# Tectonic and Stratigraphic Interpretation of a New Regional Deep-seismic Reflection Survey offshore Banks Island: A Potential New Petroleum Province in the Canadian Arctic

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## Introduction

The Banks Island segment of the Canadian Arctic passive margin covers nearly 70,000 km² (27,000 miles²), about the same area as the adjacent offshore Mackenzie Delta. The latter has been the primary focus of exploration since the 1970s with almost 250 wells and fifty identified oil and gas accumulations in the area testifying to the presence of an active petroleum system. The Banks Island margin however remains essentially untested (Figure 1).

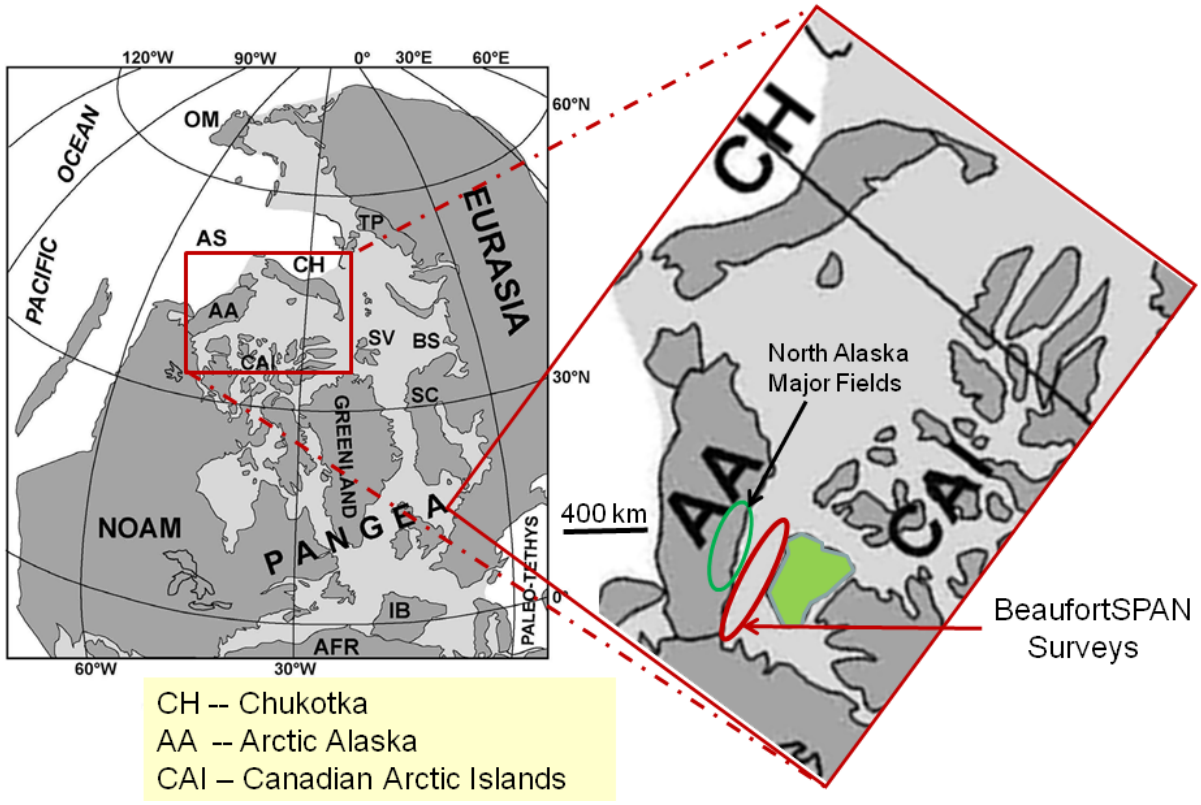


Figure 1: Reconstruction of Arctic continental fragments in early Permian (after Grantz and others, 2009). Banks Island is shown in green. Major North Slope (Arctic Alaska) hydrocarbon accumulations are shown in a conjugate location to Banks Island in this reconstruction. Seismic surveys, discussed here are located within the area of the red ellipse (see also, Figure 2).

## New Regional Survey

Since 2006 ION Geophysical (GX Technology) has acquired more than 4,000 km of 2D long-offset seismic data in the area as part of a larger Canadian Beaufort program (16,269 km). The seismic lines are located parallel and perpendicular to the Banks Island margin and in the Amundsen Gulf to the south (Figure 2). The lines extend as far as possible offshore as permitted by ice conditions and environmental considerations. The acquisition parameters have been designed to image down to the base of the crust with a 9-km long cable, 18-second recording, and final depth processing (PSDM) to 40 km. The seismic data are interpreted together with collected gravity-magnetic data to regionally map the ocean-continent boundary and the top of Moho discontinuity, and tied to existing well data wherever possible to identify the major stratigraphic sequences. Earlier iterations of this interpretation have been published (Kumar and others, 2009). However, this presentation represents our first attempt at reconciling three-years' of data acquisition, interpretation and analysis of petroleum potential of Banks Island offshore in a regional, basin-scale framework.

## Seismic Interpretation

A thick Meso-Cenozoic age, sedimentary prism underlies the Banks Island margin (Figure 2). This sedimentary wedge is 8-10 km thick at the shelf edge and upper slope, and it overlies reflectors under the shelf, inferred to correlate with Paleozoic sequences drilled by exploratory wells up dip on Banks Island onshore and farther south on Tuk Peninsula.

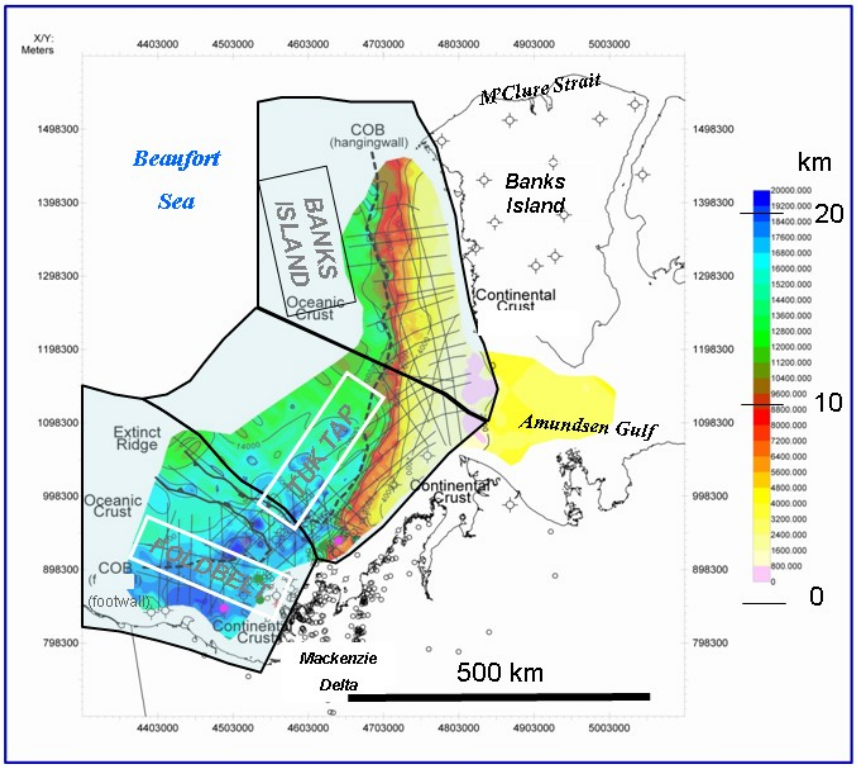


Figure 2: Location of BeaufortSPAN survey lines along the Canada Basin Margin. We have subdivided the margin into three distinct tectonic segments: The Beaufort Foldbelt, the Tuktoyaktuk Peninsula (TUK-TAP) and the Banks Island (see also Helwig and others, 2010). Colored contours show the total thickness of sediments deposited since the opening of the basin approximately 150 my ago. The total sediment thickness in the Mackenzie Delta reaches almost 20 km. In the Banks Island segment, although it is less than 11 km, it is sufficient for an active petroleum system.

## Crustal Structure

The continent-ocean transition in the Banks Island area is interpreted as a “hanging-wall” model with a wedge of underplated material between the Moho and the thinned continental crust. This interpretation is consistent with that of Lane (2002). Further discussion of our interpretation of crustal structure and the opening history of the Canada Basin is presented in Dinkelman and others (2010) and Helwig and others (2010). In all of the seismic lines, we identify major Tertiary, Cretaceous and Paleozoic horizons and regionally correlate and map them in the area. Additionally, we have mapped reflectors identified as Proterozoic, Crystalline Basement, and Oceanic Crust as well as the Moho discontinuity.

## Petroleum Potential of the Banks Island Passive Margin Prism

Major structures identified in the area include growth normal faults and associated rollover anticlines on the middle and lower slope (Figure 3). Strike lines parallel to the slope show a complex of Oligocene/Miocene channels, slumps, and interchannel facies, generally associated with slope deposits. All of these are recognized as potential hydrocarbon traps.

Although no well data are available in the offshore area to document the presence of source rocks, continuity of seismic markers from the Mackenzie Delta suggests that suitable environments of deposition formed source rocks in a much wider area than the delta itself. In addition, a fast rate of deposition and a basin with relatively low heat flow would support the existence of an oil and gas window that could be approximately 5-8 km deep. Deep-seated faults along the margin might serve as migration pathways from deep kitchen areas into shallower structural and stratigraphic traps amply seen in our data. Mapping suggests that the sedimentary wedge along the Banks Island margin is primarily derived locally (i.e. not formed from the distal components of Mackenzie Delta sediments). In fact, it appears that Amundsen Gulf acted as a significant source of sediments at least since the Tertiary Period. It is suggested that the drainage area for Amundsen Gulf might favor more sandy components than the Mackenzie River drainage. At the same time, interbedded shales would provide ample seals for traps in the area. The timing of hydrocarbon generation and migration in early to late Tertiary time would have been favorable for filling the available traps.

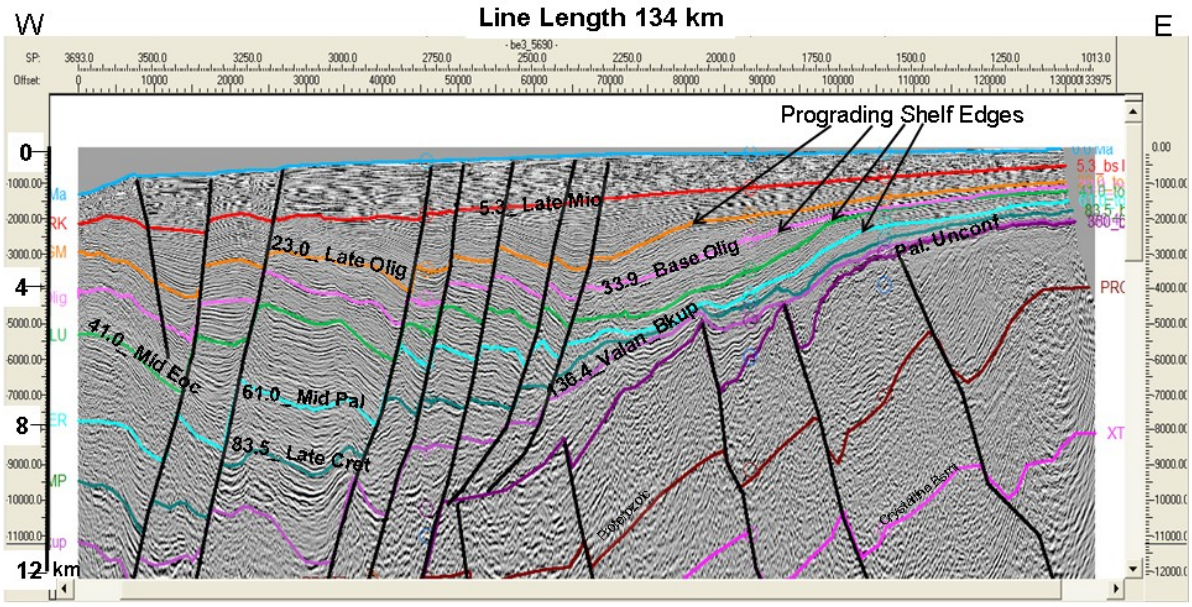


Figure 3: Prestack Depth (to 12 km) Migrated image of line 5690 (location on Figure 4). Major Tertiary, Cretaceous and Paleozoic horizons are identified. 136.4_Valanginian marks the “Breakup Unconformity” for the passive margin. Sequences present between this event and the Paleozoic Unconformity marker are interpreted as synrift. Multiple, prograding shelf edges are

identified as well as rotated fault blocks seaward of the mid-shelf. Areal extent of these shelf edges and rotated fault blocks are mapped as shown on Figure 4.

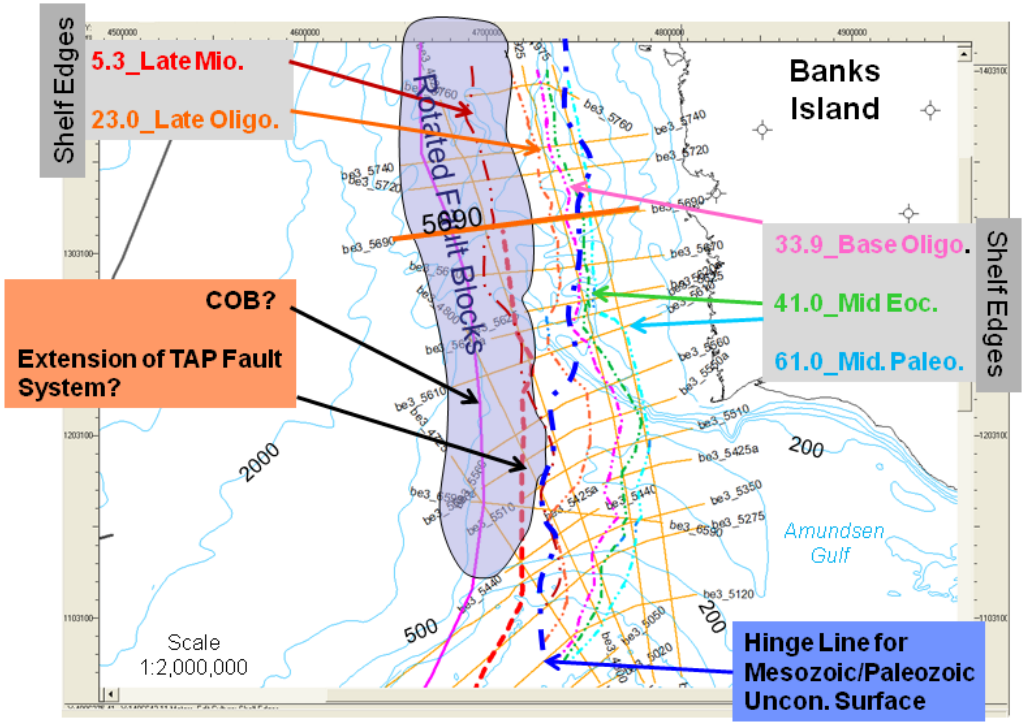


Figure 4: Stratigraphic and tectonic features (shelf edges, hinge line, rotated fault blocks) mapped along the Banks Island margin. Location of seismic line shown in figure 3 is marked. COB refers to the continent-ocean boundary.

## Conclusions

A favorable scenario for hydrocarbon accumulation suggested in this paper might encourage industry to carry out additional exploratory work and eventually drill in the Banks Island margin. Lack of well control is the biggest obstacle to proving the potential of this promising area.

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