

Mackenzie Delta: Fresh Look At An Emerging Basinpart 1

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ABSTRACT

Introduction

The Beaufort Mackenzie Basin (BMB) is emerging as a major potential source for the supply of future North American energy demands. The BMB has always been touted for its resource potential, however, as this paper will show, there have been significant

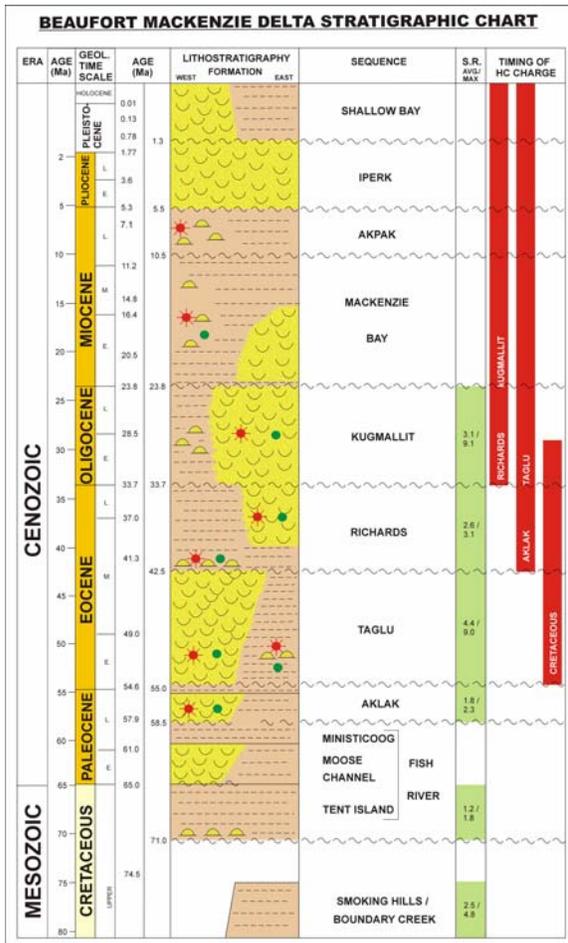


Fig. 1: Location Map

enhancements in the basin's potential from new 3D seismic surveys and a fresh look at previous exploration data. The result is recognition of several new world-class play types for the BMB. These plays, in conjunction with renewed exploration efforts, innovations and cost reductions in Arctic operations, potential for a Mackenzie Valley pipeline and favorable North American supply and demand forecasts, establish the BMB as an emerging petroleum province.

The Mackenzie delta is located in Northern Canada, in the westernmost Arctic Ocean to the east of the North Slope of Alaska (Figure 1). The Mackenzie River drainage is the second largest in North America and covers an area of roughly 697,000 square miles. It discharges into the Arctic Ocean at a rate of 9,820 cubic yards per second. This compares to the largest North American river system, the Mississippi River, with a drainage area of 1,247,000 square miles and a discharge rate of 22,970 cubic yards per second.

Stratigraphy



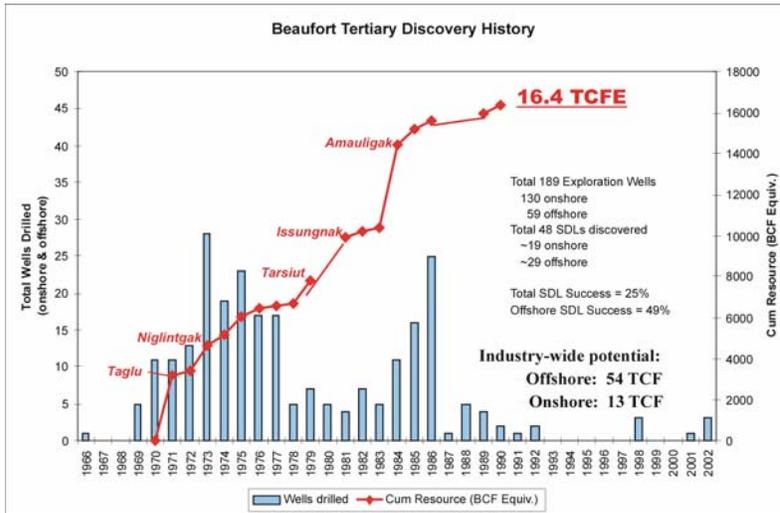
Mackenzie Delta deposition began following the Early Cretaceous formation of the Canada Basin (current day Arctic Ocean). Initial sedimentation during the Upper Cretaceous was restricted to deep marine organic rich muds of the Boundary Creek and Smoking Hills (Dixon et al, 1992). As Laramide mountain building advanced northward, major progradational pulses of sedimentation ahead of the mountain front resulted in the deposition of 12 – 16 km of Tertiary section in the developing Mackenzie delta. Five major deltaic successions, the Fish River, Aklak, Taglu, Kugmallit and Iperk, have been mapped throughout the BMB (Figure 2). The Taglu and Kugmallit contain the majority of reserves discovered to date.

Exploration History

Exploration drilling began in the BMB in the mid 1960's. Over the next 25.

Fig. 2: Stratigraphic column
 years 189 exploration wells, 130 onshore and 59 offshore, were drilled resulting in the issuance of 48 Significant Discovery Licenses (SDL's). Of these discoveries 29 SDL's are offshore with a total reserve estimate of 3.0 TCF of gas and 1.5 BBIs of oil, and 19 SDL's are onshore with a total reserve estimate of 6.0 TCF of gas and 250 MBIs of oil (Figure 3). The current total estimate of potential recoverable reserves in the Beaufort Mackenzie Basin stands at 54 TCF offshore and 13 TCF onshore (NEB, GSC, CGPC)

These reserve estimates demonstrate the commercial importance of the BMB, particularly in view of current North American gas markets. With the potential for a Mackenzie Valley pipeline by as early as 2007, the BMB is well positioned to emerge as an important source of supply. These factors combined to initiate a resurgence of exploration and development activity in the BMB since 1999. Three years of Federal and Inuvialuit licensing has resulted in the issuance of 20 new Exploration Licenses (EL's) covering approximately 3,000,000 acres. Since 1999, Industry has acquired fifteen new 3-D seismic surveys along with several thousand kilometers of new 2-D data. Seven new wells have resulted in at least one new significant discovery.



A Fresh Look

Analyses of the new 3-D seismic surveys and a fresh look at well data has resulted in the identification of several new Tertiary play types for the BMB, and have clarified several long-standing difficulties with complex structural and stratigraphic interpretations.

New Plays

Of particular interest is the identification from

Fig. 3. Beaufort Tertiary Discovery History.

3D seismic of a large shale diapir in the Western BMB. The image illustrates a reactivated growth fault that soles into the underlying Upper Cretaceous mobile shale belt, which is the probable source for the diapir (Figure 4). Flanking Taglu sediments are identified as distal deltaic sands and shales, and AVO analyses help image the extent of a potential trap.

A second new play of interest is a major canyon-filling channel/ levee/ fan succession of the Late Eocene Richards sequence. A combination of 3-D data and biostratigraphy reveals a fairly extensive canyon system with the potential for significant turbidite deposits. The 3D data reveals basal canyon scour followed by aggrading channel and levee systems (Figure 5).

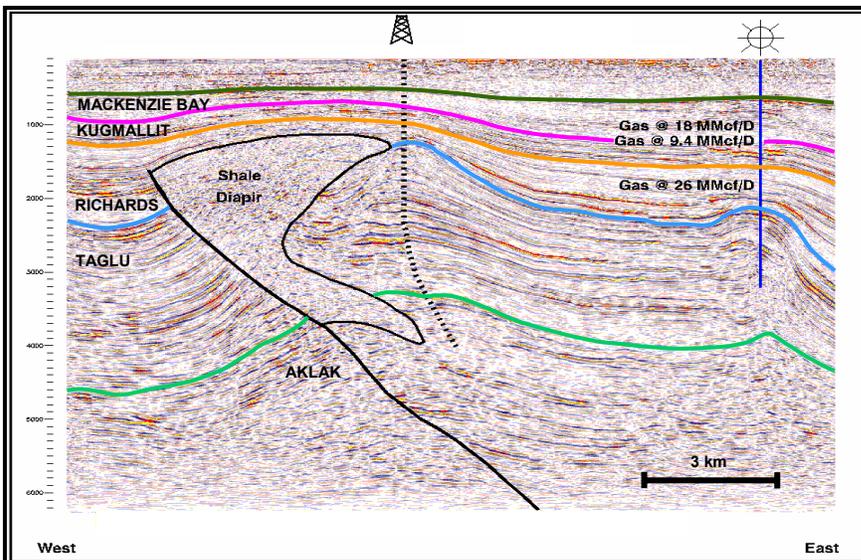


Fig. 4: Shale Diapir Flank plays from offshore BMB 3D seismic survey.

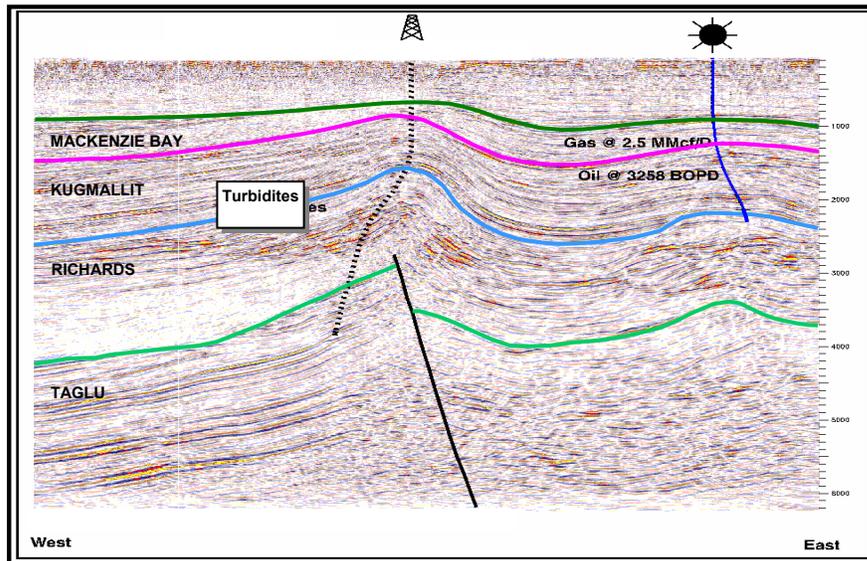


Fig. 5: Canyon-filled Channel/Levee/Fan turbidite play from the offshore BMB 3D seismic survey.

New Stratigraphic Interpretation

Stratigraphically, 3-D seismic interpretation in conjunction with biostratigraphic data from multiple sources has allowed for clarification of previous interpretations. In a particular instance, the stratigraphy of a key wellbore had been previously interpreted with older 2D seismic as having significant section removed by faulting. The 3-D image demonstrated that the well had penetrated no faults and had a continuous succession. This information was crucial in unraveling the internal stratigraphy of the Early to Mid Eocene Taglu sequence. In a further instance, 3-D interpretation of the Lower Richards imaged large fault displacement in the range of 1500 msec and confirmed the magnitude of tectonism and stratigraphic variability within this interval. Furthermore, 3-D seismic sequence stratigraphic analyses of the Richards has helped define two significant events, one in the Lower and one in the Mid Richards, that have widespread impact on play potential.

Biostratigraphic analyses has undergone a process of quantitative re-analyses of existing data sets, in conjunction with a re-sampling of raw source material from selected wells. The results have significantly improved the identification of key biostratigraphic subdivisions within the BMB. Of particular importance has been the 'pinning' of a specific shale unit within the Early Eocene Taglu sequence by the recognition of a newly documented foram, *C. galgheria* (D. McNeil, pers. comm.). Furthermore, correlations throughout Late Eocene Richards have been markedly aided by the recognition of four key biostratigraphic subdivisions (G Dolby, pers. comm.).

Overall, these analyses have helped clarify the stratigraphy of several complex Tertiary aged sequences within the BMB. This process has also aided in the identification of deep-water turbidite equivalents and in defining new reservoir potential for the Richards and Mackenzie Bay sequences.

New Geochemical Interpretation

The BMB's hydrocarbon potential has been enhanced by a re-examination of the basin's geochemistry. Historically, the Richards was identified as the primary source sequence for Tertiary oil accumulations. This association was based on analyses done by Brooks (1986, 1986a) who established a link between Tertiary oil biomarker 24-28 bisnorlupane and its occurrence in Richards kerogen. This conclusion restricted the amount of hydrocarbon generated in the BMB since the Richards generally has marginal organic richness and thermal maturity. Recently, Snowdon et al (pers. Comm.) were able to demonstrate that this same compound also exists in the Lower Eocene Taglu, thereby broadening the potential Tertiary source sequences.

The common occurrence of gas in the delta along with the relatively high TOC coaly sections in other more mature sections of the stratigraphic column also point to a much richer source potential for the BMB than simply the Richards. Modeling of existing source rock data indicates that the primary source intervals for the Tertiary BMB are likely the Paleocene Aklak and Early to Mid Eocene Taglu. Local contributions also occur from the Late Eocene Richards, the Oligocene Kugmallit in the northern portion of the basin, and the Lower Tertiary Fish River and the Upper Cretaceous Smoking Hills / Boundary Creek to the south. All of these source rocks, except the Upper Cretaceous Smoking Hills / Boundary Creek, are Type III coals or coaly intervals with sequence-average TOC's from 1.5% to 4.5% and Hydrogen Indices up to 450 kg/t.

In light of these new findings, the BMB has been transformed from a source limited Richards hydrocarbon system to a rich and mature Tertiary system with a greatly expanded range of prospectivity.

Operational Innovations

Recent innovative operational technologies decrease time, increase safety and significantly reduce costs. Arctic class, purpose built rigs have demonstrated an average reduction in drilling time by 25%. Large service rigs have been utilized for shallower onshore wells to reduce mobilization costs and to reduce the environmental footprint. In the offshore, innovative drilling and well control systems will dramatically decrease well costs and increase drilling seasons, while maintaining strict environmental safeguards.

Conclusion

This combination of new exploration data, world class plays, operational innovations, a developing infrastructure and long-term North American gas demand are behind the recent surge in exploration activity, and establish the BMB as an emerging production province for Canada.

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