Davis Strait West: petroleum potential in a volcanic rifted margin

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Summary

The Davis Strait region between Canada and Greenland is a volcanic transform margin that has seen sporadic petroleum exploration focussed on the eastern side. A review of geophysical, oceanographic and geological data shows a new interpretation of basement architecture with evidence that an unconventional petroleum system is present in two previously undescribed offshore basins east of Cumberland Sound and Cape Dyer, Baffin island, Nunavut.

Introduction

A substantial amount of detailed petroleum exploration has occurred on the eastern side of Davis Strait offshore Greenland. This resulted in ten exploratory tests, three in the last six years, that used recent seismic along with other methods like satellite oil slick mapping, but all were unsuccessful.

There is little exploratory drilling present on the western side of Davis Strait, all three wells in the southern portion bottom in basalts although one well, Hekja O-71, is a significant gas discovery in the Cenozoic age Saglek Basin. The volcanic transform margin nature of Davis Strait is well established (Oakey and Chalmers, 2012) and the rifting dates from the Cretaceous to Eocene. The petroleum potential would appear to be low as basin depths are less than 5 kilometers and basalt from extensive basement structures is present building up to the seafloor over large areas, reducing the volume of sedimentary rocks needed for a conventional hydrocarbon kitchen.

A significant amount of marine dredge sampling and shallow core drilling was performed by the Geological Survey of Canada that establish the seafloor geology (Figure 1). One core from the GSC shallow drilling program, labelled "Petro Core", is notable for being petroliferous, the sample vigorously exuded methane bubbles and the high resolution seismic data used to target the drill site shows acoustic wipe out zones explainable as gas filled sediments (Maclean and Srivastava, 1981). More recently, the satellite mapping of oil slick features on the sea surface by synthetic aperture radar shows interesting distributions of slick anomalies in relation to sub seafloor seismic mapping (Jauer and Budkewitsch, 2010). Oceanographic sampling that focused on the oil slick features previously mapped measured anomalously high dissolved methane in the water column off Cape Dyer adjacent to a cluster of oil slick features (Punshon et al., 2014). While most of the Cenozoic onshore geology has been eroded, recent coring of kimberlite diatremes on the Hall Peninsula does find entrained xenoliths dating from the Paleozoic, prior to the rifting events that form the margin. The Chidliak kimberlite area has one core that is an oil prone source rock, a Silurian age shale (Zhang et al., 2014). Similar age rocks must be resident in any pre-rift basins.

Method

An integrated approach of interpreting the seismic data with filtered Bouguer anomaly gravity data shows the major structural elements, with volcanic based highs dominating the regional geology. A seismic depth map to the volcanic basement is shown based on velocity analysis of surrounding well data.

Two new basins are named, the Tariut Basin just offshore of Cumberland Sound and the Imapqik Basin immediately south of Cape Dyer. The Tariut Basin outlined (Figure 1) is mapped with both seismic and gravity while the Imapqik Basin outline is seen only on gravity (Figure 2) and does not appear on the magnetic data.

The onset of this basin is visible on our nearest seismic line showing the Cape Dyer flood basalts climbing towards surface in Figure 2.

Examples

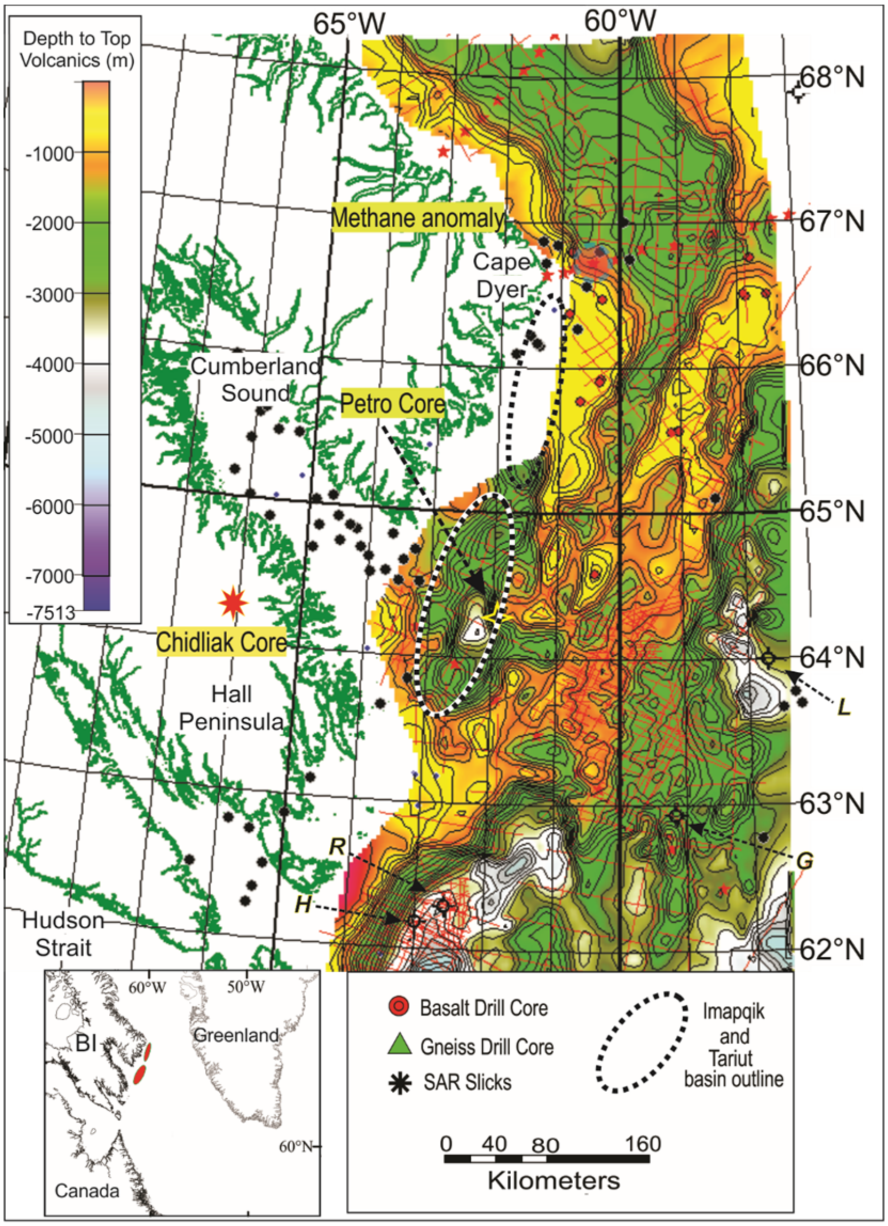

Figure 1 Computed seismic depth structure of Top Volcanics for western Davis Strait.The Tariut Basin is the structural low immediately west of the “Petro Core” bounded by the Imaqpik Basin and Cape Dyer basalts to the north and probable gneissic basement to the south. Exploratory wells shown by letter;

H= Hekja O-71, R= Ralegh N-18, G= Gjoa G-37, L= LF7-1

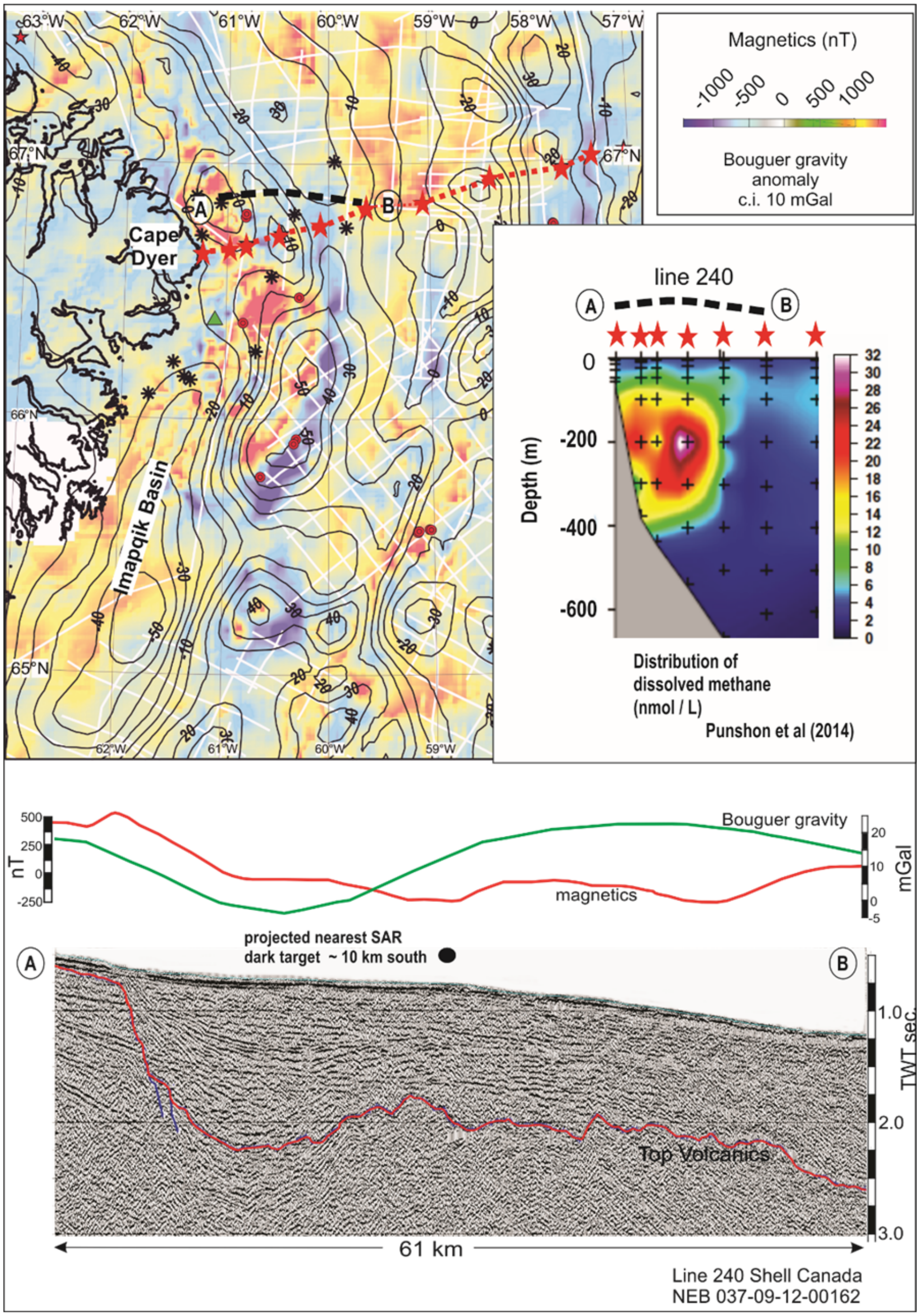

Figure 2 Magnetic data grid with overlain Bouguer gravity anomaly contours offshore Cape Dyer with oceanographic transect measuring dissolved methane in depth sampled seawater, adjacent oil slick features and shallow drill cores. Gravity data contours show up-dip basin edge of the northern Imapqik Basin leading into the methane anomaly area with clusters of radar imaged oil seep features.

Conclusions

Given the concentration at the seafloor and very short duration time of methane resident in sea water there must be active replenishment of hydrocarbons. This is likely due to up-dip hydrocarbon migration from the Imaqpik Basin offshore Cape Dyer.

The charging of overlying sedimentary rocks with hydrocarbons seen from the one core and shallow seismic data is explainable as this site is on the edge of the Tariut Basin which shows sill intrusions present, which would produce thermogenic hydrocarbons in shales. The accuracy of the interpreted oil slick features, although as yet unverified by sampling, appears to be a good indicator for the presence of hydrocarbons.

Based on the combined evidence of oil slick anomalies, petroliferous core, source rock presence, dissolved methane readings in the water column, combined with an extensive flood basalt system that has trapped, sealed and thermally enhanced the maturation of suitable source rocks filling the two inshore basins, we conclude that a nonconventional petroleum system is present. The relationship between magmatism and sedimentary basins with respect to hydrocarbon occurrence has become better known within the last few years (Jerram, 2015) and all the elements for a significant petroleum deposit are present in these new basins.

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