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# Identification and Characterization of Petroleum Systems in the Labrador Sea Using Seafloor Sampling and Seep Studies

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## Summary

The offshore basins in the Labrador Sea are vast and largely unexplored, and to date only gas accumulations have been confirmed. During the summer 2014, we sampled 184 sites in the Labrador Sea in order to identify and characterize liquid hydrocarbons from the St. Anthony, Hawke, Orphan, Hopedale, and Saglek basins (Fig. 1). Analyses of seep samples using three different geochemical and biochemical methods show that liquid hydrocarbons are seeping onto the seafloor, suggesting the presence of an active pretroleum system in the survey area. This ongoing study will further provide information on the depositional environment, maturation, and age of the source of the seeped hydrocarbons.

## Introduction

Successful seafloor sampling relies on identifying the location of shallow seismic anomalies, some of which could be associated with surface oil slicks. During the summer 2014, we carried out the Labrador Sea sampling survey (LBS14) in order to identify and characterize seeped liquid hydrocarbons from the St. Anthony, Hawke, Orphan, Hopedale, and Saglek basins. In order to meet these objectives, we collected hydrocarbon seep samples using the gravity coring on shallow seismic anomalies. These seismic anomalies typically correspond to the terminations at the seabed of deep-seated faults, shallow amplitude anomalies, and depressions on the seafloor. These potential macro-seep structures have been sampled mostly along the shelf break. Accurate positioning was important since sub-cropping faults and depressions in the seafloor are small targets, and good results are location dependent.

## Method

The operations were carried out using the *M/V Polar Prince*, an ex-coastguard and icebreaker/buoy tending vessel during the summer 2014.

The positions of the sampling targets identified on 2D seismic data were fine-tuned on site using the sub-bottom profiler (SBP) data acquired immediately before the actual sampling. The gravity corer was positioned as close as possible to the target using an underwater positioning system (USBL, ultra short baseline).

Clay samples were collected from the recovered material in sealed containers for standard seep studies at TDI-Brooks (Total Scanning Fluorescence or TSF, gas chromatography techniques, and biomarkers), amplified geochemical imaging (AGI), and in sterile bags for microbial prospecting technology (MPOG).

In addition to collecting clay from the seabed, we tried to sample slicks on the sea surface. This approach relies on historical satellite data to locate long-lived slicks, and on the most recent imagery to locate these slicks that drift depending on currents. Although no slick have been visualy identified, we used the AGI slick sampling kit whenever safe conditions permitted at each coring location.

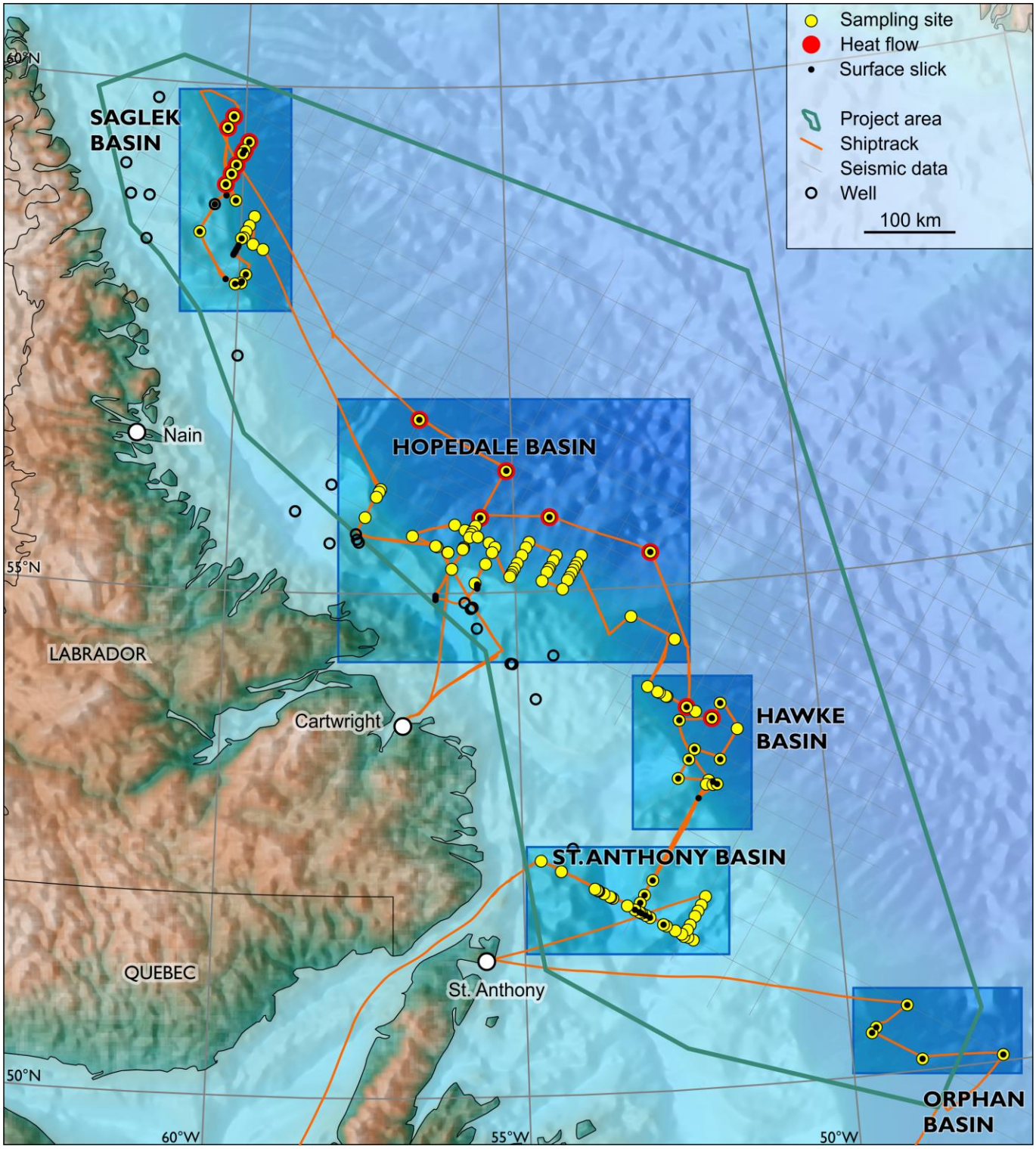


Fig. 1. Bathymetry map showing sampling locations, shiptrack, and exploration wells.

## Results

The LBS14 survey was successful, with a total of 184 sites samples allowing the recovery of 245 m of sediment core, 132 seep samples (TDI-Brooks, AGI), 135 micro-biological samples (MPOG), 79 surface slick samples, and 18 heatflow measurements (Fig. 1).

The gas-chromatography analysis carried out on the 132 samples allowed the identification of 31 samples based on TSF intensities and UCM values (unresolved complex mixture) in the 260000-100000 and 28-15 ranges, respectively. These values are suggesting micro-seepage of hydrocarbons. These 31 samples are currently subjected to biomarker analysis to provide information on depositional environment, maturity, and age for the source of the seeped hydrocarbons.

The AGI micro-seep results shows hydrocarbon signatures that consist of a broad range of compounds, suggesting a thermogenic expression of a liquid hydrocarbon phase. The AGI method further allowed the identification of several potentially charged structures. In addition, a distinct difference between the entire survey with the 4 sites in close proximity to the Orphan Basin was identified by cluster analysis.

Overall, the average MPOG oil indication in the survey area shows considerable hydrocarbon potential, with more than 35% of the samples displaying significant oil indications, while the gas indications are significantly lower. Oil and gas anomalies correlate well, possibly suggesting that the gas is associated with oil accumulations.

Finally, two of the surface slick samples identified anomalous levels in hydrocarbon coumpounds that could indicate the presence of weathered oil slick drifting on the sea surface

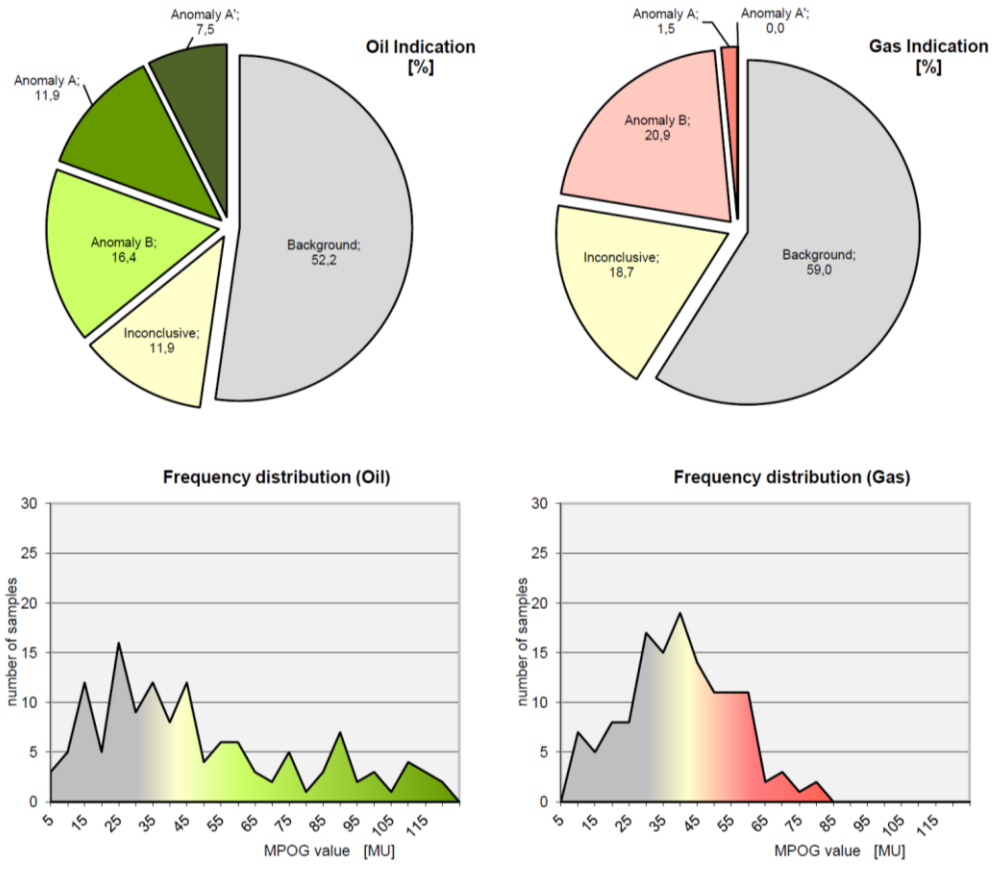


Fig. 2. Frequency diagrams showing the distribution of MPOG oil and gas indications for the LBS14 samples.

## Conclusions

The results from the three different analytical methods correlate well in terms of seep locations and identification of either oil or gas phase. Besides showing the presence of a working petroleum system with likely oil accumulations at depths in various parts of the Labrador Sea, this study also demonstrate that successful seafloor sampling surveys for hydrocarbon identification in frontier basins are based on recovering samples at sites characterized by distinct shallow seismic anomalies.

## Acknowledgements

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