

The East Shetland Platform and Mid North Sea High

An introduction to the Devonian-Paleogene prospectivity of the key areas of interest for the UKCS 29th Frontier Licensing Round.

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The East Shetland Platform (ESP) and Mid North Sea High (MNSH) remain relatively underexplored platforms, with less than 10 wells per 1,000 km². Over Quadrants 3, 8–9, 14–16, 35–38, 41–43 (Figure 1), the clearer imaging of the modern broadband dual-sensor towed streamer surveys (GeoStreamer[®]) provides new insights into the geology and the petroleum systems of these frontier areas, which are proposed for inclusion in the upcoming UKCS 29th Frontier Licensing Round.

The following is a short summary introducing the main play concepts. A much more comprehensive description and discussion of these areas have formed several technical papers and presentations, some of which are referenced here.

Source Rocks

The majority of the hydrocarbons found in the Northern and Central North Sea are sourced from the oil-prone upper Jurassic Kimmeridge Clay. In contrast, in the Southern North Sea, the main source rocks are gas-prone Westphalian coals and shales. The source kitchens in both regions are restricted to basinal depocenters, with charge to the platform margins occurring via lateral migration (Figure 1). A deeper source rock is needed in order to extend prospectivity beyond these margins (Patruno & Reid, in review).

On the ESP, middle-Devonian lacustrine source rocks have been penetrated by numerous wells and oil seep data has revealed a working petroleum system up to 80 km away from the Jurassic source kitchen (Richardson et al., 2005). This Devonian source is proven to work in the Inner Moray Firth (Beatrice Field) and West of Shetlands (Clair Field) and may provide a secondary charge for large Witch Ground Graben fields (e.g., Claymore, Piper) (Mark et al., 2008; Cornford, 2009). 1D basin modeling supports the hypothesis of Cornford (2009) and suggests that the best-case scenario for the maturation of the middle-

Devonian source rock (i.e. post-Jurassic maturation) occurred over parts of the ESP (Patruno & Reid, in review).

On the MNSH, the Westphalian interval has been significantly eroded due to Variscan uplifting. Older source rocks (e.g., Carboniferous Scremerston Formation) could provide hydrocarbon charge beyond the platform margins. So far, all wells north of Quadrant 36 have been dry, suggesting that the central and northern MNSH may be affected by fundamental source/charge issues.

Reservoirs

Existing discoveries on the ESP and MNSH highlight the presence of multiple working reservoirs.

The ESP hosts predominantly Paleogene-age reservoirs (e.g., Mariner, Kraken) as well as Upper Jurassic sandstones (e.g., Hood, Claymore). Large Devonian-age discoveries are present in the West of Shetlands and Central North Sea (e.g., Buchan, Clair; Fig. 1). Clair, in particular, with >1,100 MMboe, is the sixth largest oil field in the UKCS.

The MNSH main reservoir intervals are Carboniferous in age (e.g., Breagh,

Crosgran). Additional potential within the MNSH is located in the Zechstein Group, with Z2-age carbonates (Hauptdolomit Formation) being a proven reservoir in Crosgran, onshore Yorkshire and throughout the Southern Permian Basin (Figure 1; Patruno et al., in review). In addition, the Z1 carbonates also constitute a proven reservoir (e.g. giant Hewett gasfield).

Seals

Within the study area, hydrocarbon discoveries and potential traps are generally buried beneath 1 second (TWT) of sediment (Figures 2–3). In the ESP, most of the overburden is composed of Mesozoic-Tertiary mudstone-prone sealing lithologies (Patruno & Reid, in review). In contrast, in the MNSH, Zechstein evaporites constitute the top-seal for Carboniferous and intra-Zechstein reservoirs, and additional seals are provided by the overlying mudstone-rich Triassic-Tertiary units (Figure 3).

Traps and Unexploited Potential

The existing discoveries on the ESP

rely predominantly on Paleogene-age traps, ranging from stratigraphic (e.g., Brae-West, Harding) to structural (e.g., Balmoral, Skipper). Upper Jurassic discoveries close to the Witch Ground Graben edges are structural (e.g., Claymore) or mixed stratigraphic-structural (e.g., Hood – Figure 2A). Fields with Paleozoic-Triassic reservoirs rely on structural, fault-block-related traps (e.g., Crawford, Stirling, Cairngorm) (Patruno & Reid, in review).

Additionally, several yet-undrilled traps and structures have been mapped throughout the ESP (e.g. Reid & Patruno, 2015). These include newly imaged Devonian-Jurassic fault systems, Devonian fault-blocks, anticlines, and intra-platform Permo-Triassic basins (e.g. the Crawford-Skipper Basin). The clear seismic imaging has also better defined the Mesozoic-Tertiary interval, identifying a number of potential exploration leads. These include Paleogene anticlines and pinchouts with amplitude anomalies; DHIs associated with Eocene-age clinoforms; and high-angle Eocene injectites (Figure

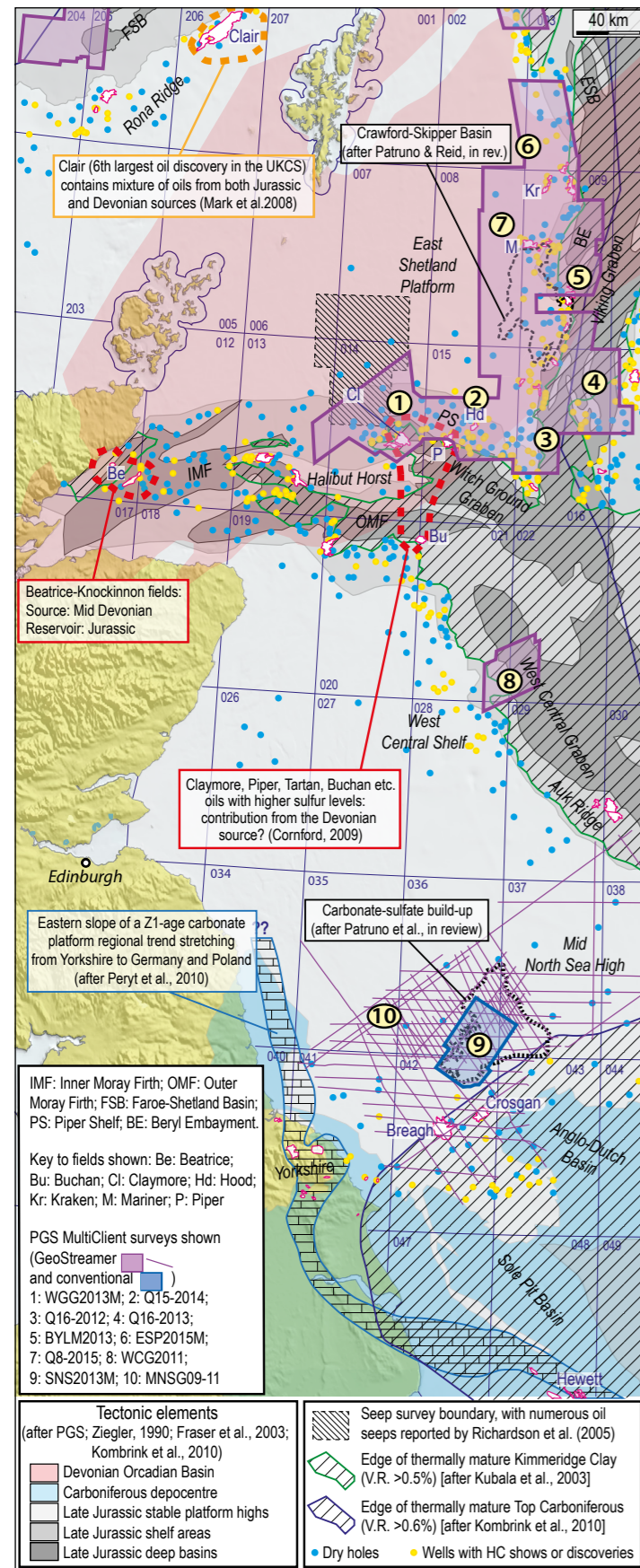


Figure 1: Structural elements, main fields and well results on the eastern UKCS. All the surveys shown, except MC3D-SNS2013M, are GeoStreamer, constituting >18,520 km² of modern (post-2010) 3D seismic and approximately 5,700 line-km of regional 2D (2009-2011).

Charity Photo Competition

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The Cyrenians are a charity based in Aberdeen, working to support all sections of the community, including many who have been devastated by the downturn in the oil industry.

GEOExPro and PESGB are delighted to announce their partnership with the Aberdeen Cyrenians in 2016. Our first initiative is a photo competition. A selection of the best photos will feature on an A1 2017 Calendar Poster available to buy from the GEO ExPro stand at PETEX in November.

All proceeds go to the Aberdeen Cyrenians.

PETEX delegates will have the opportunity to vote for their favourite photo and the most popular shots will feature as the covers of both the PESGB magazine and GEO ExPro magazine in 2017.

How to Enter:

Send your photograph and caption to rosy@pesgb.org.uk

Image must be high resolution, at least 300dpi

Multiple entries welcome but maximum 10 entries per category

Enter one or more categories

Entrants agree use of accredited images in future PESGB and GeoPublishing publications

Deadline September 30th 2016

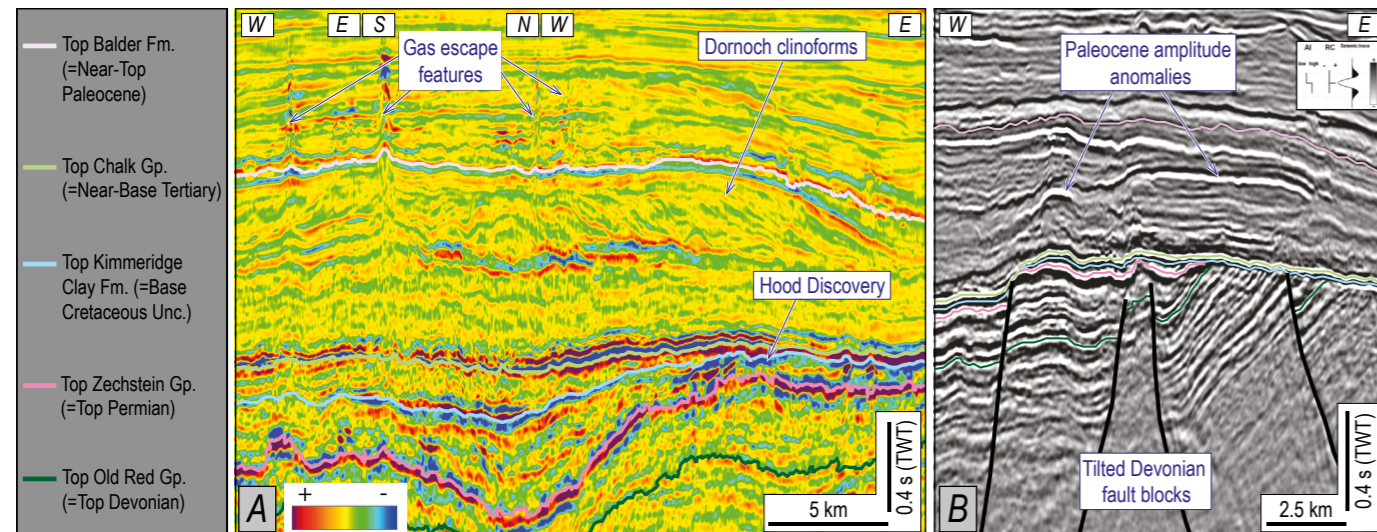


Figure 2: MC3D-Q15-2014 GeoStreamer from the East Shetland Platform. (A) Post-stack run-sum showing possible gas escape features; (B) Full-stack Paleocene amplitude anomalies and Devonian fault blocks.

2). As with existing multi-reservoir discoveries (e.g., Claymore, Crawford), some newly-defined leads on the ESP comprise stacked targets, such as the Eocene clinoforms, Paleocene amplitude anomalies and Devonian fault blocks seen in Figure 2.

A relationship between the deep-seated Paleozoic-Mesozoic fault systems and the Tertiary leads and discoveries has now been documented (Figure 1; Patruno & Reid, in review), with existing hydrocarbon discoveries on the ESP clustering in the vicinity (<7 km) of intra-platform Permo-Triassic basin margins. Exploration near such basins is less risky due to possible positive influences of

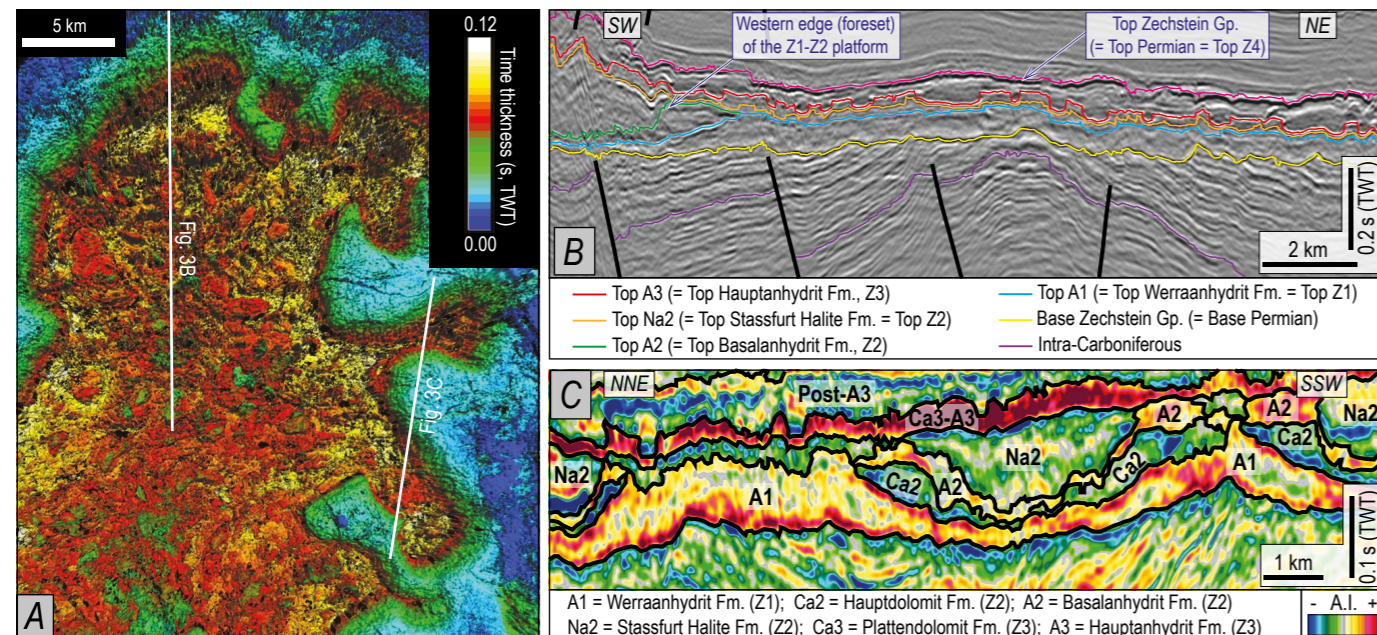
deep-seated structures on the petroleum system, such as the formation of Meso-Cenozoic closures via fault-inversion; Devonian source maturity; the presence of simple structural migration pathways, and the viability of sub-Jurassic reservoir-trap-seal configurations (Patruno & Reid, in review).

The southern MNSH hosts several trap types. These include Carboniferous-age 4-way dip closures resembling existing discoveries (e.g., Breagh; Figure 3B); Devonian Kyle Limestone fault blocks, mapped in 3D for the first time; and a 2,284 km², newly described sulfate-carbonate platform (Figures 1 and 3) (Patruno et

al., in review). This sulfate-carbonate platform comprises a series of prograding-aggrading clinoforms of lower Zechstein age (Z1-Z3), with some composed of anhydrite (high impedance) and others of carbonate (lower impedance) (Figure 3C). The Z2 carbonates form the most prospective clinoforms, both regionally and locally (Patruno et al., in review). Although gas shows have been identified in at least 21 nearby wells which penetrated the tight Z2 bottomset carbonates, the thickest and most permeable part of these clinoforms (i.e. foresets) has never been drilled in this area.

A full list of references is available online. ■

Figure 3: MC3D-SNS2013M (Mid North Sea High). (A) TWT-thickness map of a Z1-Z2 sulfate-carbonate platform. (B) Full-stack Carboniferous structures and Zechstein build-ups. (C) Relative acoustic impedance, with lithological discrimination of intra-Zechstein evaporite and carbonate clinoforms.



Africa: What's Next?

The 15th HGS-PESGB Conference on African E&P

September 12-14, 2016

The Westin Houston, Memorial City, Houston Texas

Six of the IHS Top Ten discoveries of 2015 occurred on the African continent. This clearly illustrates why Africa is so important in the search for oil and gas. The annual HGS-PESGB Africa conference, alternating between Houston and London, has established itself as the premier technical E&P event on this fascinating, and frustrating continent. If you are currently exploring or are thinking about exploring the African continent you cannot afford to miss this conference! Scheduled speakers include the top explorers and researchers working Africa and its margins. A primary goal of the HGS during this difficult business climate is to provide inexpensive, quality training and networking opportunities for our membership and the greater geological community. We believe we have met this goal with the speakers, short courses, geophysical showcase and geological workshop we have assembled for this conference. Typical conference attendees include industry operators, consultants, governments, and academia.



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The Second Annual Interactive Seismic Showcase and Geology Workshop will feature geophysical and geological vendor presentations highlighting their products and services. This proved to be a big attraction in London in 2015 and we are anticipating similar excitement at this year's event.

Short Courses

Two short courses will be held in conjunction with the conference
Duncan Macgregor – *Petroleum Basins and Recent Discoveries in North and East Africa*

Ian Davison – *South Atlantic Margins: Geology and Hydrocarbon Potential*

Conference Opening Evening Lecture

Prof. Andrew Nyblade (Penn State University) will present the conference opening lecture on *Imaging First-Order Structure of Large Karoo and Younger Basins in Central, Eastern and Southern Africa Using Passive Source Seismic Data*. The lecture will be held on the evening of Monday September 12th. This event has limited seating and requires a separate reservation. Details will be on the HGS webpage under "Events".

Conference

Early Bird registration April 1 through June 30, 2016 = \$300
Regular registration July 1 through August 31 = \$400
Late/onsite registration September 1 through September 14, 2016 = \$450

Short Courses

Early Bird registration April 1 through June 30, 2016 = \$200
Regular registration July 1 through August 31 = \$250
Late/onsite registration September 1 through September 14, 2016 = \$300

A \$50 discount will be given to individuals that sign up for both the conference and a short course