Seismic volcano-stratigraphic characteristics of the Jan Mayen Micro-Continent area and the possible distribution of volcanic intrusion complexes and hydrothermal vents.

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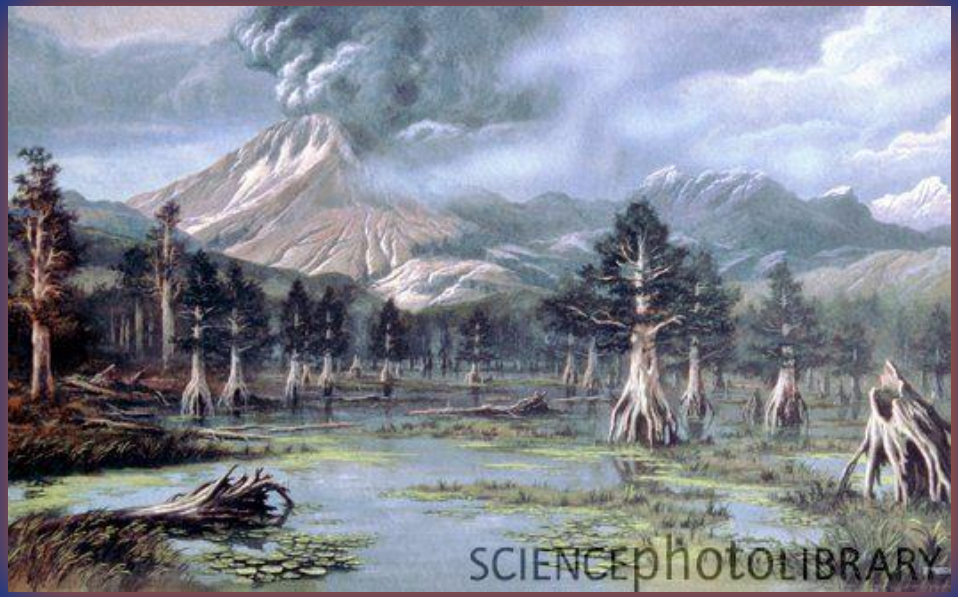

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Applying seismic volcano-stratigraphic in the Jan Mayen Micro-Continent area

… an ongoing & evolving study ...

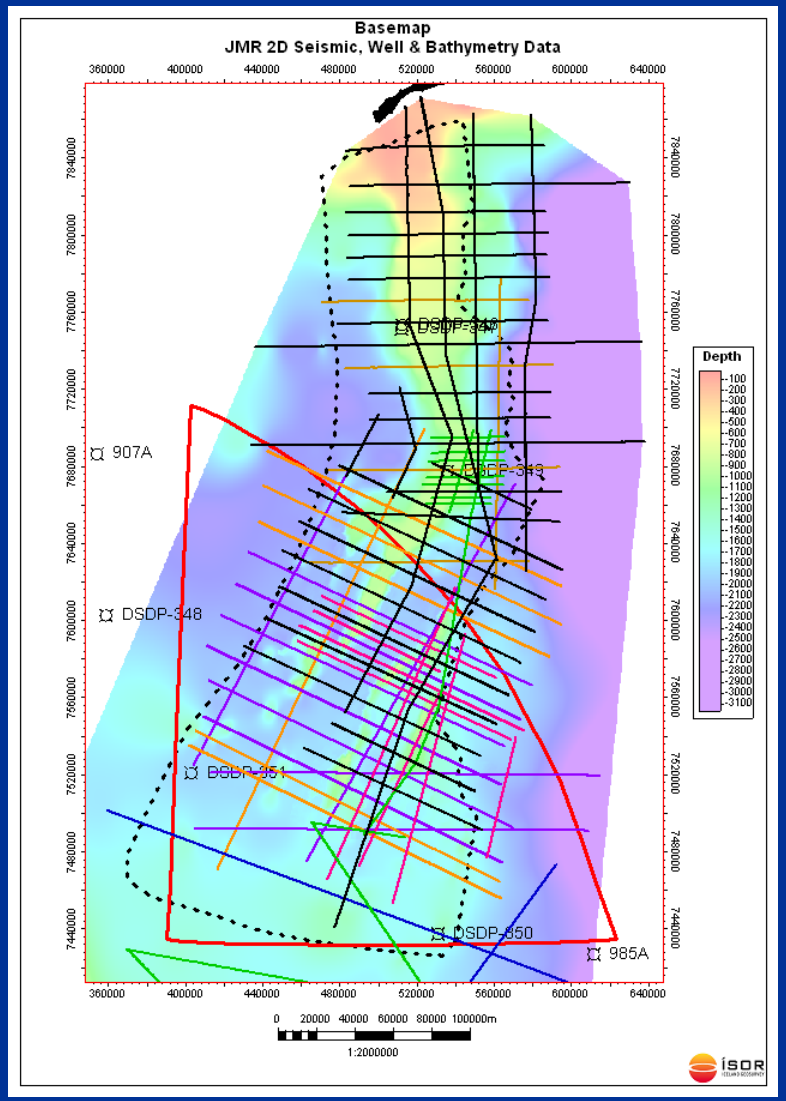
- Improved seismic and recent seafloor sample data make it possible to generate an improved stratigraphic / volcano-stratigraphic characterization.

- Importance of understanding the igneous features and characteristics of the area in regards to:
  - Understanding the structural model and processes.
  - Differentiating amplitude anomalies, what is igneous vs. stratigraphic, diagenetic or hydrocarbon related?
  - What groups and types of igneous complexes and features can be described?
  - What areas are specifically affected?
  - Conclusions in regards to the timing of the igneous events with the available data?

Seismic data

Bathymetry map, well & seismic data

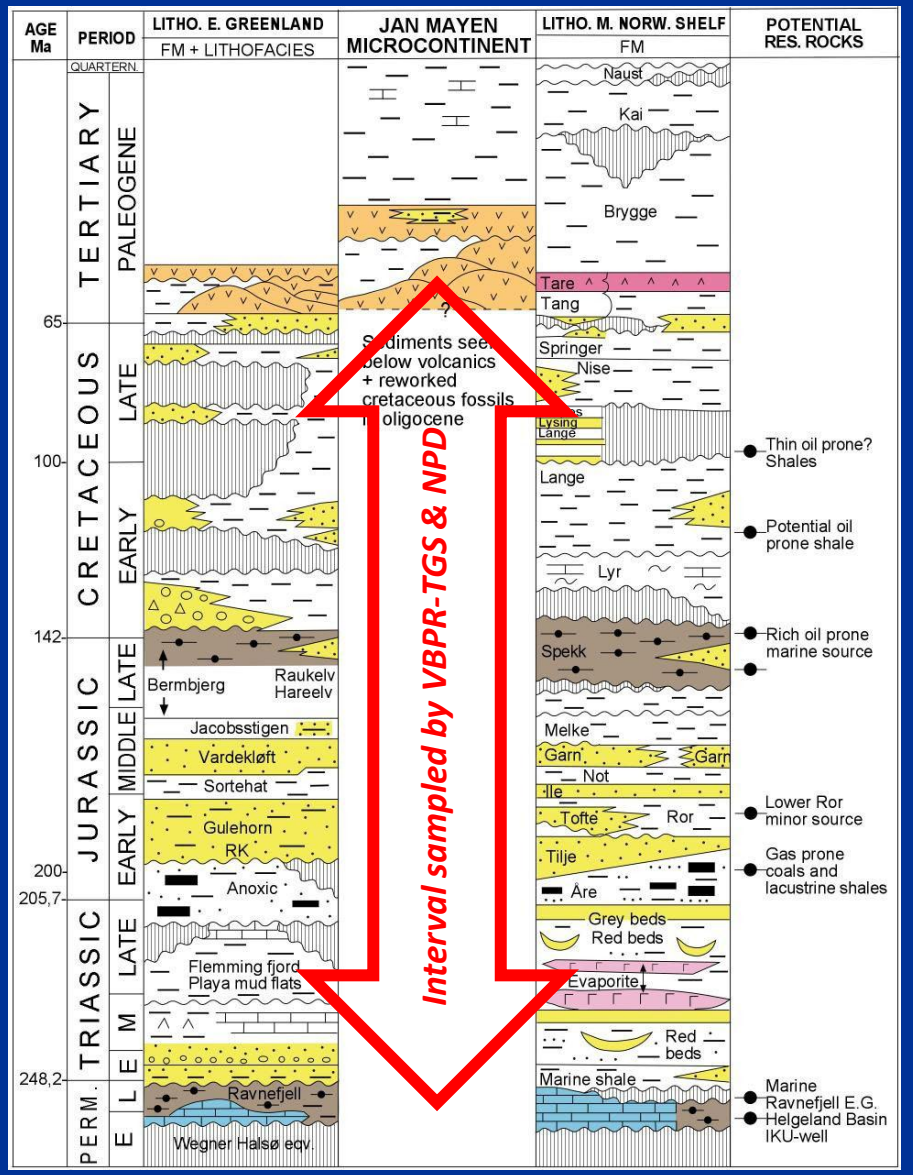
- JM-79
- JM-85 & data 2009 reprocessed
- JM-88
- IS-01-JMR
- IS-01-JMR 2008 reprocessed
- WI-JMR-08
- ICE-02



Stratigraphy

Sample campaign by NPD
&
1000m pseudo-well interpretation by VBPR / TGS

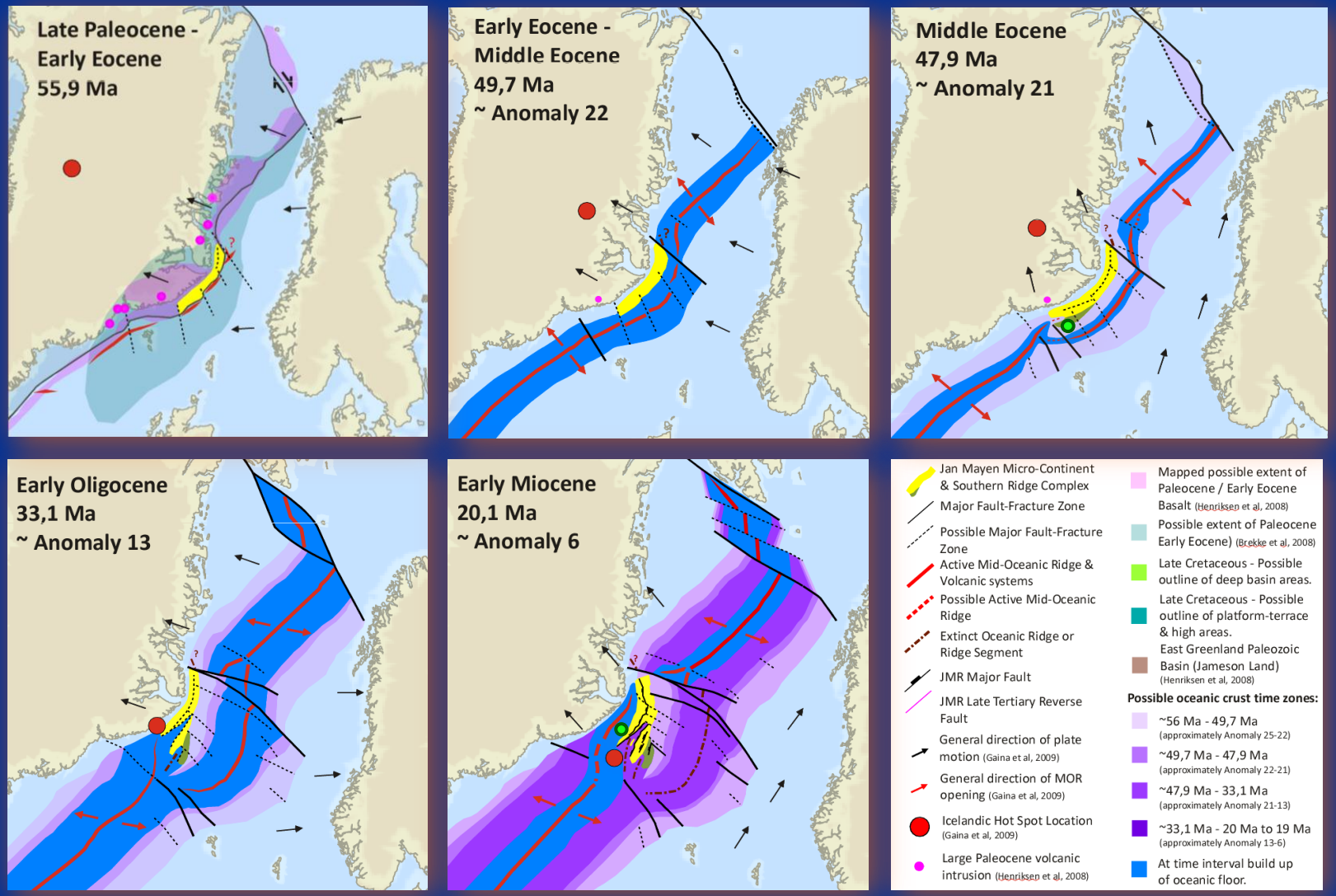
- Samples age ranges from Miocene-Oligocene to Permian-Triassic
- Hard data to substantiate seismic interpretations for Mesozoic basin stratigraphy, lithology and depositional environment of the Jan Mayen Ridge
- Grab sample & core logging, petrography, XRD, SEM, and biostratigraphy



Hagevang et al., 2008

Tectonic History – Main igneous periods affecting the JMMC

Collage based on results of many research publications (since the 1970´s) and observations at the JMMC



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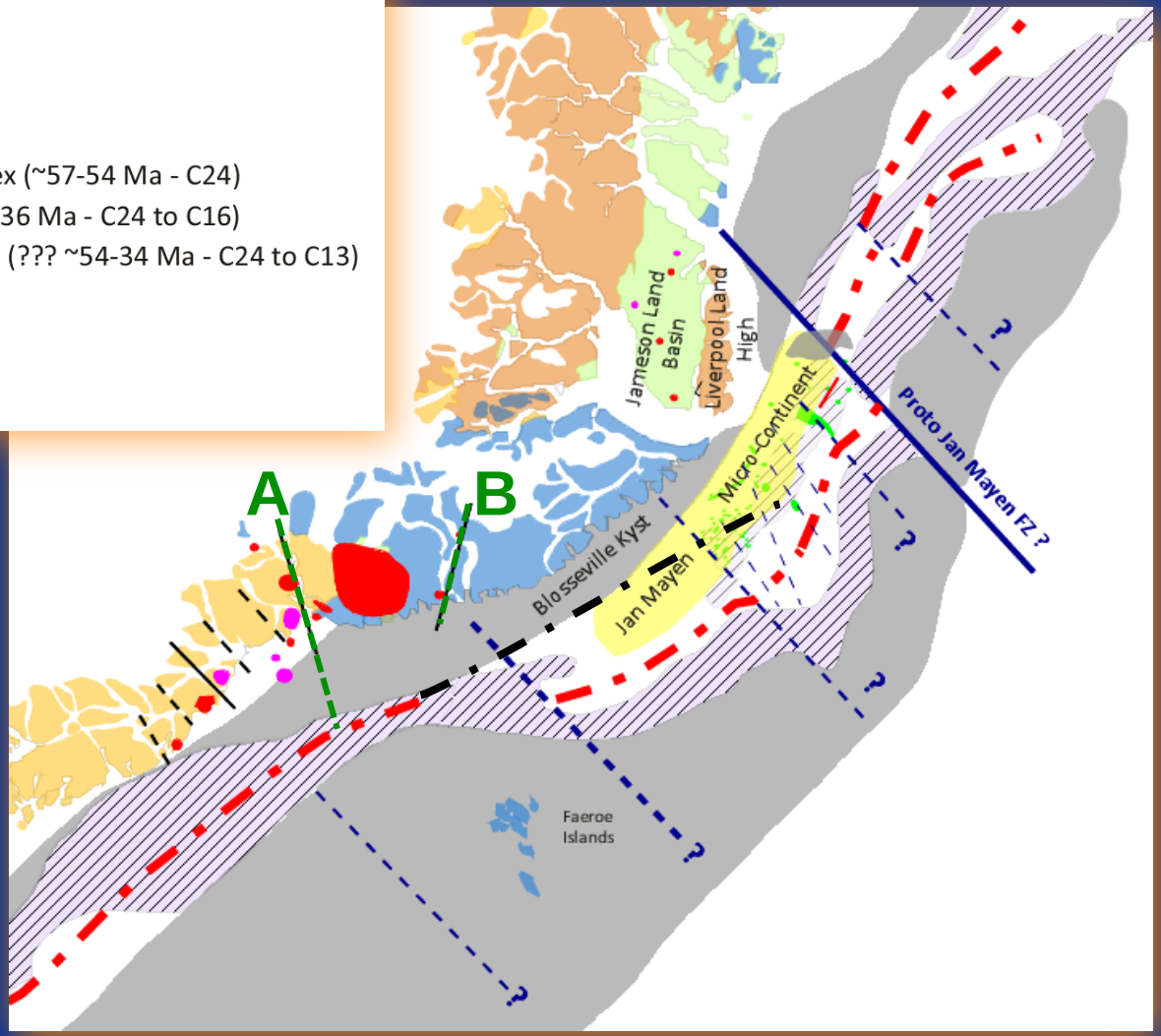
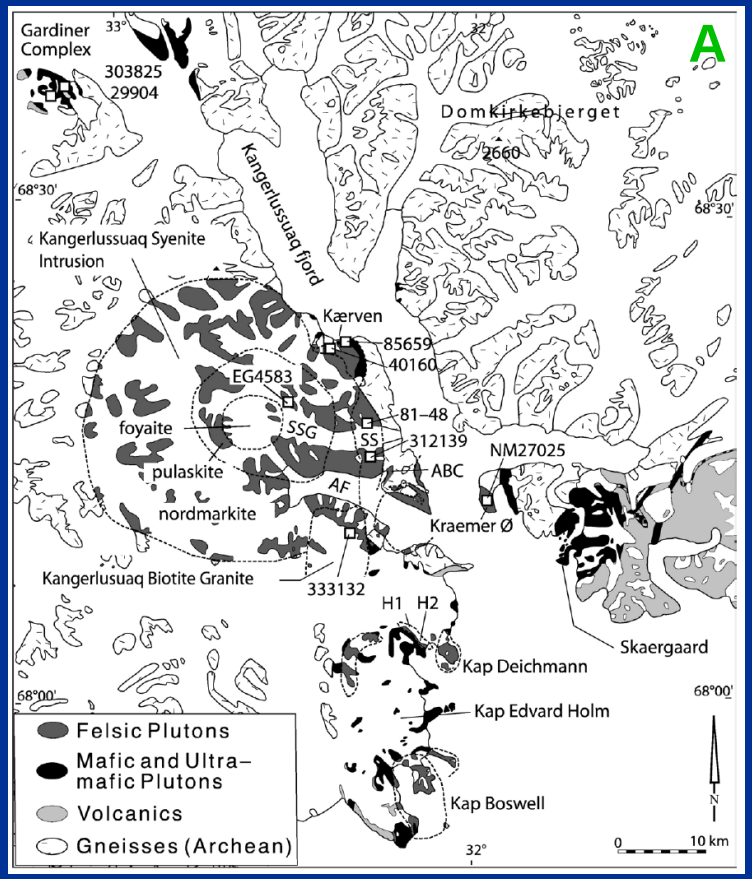
Central East Greenland coastal break-up

(57-54 Ma; ~C24) magmatic centers / complexes, and post break-up intrusions (~53-36; C23-C16)

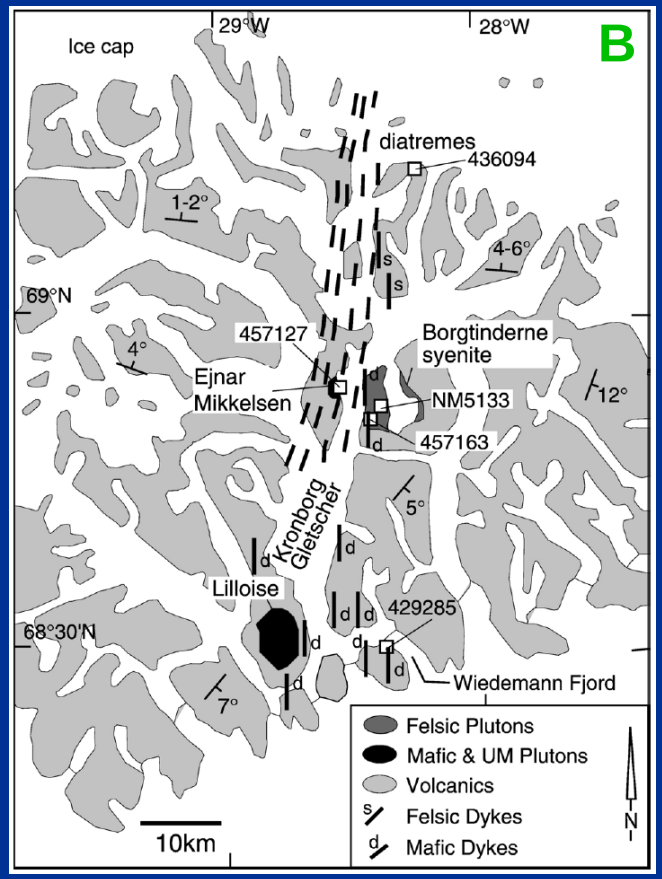


Central East Greenland coastal break-up

Southwestern region of the Jan Mayen Micro-Continent prior to rift separation from the East Greenland coast. Analogue for igneous features and structural lineaments in time & scale of the Southern Ridge Complex.



Geological map of the Kangerlussuaq Fjord region



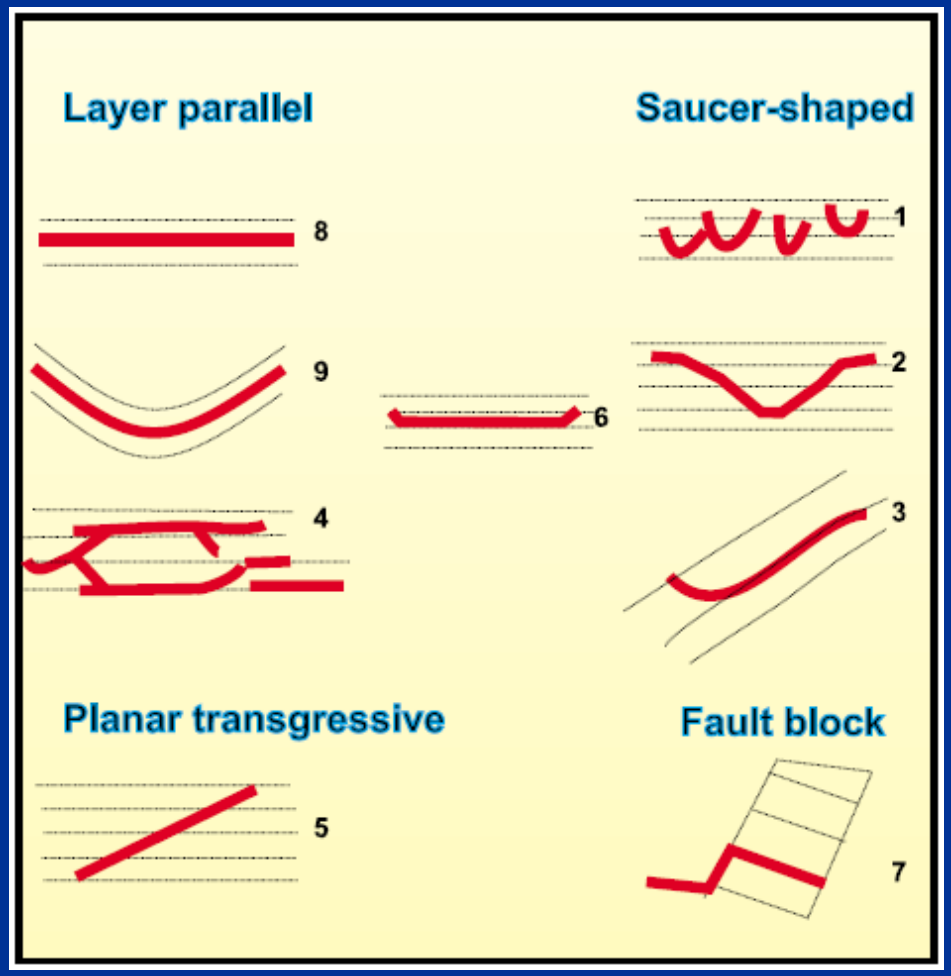
Geological map of the Wiedemann Fjord–Kronborg Gletscher tectonic lineament

Sill seismic facies analysis

Case study – analogue for JM

Planke et al, 2005

Sill seismic facies units.



Saucer-shaped:

(1) Shallow Intrusions
(2) Deeper Level Intrusions
(3) Climbing Saucer-Shaped

Layer parallel:

(4) Layer-Parallel Rough (~1.5-4s)
(6) Slightly Saucer-Shaped (~1.5-4s)
(8) Smooth Layer-Parallel (~2.5-5s)
(9) Basin-Parallel (~2.5-5s)

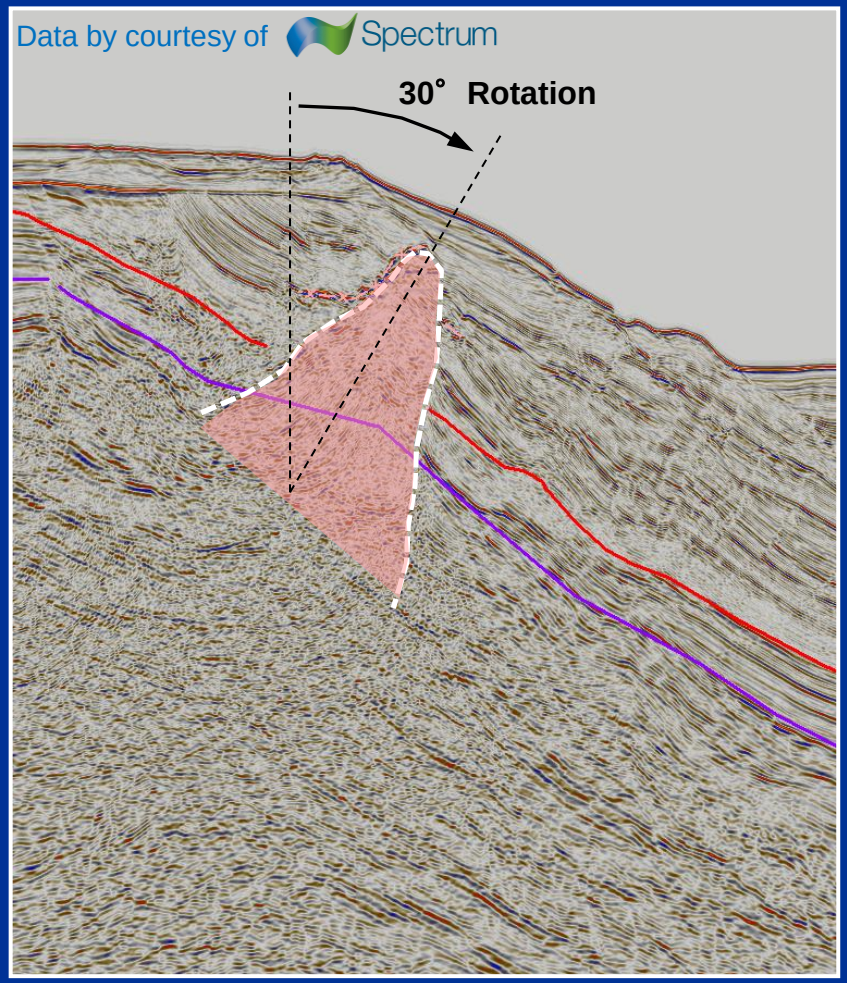
(5) Planar transgressive

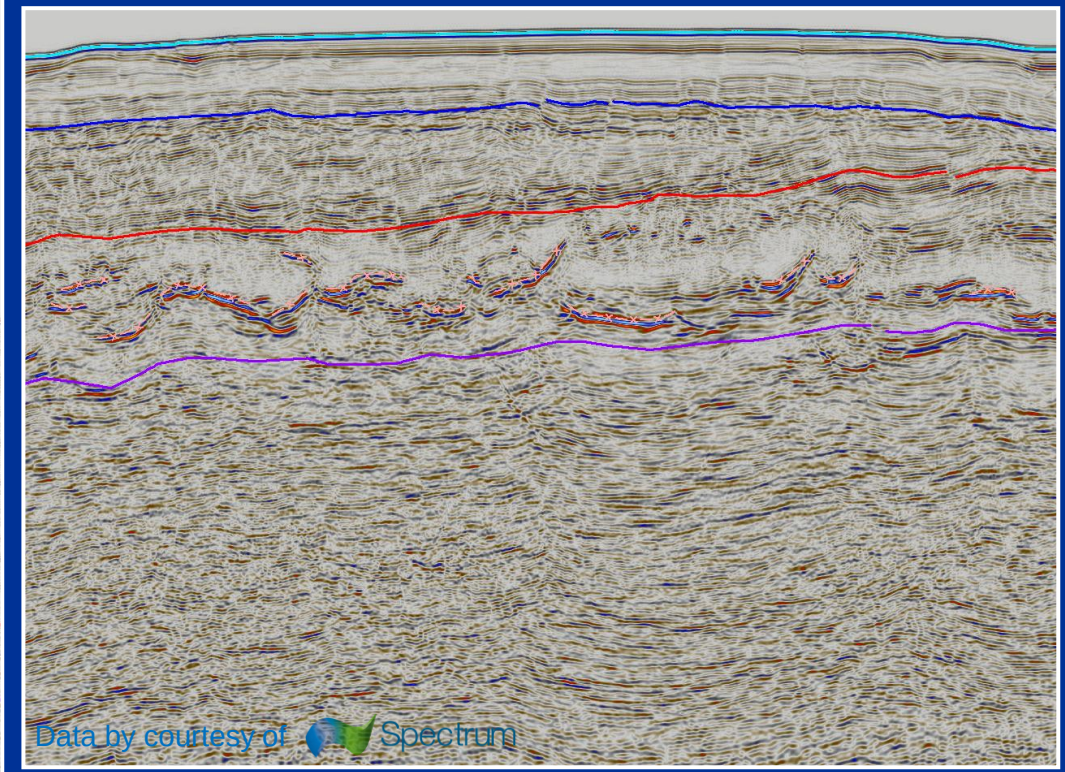
(7) Fault block

Igneous feature examples at the JMMC

Larger scale intrusion complex and sill intrusions

Seabed
UC Late Oligocene - Miocene
UC Eocene
UC Top Paleocene
Intrusive



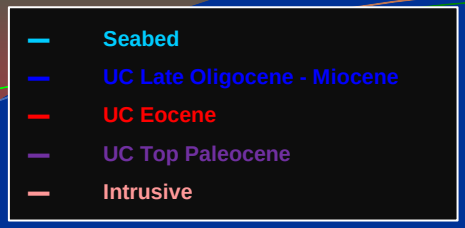


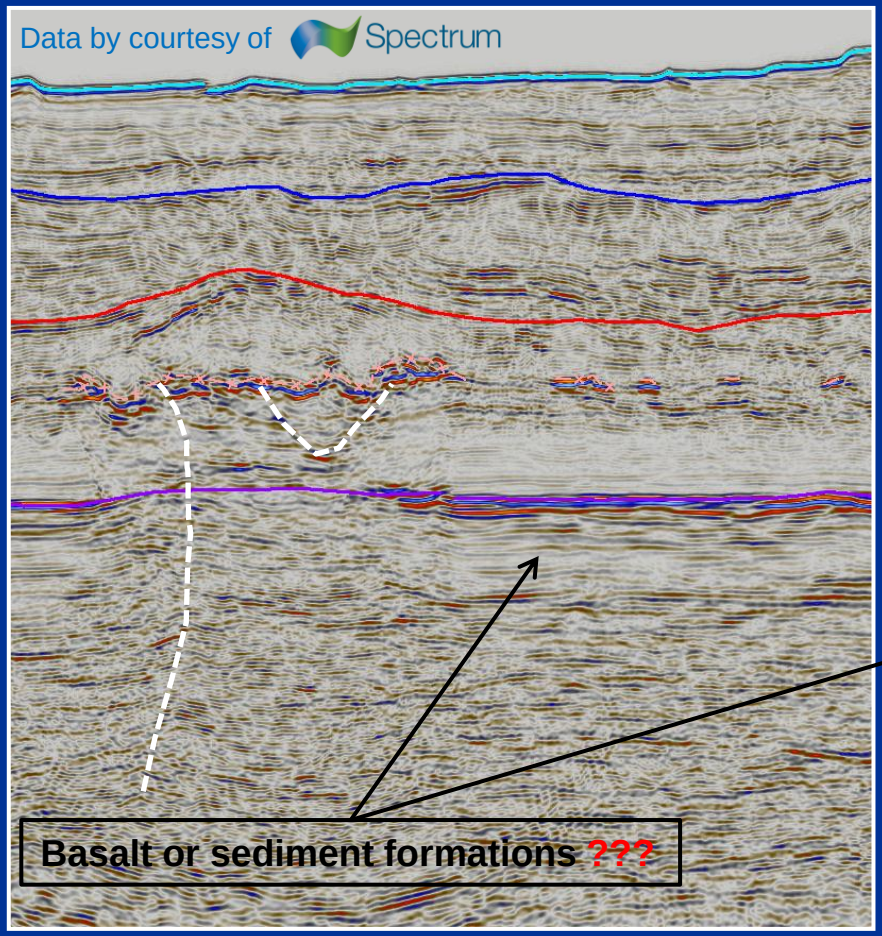
Middle Eocene saucer shaped rough wide vent about 0,7-1,2 second below seabed.

Intrusion into shallow sediment probably along a fault zone and saucer shaped rough wide vent about 0,25-1,5 second below seabed. Possibly this intrusion happened before the Oligocene erosion.

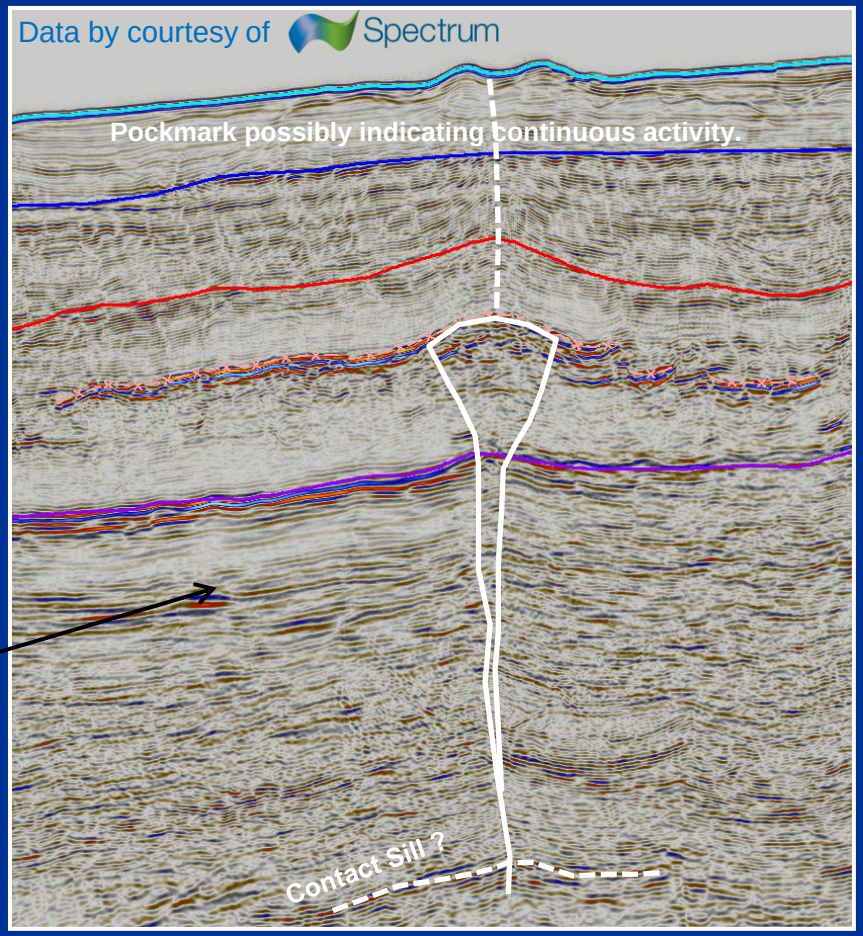
Igneous feature examples at the JMMC

Sill intrusion and hydrothermal vent complex





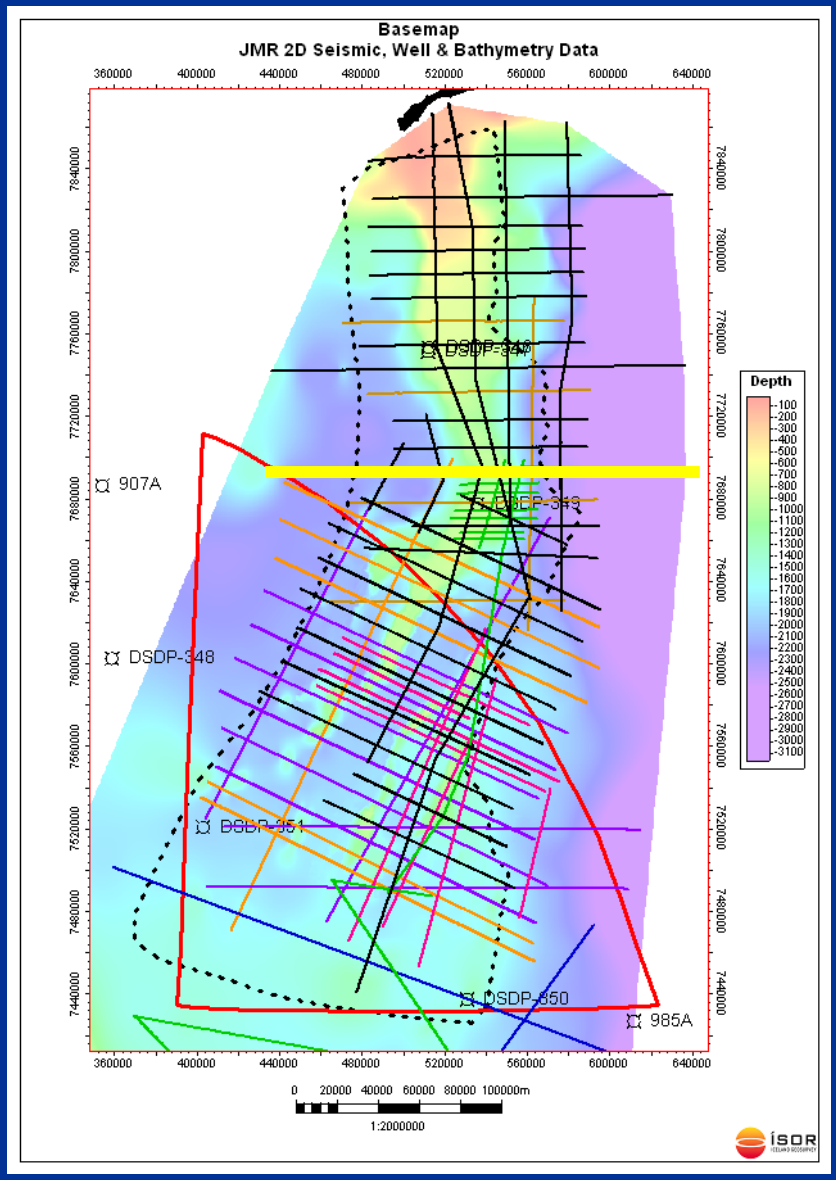
Eocene-Early Oligocene saucer shaped rough wide vent about 1 second below seabed.



Possibly Early Oligocene hydrothermal vent about 0,8 second below seabed and slightly rough shaped sills.

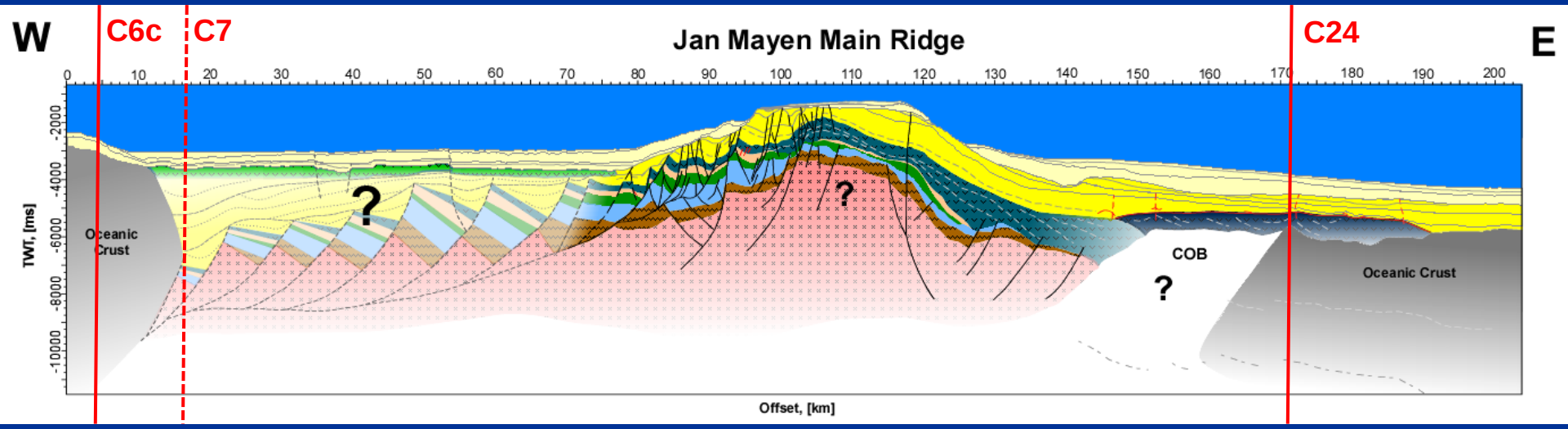
Stratigraphic / volcano-stratigraphic characteristics

Key line interpretation across the central Jan Mayen Ridge Complex



Volcano-stratigraphic characteristics

Jan Mayen Main Ridge – main subdivision

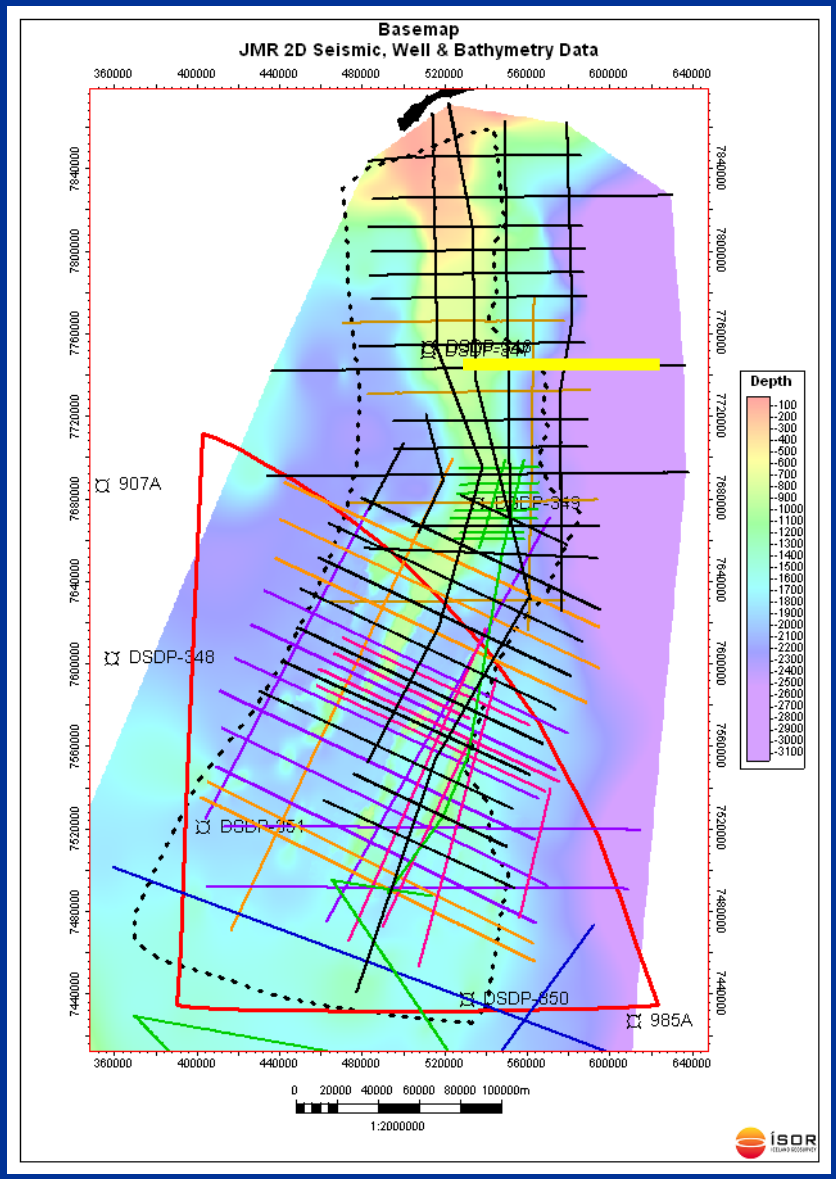


Legend:

- Late Quaternary - Late Oligocene
- Early Oligocene - Paleocene
- Lower Paleocene
- Paleocene - SDR/Volcanics/Basalt
- Volcanic centre Post-Paleocene
- Late Oligocene to Early Miocene shallow Basalt Intrusions
- Poss. Low Cretaceous
- Poss. Jurassic/Triassic
- Poss. Paleozoic
- Poss. Caledonian Basement
- Oceanic crust

Stratigraphic / volcano-stratigraphic characteristics

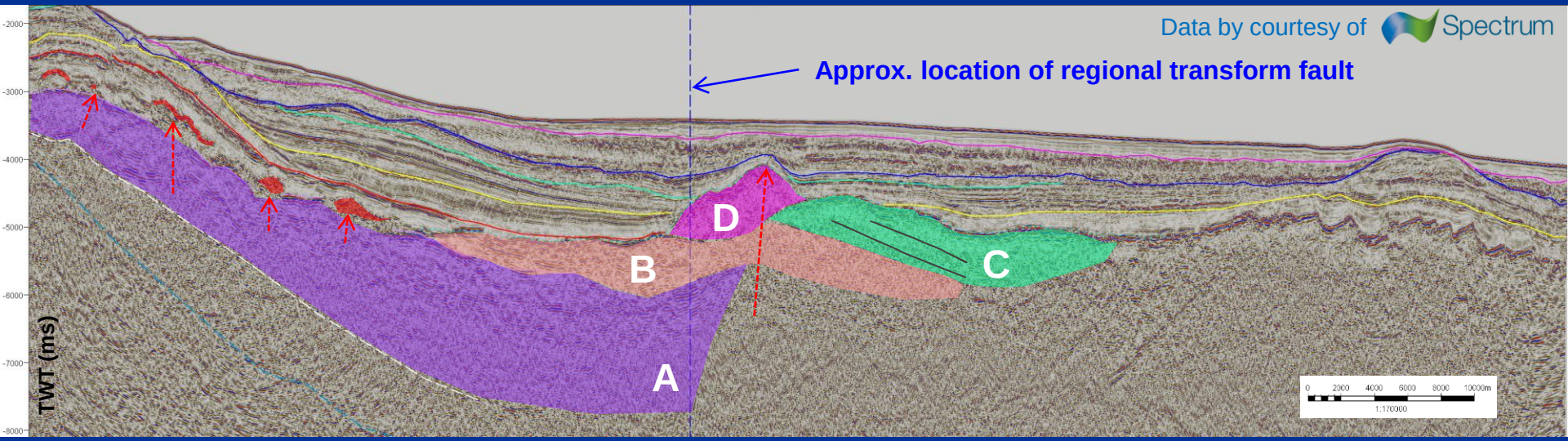
Key line interpretation at the eastern flank of the Jan Mayen Main Ridge, just south of the so called Jan Mayen High



Volcano-stratigraphic characteristics

Northern edge of the Dreki licensing area

W E



- UC Early-Middle Miocene
- UC Late Oligocene - Miocene
- Early-Middle Oligocene
- UC Early Oligocene
- UC Eocene
- UC Top Paleocene
- Top Paleozoic poss.
- Top Basement poss.

(A) Paleocene Volcanics (Plateau basalts & SDR ?)

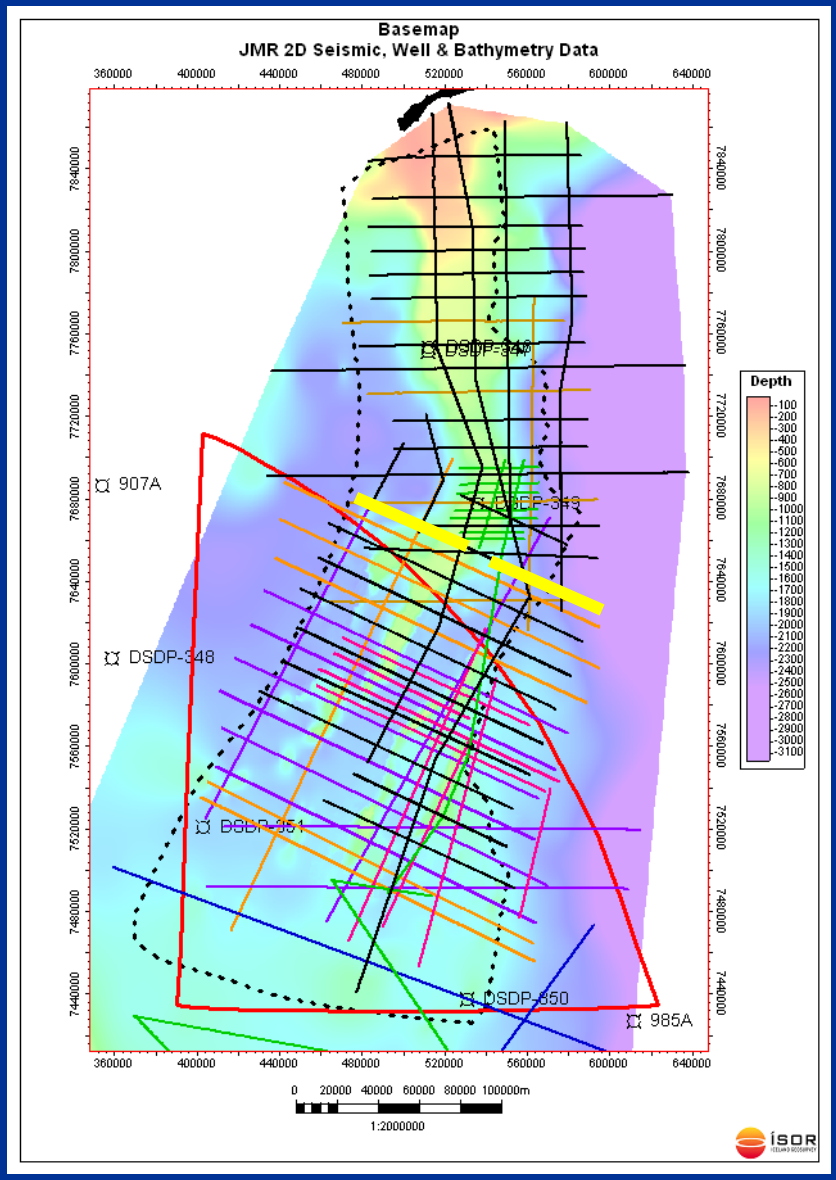
(B) Eocene Escarpment / Sill intrusives on the Main Ridge

(C) Poss. Early Oligocene Escarpment

(D) Poss. active Volcanic Complex from Eocene to Early Miocene close to regional transform fault

Stratigraphic / volcano-stratigraphic characteristics

Key line interpretation at the central ridge of the JMMC



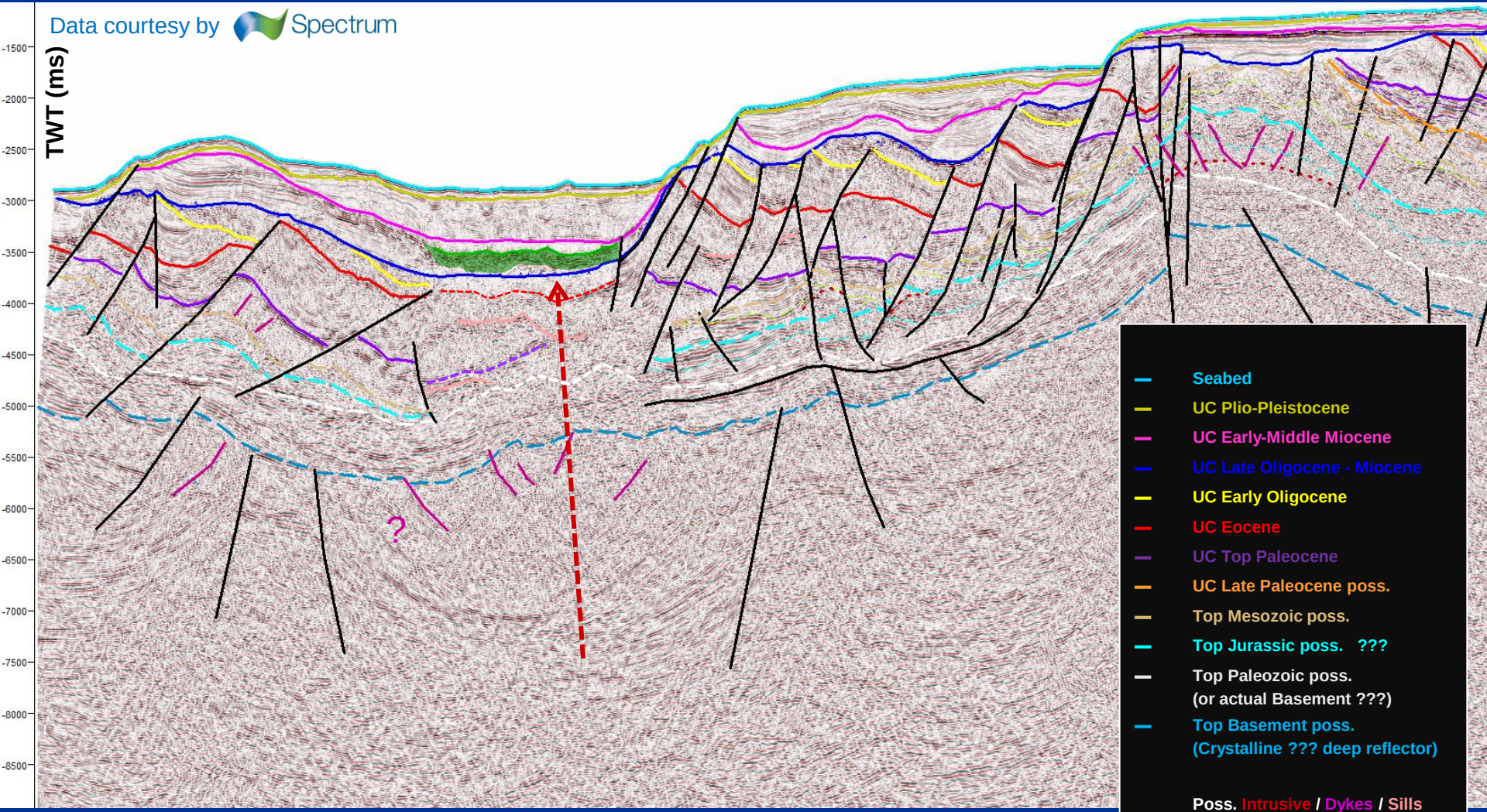
Volcano-stratigraphic characteristics

Northern edge of the Dreki licensing area

WNW

ESE

Data courtesy by Spectrum



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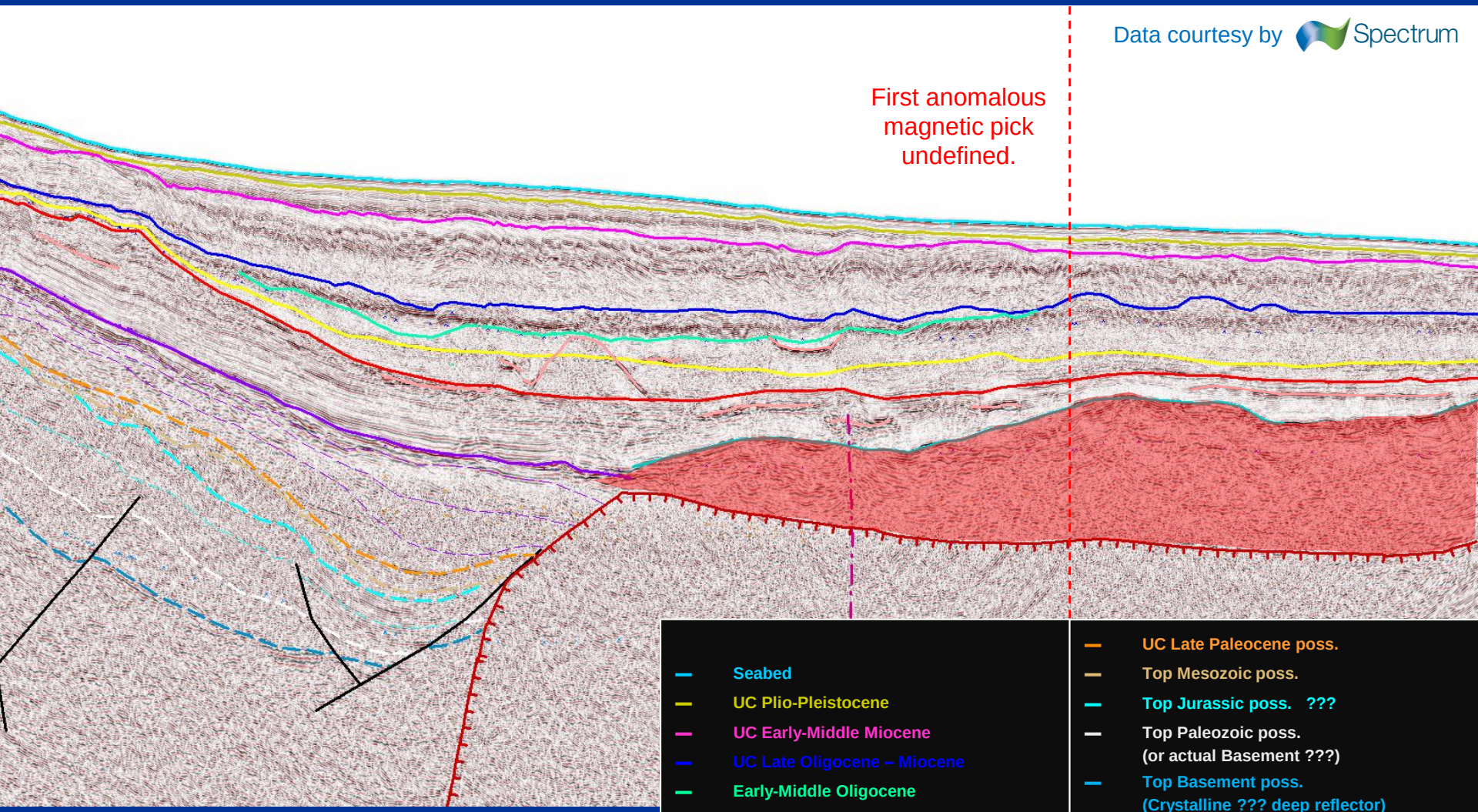
Volcano-stratigraphic characteristics

Northern edge of the Dreki licensing area

WNW

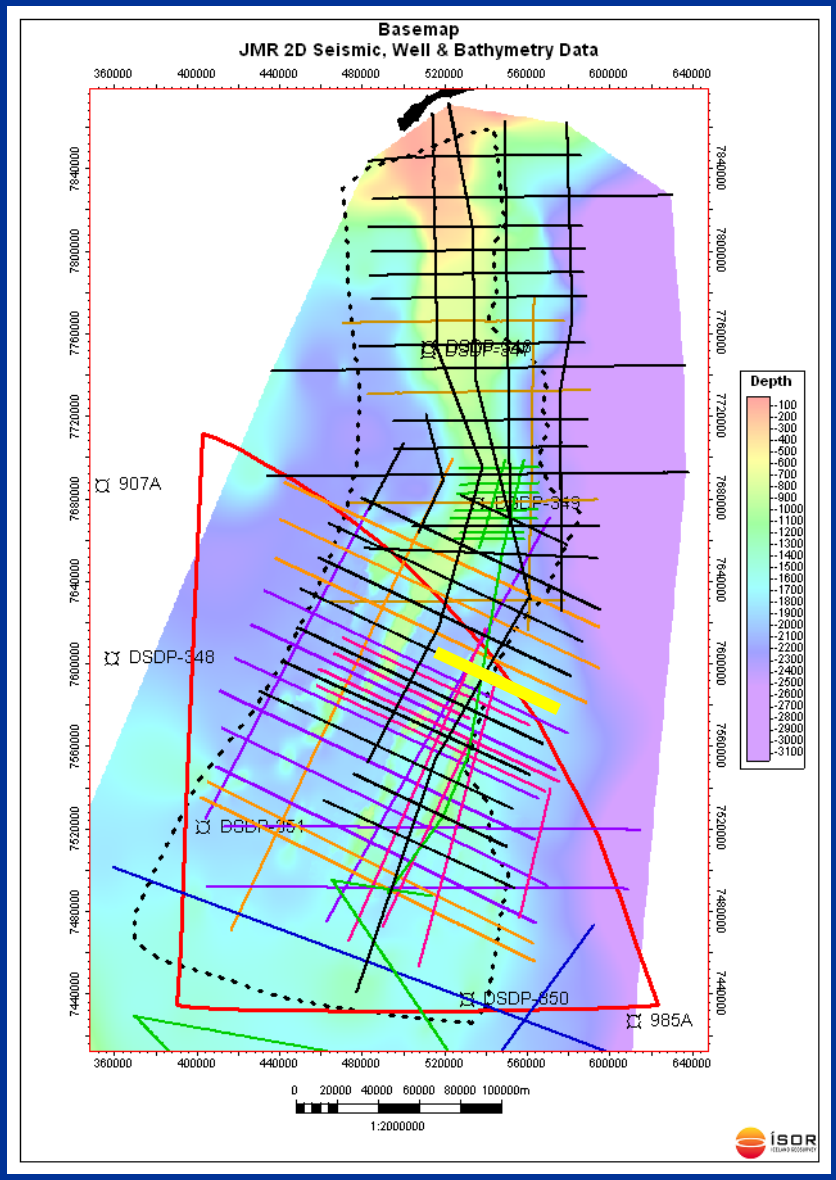
ESE

Data courtesy by Spectrum



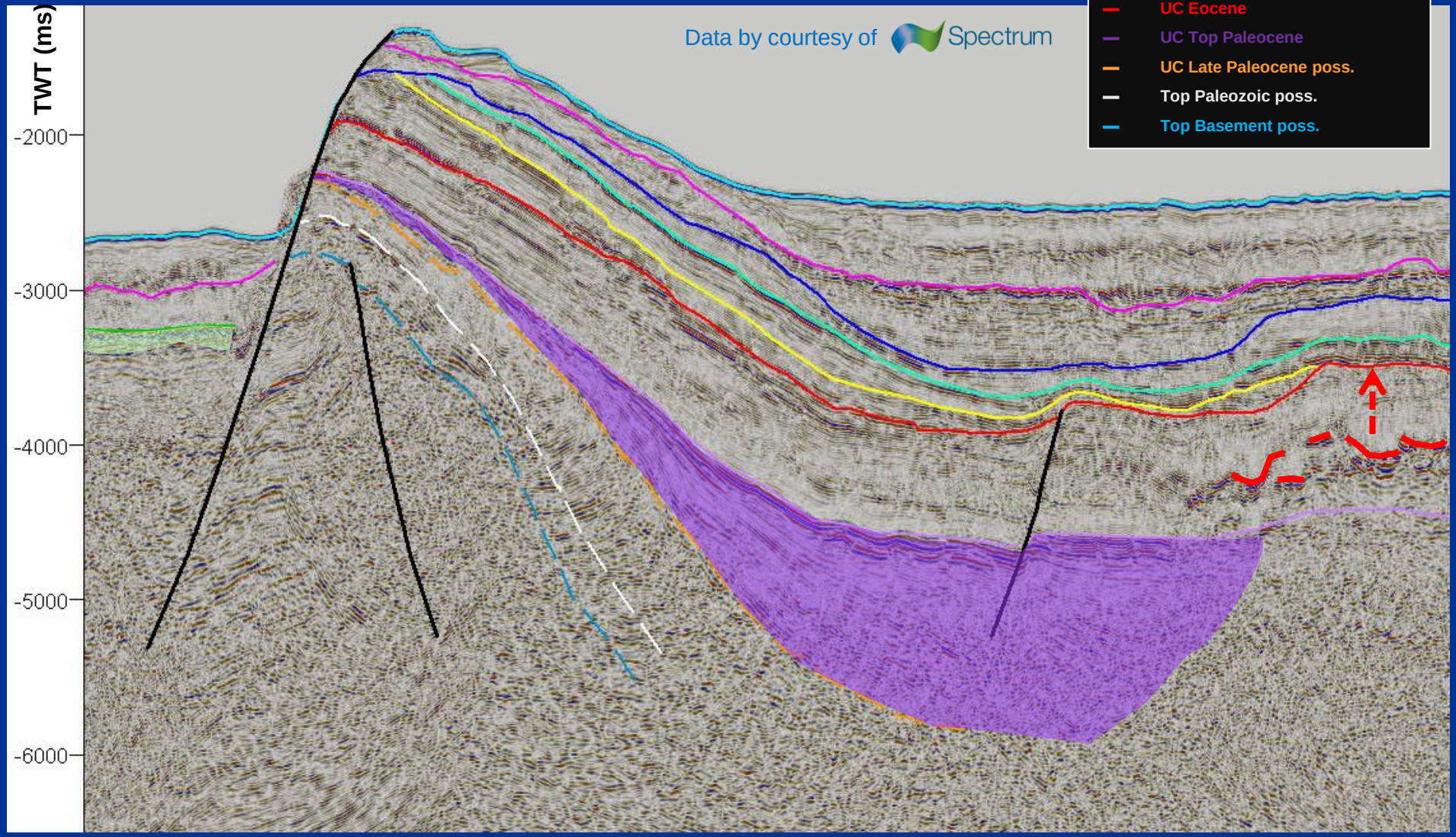
Stratigraphic / volcano-stratigraphic characteristics

Key line interpretation at the northern edge of the Southern Ridge Complex



Volcano-stratigraphic characteristics

Eastern edge of the Dreki Licensing area



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Stratigraphic / volcano-stratigraphic characteristics

Key borehole interpretation at the southern edge of the Southern Ridge Complex

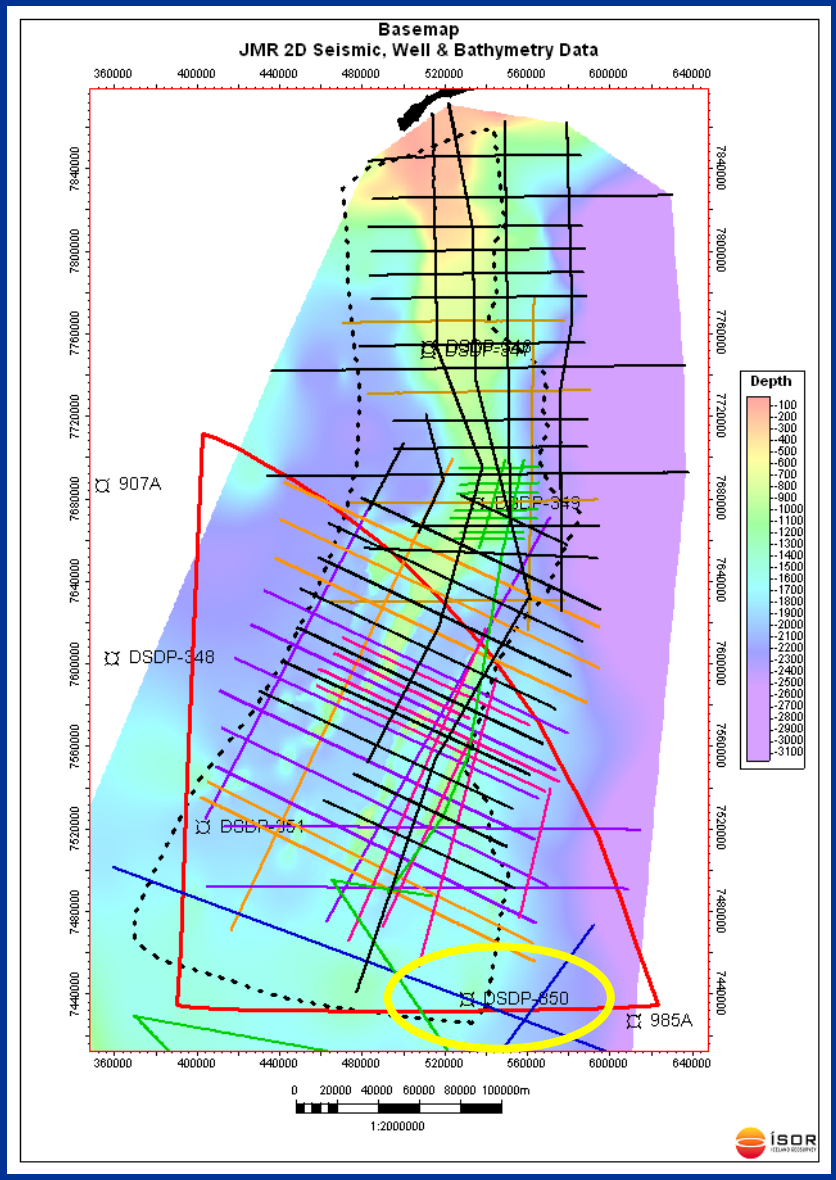
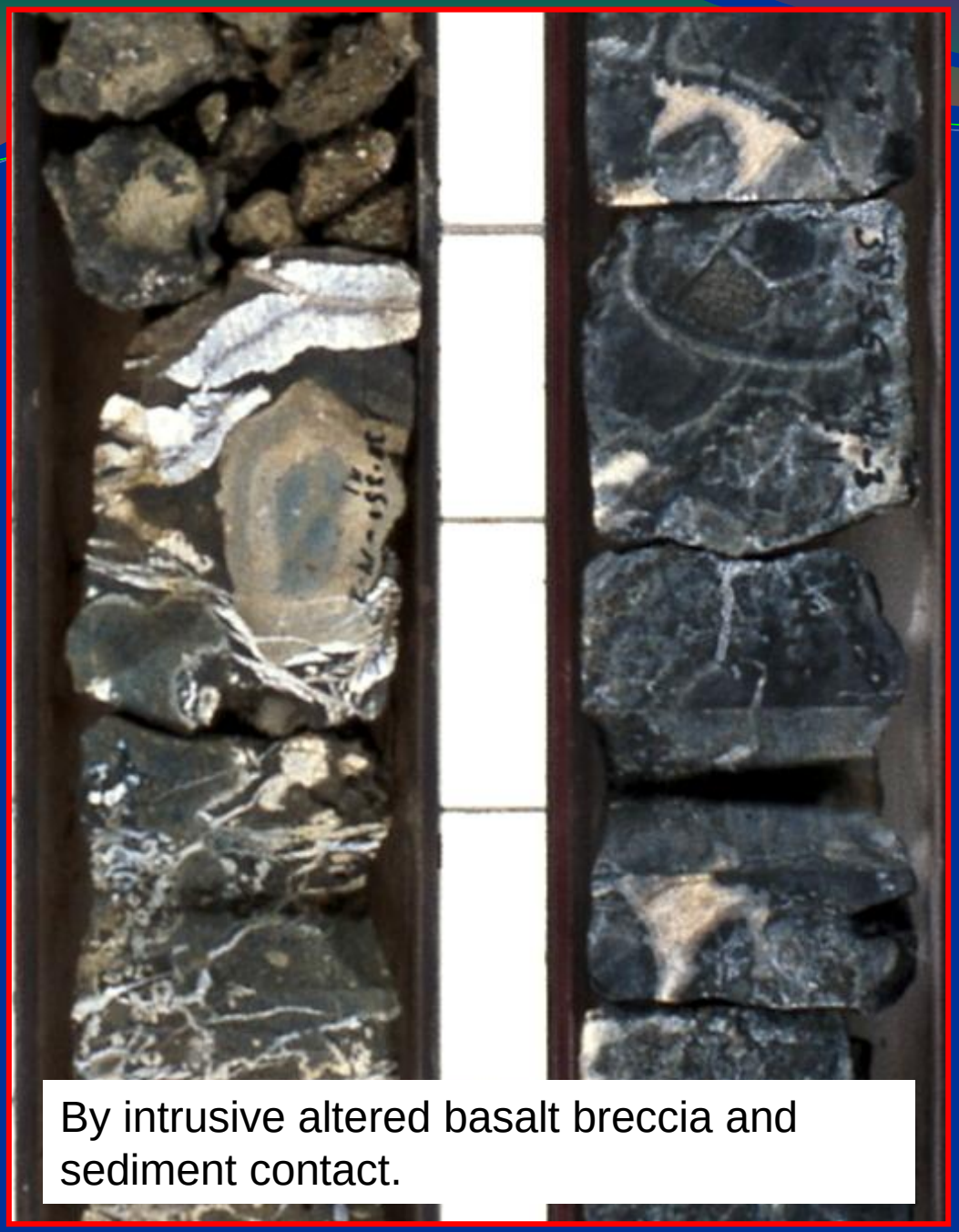
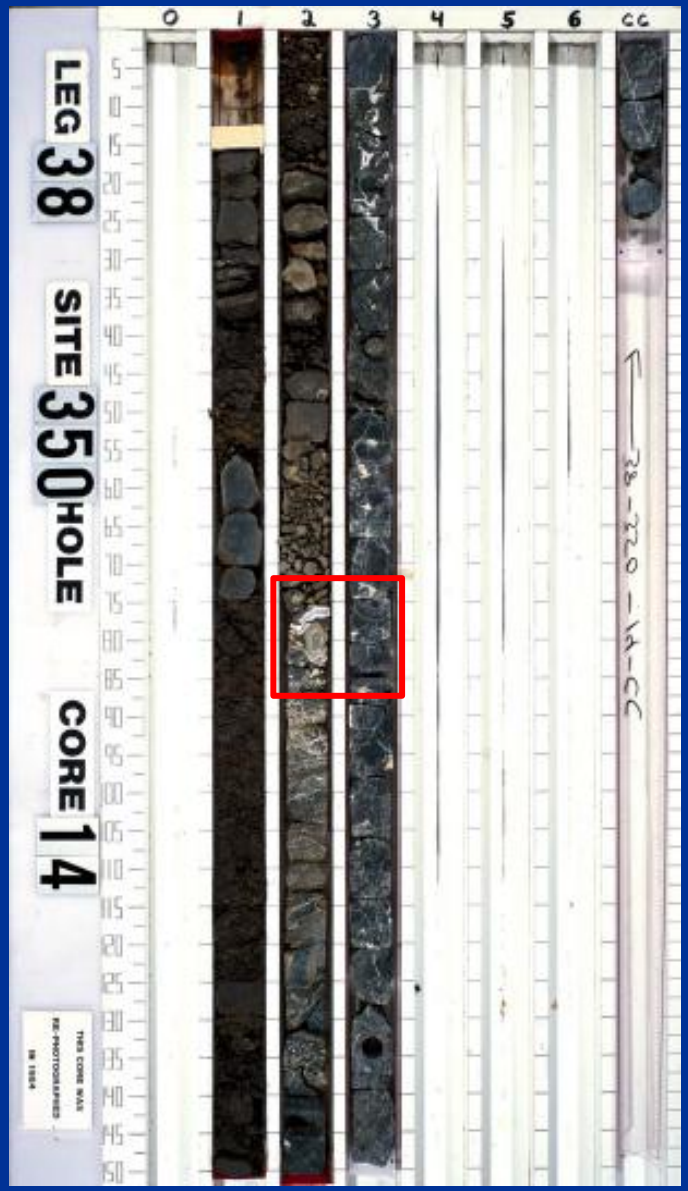


Photo Source: IODP / TAMU



By intrusive altered basalt breccia and sediment contact.



Time determination uncertainties !!!

Possibly glassy contact of younger Middle Eocene intrusion into an older basalt breccia formation.

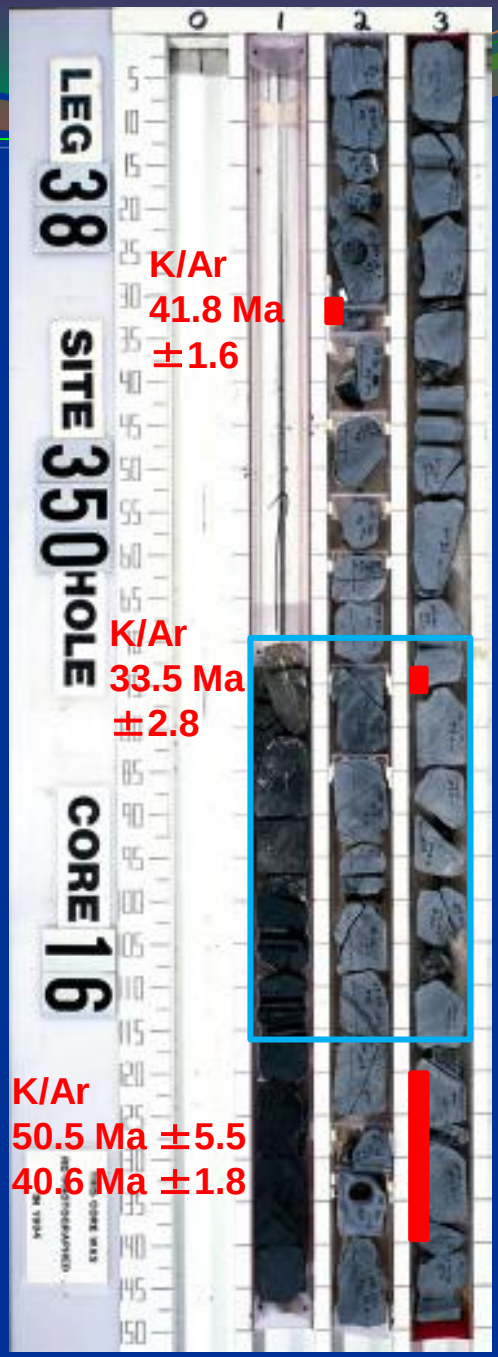


Photo Source: IODP / TAMU

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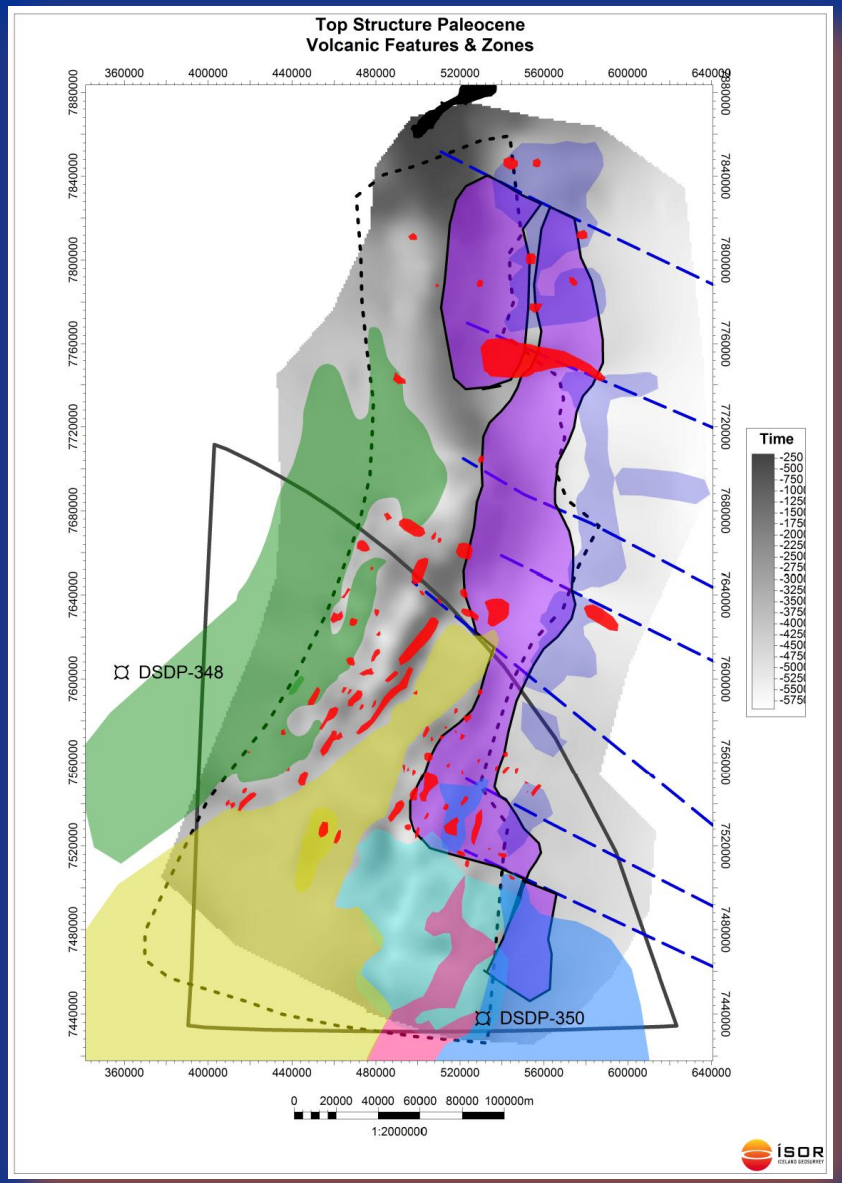
Volcanic zones of JMMC

Possible scenario

- SDR (Seaward Dipping Reflectors)
- Poss. post break-up, deeper seated larger intrusions
- Volcanic complexes / escarpments just above the Top Paleocene marker
- Possibly anomaly 20 to 17 basalt (Middle Eocene) province
- Probably faulted oceanic ridges / transition area
- Possible rift attempt between anomalies 17 to 13 (Late Eocene – Earliest Oligocene)
- Jan Mayen Trough covered by flat-lying shallow intrusions / sills
- Latest Oligocene – Early Miocene composite sheet of flat-lying, shallow intrusive (approx. ~ anomalies 7 to 6)
- Important fault / fractures zones that influence and subdivide the JMR.



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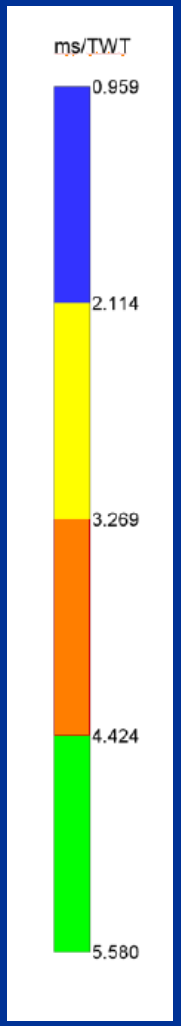
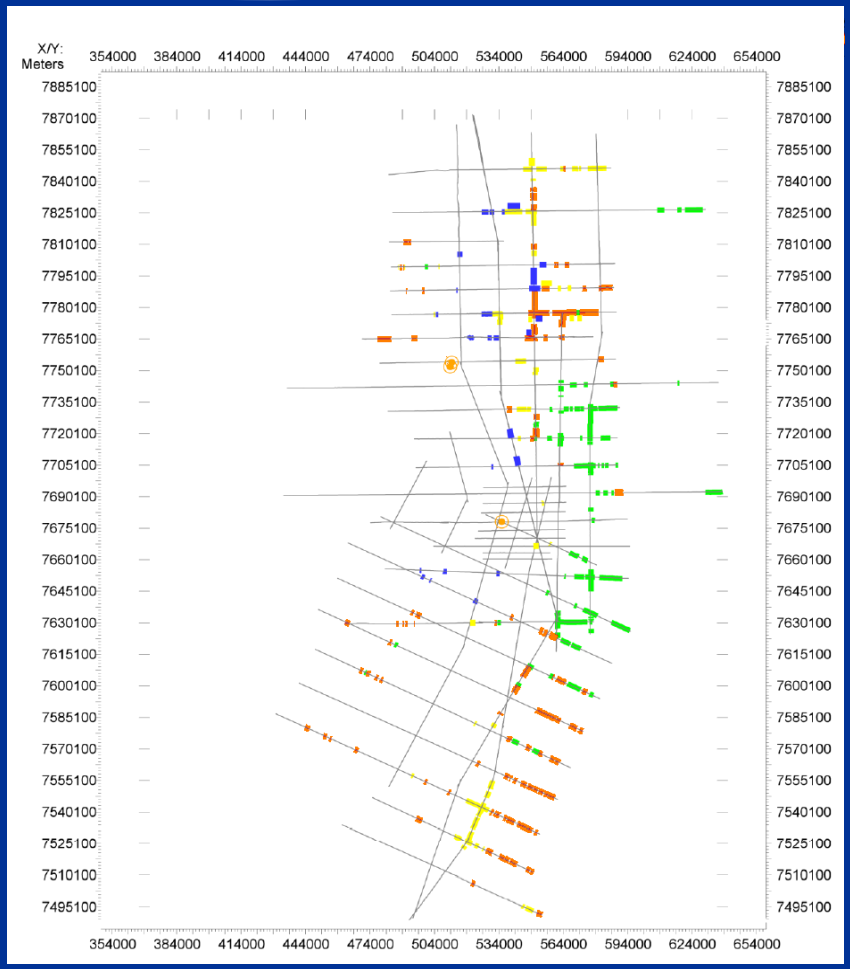
Distribution and depth level of single *sill intrusions* only above the Top Paleocene stratum of the Jan Mayen Ridge

Ögmundur Erlendsson, MSc. Thesis, 2010

- Deepest sill intrusions (green & orange), first and the main phase: Top Paleocene to Middle Eocene
- Medium deep (yellow), second phase: Eocene to Early Oligocene
- Shallow (blue), third phase – Early to Middle Miocene





Summary

- Igneous feature within the main ridge below the Paleocene are probably analogue to East Greenland coast with series of dyke intrusions close to structural weak zones.

- Paleocene Volcanic formation of plateau basalts & SDR´s are difficult to differentiate seismically, if not confirmed by drilling. The SDR are not a-typical and appear to vary along the east flank of the JMMC and might just represent the first onto the ridges on-lapping sections, with their main thick intervals being not visible on seismic data below the younger volcanic complexes.

- A small accommodation space (low) was formed along the eastern edge of the Jan Mayen Main Ridge with its eastern edge being the Eocene volcanic complexes along the eastern margin.

Summary

- **Post-Paleocene Activities:**

  1) Top Paleocene to Middle Eocene escarpments, sills, larger scale intrusives especially along the east ridge flank.

  2) Possible Late Eocene to Early Oligocene escarpment, sills, larger scale intrusives, especially along the east flank but also along the west ridge flank and sub-basin areas.

  3 a) Poss. active volcanic complex from Eocene to Early Miocene close to regional transform fault, especially along the NE edge of the JMMC and south of the Jan Mayen Volcanic complex itself.

  3 b) Early to Middle Miocene shallow and regional extensive intrusions along the western and southern edges of the micro-continent, most likely simultaneous as the opening of the Kolbeinsey Ridge.

- **Diagenetic impact of surrounding sediments by intrusions was observed to be around 200m, as observed in DSDP well 38-350, and amplitude anomalous areas above the intrusive features on seismic data.**

Thank you very much for your attention !

Acknowledgements:

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