Mackenzie Delta: Fresh Look At An Emerging Basin Part 2

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ABSTRACT

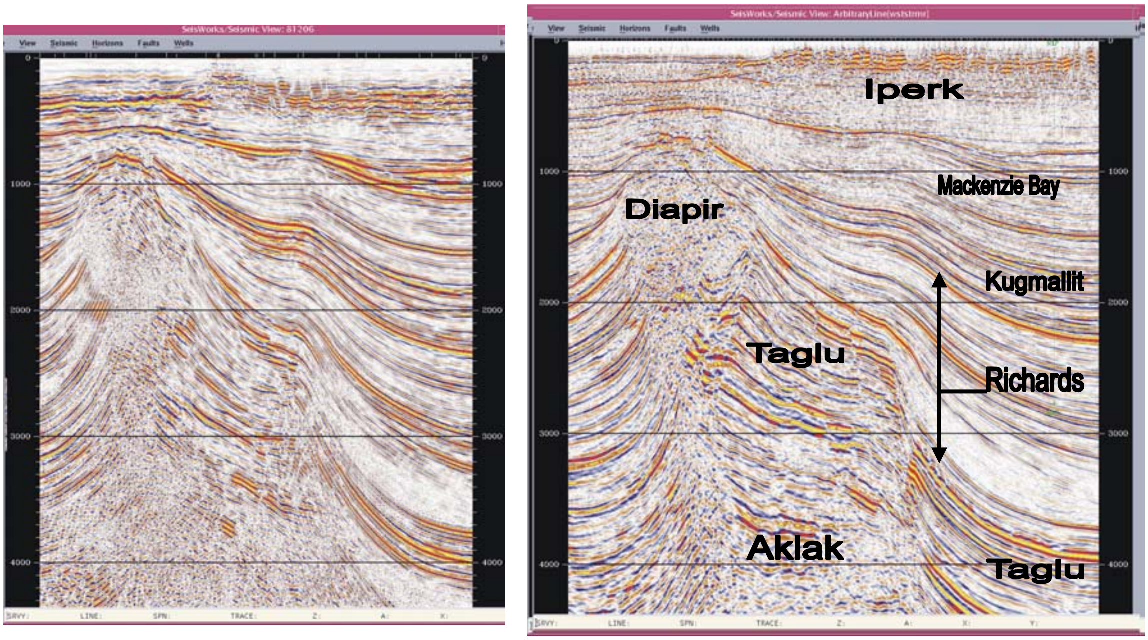
Introduction

Over 1800 km2 of high-resolution 3D seismic data was acquired by Devon Canada in the shallow offshore Beaufort Sea during the summers of 2001/2002. An additional seven onshore 3D surveys have been acquired, and six exploration wells drilled since 2000. This surge in Beaufort Mackenzie Basin (BMB) exploration has resulted in the definition of five (5) new Tertiary play types, identification of new prospects in previously defined plays and a better understanding of regional tectonics and depositional environments.

Diapir Flank Play

The largest of the new plays is the Diapir Flank Play (see Figure 4, Pt 1). From 3D seismic we have interpreted a large shale diapir in the central core of the structure (Figure 2), versus an earlier interpretation of a tightly folded anticline as seen on 2D (Figure 1). The diapir appears to have initiated as an early Eocene-Paleocene growth fault that soled into underlying Upper Cretaceous to lower Tertiary shales. Subsequent SW-NE shortening may have mobilized over pressured clays and mudstones to form the central core of the diapir in the cores of detachment folds. Tectonism continued till the end of the Eocene, followed by local late Tertiary crestal collapse (interpreted due to dewatering) and renewed compression of the diapiric complex at post-Miocene Mackenzie Bay time.

The Diapir Flank play consists of Tertiary-aged sediments flanking, onlapping and overlying an over pressured shale core. Flanking sediments are early to middle Eocene Taglu distal delta front sands and shales and transitional to deep-water turbidites in the Paleocene Aklak. The late Eocene Richards onlaps and pinches out on the flank of the diapir, while the Oligocene Kugmallit overlies the crest of the complex. An offset well tested a combined 27.4 MMCF/d from two zones in the Kugmallit and 26 MMCF/d from a conglomerate in the lower Richards. Significant reservoir quality sands were also encountered within the upper part of the Taglu that was penetrated. AVO indicates multiple levels of gas charged sands.



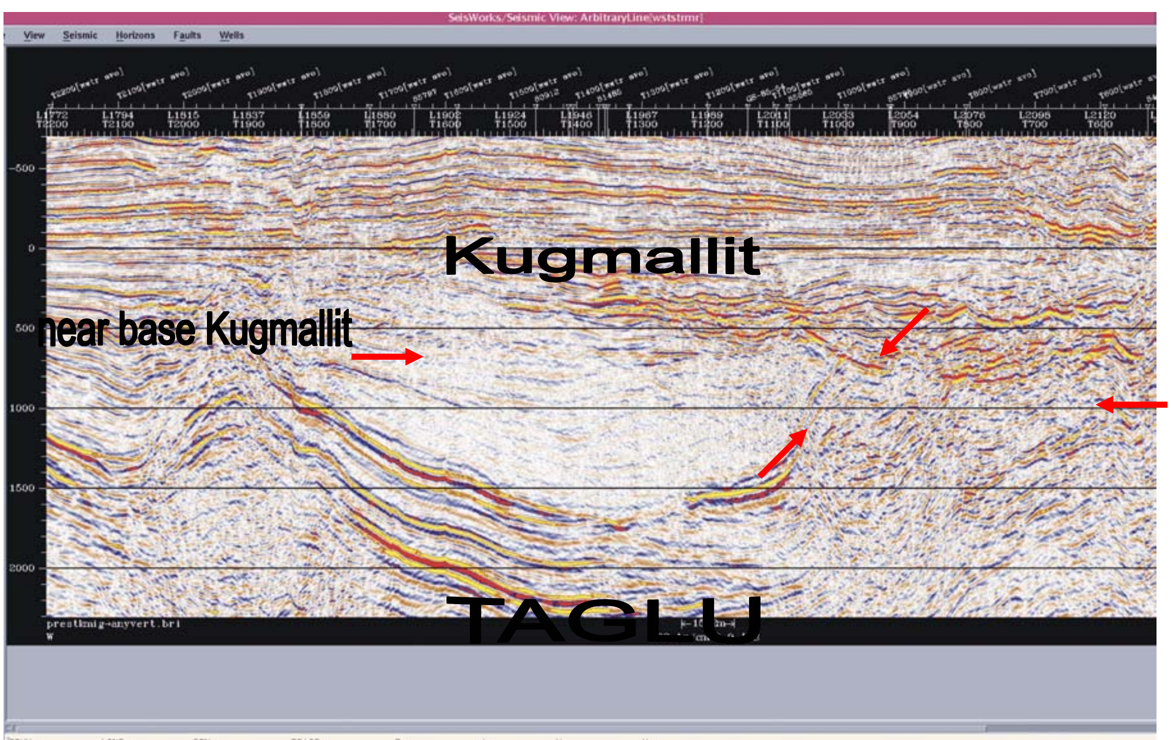
Figs. 1 & 2: Shale Diapir on old 2D (left) and new 3D (right) seismic data

Canyon-Filling Channel/ Levee/ Fan Play

A second major new play type imaged on the offshore 3D is a canyon-filling channel/ levee/ fan succession of the Late Eocene Richards (see Figure 5, Pt 1).

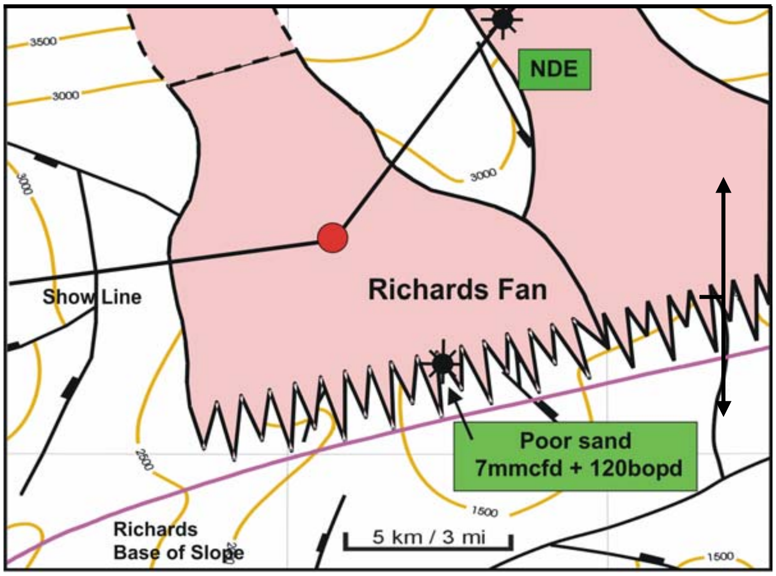
Flattened 3D data shows a major canyon system with multi-phase down cutting and infilling (Figure 3). Total canyon thickness is on the order of 1000 meters, with at least three phases of infill. The amalgamated width is approximately 20 km, draping over the two Nipterk ridges to the east and infilling lows between them (Figure 4). The Canyon-filling Channel/ Levee/ Fan Play consists of

Fig. 3: W-E 3D seismic section flattened on 'near base Kugmallit', showing



Canyon-filling Channel Complex in the late Richards between red arrows.

Fig. 4: Schematic of Canyon-filling Channel/ Levee/ Fan Play



multiple stacked and offset channel/ levee/ fan deposits with a combination structural drape and stratigraphic pinchout forming the trap. An offset well on the southern fringe penetrated a portion of the fill and tested 7 MMCF/d & 120 BOPD from an Upper Richards channel sand. AVO indicates probable gas-charged sands within this upper Richards complex. Worldwide analogies include recent major discoveries at the Girassol field in Angola (Beydoun et al, 2002), the Zafiro field in Equatorial Guinea (Shirley, 2003), the Bonga field in Nigeria (Chapin et al, 2002) and numerous examples in the deepwater Gulf of Mexico.

Additional Play Types

Other new play types include 1} ponded Aklak, Taglu and Richards turbidites in intra-slope mini-basins; 2} basin floor mounds and sands related to a lower Richards unconformity; and 3} structural trapping against a vertical shale weld on the flank of the previously discussed shale diaper. New prospects in proven plays include segmented crestal anticlines and tilted fault blocks.

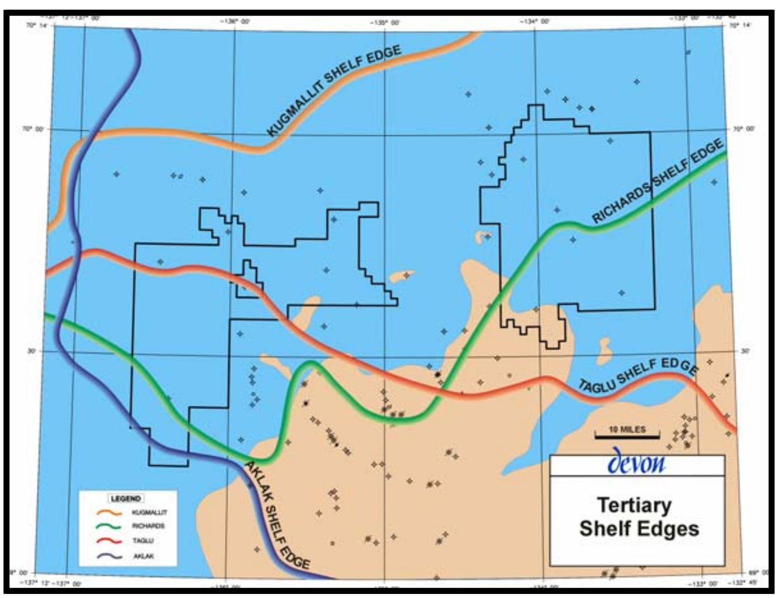
Regional Tectonics And Sedimentary Environments

3D seismic and reprocessing then reinterpretation of older 2D data has also provided a much clearer understanding of the regional tectonics and depositional environments.

Prior to the Early Cretaceous, the BMB was the northern continuation of the ancestral western margin of North America and thus its structural-tectonic history during this period is the same as that of the Western Canada Sedimentary Basin. Mackenzie delta depositional history begins in the Early Cretaceous with the opening of the Canada Basin (Arctic Ocean). The Smoking Hills and Boundary Creek formations were deposited during the Late Cretaceous along the rift margin as it thermally cooled and sagged. As Tertiary Laramide mountain building progressed northeasterly across the passive margin, the Canada Basin provided accommodation space for the large volumes of sediments being shed from the advancing mountain front. Deltaic sediments of the Paleocene Fish River began to appear in the Western Beaufort as the Mackenzie Delta depocenter shifted north of advancing Laramide (or Brookian) mountain building Deltaic sedimentation continued to be focused in the Western Beaufort through the Paleocene Aklak and on into the Early to Middle Eocene Taglu. The depocenter shifted to the northeast for much of the Late Tertiary and was dominated by the Oligocene Kugmallit deltaics (Figure 5). Sequence stratigraphic interpretation of 3D seismic, along with core analyses and biostratigraphic revisions identify deepwater 'turbidite' equivalents to each of these major sequences, as well as to the Late Eocene Richards. The entire basin has undergone uplift from the south and the last major deltaic pulse, the Plio-Pleistocene Iperk, regionally truncates most of the BMB with substantial erosion.

Growth faults record the depositional timing of these major Tertiary deltaic sequences as they stepped northeastwards. Thinning of beds onto large detachment folds record the timing of later Laramide contractional deformation. The detachment folds formed above a mobile shale substrate and as a result shale diapirs core many of the large ridges in the BMB. Because Laramide mountain building swept obliquely along the continental margin, there is a significant right-lateral component to the Tertiary structural history of the BMB.

Fig. 5: Tertiary Deltaic Shelf Edges



Summary
New 3D seismic surveys and a fresh look at old exploration data have identified five new play types and multiple world-class prospects in the BMB. The potential to evaluate these enhances the BMB as an emerging North American basin.

References

Beydoun, W., Kerdraon, Y., Lefeuvre, F., Bancelin, J.P., Medina, S. and Bleines, B. (2002) Benefits of a 3DHR survey for Girassol field appraisal and development, Angola. The Leading Edge, November 2002, p. 1152-1155.

Chapin, M., Swinburn, P., Van Der Weiden, R., Skaloud, D., Adesanya, S., Stevens, D., Varley, C., Wilkie, J., Brentjens, E., and Blaauw, M. (2002) Integrated seismic and subsurface characterization of Bonga field, offshore Nigeria. The Leading Edge, November 2002, p. 1125-1131.

Shirley, K. (2003) Equatorial Guinea on fast track. AAPG Explorer, Jan. 2003, p. 12-25.