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 9/16-3 9/16-2 (projected)

1980’s Conventional seismic

TWT (s)

0.5 s (TWT)

- Oil Show
- Source Rock (penetrated by wells)
- Near base-Paleocene = Top Chalk Gp.
- Base Cretaceous Unconformity
The initial understanding

- TWT Base Cretaceous
- 5 km
- 0.5 s (TWT)
- Near base-Paleocene = Top Chalk Gp.
- Base Cretaceous Unconformity

GeoStreamer

- Oil Show
- Source Rock (penetrated by wells)
Contents

- 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

- Many other Paleozoic discoveries in CNS and WoS
- E.g., Buchan, Sterling, Clair
- Clair is 6\textsuperscript{th} 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)
- Inner Moray Firth: Beatrice
- Burial history modelling suggests late generation / 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

- 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

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

* Devonian-Carboniferous 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
Structural summary

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After: Reid & Patruno (Nov 2015, GeoExpro); Patruno & Reid (Dec 2016, FirstBreak)
Crawford-Skipper Basin

After Patruno & Reid (First Break, Dec 2016 and Jan 2017):

- 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


Northern edge of the Crawford-Skipper Basin.
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 $I_p$) than surrounding shales or non–porous sandstones.
Upper Devonian relative Ip: a proxy for porous sandstones?
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Jurassic - Paleocene

Effective porosity (wells)

High

Relative Ip (seismic)

Low

1,000 m

1.7

1.8

1.9

2.0

2.1

2.2

9/16-2

Jurassic-Paleocene

Rottliegend Gp.

Upper Devonian

Lower-middle Devonian

9/16-3

High

Low

High

0

High

0

High

0

0% 9 18

Effective porosity (wells)
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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References


- Reid, W., Patruno, S., 2015. The East Shetland Platform: unlocking the platform potential. With significant advancements in seismic acquisition technology, it is time to re-visit the East Shetland Platform. GeoExpro, November 2015, 12(6), 41-46.


