EAGE

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Seafloor Sampling of Frontier Basins for Detection of Active Hydrocarbon Systems and Stratigraphic Tie

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SUMMARY

Gravity coring and dredging has been used to obtain extensive seabed sampling of potential hydrocarbon seep sites and escarpments offshore in Arctic frontier basins. Sampling of subcropping strata and thin overburden sediments provide consistent information on ages of the strata and the nature of potential active hydrocarbon systems. Our results are the first to document active hydrocarbon systems in the Baffin Bay, the northeast Greenland shelf, and on the southern Jan Mayen Ridge.

Introduction

Since 2000 VBPR and TGS surveyed four areas around Greenland, one in the Jan Mayen Microcontinent, and one in the Mid-Norway Margin using our seafloor sampling strategy (Figure 1). There, seismic reflection data from frontier basins for oil and gas exploration can image seep structures and truncated reflections at the seabed. Seafloor sampling using a gravity corer and a dredge specifically targeting these anomalies aims at identifying and characterizing active petroleum systems, and providing geology-tie to seismic data (Figures 2 and 3).

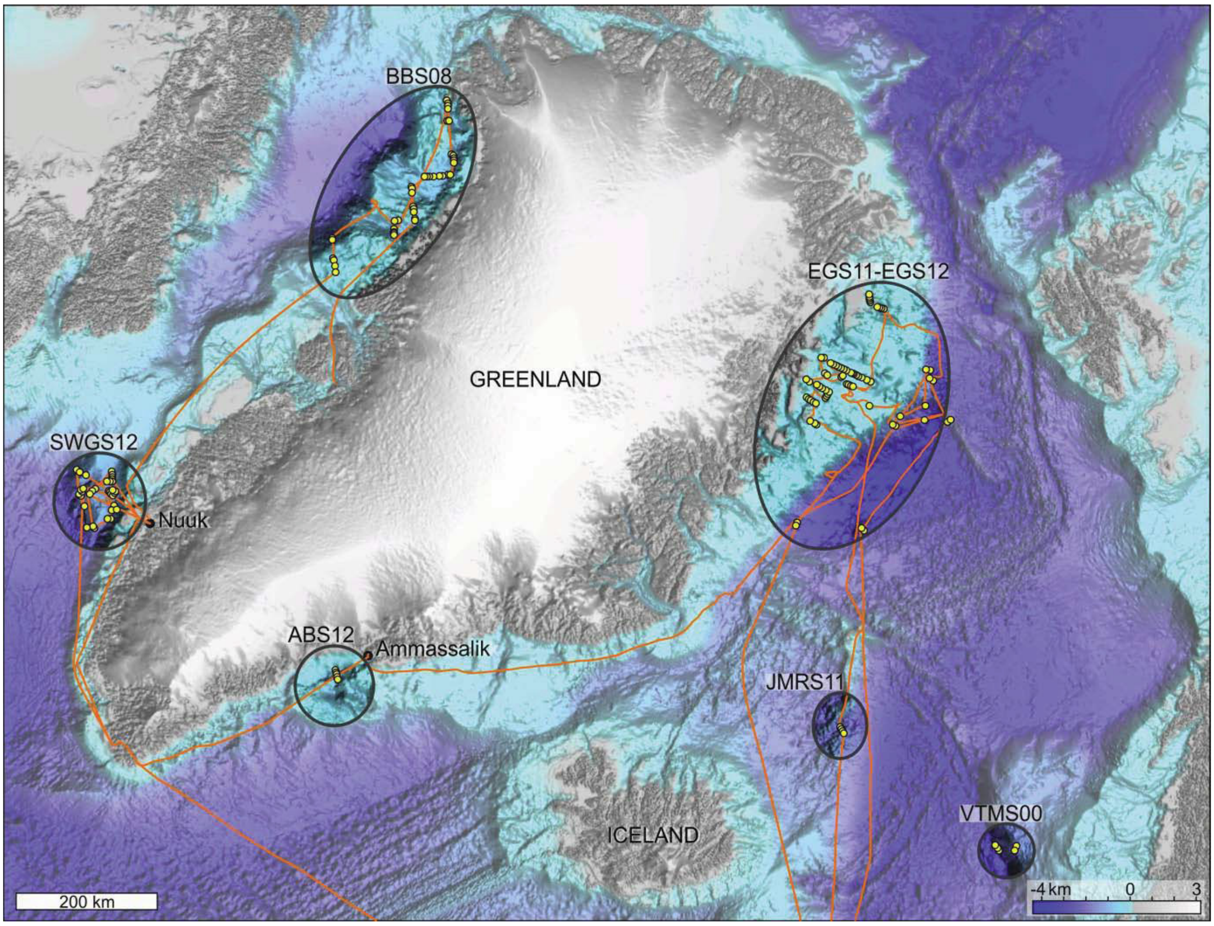

Figure 1 Seabed sampling stations (yellow circles) around Greenland and in the NE Atlantic Ocean.

Data and Methods

A dredge can sample subcropping sediment fragments along kilometre long profiles. The dredge is a heavy duty basket with a chain bag that is dragged across steep escarpments. The advantage of dredging is that we can recover large volumes of near in situ sediment fragments that may not have been sampled by gravity coring. A gravity corer can sample seep sites and subcropping strata. Our gravity corer consists of a 3 m long core barrel attached to a 800 kg lead weight, and is dropped onto the seafloor. The seep targets imaged on seismic include depressions on the seafloor connected to chimney-like structures, shallow amplitude anomalies, outgoing stratigraphy, sites above diapir structures, and termination of deep-seated faults. The stratigraphic targets are sites with truncated seismic reflections at the seabed showing little to no overburden. Standard seep geochemistry and amplified geochemical imaging are two independent methods that strengthens our confidence in identifying and characterizing petroleum systems. In addition, the biostratigraphy and TOC and Rock-Eval are carried on material from interpreted subcrops.

Figure 2 Left: Contents of a dredge emptied on the deck. The hemipelagic clay is washed and rock fragments arranged in lithological groups. Right: Gravity corer recovered on deck, the cutting shoe is removed and checked for the presence of hydrocarbons. The liner is then extracted from the core barrel, cut into 1 m sections, and sampled.

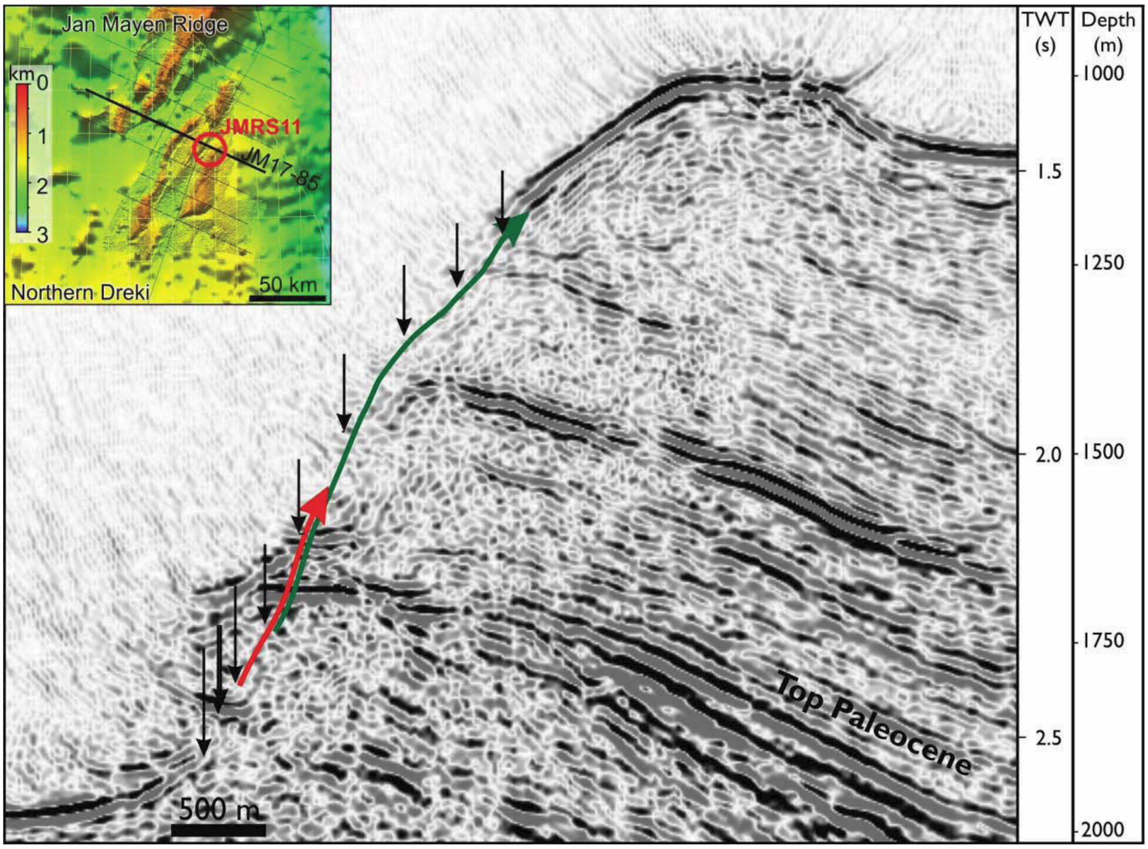

Figure 3 Seabed sampling locations along the southern Jan Mayen Ridge in the Northern Dreki area. Vertical black arrows show gravity core locations. Red and green arrows show dredge profiles.

Results

We recovered near in situ Cenomanian-Turonian source rocks and identified active hydrocarbon seepage in the Baffin Bay. In addition, we discovered a well-developed Late Jurassic source rock interval and an active Jurassic petroleum system offshore NE Greenland. The Ammassalik Basin in SE Greenland was also characterized by seeped Jurassic hydrocarbons associated with a near in situ Middle Jurassic reservoir unit. Near in situ sediments were recovered below the breakup basalts on the southern Jan Mayen Ridge (Figure 4), and pre-breakup Late Cretaceous subcropping strata was recovered on the Vøring Transform Margin. In all these studies, biostratigraphic results from stratigraphic sampling showed that gravity core samples are arranged in the correct stratigraphic sequence, thus allowing to construct pseudo-wells combining gravity core and dredge samples.

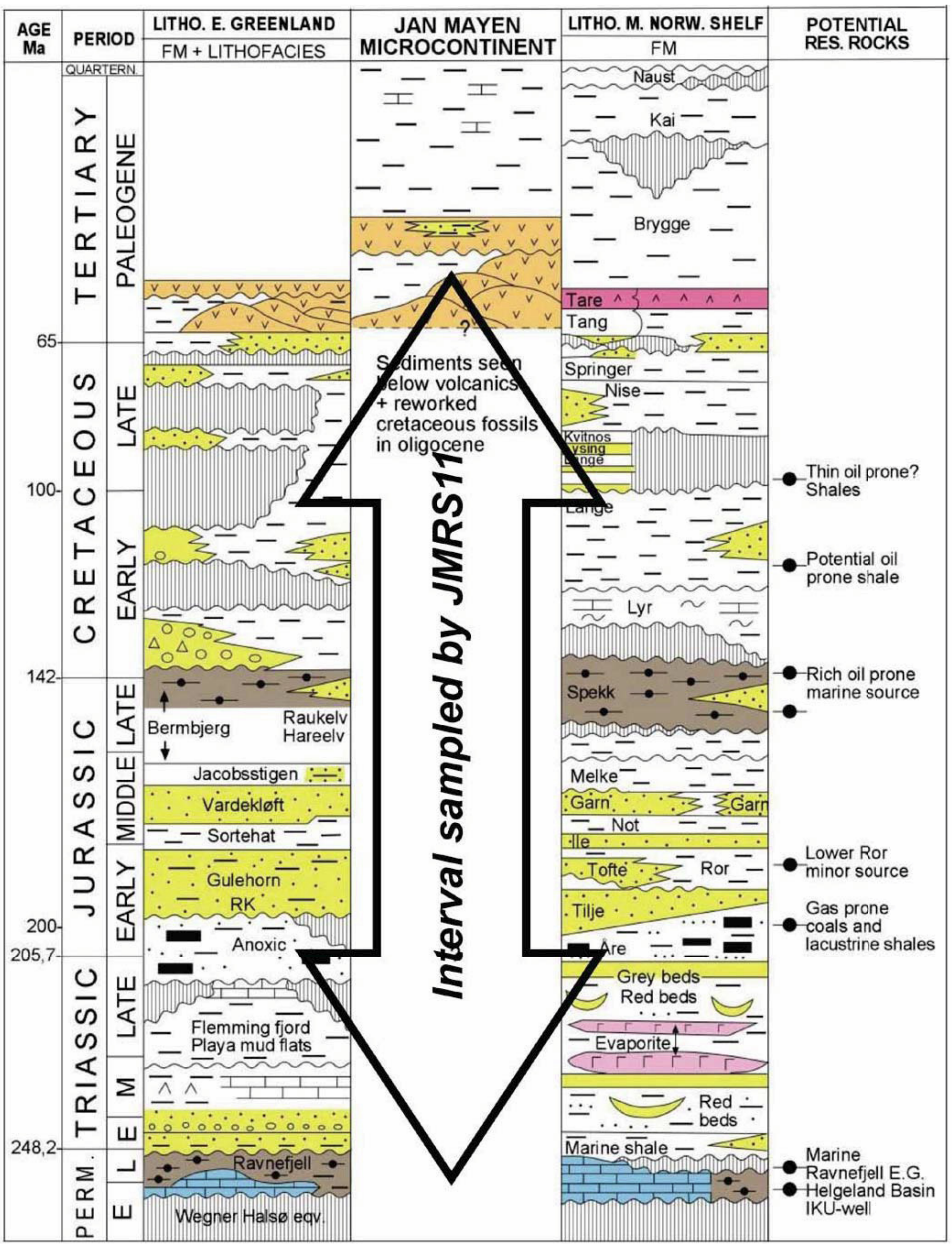

Figure 4 Lithostratigraphic chart showing that the Mesozoic stratigraphic succession is well know from East Greenland and Mid-Norway. However, the succession is not yet drilled on the shelf of East Greenland, and therefore uncertainties remain with the pre-breakup sequence in the Jan Mayen Ridge (Figure after Sagex, 2008).

Implications

The results from the NE Greenland margin, Ammassalik Basin, Vøring Transform Margin, and Jan Mayen Ridge sampling surveys are important for understanding the Mesozoic petroleum systems across the conjugate margins (Figure 5). Structural interpretations and gravity and magnetic anomaly maps restored to breakup are used to delineate basins and highs across the conjugate margins prior to seafloor spreading. Data and knowledge from geology onshore northeast Greenland and offshore the mid-Norway margin can be used to assess the petroleum potential on the northeast Greenland shelf, however the results from integrated studies offshore northeast Greenland may be equally important in assessing the potential for petroleum traps beneath the flood basalts on the western Møre and Vøring basins and hydrocarbon potential in the SW Barents Sea.

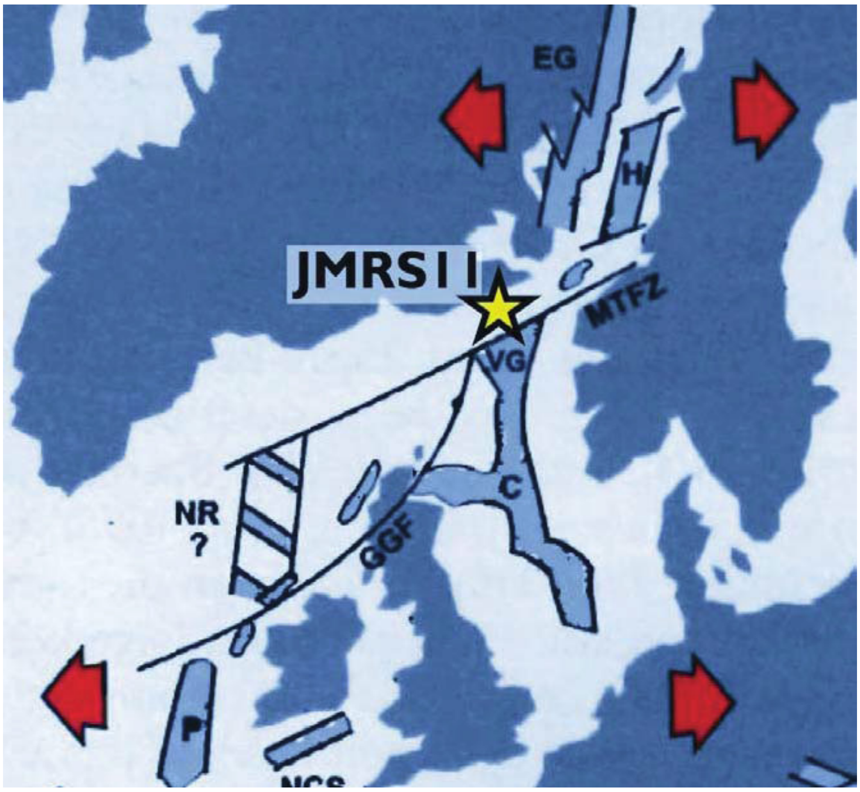

Figure 5 Pre-breakup plate reconstruction showing the position of the Jan Mayen Microcontinent in relation with the Mid-Norway and East Greenland Margin, suggesting similar geology between each province (figure after Dore et al., 1999).

The identification of microseepage and of Cenomanian-Turonian source rock interval supports the presence of a working hydrocarbon system in the Baffin Bay area. The Cenomanian-Turonian source rocks is an important world-wide source rock interval, and have been studied extensively on the Ellesmere Island to the north, but were never drilled or sampled along the West Greenland Margin.

Conclusion

This robust sampling approach can be applied during early exploration phases in any frontier region. The results can constrain seismic interpretation and can be integrated into basin models to identify better exploration targets and increase exploration success.