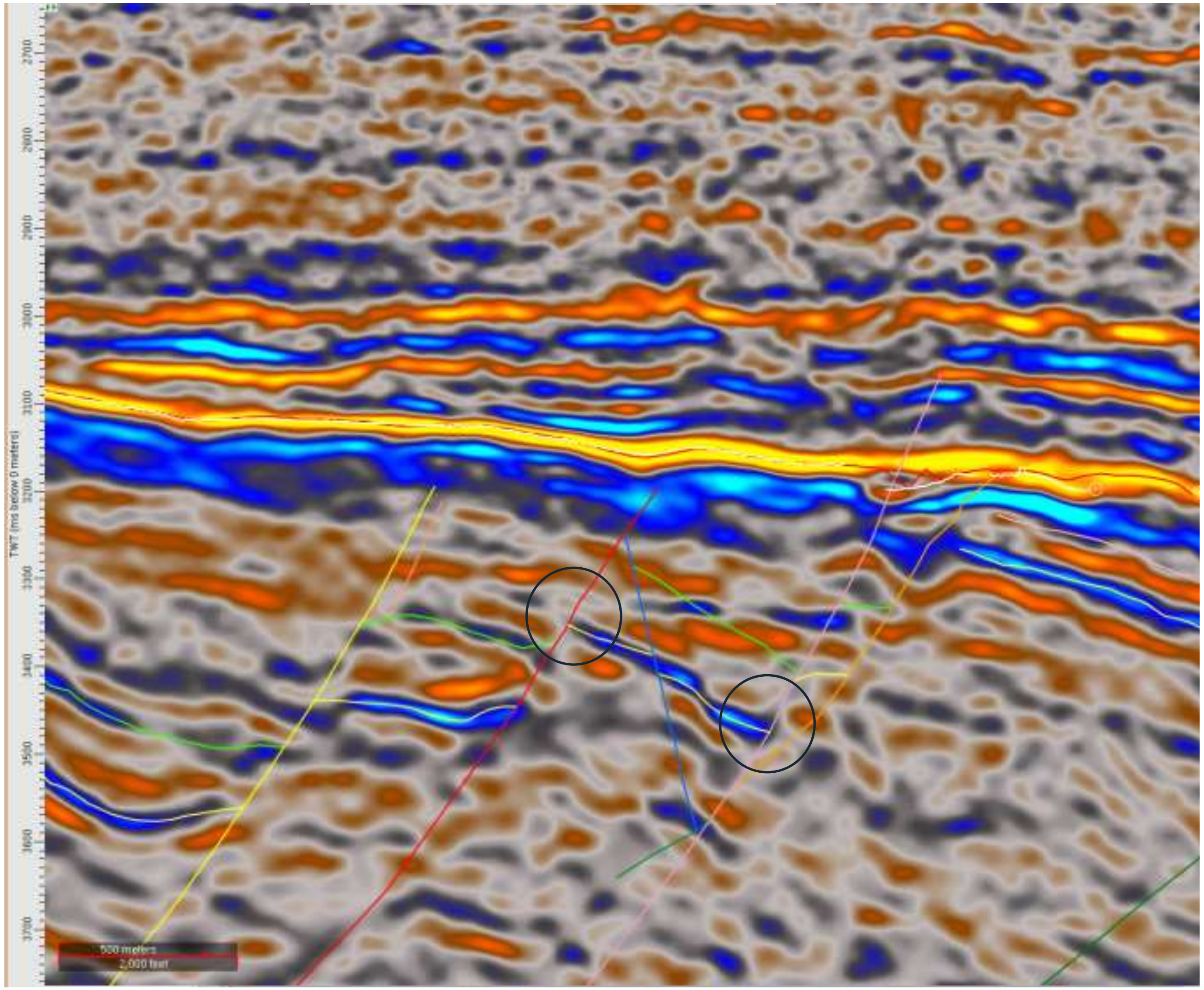




Seismic section: West → East
Seismic cube: TO1301MLERQ18-Near AZ351



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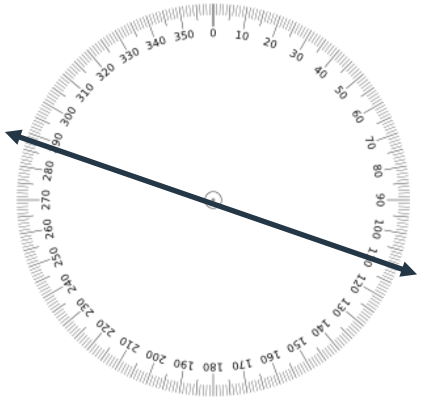
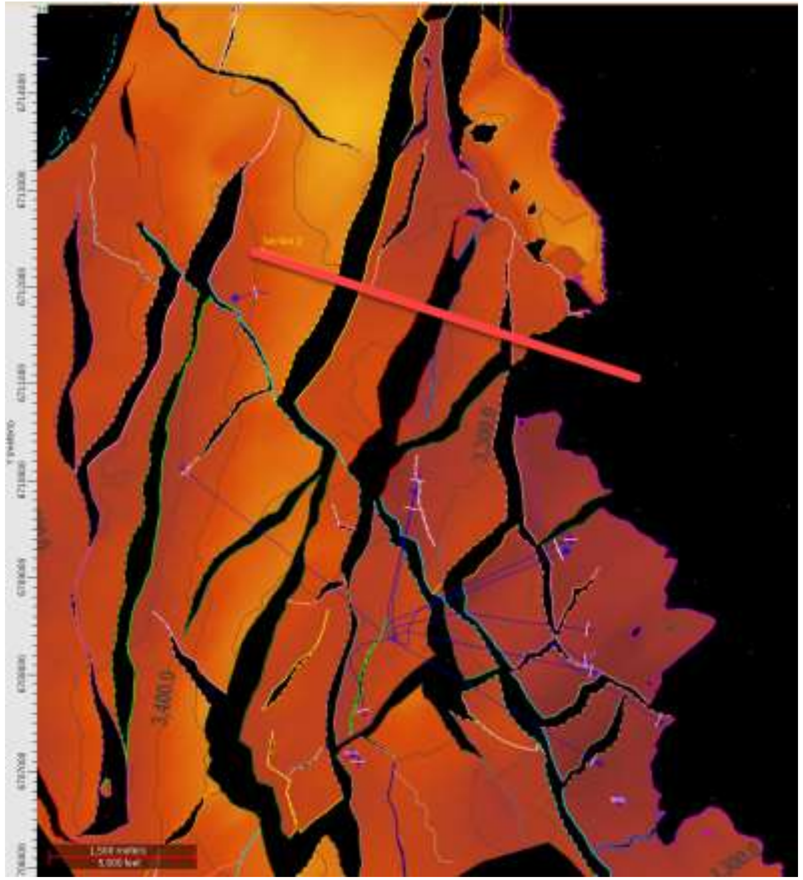
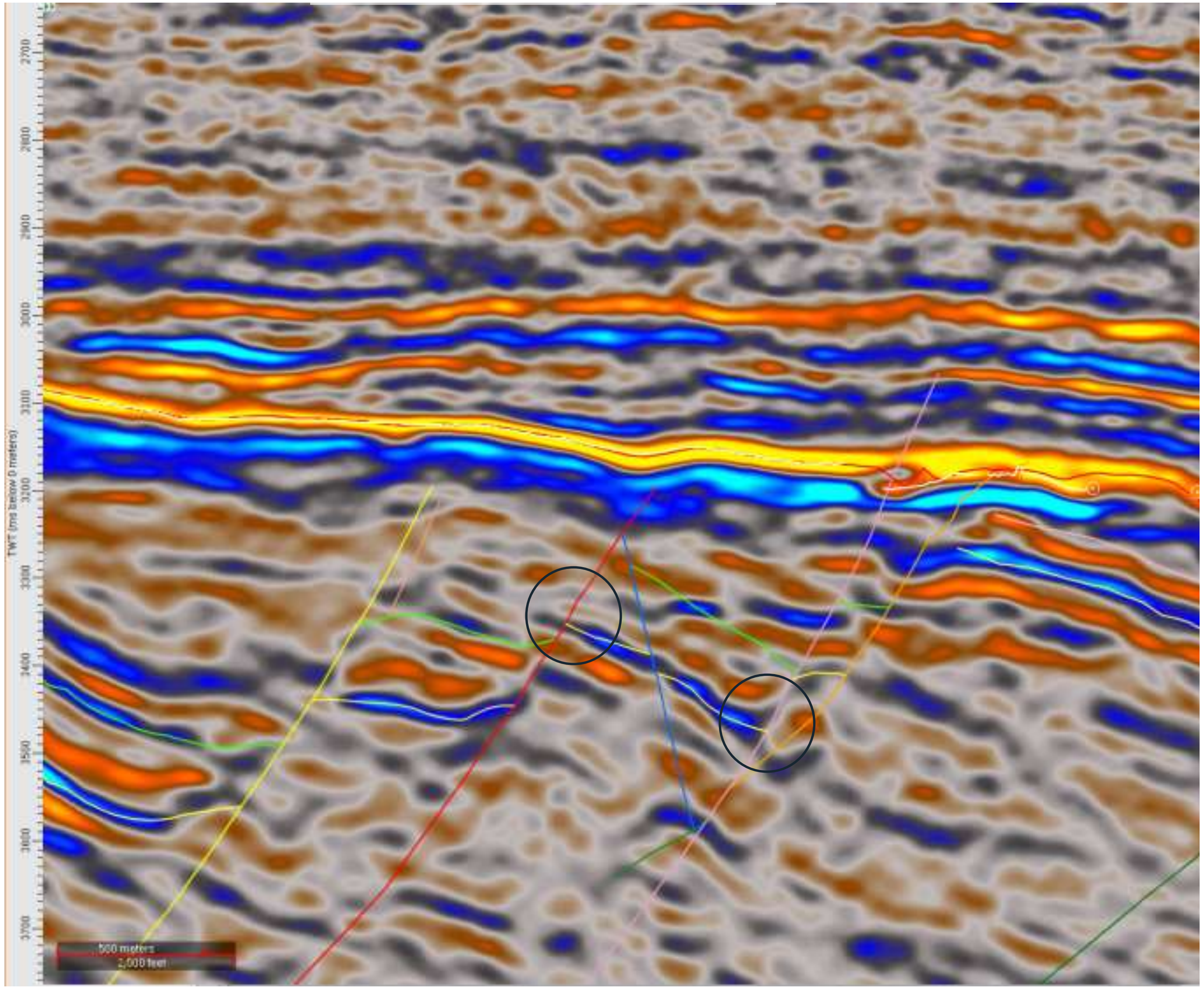




Seismic section: West → East
Seismic cube: TO1301MLERQ18-Near AZ111



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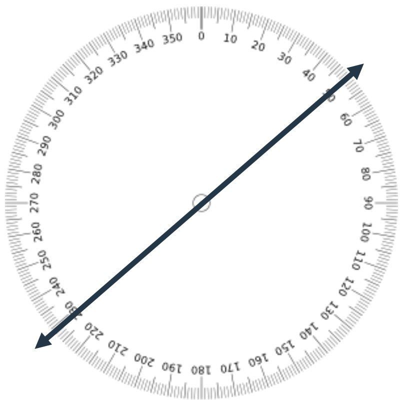
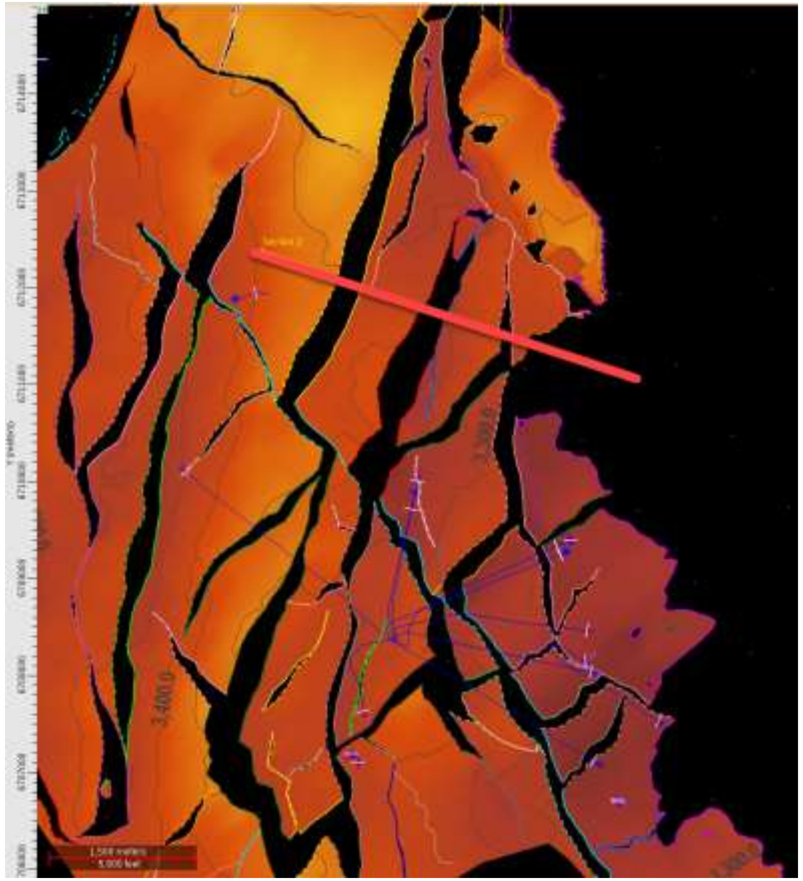
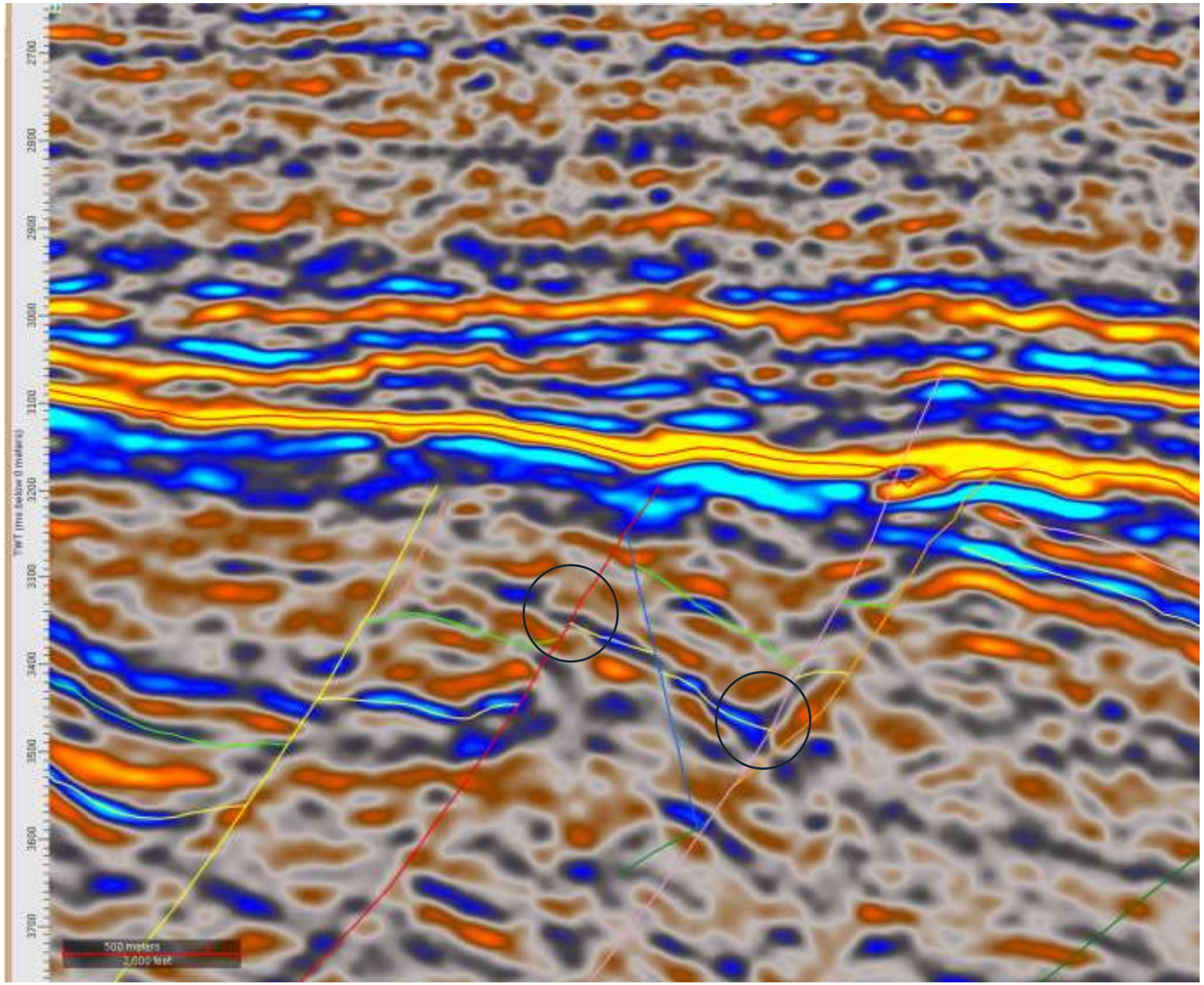


Seismic section: West → East
Seismic cube: TO1301MLERQ18-Near AZ051





Establishing suitability of data for a possible MAZ

- MAZ processing requires fundamentally data from different azimuths
- The NPD factpages are excellent for acquisition overview but they don´t contain
  - Th acquisition azimuth
  - The acquisition polygon (the polygon provided includes turns)
- The lack of this information requires companies to build their own database of polygons with all the required information
- Only then is it possible to take an AOI shapefile and list all the data that cover it and their respective azimuth
- To maximise the use of the seismic data on the NCS – some suggestions
  - Record the acquisition azimuth
  - Store the acquisition polygon, full fold polygon and migrated polygon

Using partitioned stacks to simulate potential MAZ uplift

TYPES OF VIPs – Cartesian

- Rectangular (Cartesian)
  - Specified by the number of bins in both the primary & secondary directions
  - Orientated relative to the 3D grid, **NOT** relative to north.

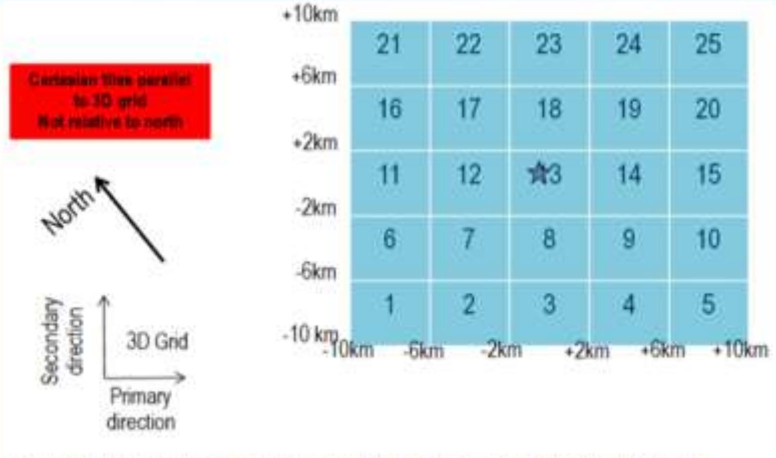
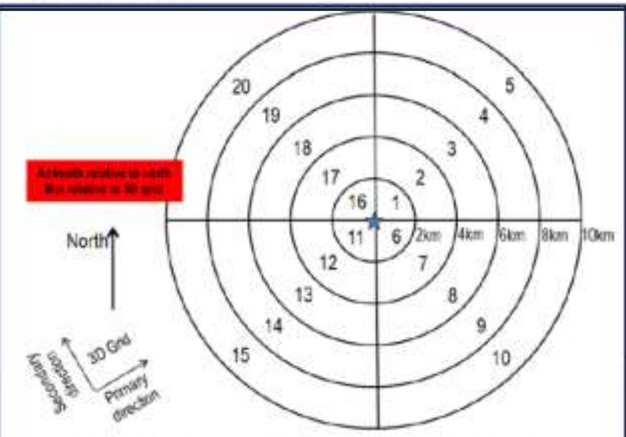


Figure 2. Cartesian VIP bins for a particular output (image) location. The binning is 5 x 5 (primary x secondary directions), with each bin 4 km in each direction.

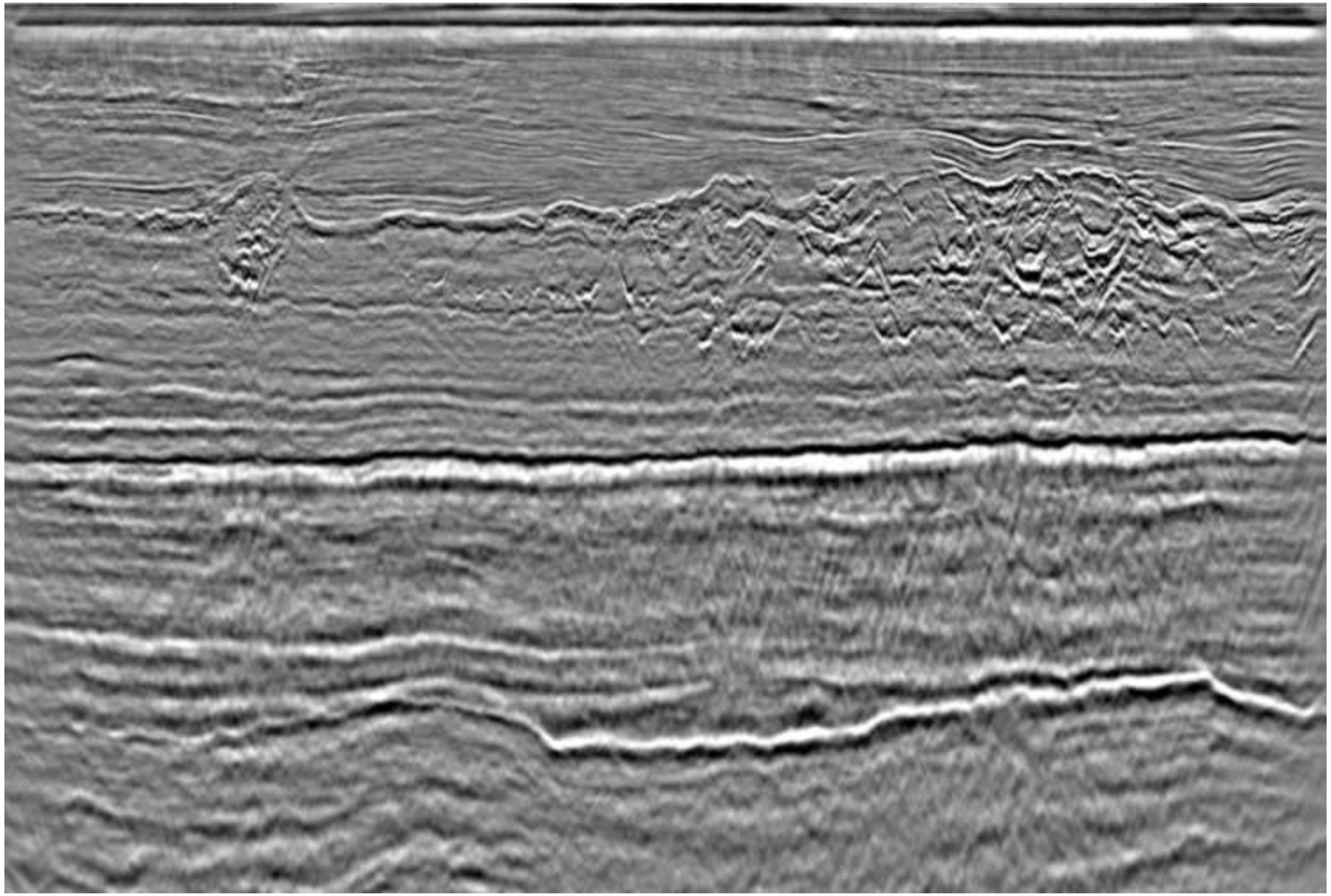
TYPES OF VIPs – Polar

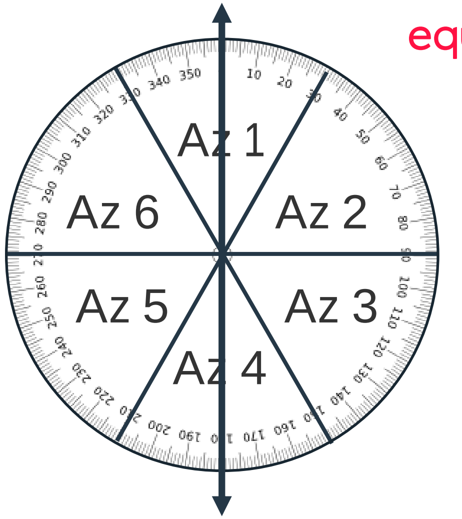
- Cylindrical (Polar)
  - Specified by the number of bins and the maximum distance for the bins in both the primary & secondary directions
  - Orientated relative to the North, **NOT** relative to 3D grid orientation.



Using Polar VIPs, allows the relative contribution of other data on different azimuths to be evaluated

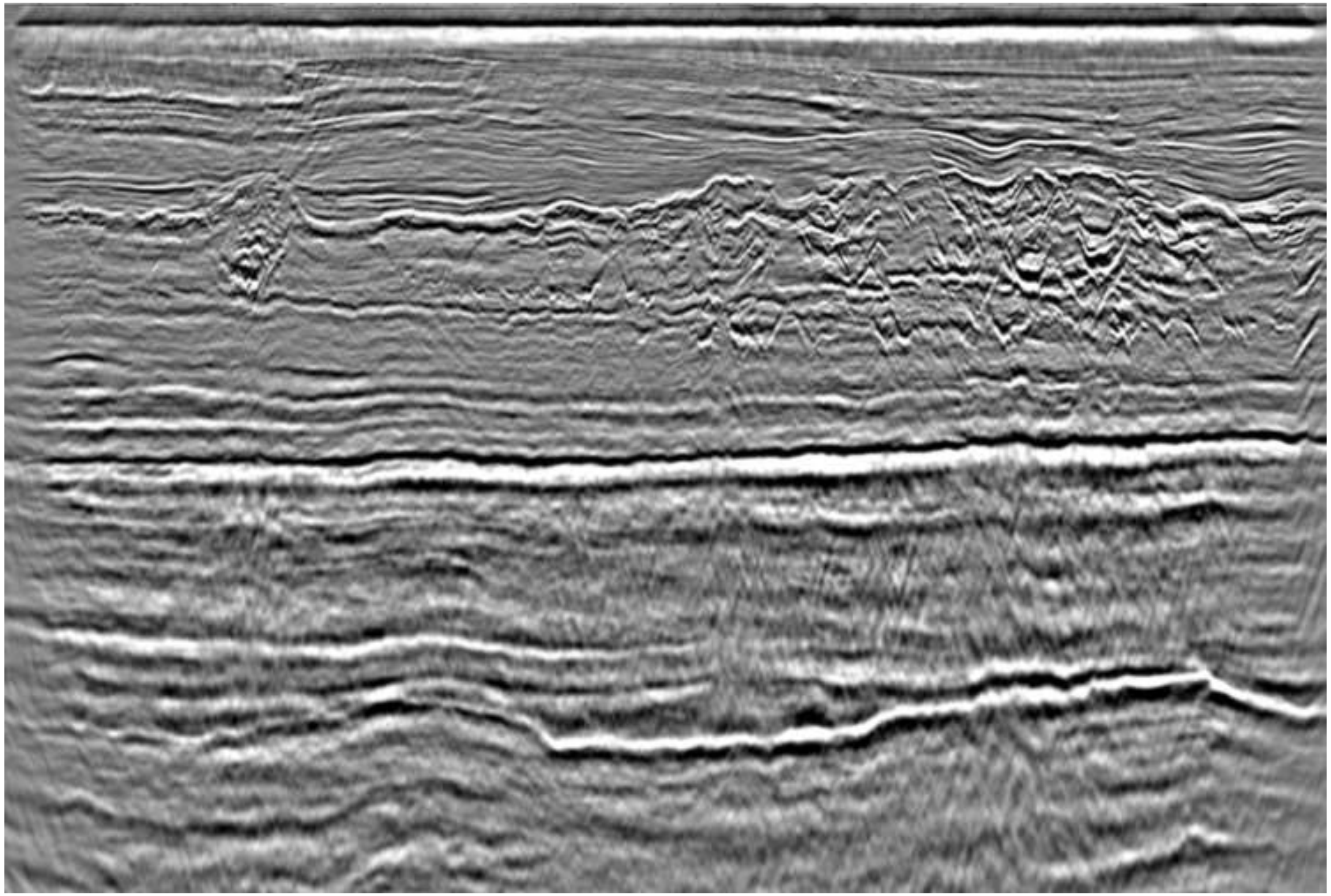
RTM Full Stack, CGG16001

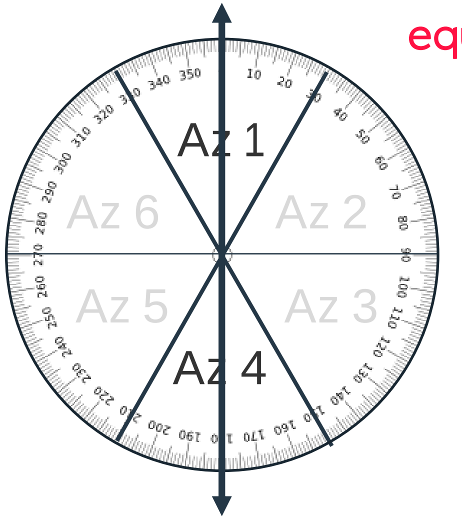




Acquisition direction N-S,
i.e. along Az1 – Az4

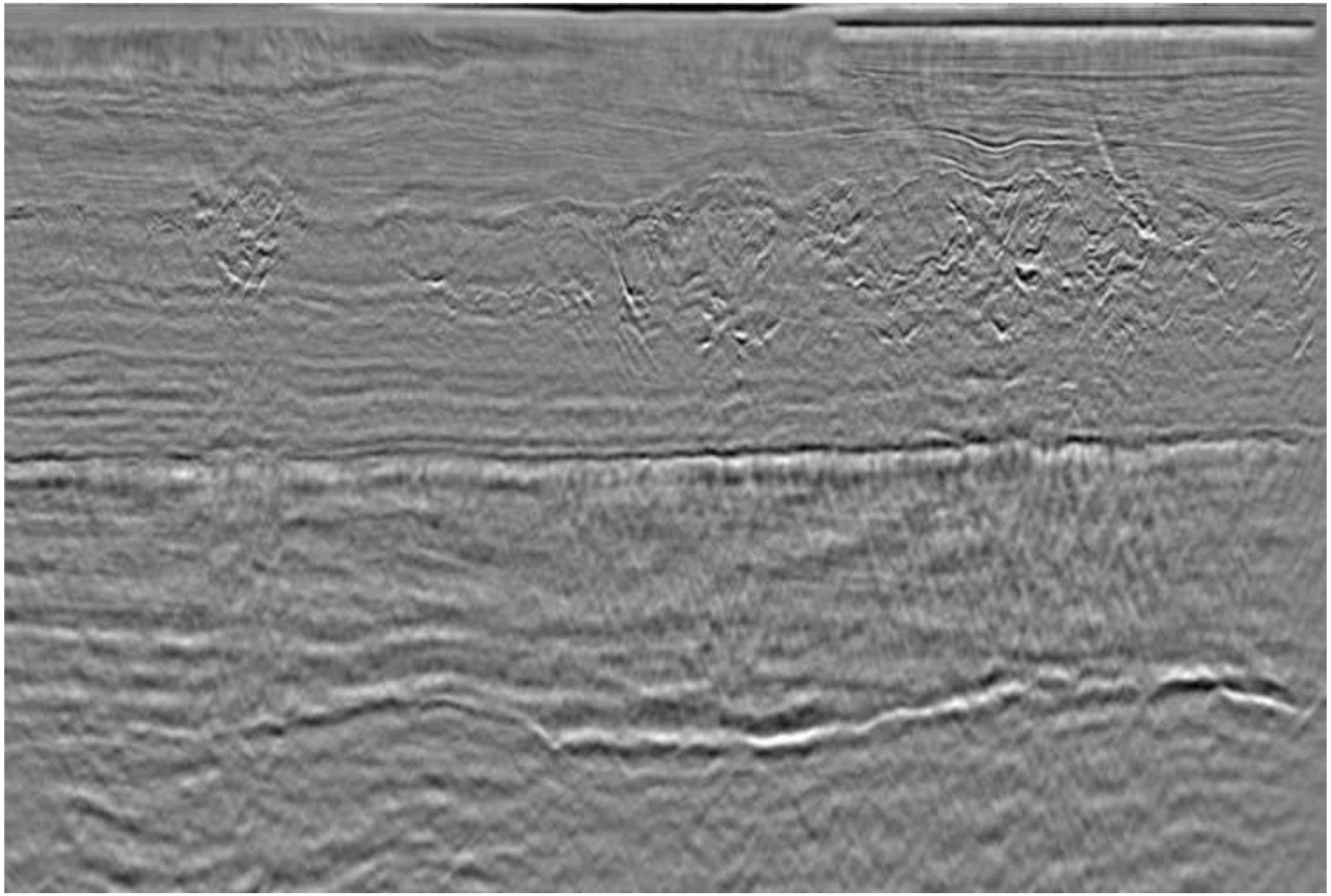
RTM Polar Vips Stack, Az 0/180

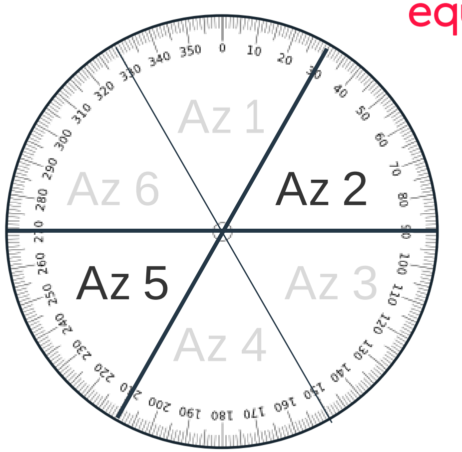




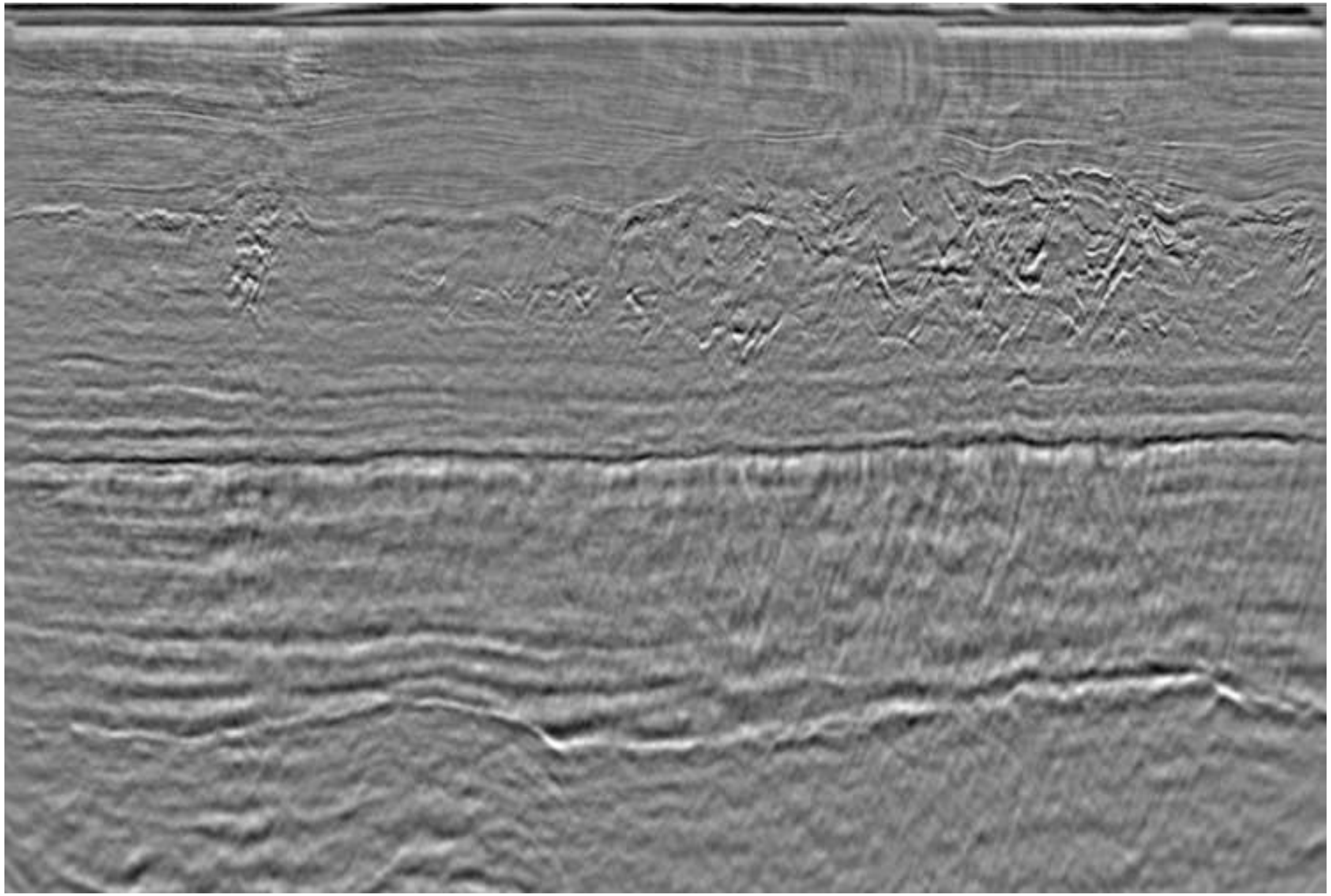
CGG16001

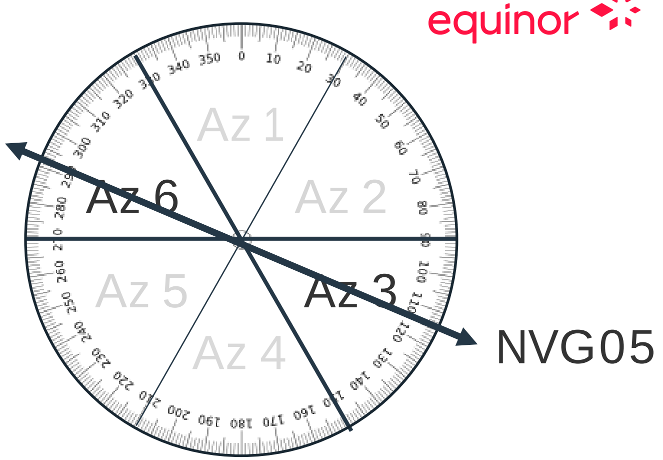
RTM Polar Vips Stack, Az 60/240





RTM Polar Vips Stack, Az 120/300





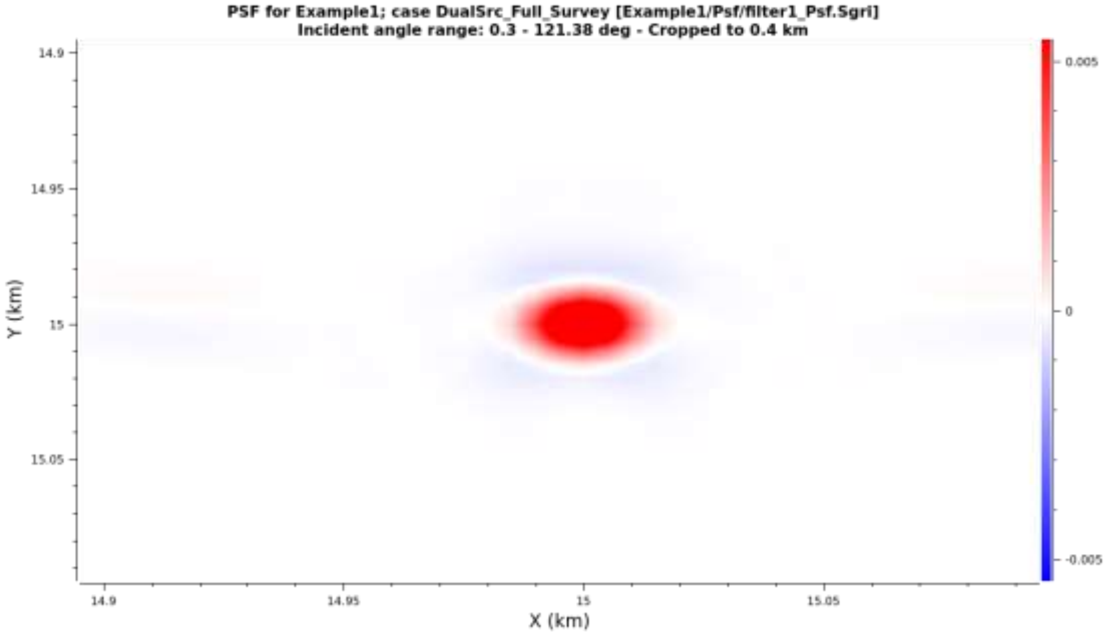
Point Spread Functions

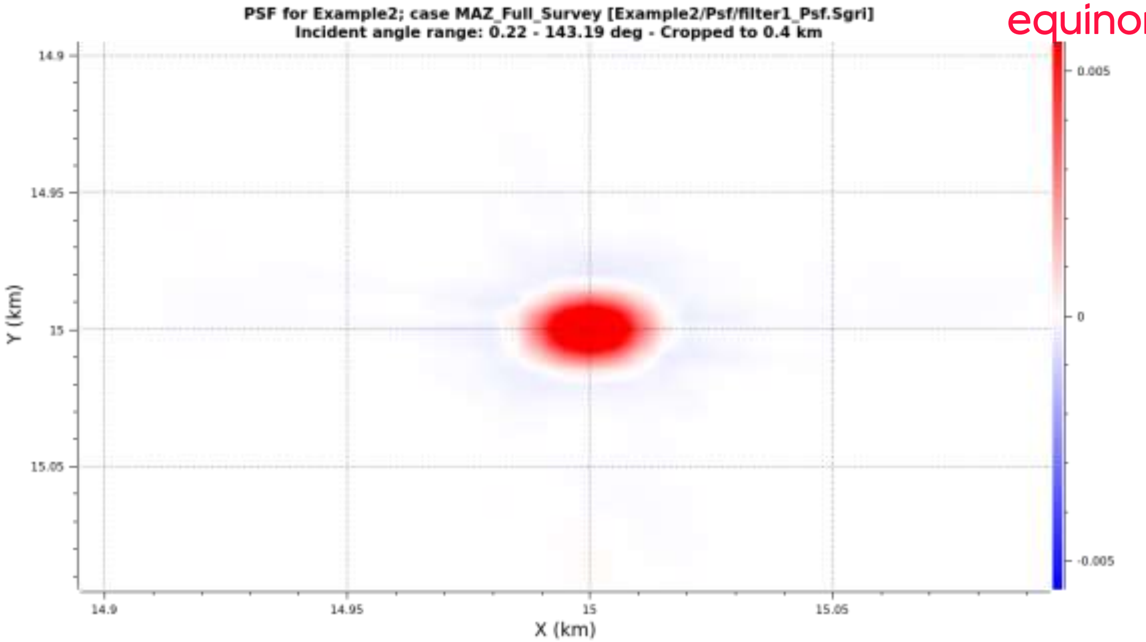
- Ability to test the effect of different acquisition geometries
- Possible to analyse the vertical and lateral resolution at the target level

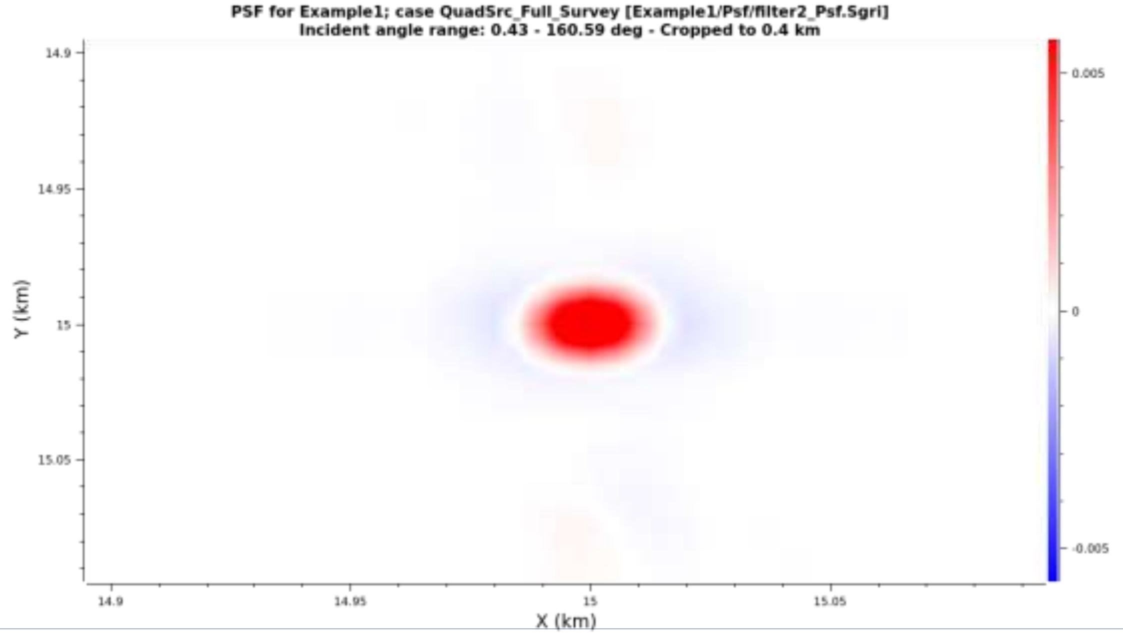
But

- There must be a good PSDM model available to generate representative wave propagation information to yeld meaningful results

Example use of PSFs







Acknowledgements

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Equinor Martin Linge, Petoro for permission to display the data from Martin Linge

PGS for permission to show their data
CGG for permission to show their data

Examples of multi-azimuth processing and how to analyse potential uplift

mrh@equinor.com