SPE “Seismic 2017” conference presentation – 11 May 2017, Aberdeen (UK)

Deep frontier plays revealed by new 3D broadband dual-sensor seismic covering the East Shetland Platform

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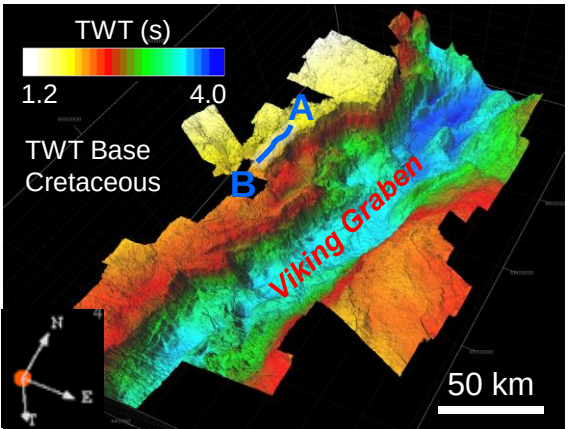
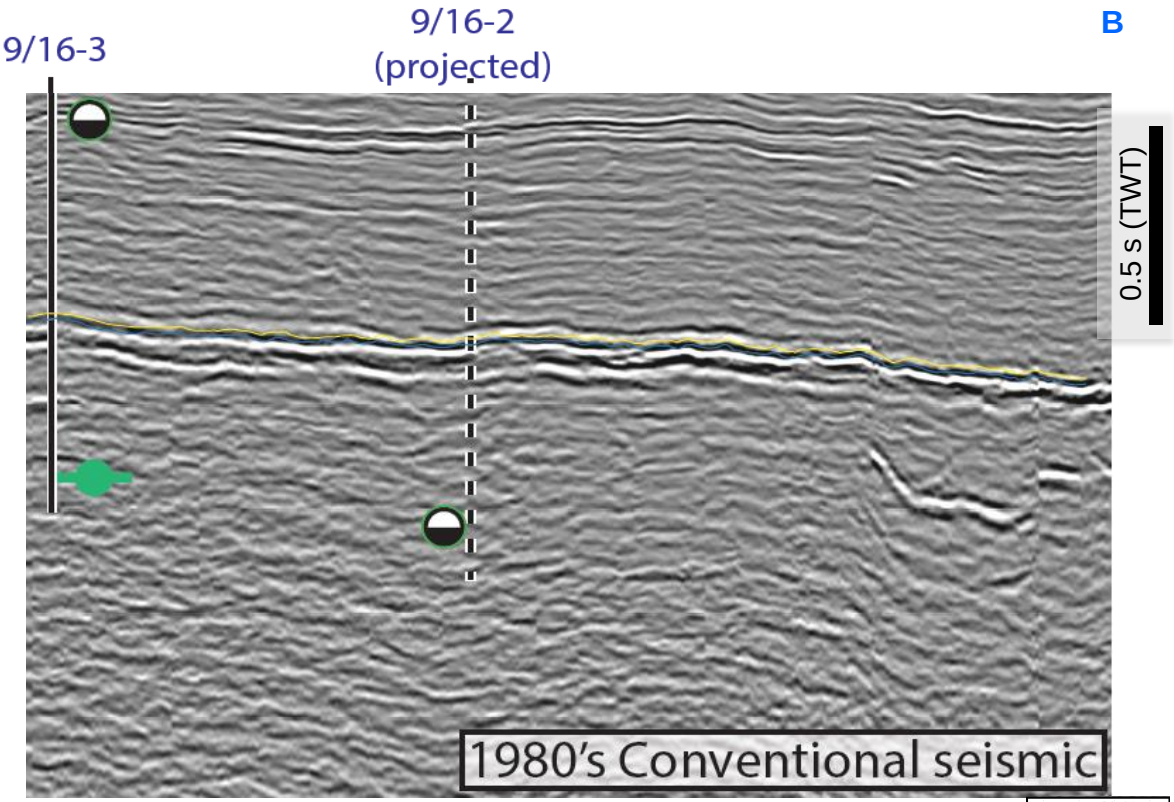
The initial understanding

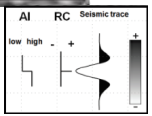
A

5 km



B





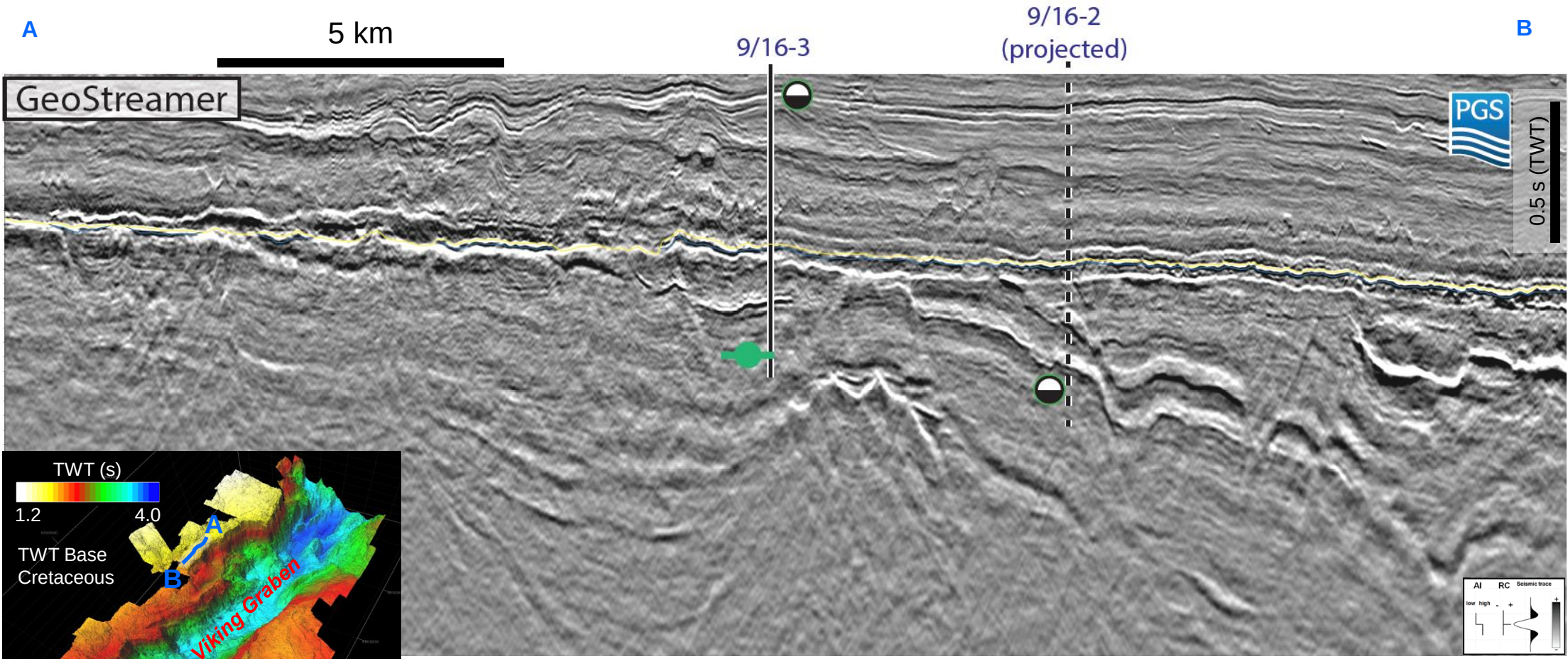
Oil Show

Source Rock (penetrated by wells)

Near base-Paleocene = Top Chalk Gp.

Base Cretaceous Unconformity

The initial understanding



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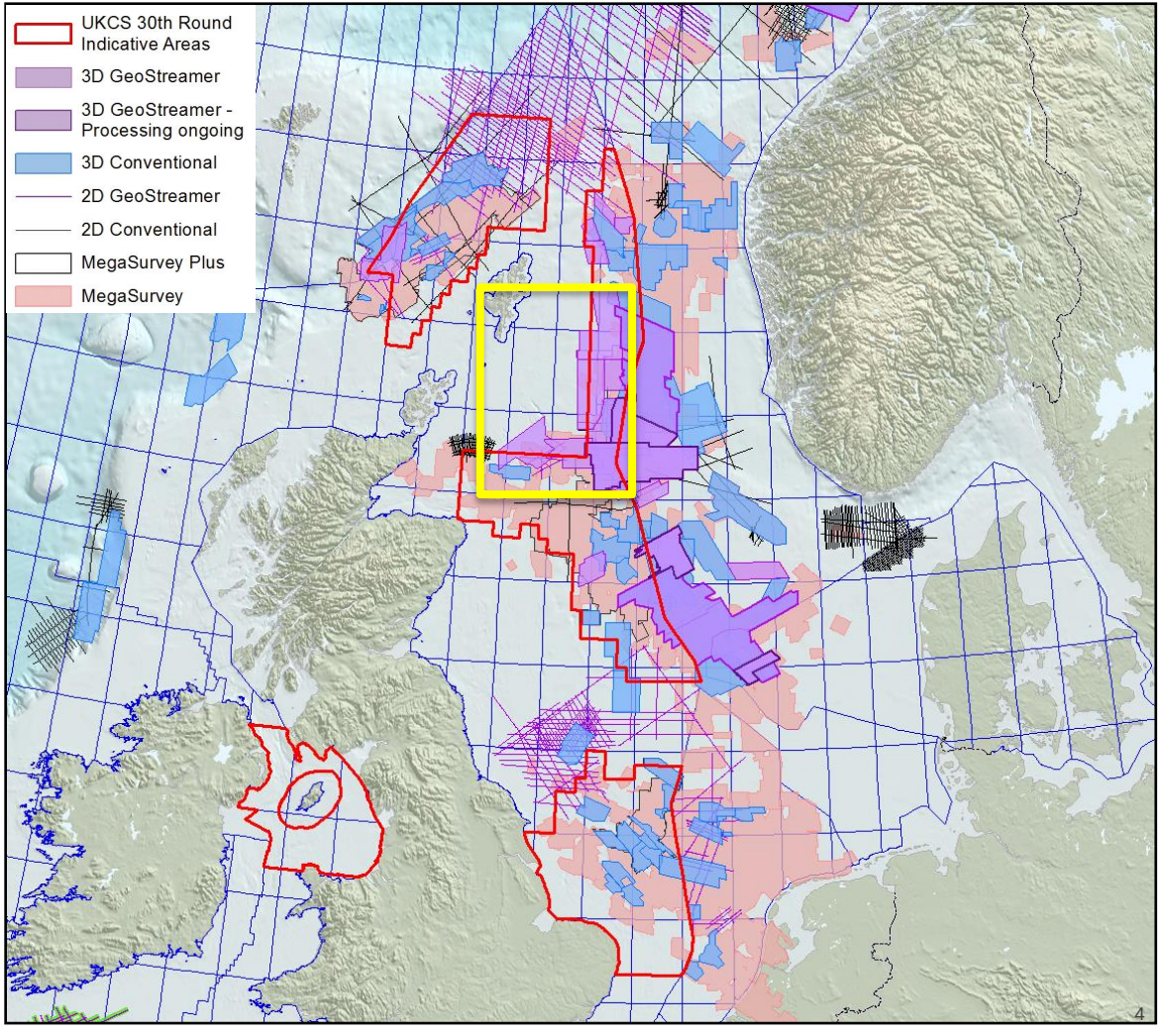
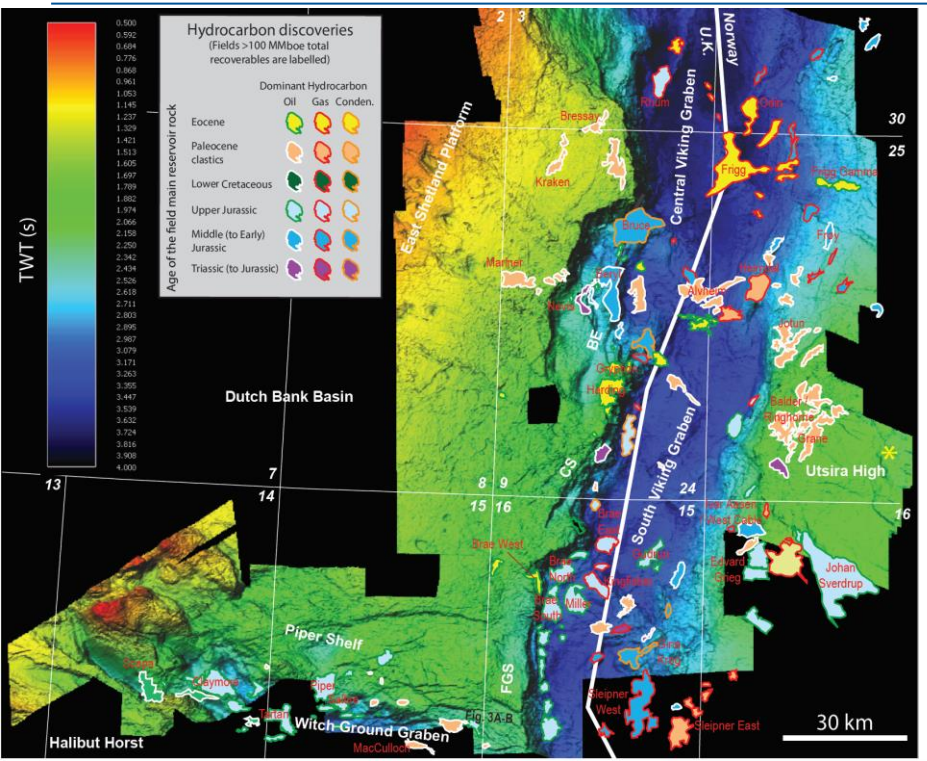
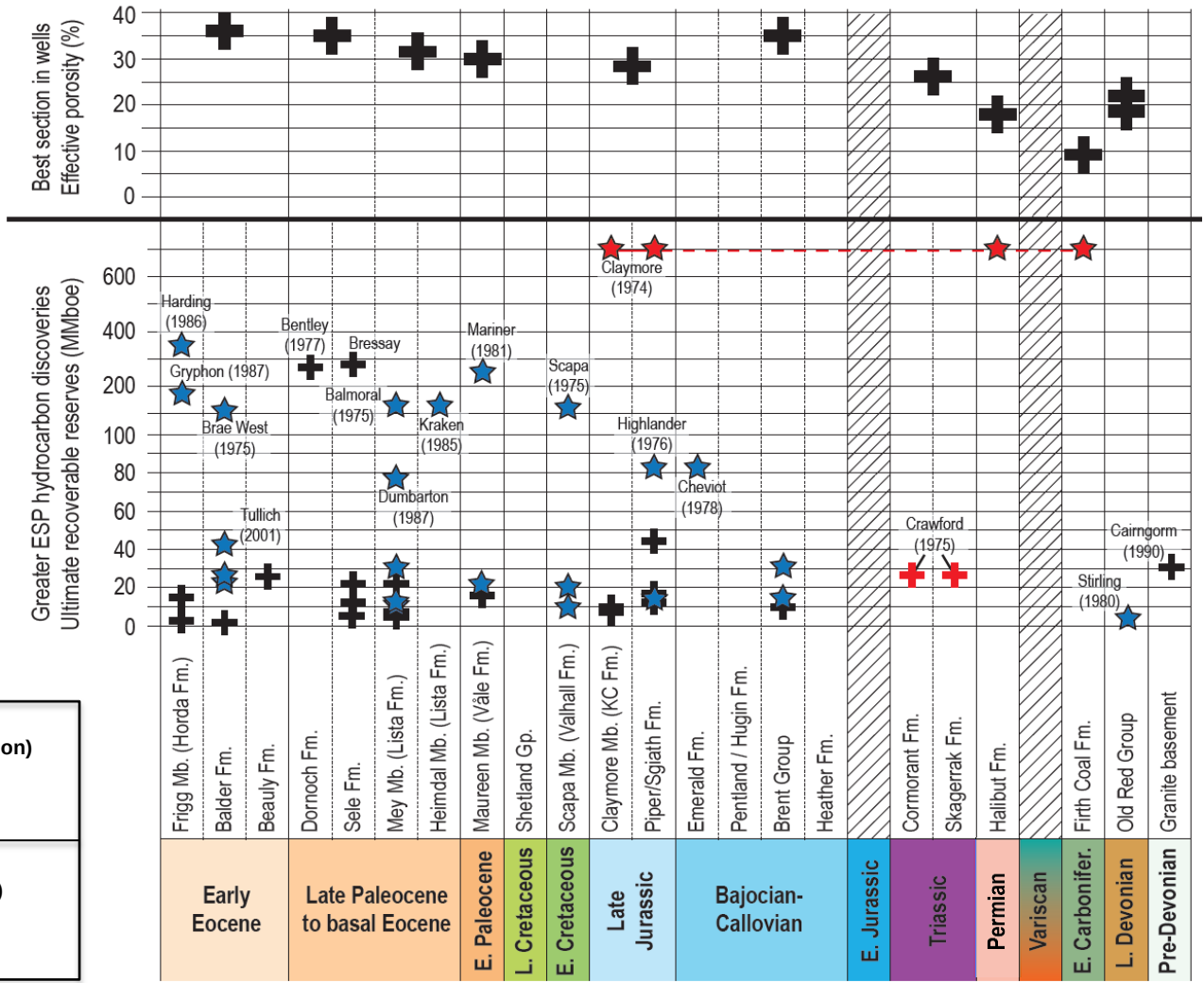
- Petroleum geology summary of the ESP
- The Paleozoic on the ESP: Regional seismic-stratigraphic observations
- The Paleozoic on the ESP: Reservoir-scale observations
- Conclusions



Petroleum geology summary

Proven and potential reservoir units on the ESP





HC Fields (development / production)

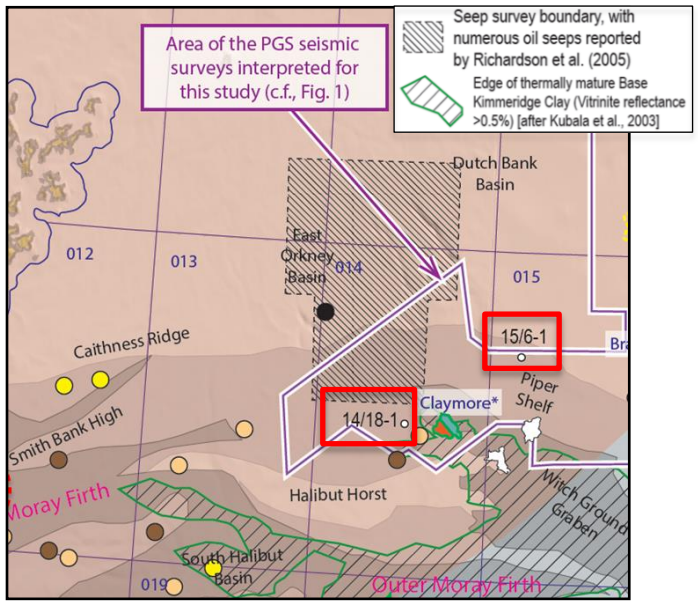
- >1 main reservoir
- 1 main reservoir

HC Discoveries (yet to be developed)

- >1 main reservoir
- 1 main reservoir

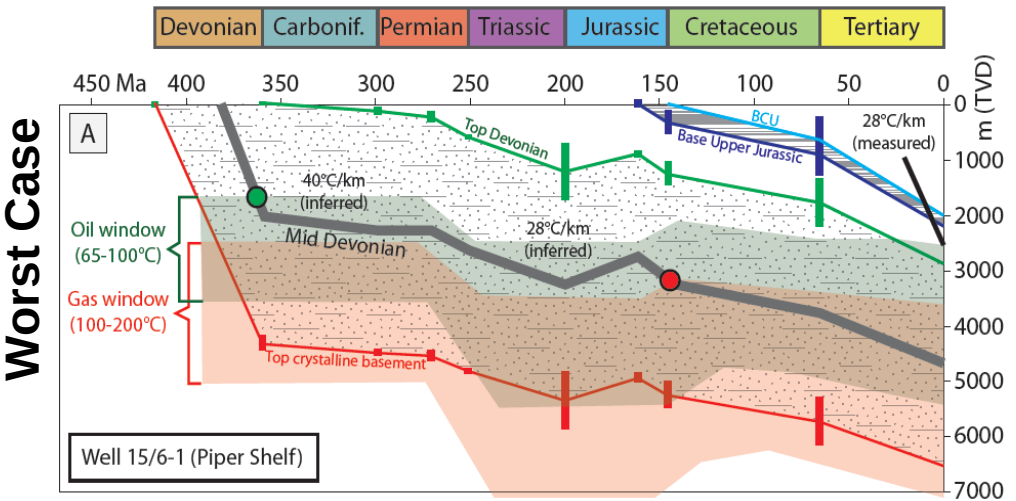
- Many other Paleozoic discoveries in CNS and WoS
- E.g., Buchan, Sterling, Clair
- Clair is 6th largest oil field in whole UKCS

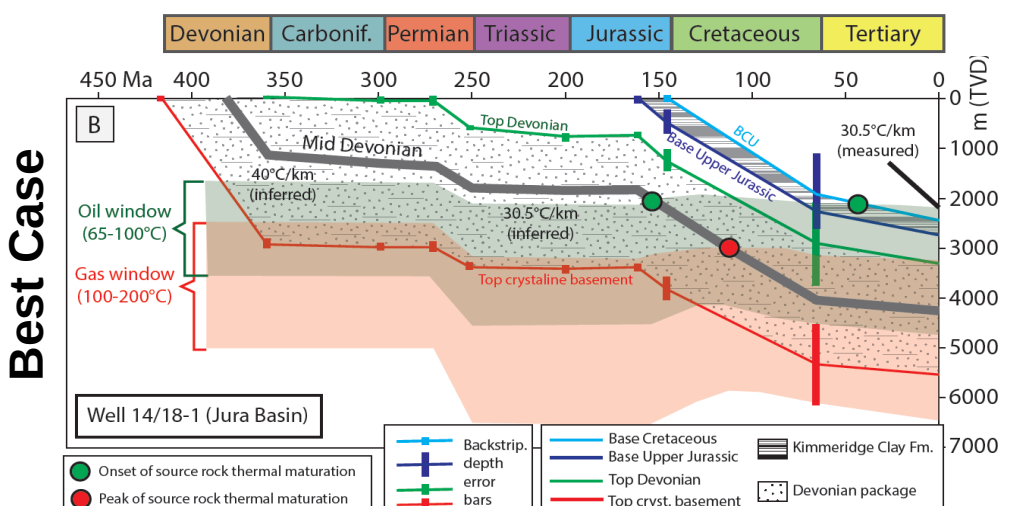
Source and maturity on the ESP (1D burial history)



MID DEVONIAN SOURCE ROCK

- Penetrated by several Orcadia Basin wells
- Inner Moray Firth: e.g., **Beatrice**
- Secondary component for **oils of large fields in Witch Ground Graben / WoS** area (incl. Clair, Claymore) (Cornford, 2009; Mark et al., 2008)





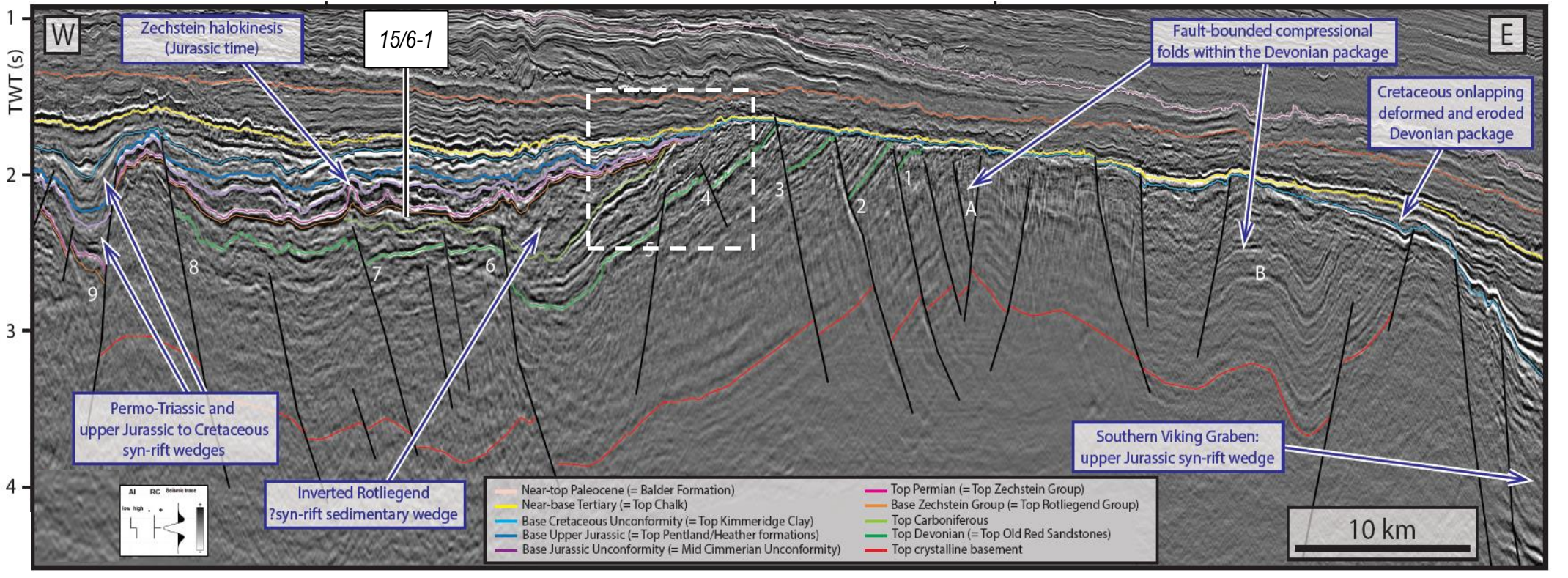
- **Worst case**: areas subject to early generation (A)
- **Best case**: areas with most of the HC expulsion **after the end of Jurassic rifting** (B)

- Burial history modelling suggests late generation / expulsion over parts of the greater ESP region, e.g. near Claymore (consistent with Cornford, 09)

The Paleozoic on the ESP:
regional seismic-stratigraphic observations

Structural summary

After: Reid & Patruno (Nov 2015, GeoExpro); Patruno & Reid (Dec 2016, FirstBreak)



- Up to four regional unconformities, merging into fewer erosional surfaces on persistent highs
- Constrained by well correlation and regional seismic sections
- Several sub-BCU faults with different timing of activity

- Devonian-Carbonifeorus tilted and truncated by Base Permian Unc.
- Zechstein-?Triassic tilted and truncated by Base preserved Jurassic Unconformity
- Upper Jurassic tilted and truncated by Base Cretaceous Unconformity

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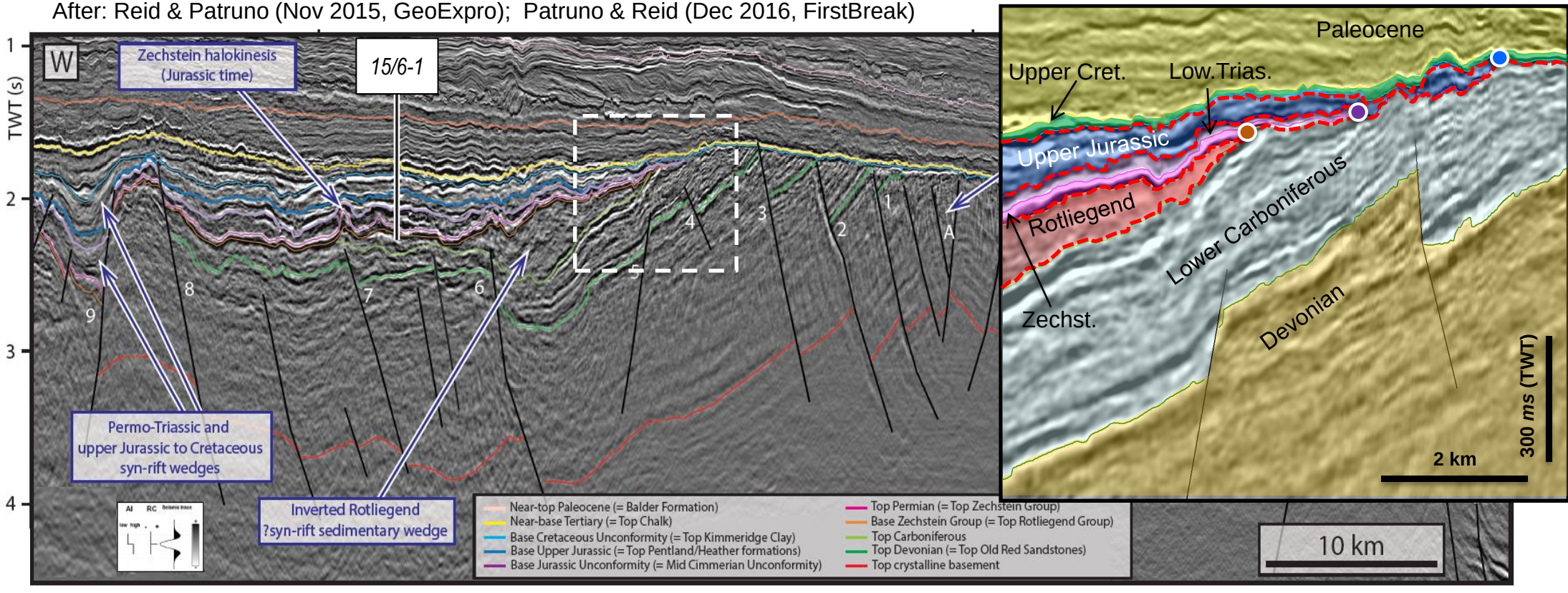

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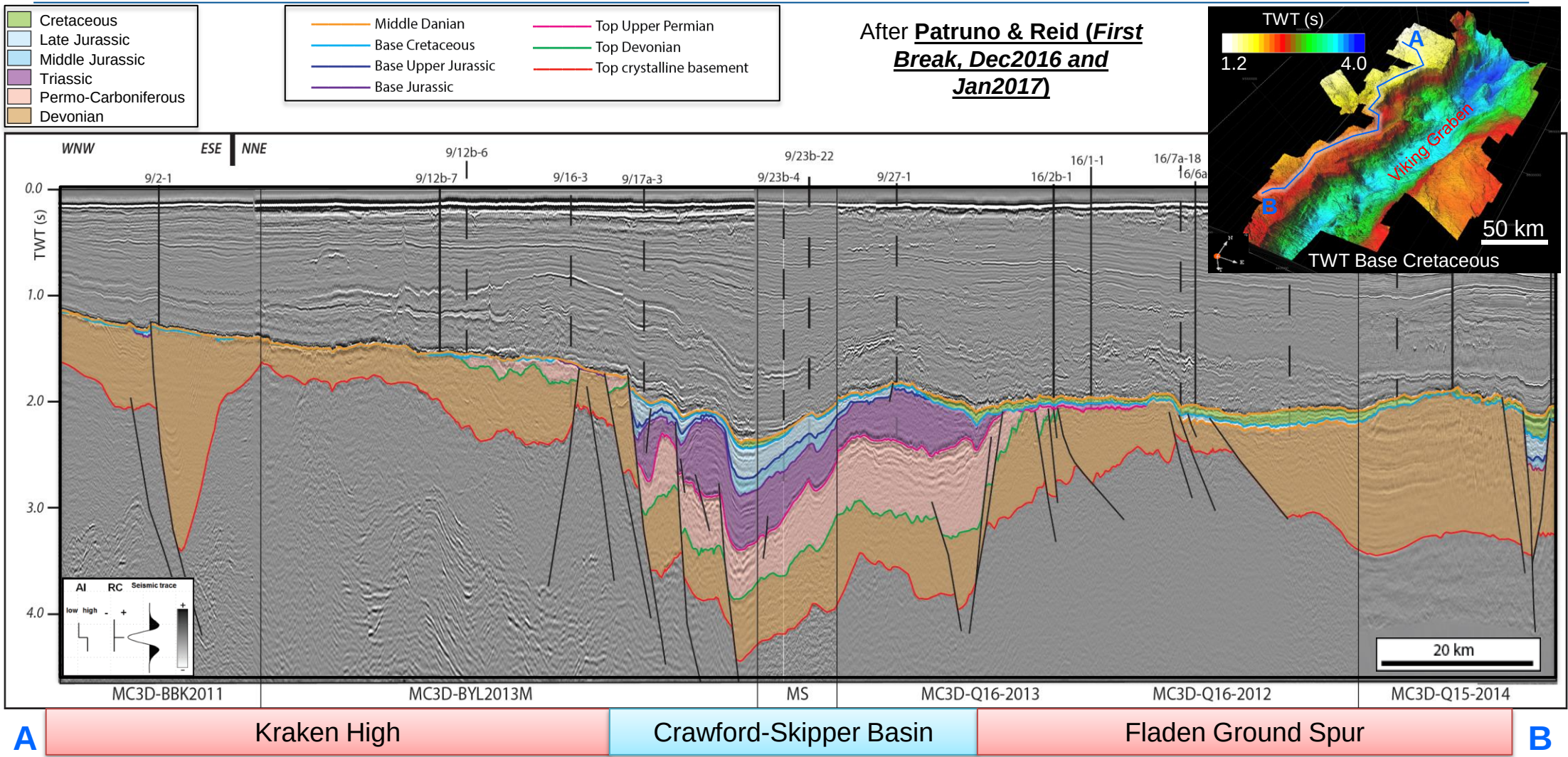
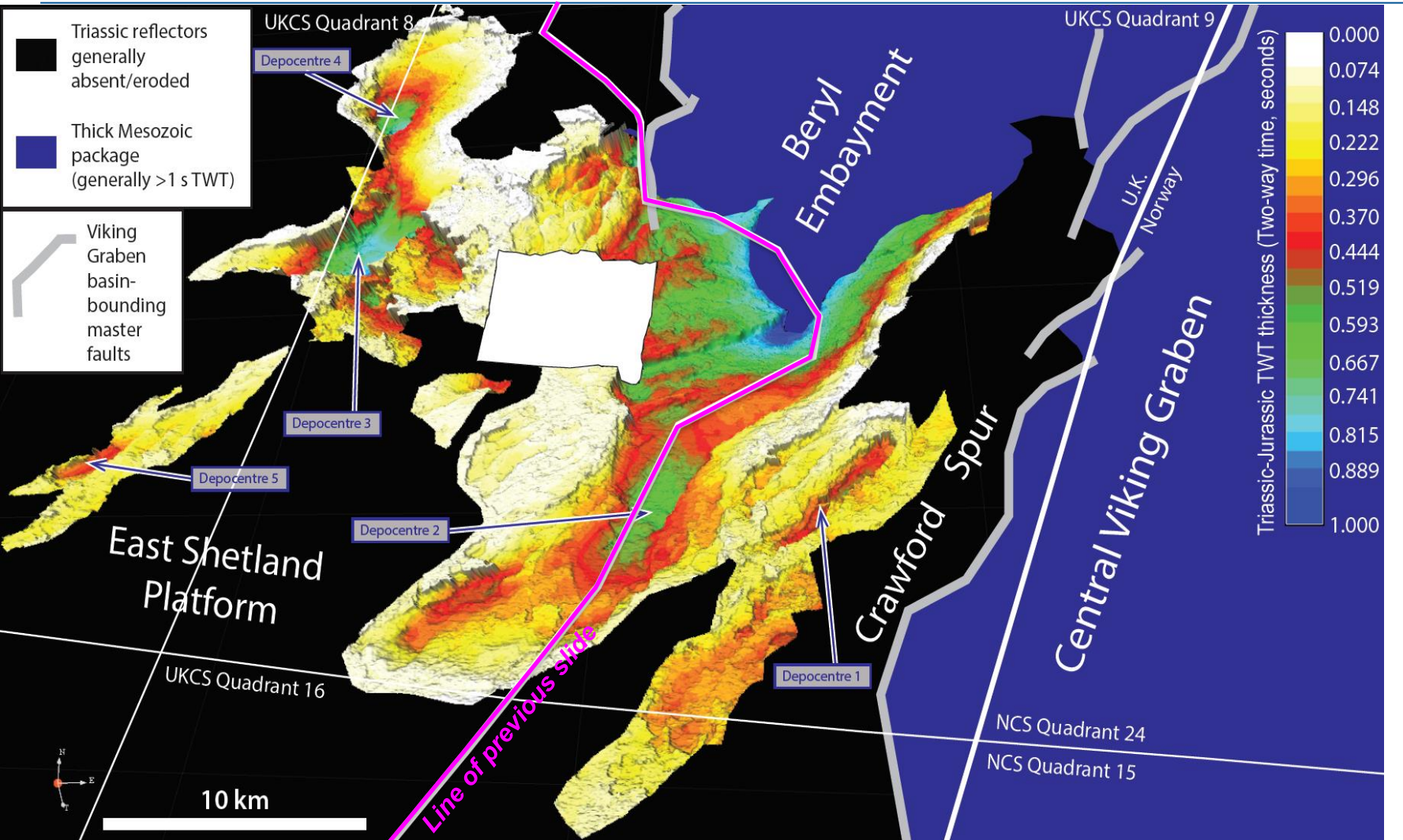
Crawford-Skipper Basin



Crawford-Skipper Basin

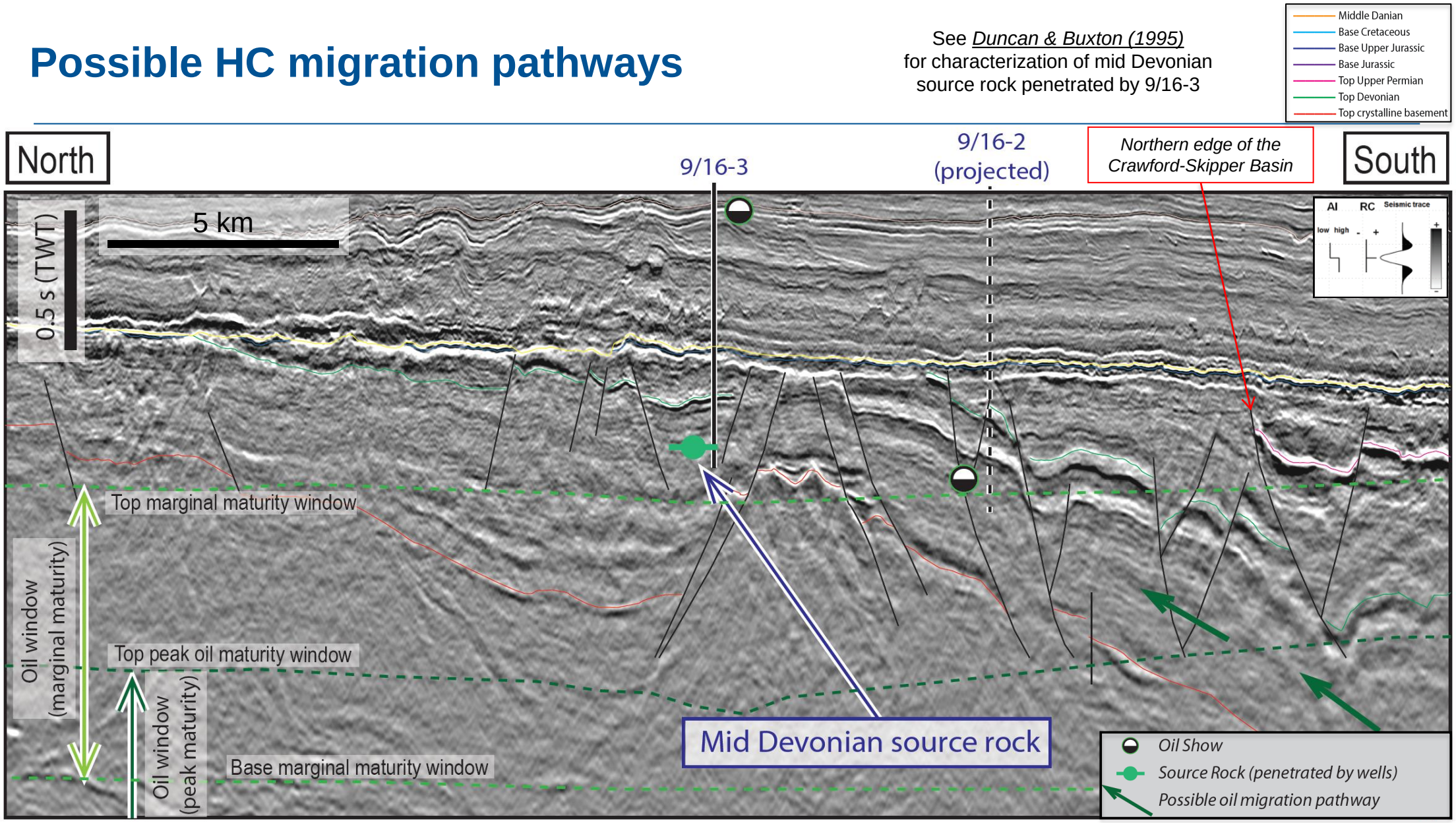


After **Patruno & Reid (*First Break, Dec2016 and Jan2017*):**

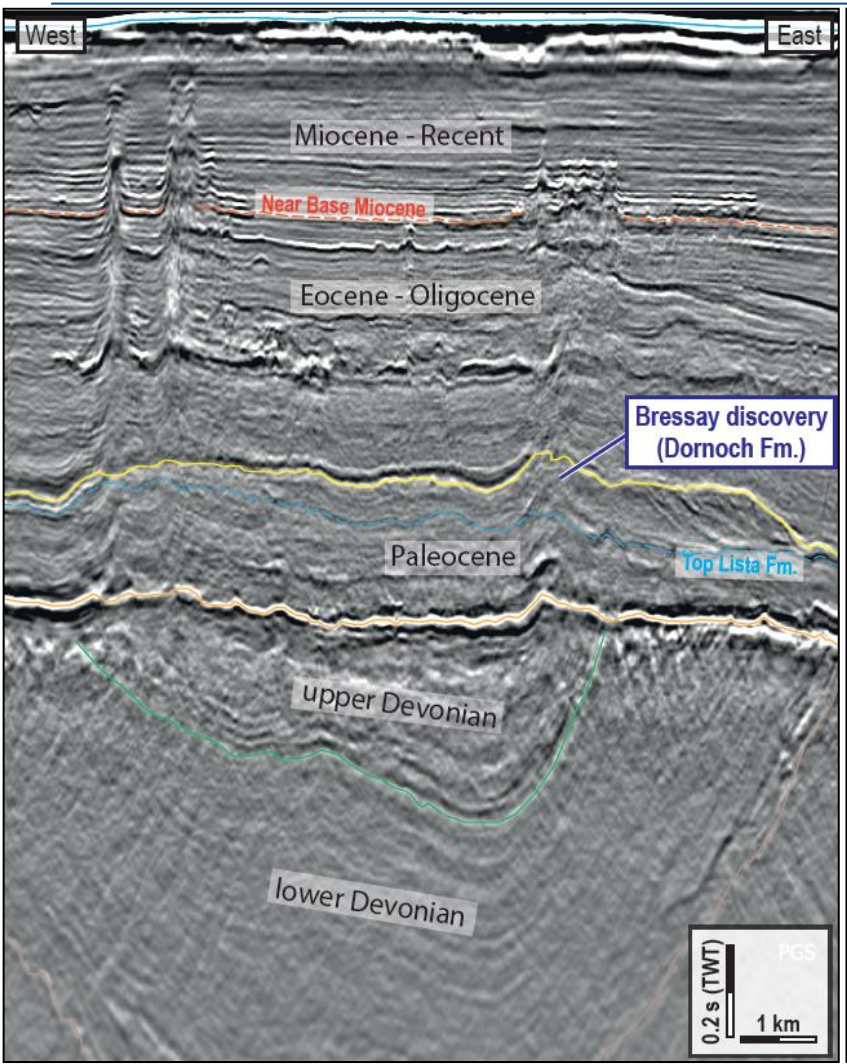
- Erosional surfaces on persistent highs
- Elsewhere on the ESP, predominantly subsiding Permo-Triassic depocentres contain a nearly continuous Paleozoic-Mesozoic succession.
- The most prominent of these, to the south and south-west of the Beryl Embayment, is referred to as the 'Crawford-Skipper Basin'

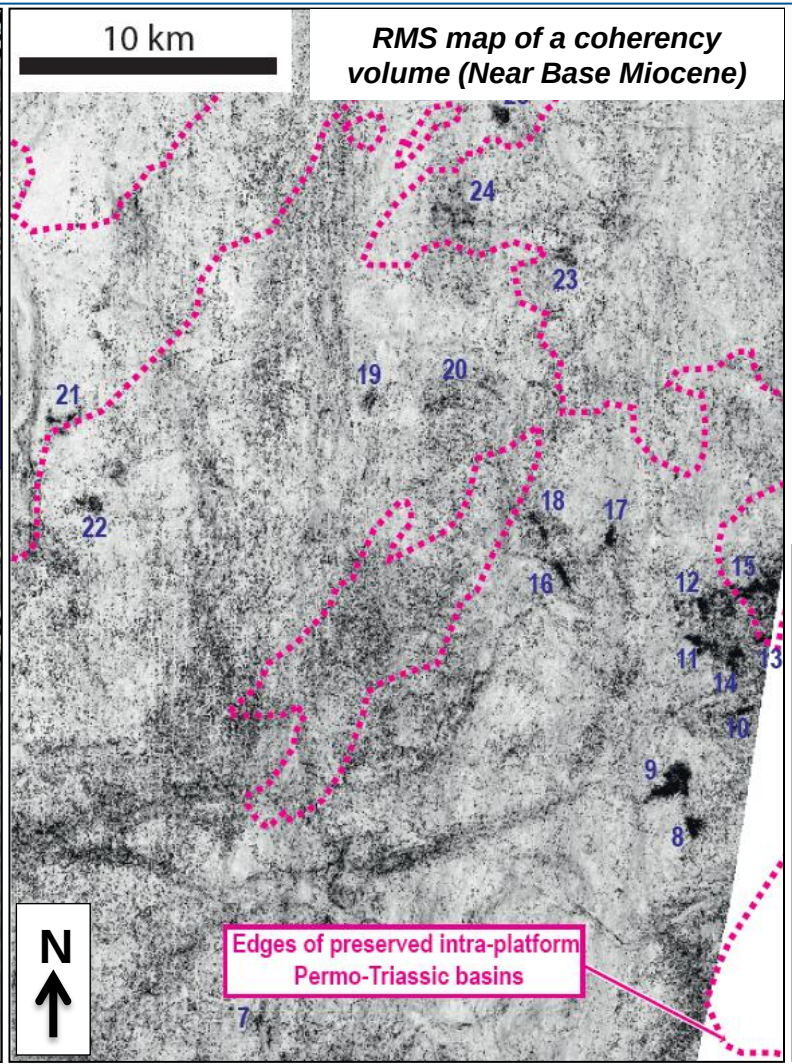
Possible HC migration pathways

See *Duncan & Buxton (1995)* for characterization of mid Devonian source rock penetrated by 9/16-3

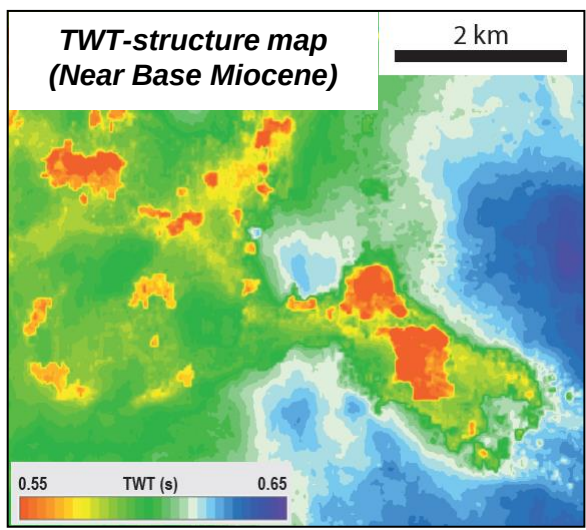


Possible HC migration pathways: vertical amplitude anomalies



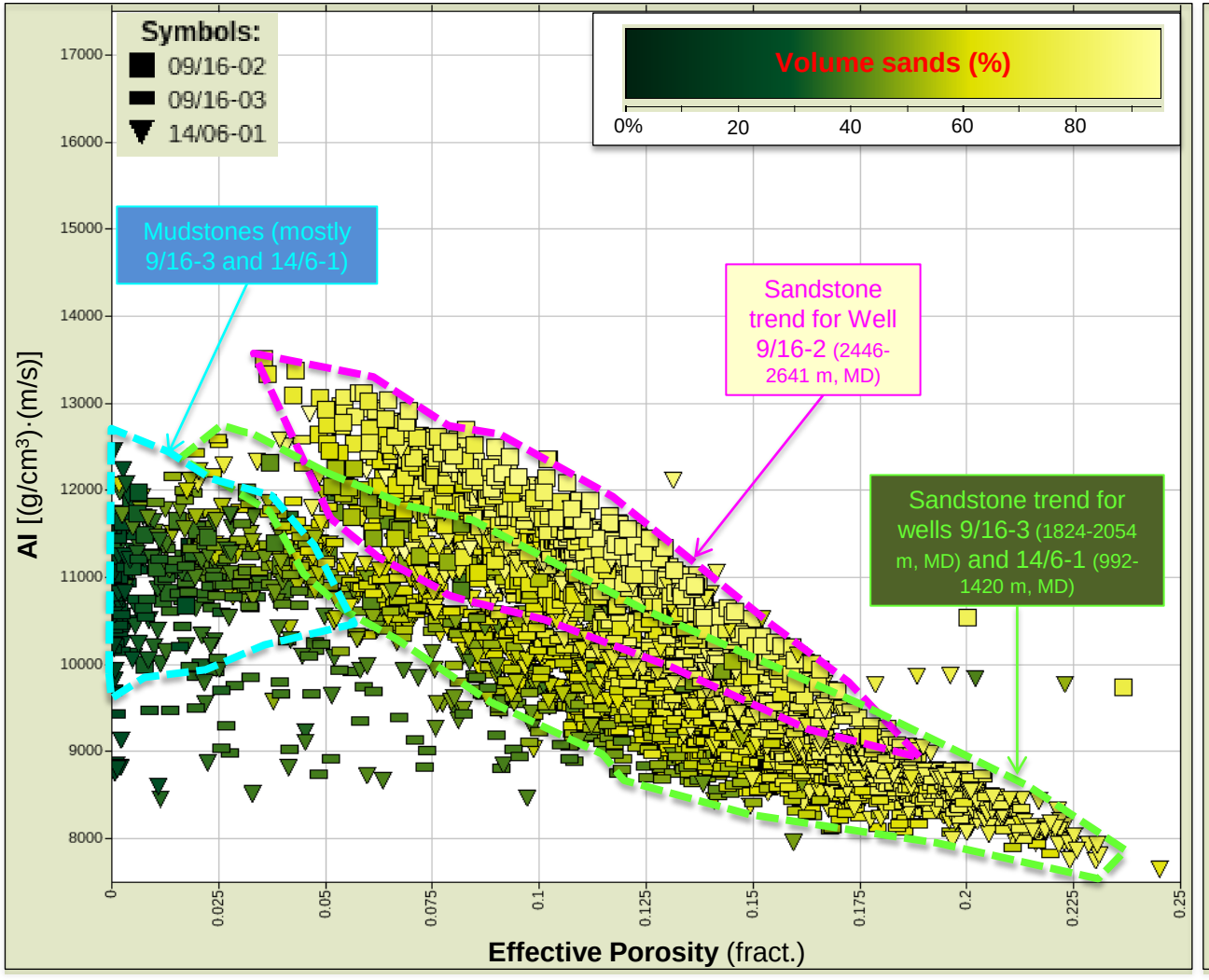


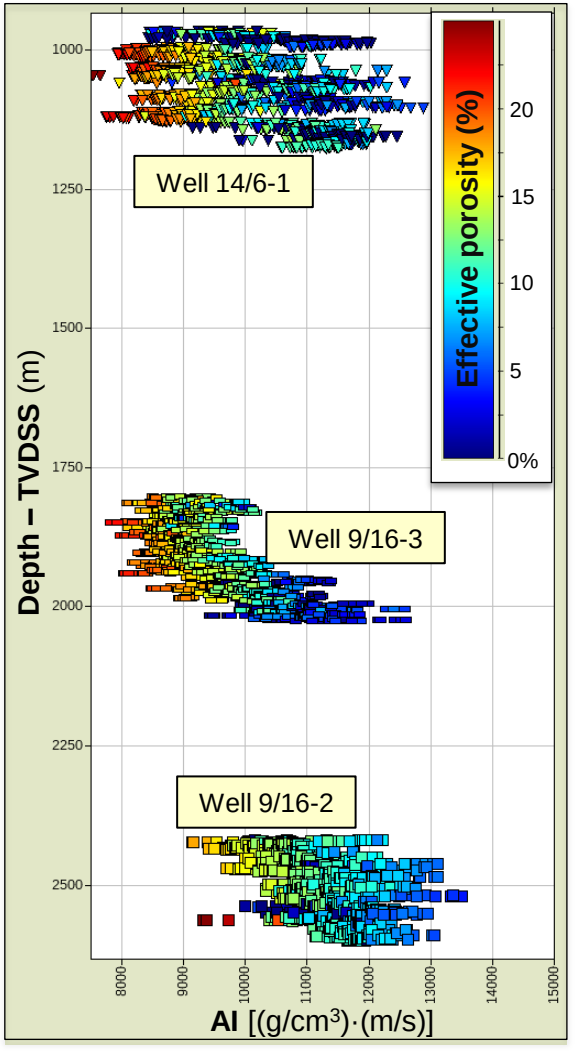
- Widespread vertical amplitude anomalies (or "pipes") in the Tertiary
- Particularly abundant at the edge of the Crawford-Skipper Basin
- Possible fluid escape features (originating from a Paleozoic source kitchen?)



The Paleozoic on the ESP: reservoir-scale observations

Upper Devonian reservoir quality and impedance values





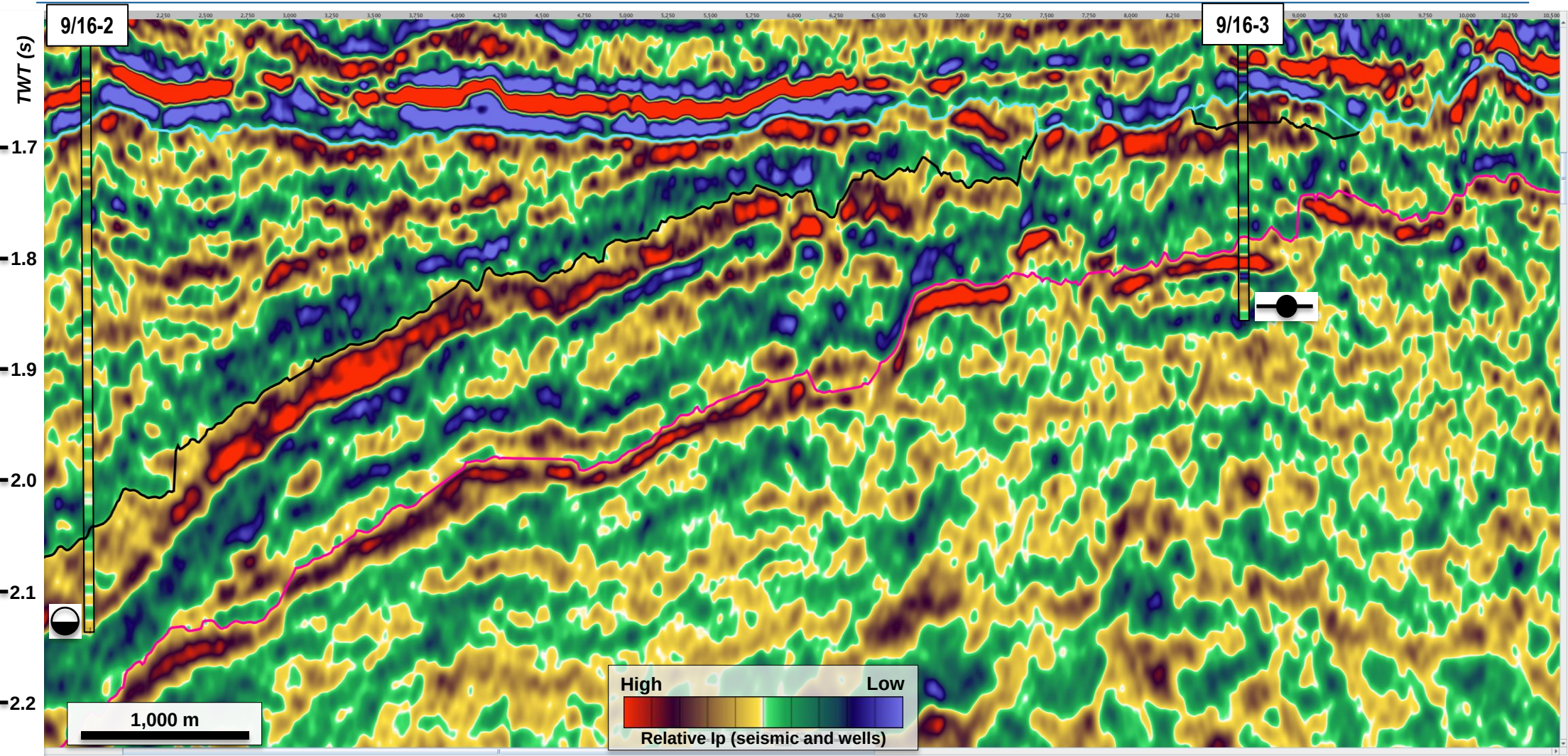
Reservoir quality:

- Variable: ***best porosities ~22%***
- Clean sands can have little or no porosity (<10%) – potentially cementation effects

Porosity-acoustic impedance trend:

- Porous sandstones tend to be softer (= *lower Ip*) than surrounding shales or non–porous sandstones.

Upper Devonian relative Ip: a proxy for porous sandstones?



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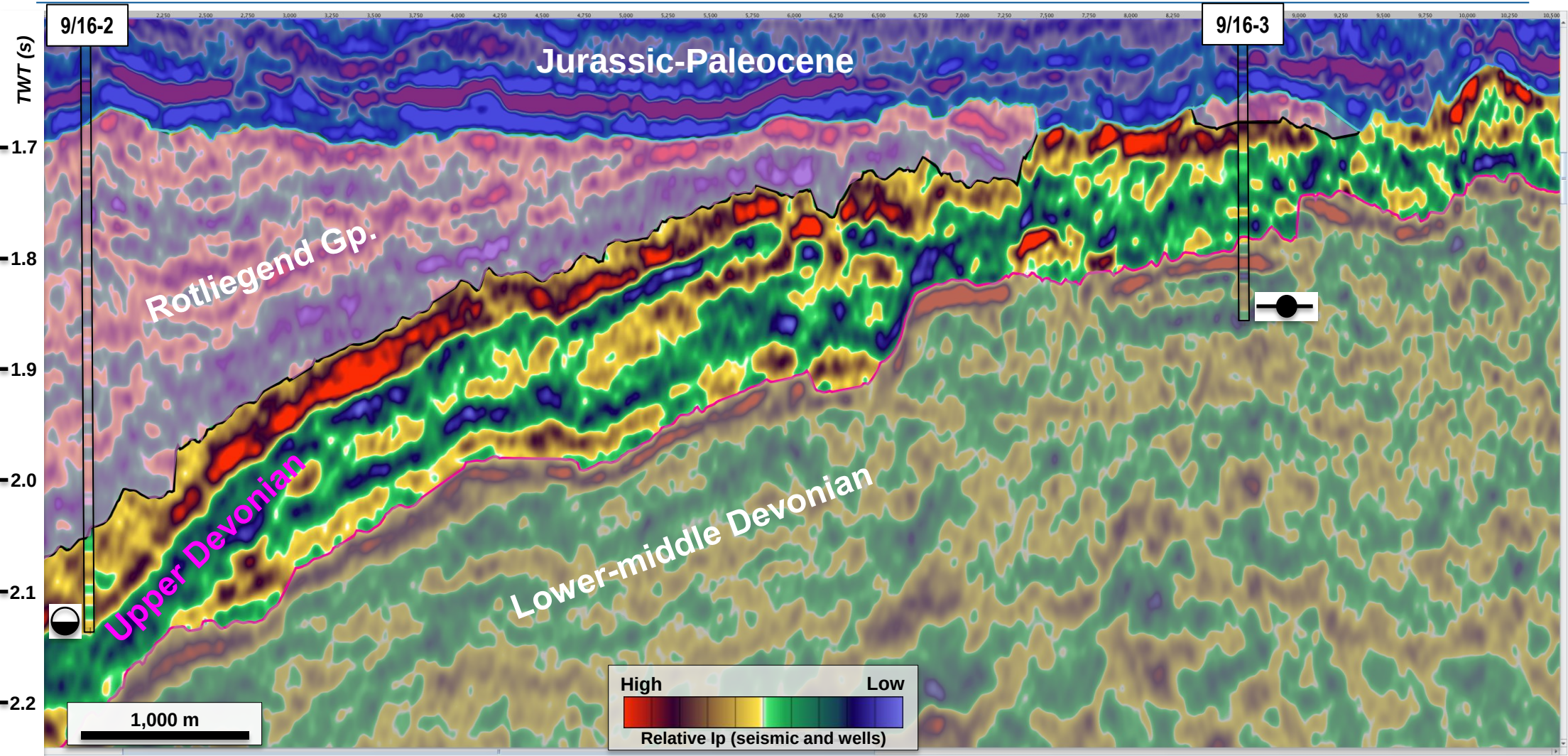

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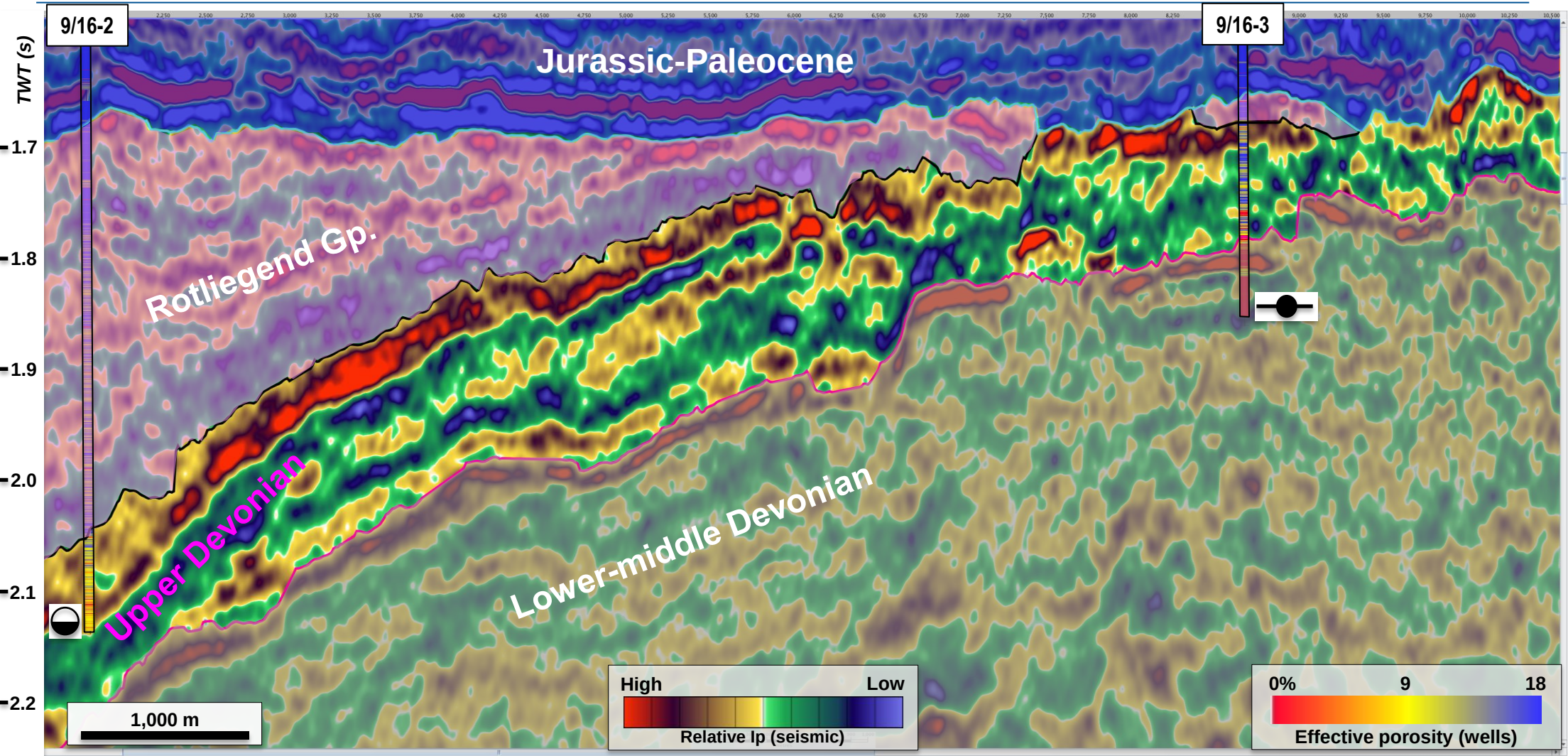
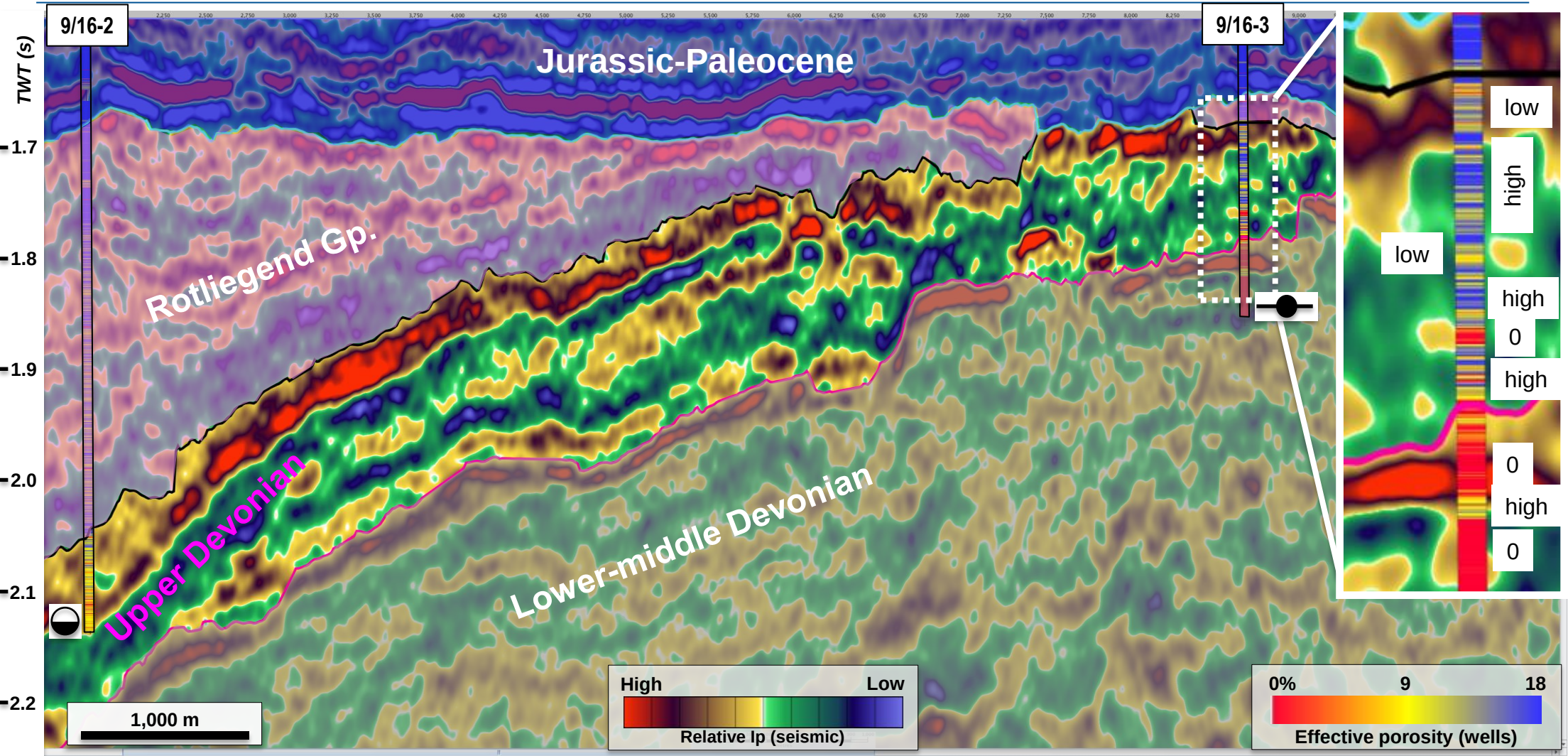
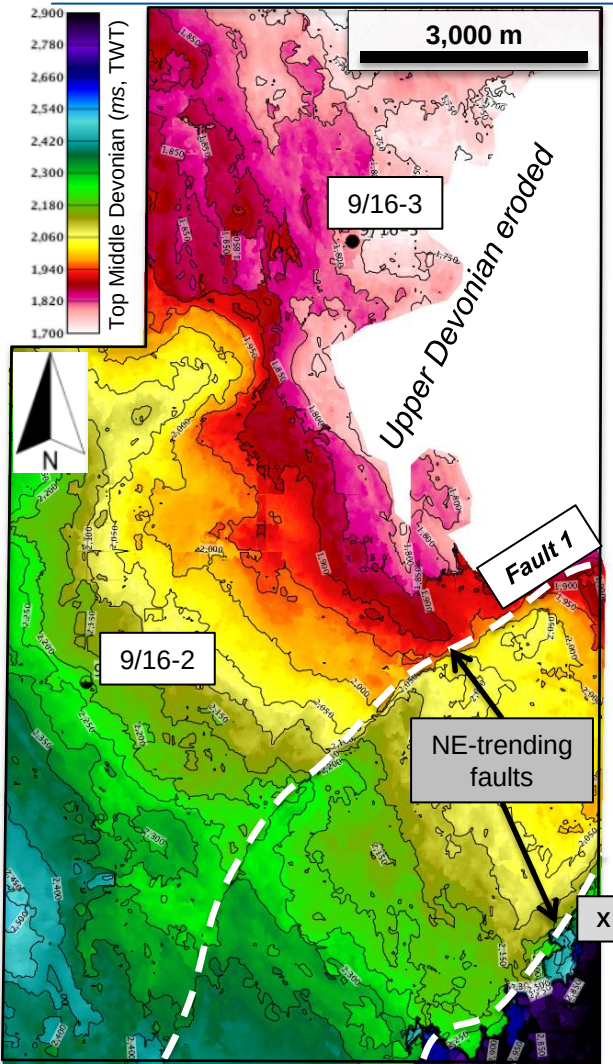
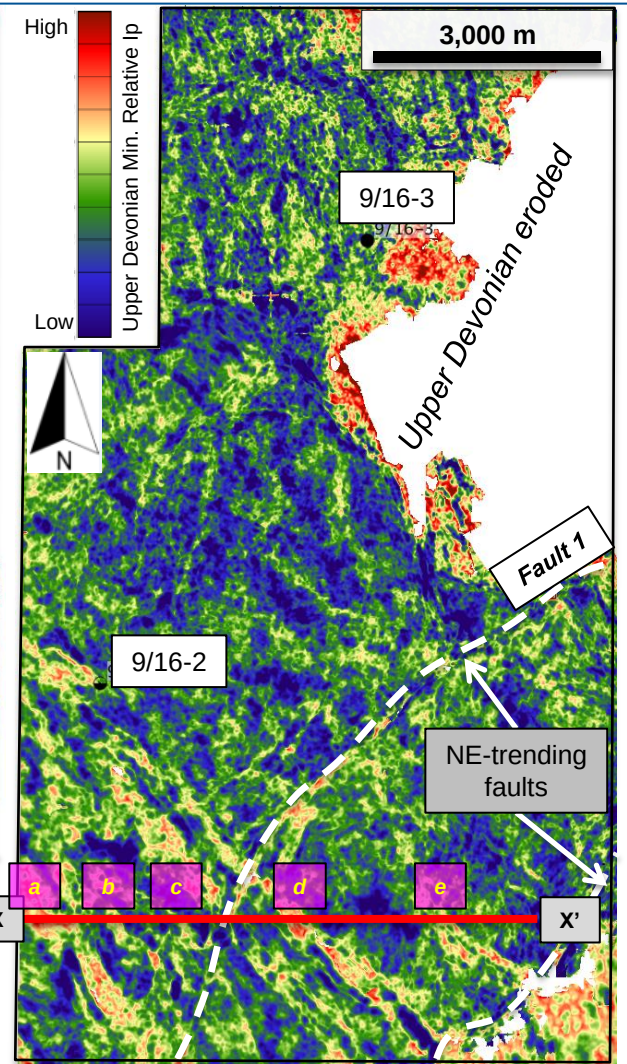


Upper Devonian relative Ip: a proxy for porous sandstones?

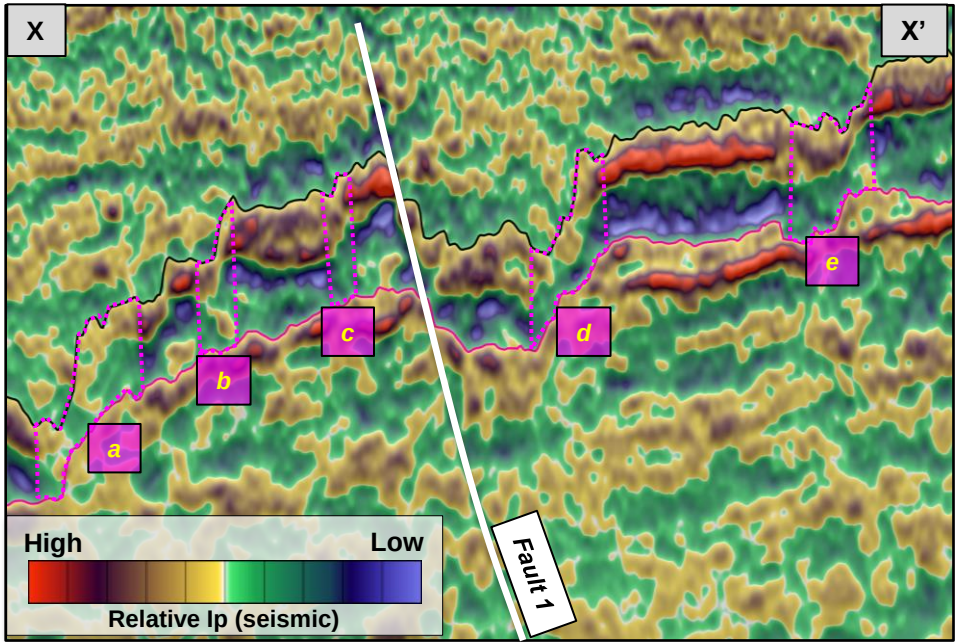


Upper Devonian interval: TWT-structure and min. rel. Ip maps





- Rock physics: upper Devonian relative Ip is a proxy for effective porosity
- Minimum Ip map: the area between 9/16-2 and 9/16-3 commonly hosts high porosity upper Devonian
- Wells 9/16-2 and 9/16-3 do not penetrate the best upper Devonian reservoir (i.e., with lowest Ip)
- NW-striking Ip patterns in the maps corresponds to greater structural dips due to structural lineaments



Conclusions

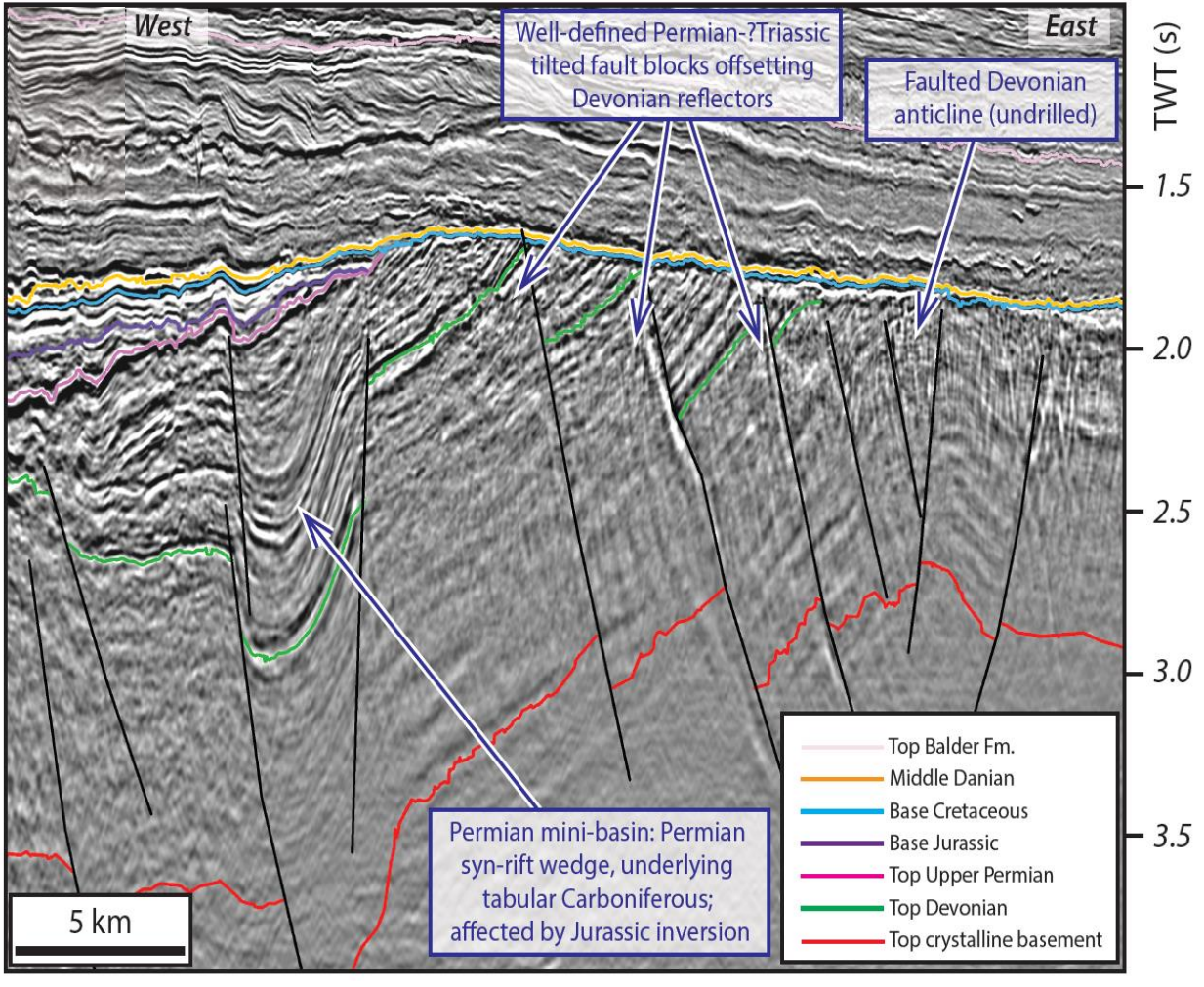
Reasons to revisit the East Shetland Platform

A VIABLE PETROLEUM SYSTEM

- Multiple possible **reservoirs**:
  - Eocene (e.g., Skipper, Brae West)
  - Paleocene (e.g., Mariner, Kraken etc.)
  - Jurassic-Triassic (e.g., Crawford, Hood etc.)
  - Permian carbonates (e.g., Ettrick, Claymore, J. Sverdrup)
  - Devonian (e.g., Buchan, Sterling, Clair)
- Tertiary **seal** (usually >1 s TWT)
- Multiple possible **source rocks**:
  - Kimmeridge Clay (horizontal migration)
  - Mid Devonian (vertical migration)

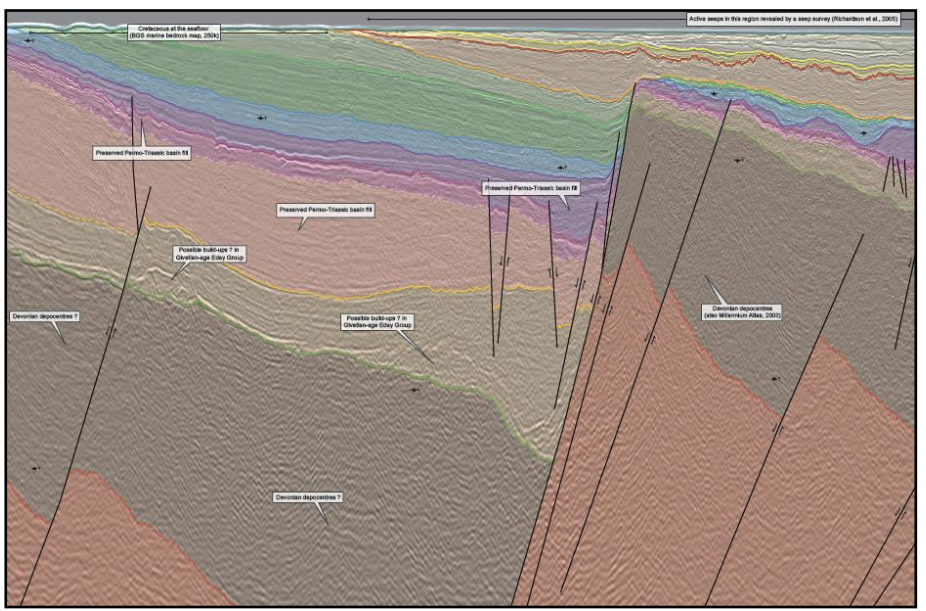
IMPROVED SEISMIC IMAGING:

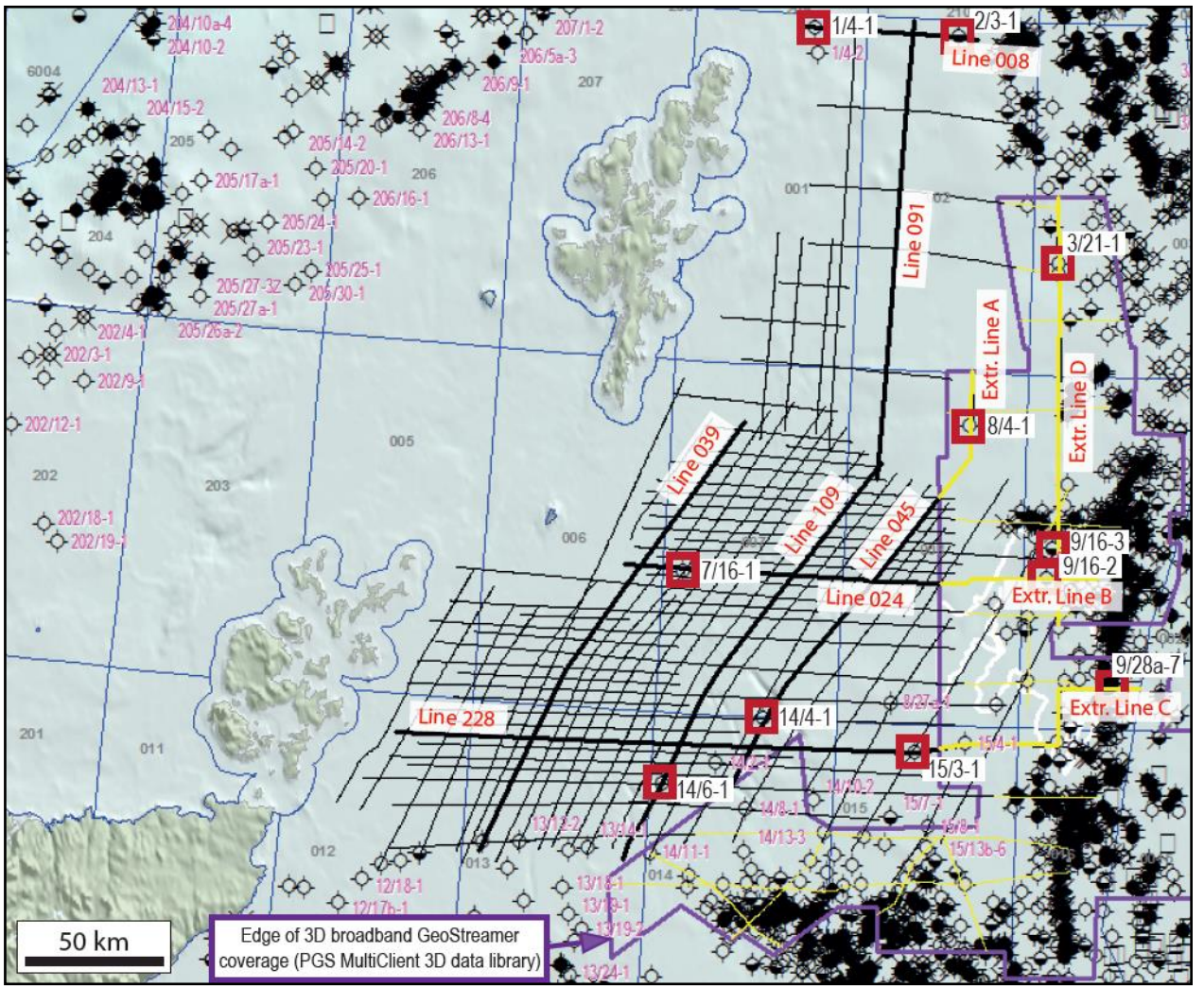
- Large Devonian structures (c.f., fields in OMF, WOS)
- Subtle Carboniferous-Triassic stratigraphic features
- Major improvements in imaging of Mesozoic-Cenozoic interval
- Reservoir characterization of the upper Devonian
  - Ip as a porosity proxy (as high as 22%)
  - Ip highlights subtle structural trends



Future work

- Following the 29th UKCS Frontier Licensing Round (2016), seismic acquisition and exploration efforts have shifted westwards on the ESP.
- In 2016, 7,701 line km of additional 2D regional GeoStreamer data have been acquired,
- Aim better defining the overall structure
- A start-up interpretation package was prepared by PGS on behalf of OGA and will be freely distributed with the data





Thank You!

PGS and OGA are gratefully acknowledged for the permission to utilize the seismic data for this presentation

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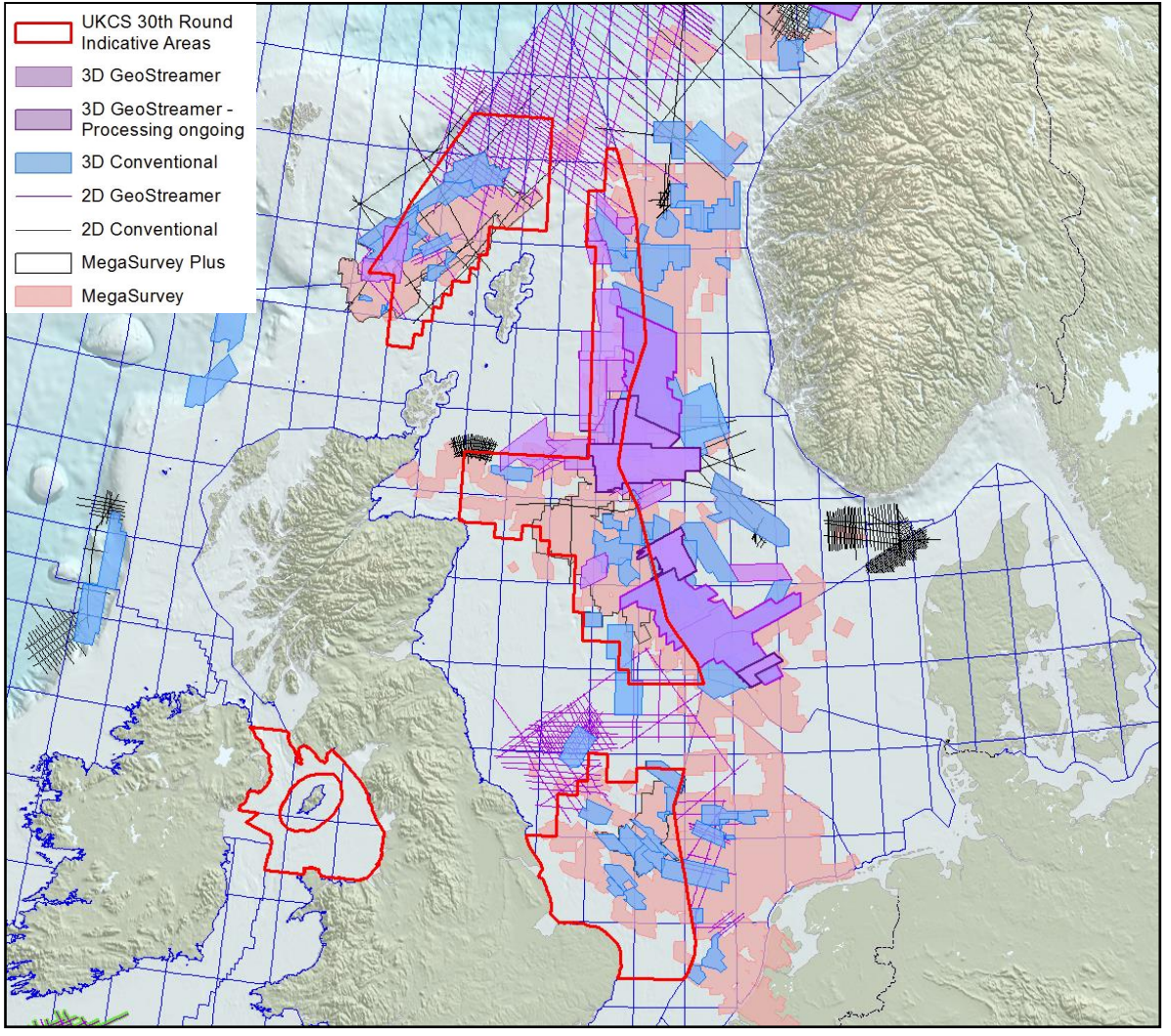

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