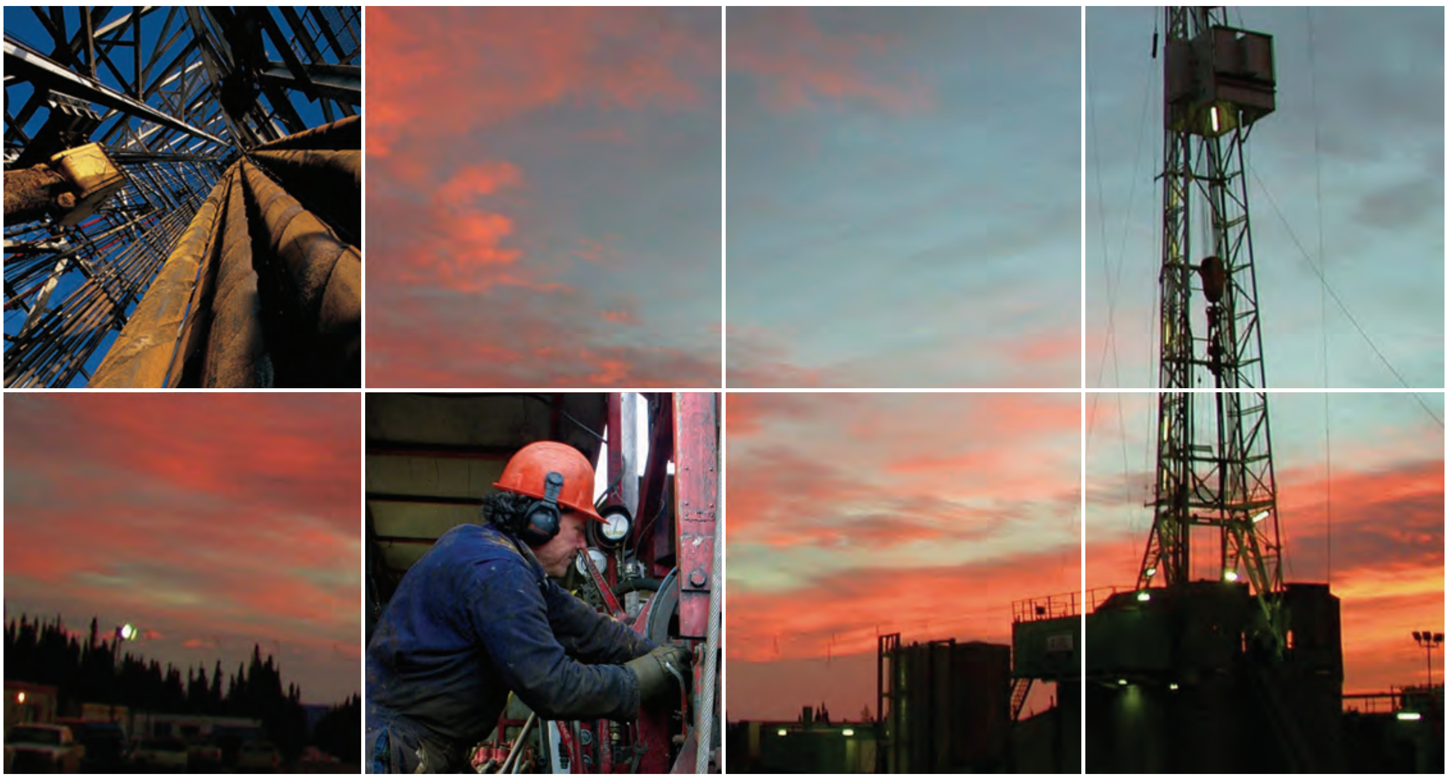
Conventional Natural Gas Play Atlas Northeast British Columbia

Petroleum Geology Publication 2006-01



Oil and Gas Division
Resource Development and Geoscience Branch

BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources

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The Northeast BC Play Atlas

The Resource Development and Geoscience Branch of the BC Ministry of Energy and Mines and Petroleum Resources (MEMPR) in partnership with the National Energy Board (NEB) have undertaken an assessment of British Columbia's undiscovered resources. The final report entitled *Northeast British Columbia's Ultimate Potential for Natural Gas Report - 2006A* is now available through both the NEB and MEMPR websites. To access the report on the provincial government website, go to:
http://www.em.gov.bc.ca/subwebs/oilandgas/resource/cog/cog.htm.

While this new report covers all of BC's gas potential areas, the major focus of the assessment is the quantification of the remaining undiscovered conventional gas potential of NEBC.

As a companion to the joint NEB/MEMPR Northeast British Columbia's Ultimate Potential for Natural Gas report, MEMPR has developed this *Conventional Natural Gas Play Atlas, Northeast British Columbia*. The play atlas was created to provide a framework for the assessment process and to provide a reference point for future analyses. As is the case with any resource estimate, the current play definitions represent a snapshot in time as they continually evolve through the interplay of new geological concepts, technological developments and changing commodity prices.

The Conventional Natural Gas Play Atlas contains both established and conceptual plays, and also contains some plays that could arguably be identified as unconventional. For the purpose of both the joint NEB/MEMPR resource estimate and the play atlas, a broad definition of "conventional gas resources" was utilized. Within this atlas, play definitions generally include the spectrum of resource exploration concepts that have been traditionally exploited in British Columbia's portion of the Western Canadian Sedimentary Basin (WCSB), and are considered proven and developable with today's technology. They are relatively low risk and thus have a high probability of being commercially productive. Unconventional resources, were deemed to be those resources that were generally not currently productive as of year end 2003. Examples include coalbed gas (CBG), some tight gas, shale gas and gas hydrates. Although unconventional CBG and shale gas resources are now contributing significantly to U.S. production stream they are for the most part currently unproven in NEBC.

In addition to this hardcopy version, a CD will also be available that will include all maps and descriptions in a digital format and a complete database presenting results of the joint NEB/MEMPR Northeast British Columbia's Ultimate Potential for Natural Gas Report - 2006A.

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Significant contributions were provided by:

The National Energy Board
Jim Davidson
Bobbi Feduniak

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1.0 Northeast BC Geographic Areas

To aid in subsequent analysis, northeast British Columbia has been subdivided into six resource regions: Liard Basin & Fold Belt; Fort Nelson/Northern Plains; Fort St. John; Northern Foothills; Southern Foothills; and the Deep Basin.

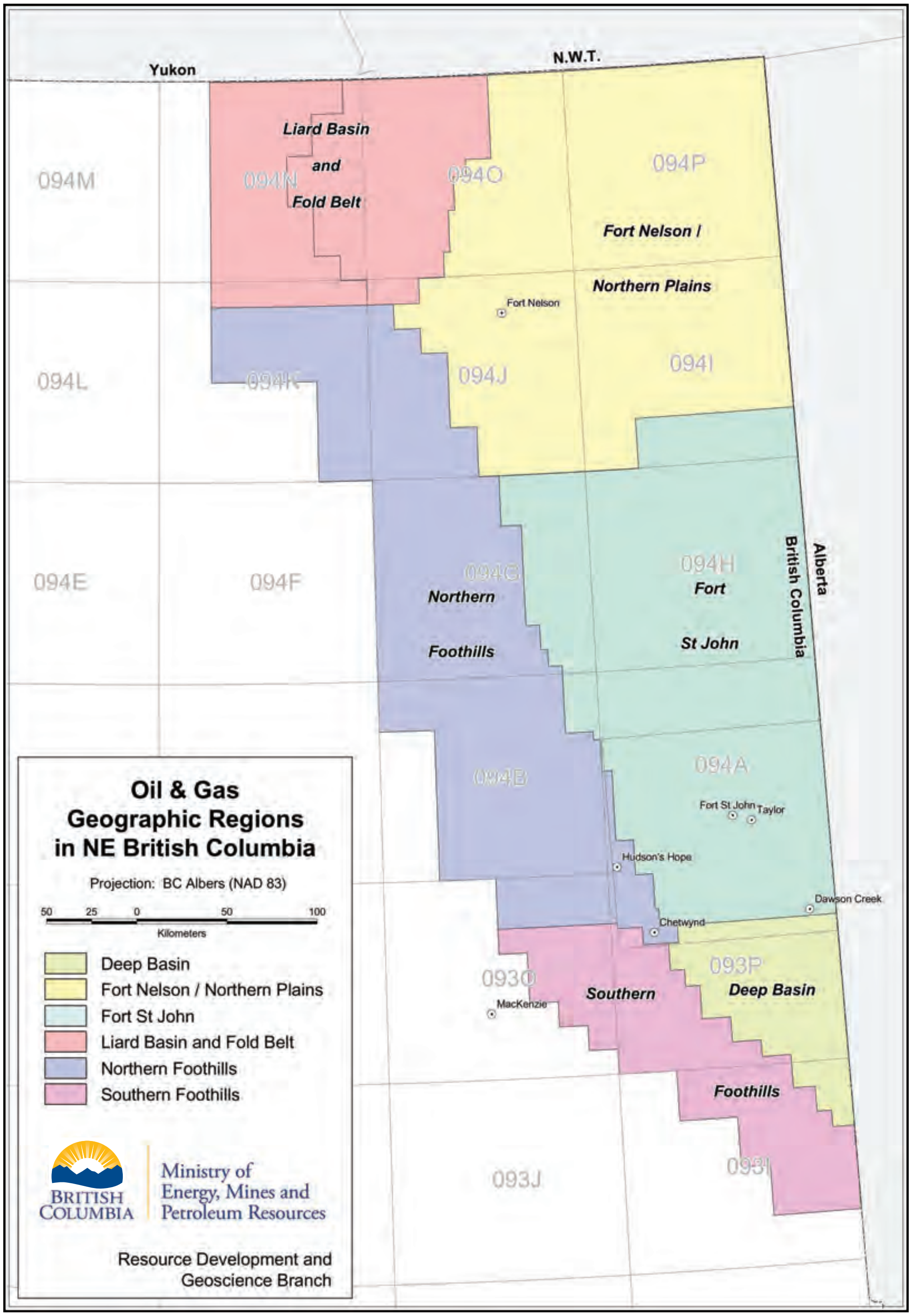


Figure 1. Resource regions of northeast British Columbia utilized within this report.

1.1 Liard Basin & Fold Belt

Bounded to the north by the Northwest Territories and Yukon Territory and to the south and east by the Northern Foothills and Northern Plains, respectively, the Liard Basin is a relatively unexplored region situated immediately east of the Cordilleran fold and thrust belt. For the purpose of this assessment, the Basin has been combined with the Liard Fold and Thrust Belt, a region with significant Laramide deformation. In northeast British Columbia, the Liard Basin & Fold Belt covers an area of approximately 1.25 million hectares and contains over five kilometres of sedimentary strata of Cambrian to Upper Cretaceous age. Potential hydrocarbon objectives occur in the Devonian Dunedin/Nahanni Formation, the Mississippian Banff, the Debolt and Mattson formations, the Permo-Pennsylvanian Kindle and Fantasque formations, the Triassic Toad Formation, and the Cretaceous Chinkeh and Scatter formations. The Nahanni Formation holds significant potential in dolomitized reservoirs in the structural belt. The Debolt, Mattson, Kindle, Fantasque formations, and possibly the Triassic Grayling and Toad formations, are potential objectives in structural closures on the Bovie Lake structure along the margin of the basin. To the east on the platform, stratigraphic traps within the Banff and Debolt formations are also potential objectives.

1.2 Fort Nelson/Northern Plains

Located in the northeast corner of British Columbia, the Fort Nelson/Northern Plains region (Figure 1) covers an area of 3.85 million hectares. In terms of oil and gas exploration, the region has been active since the 1960's with the search for natural gas dominated by the Middle Devonian Keg River, Pine Point and Slave Point carbonate plays. These plays have high reserves and high deliverability and include BC's largest recognized gas accumulation at Clarke Lake (3.7 Tcf OGIP). However, within the last 10 years, the Upper Devonian Jean Marie Formation has become the major target for operators and natural gas from this interval now dominates new production from the region.

Other potential hydrocarbon objectives in the Fort Nelson/Northern Plains region are the Debolt, Pekisko and Shunda subcrop edges. Cretaceous targets include a detrital lag at the top of the Mississippian and the Bluesky Formation. New conceptual gas opportunities may also be found in Tertiary/Quaternary sediments similar to the Sousa play in NW Alberta.

In addition, the region is a major contributor to the province's oil production stream. There is continued development of the Hay River Bluesky heavy oil pools along with the revival of the Desan, Pekisko and Shunda oil pools.

1.3 Fort St John

The Fort St John region covers an area of 3.7 million hectares and continues to be the hub of activity and production for the province. The region has a variety of geologic settings, which combine to offer good quality, low-risk, gas and oil prospects through stacked multi-zone potential. The deep (2 800 to 3 200 metre true vertical depth) Slave Point play along the Hotchkiss Embayment continues to entice exploration since the discovery of the Ladyfern A, B and C pools (762 Bcf OGIP) in 2000. Deeper conceptual plays also occur in the Middle Devonian clastics and Keg River carbonates. On the western side of the area, Laramide-induced folding and structural trapping provides opportunity for gas in the Debolt, Halfway, Charlie Lake and Baldonnel formations and various Cretaceous sands. The Fort St. John Graben houses numerous structural and stratigraphic objectives ranging from hydrothermal dolomites in the Wabamun Formation to sands in the Mississippian Kiskatinaw and Permian Belloy formations. Traditional targets in the region have been the Triassic stratigraphic and erosional edge plays in the Montney, Doig, Halfway, and Baldonnel formations and numerous Charlie Lake members. Lower Cretaceous clastics have also been sought after in the region, with the Dunlevy, Gething and Bluesky formations being major production horizons. Recently, both the tighter Gething sands in erosional valley systems and lowstand Notikewan sands have been the target of focused development north of the Peace River Block.

1.4 Deep Basin

The Deep Basin region comprises an area of 692 000 hectares and offers thick sequences of stacked, regionally extensive, gas-saturated Mesozoic clastic reservoirs. Traditionally, exploration has focused on identifying stratigraphic sweet spots in the Cadotte and Falher formations that feature conventional reservoir quality. In fact, some of these conglomeratic reservoirs continue to offer some of the highest initial deliverability rates in the province. The tight gas component of the Deep Basin, however, offers a huge potential resource that is just beginning to be exploited. In the BC Tight Gas Exploration Assessment (BC MEM 2002), the gross OGIP resource is estimated at 70 to 200 Tcf. Potential Deep Basin tight gas targets include the Cardium, Dunvegan, Cadotte, Bluesky, Cadomin, Nikanassin, Halfway, Doig and Montney formations. In 2004, development of the Cadomin Formation began in earnest and as of early 2006 production had reached above140 MMcf/d.

1.5 Northern Foothills

The Northern Foothills Region (Figure 1) incorporates an area of 2.9 million hectares and covers mostly foothills and mountainous terrain. Laramide-aged structures provide the opportunity for structural traps where natural gas may accumulate. Prospective intervals include Cretaceous clastics but traditional targets are the Triassic Baldonnel, Charlie Lake and Halfway formations as well as the Mississippian Debolt Formation. The western boundary of the Triassic play is constrained by outcrop and subsequent breaching of any trap. The Mississippian play is typified by the Sikanni and Pocketknife fields where natural gas is trapped in linear northwest trending thrust-fault related structural features. To the east of the Northern Foothills Region Devonian Keg River and Slave Point formations are hosts to major natural gas accumulations, such as in the Clarke Lake area. These occur in ancient barrier reef complexes and atoll trends which, despite limited deep well control, can be traced into the Northern Foothills. Conceptually, these rocks are extremely prospective in areas where they have been structurally uplifted raising the possibility of significant undiscovered natural gas accumulations in the region. The western limit for Devonian play-types is defined by a line about five to ten kilometres west of the outcrop belt of Devonian or older sediments. This five-to-ten kilometre wide band accounts for the possibility of encountering second-sheet Devonian reservoir in an overthrust scenario.

1.6 Southern Foothills

The Southern Foothills region (Figure 1) of northeast British Columbia covers an area of 1.2 million hectares. The region has varied topography ranging from low rolling hills in the east to anticlinal hills with a relief of up to 1,800 metres in the west. This topography reflects the composition and structure of underlying bedrock, which consists of Paleozoic age carbonates in the southwest to Upper Cretaceous clastics in the northeast. Exploration for natural gas in the Southern Foothills region tends to hold a moderate to high associated risk along with high capital costs. Offsetting this is the potential within these folded and faulted structures for hydrocarbon traps containing large reserves of natural gas, sometimes with extraordinary productivity. Faulted Triassic Baldonnel and Charlie Lake formations are the principal exploration targets in the region.

2.0 Spatial Cumulative Resource/Reserve Mapping

In support of the joint NEB/MEMPR Northeast British Columbia's Ultimate Potential for Natural Gas Report - 2006A, spatial data representing produced, discovered and undiscovered gas resources have been created. For ease of reference, acronyms for specific data products are assigned as follows:

Discovered (Reserves):

GIP – Gas in Place
IEGR – Initial Established Gas Recoverable
IEGM – Initial Established Gas Marketable
RGR – Remaining Gas Recoverable
RGM – Remaining Gas Marketable

Production:

ARGP – Annual Raw Gas Produced
CRGP – Cumulative Raw Gas Produced
CMGP – Cumulative Marketable Gas Produced

Undiscovered:

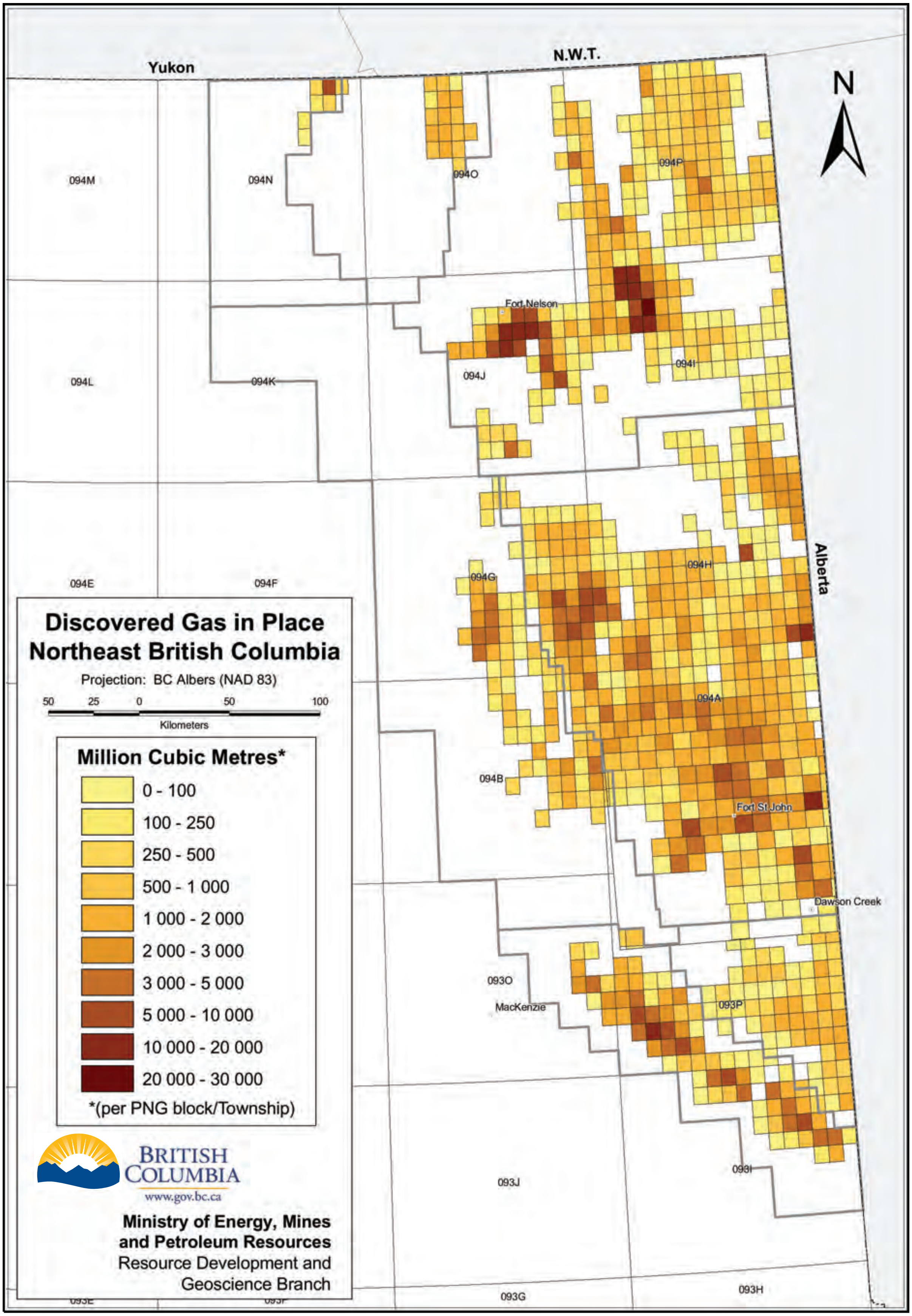
UGIP – Undiscovered Gas In Place
URECVR – Undiscovered Recoverable Gas
UMARKT – Undiscovered Marketable Gas

Ultimate Resource:

ULGIP – Ultimate Gas in Place (GIP + UGIP)
ULRECVR – Ultimate Recoverable Gas (IEGR + URECVR)
ULMARKT – Ultimate Marketable Gas (IEGM + UMARKT)
ULREMMARKT – Ultimate Remaining Marketable Gas (RGM + UMARKT)

A series of maps were created to spatially display cumulative data for all plays throughout northeast British Columbia:

1. Discovered Gas In Place
2. Discovered Initial Established Gas Marketable
3. Discovered Remaining Marketable Gas
4. Cumulative Marketable Gas Produced
5. Undiscovered Gas In Place
6. Undiscovered Marketable Gas
7. Ultimate Gas In Place
8. Ultimate Marketable Gas
9. Ultimate Remaining Marketable Gas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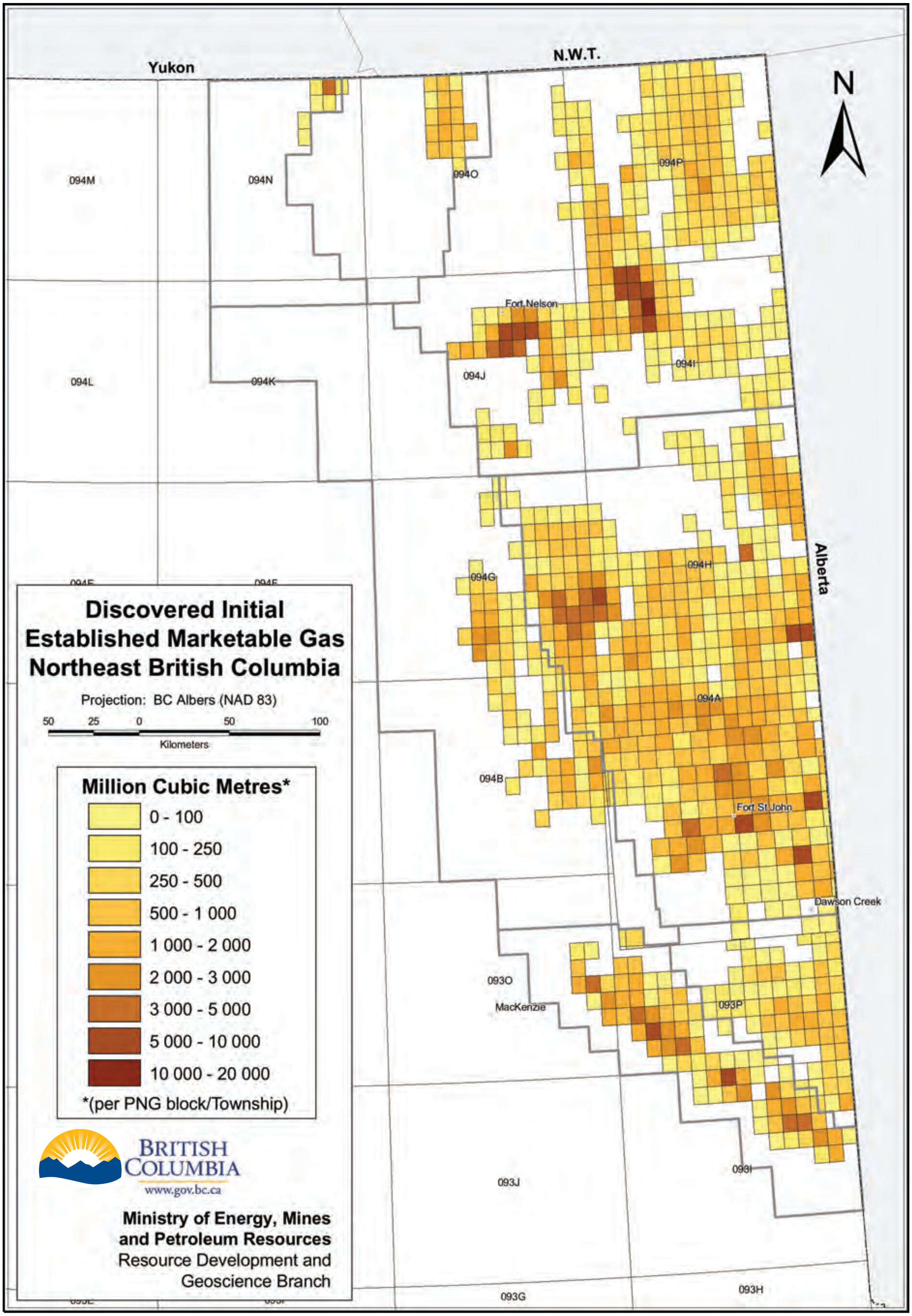
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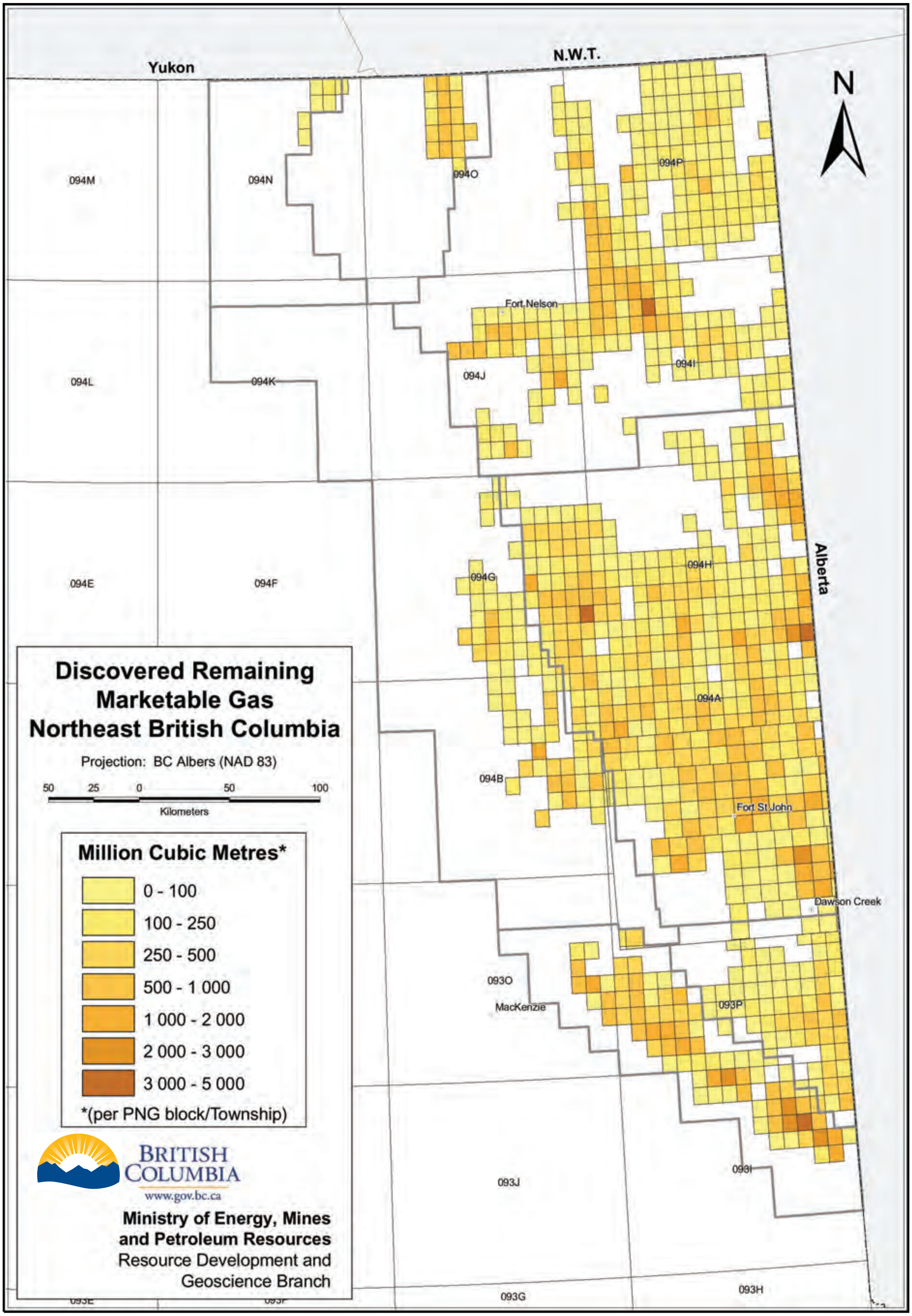

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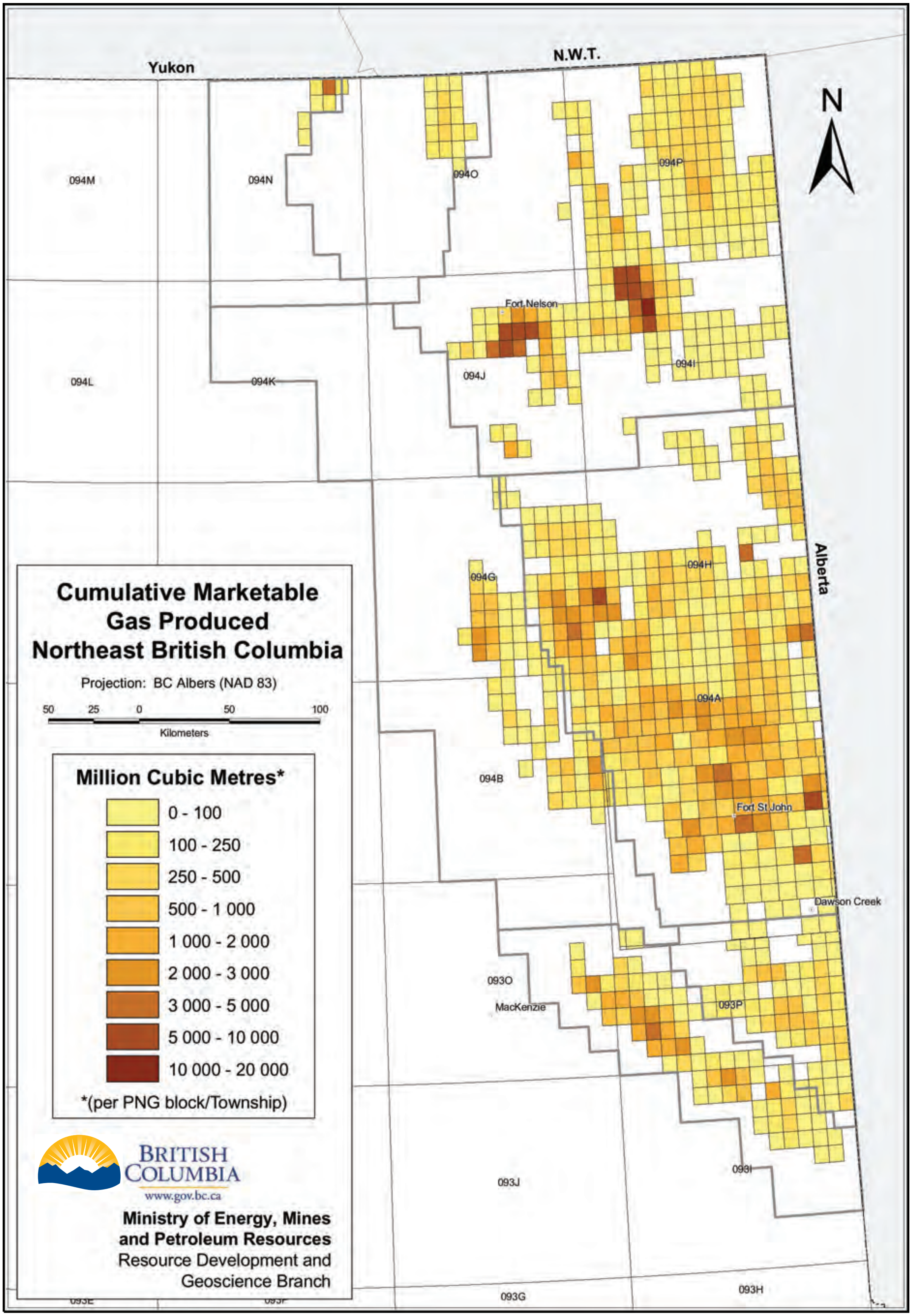

Cumulative Marketable Gas Produced Northeast British Columbia
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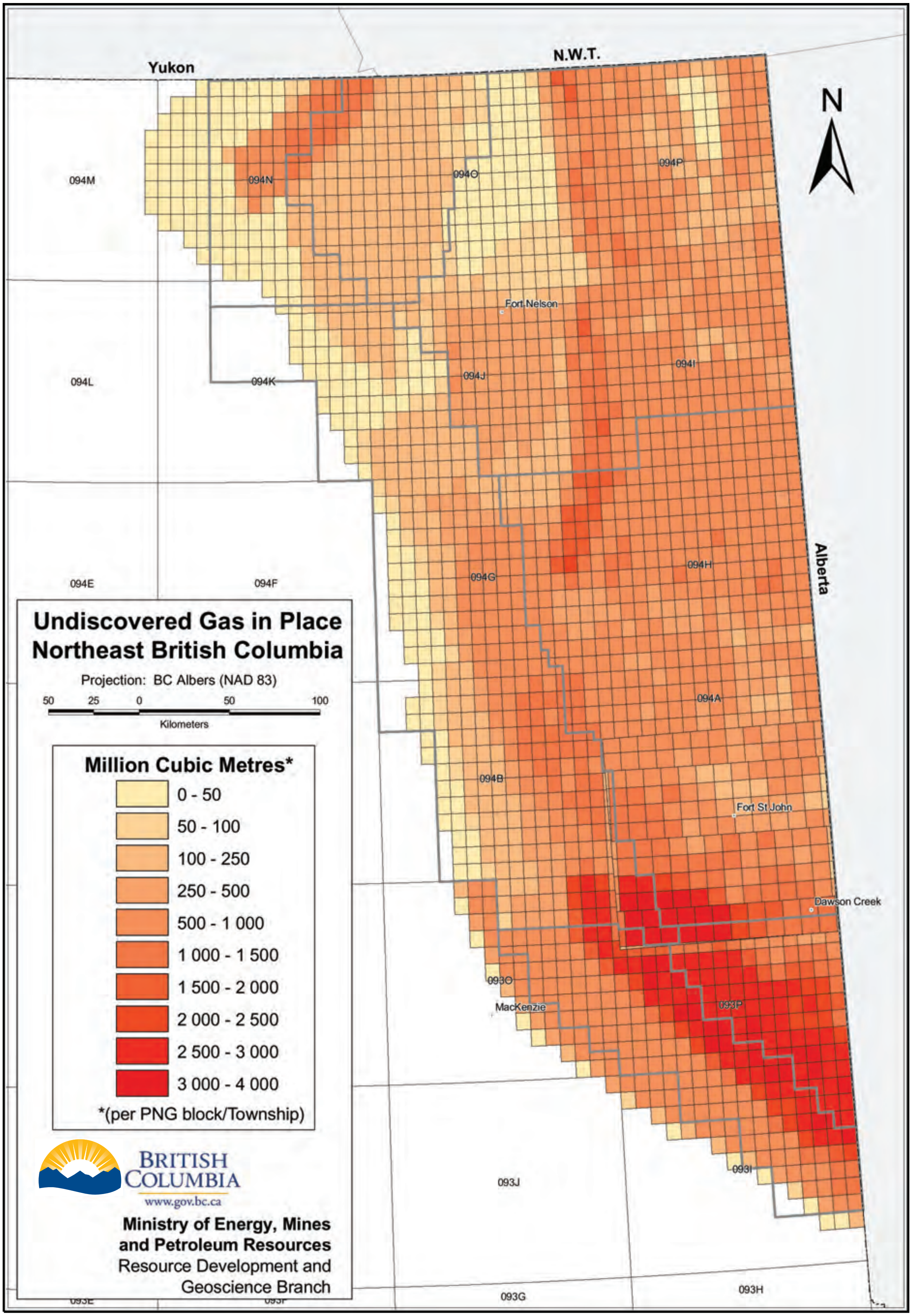
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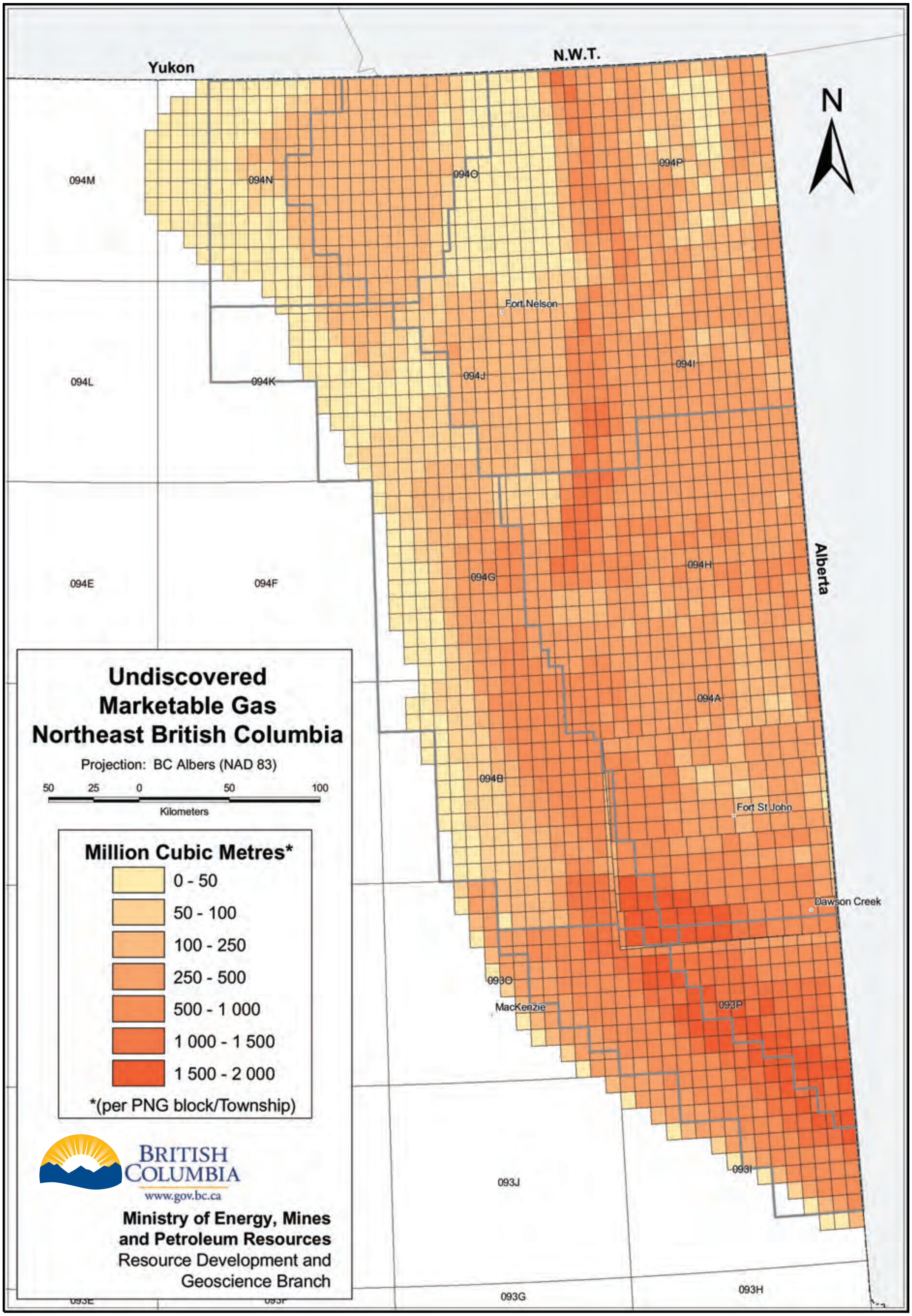
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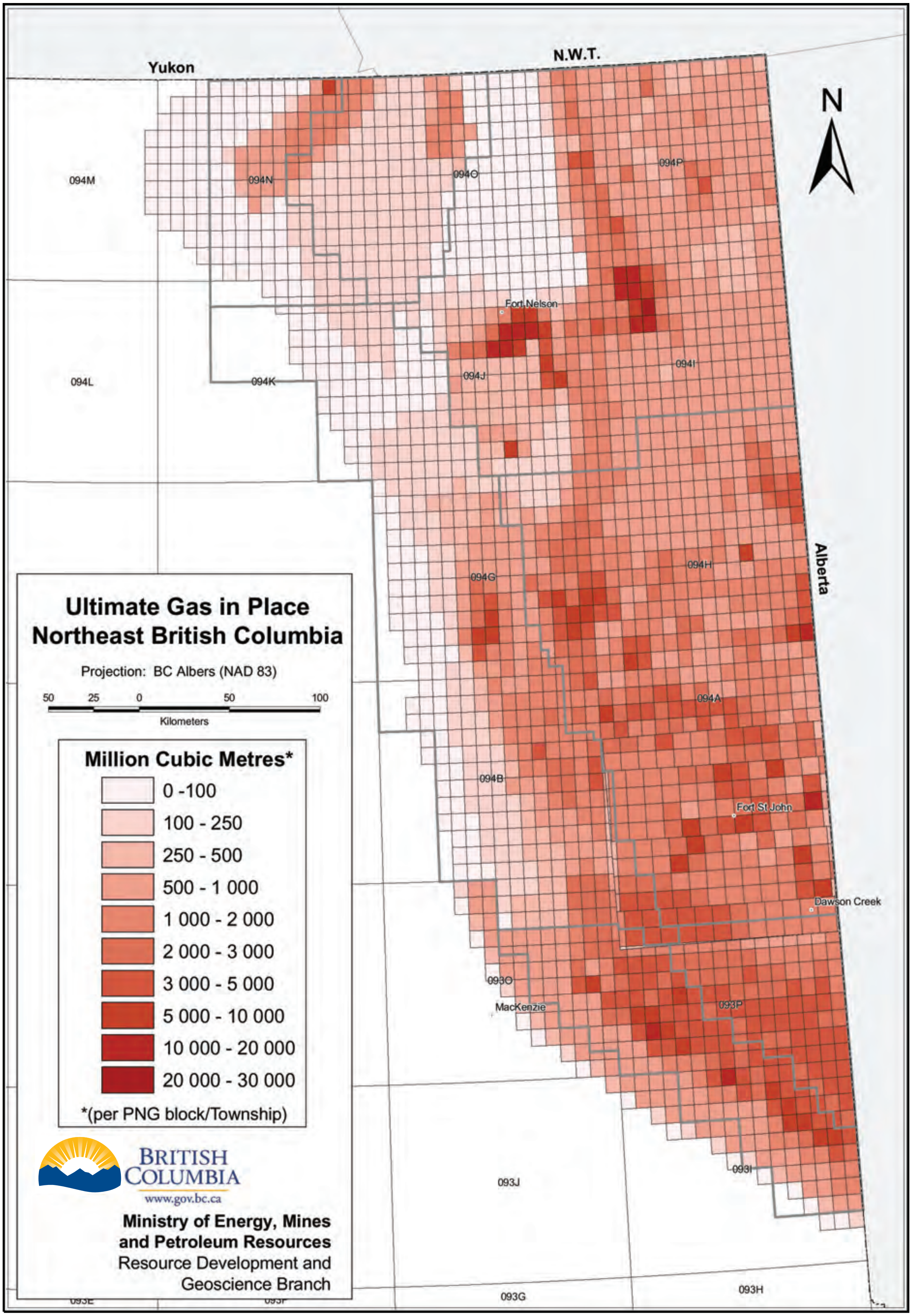
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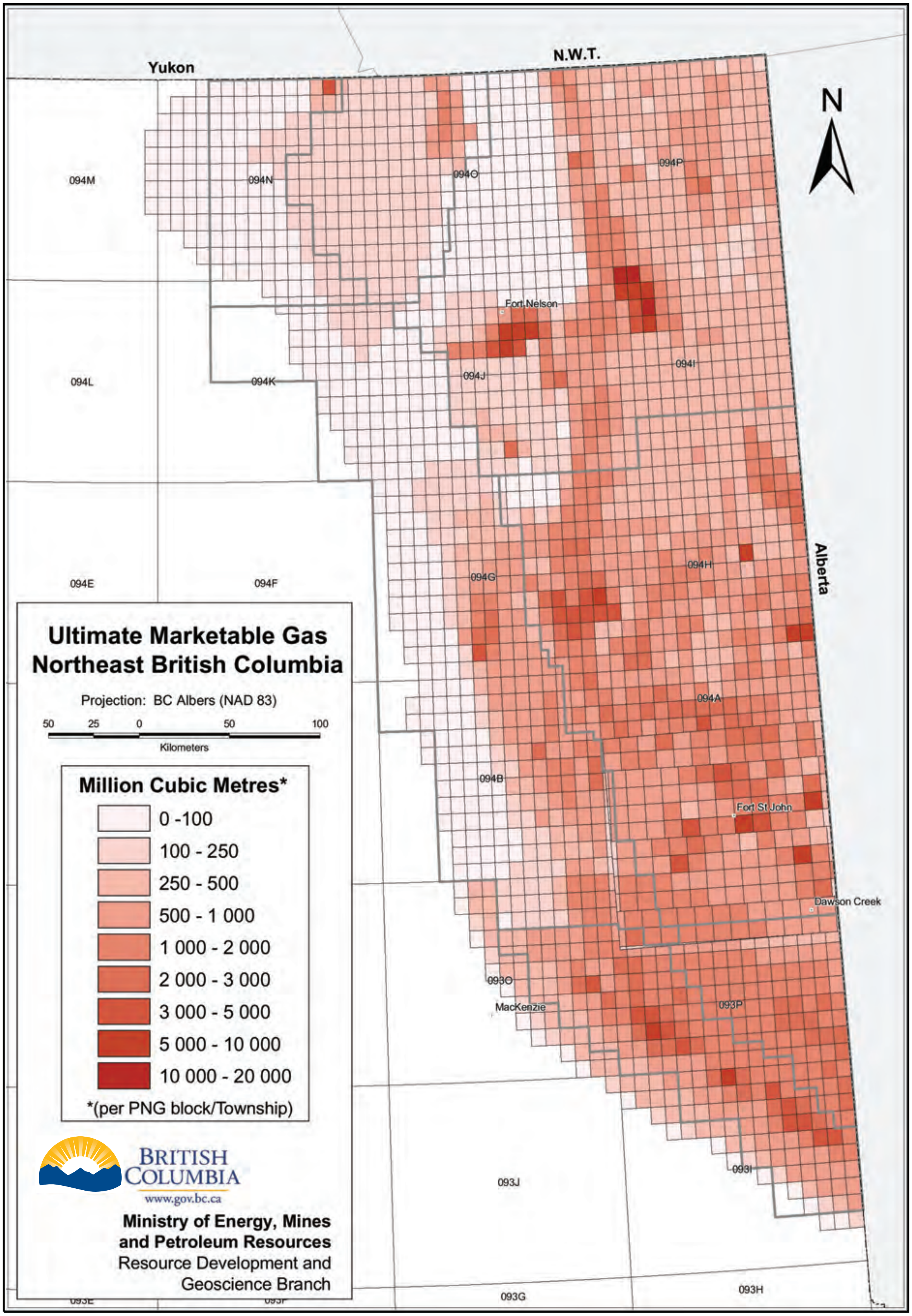
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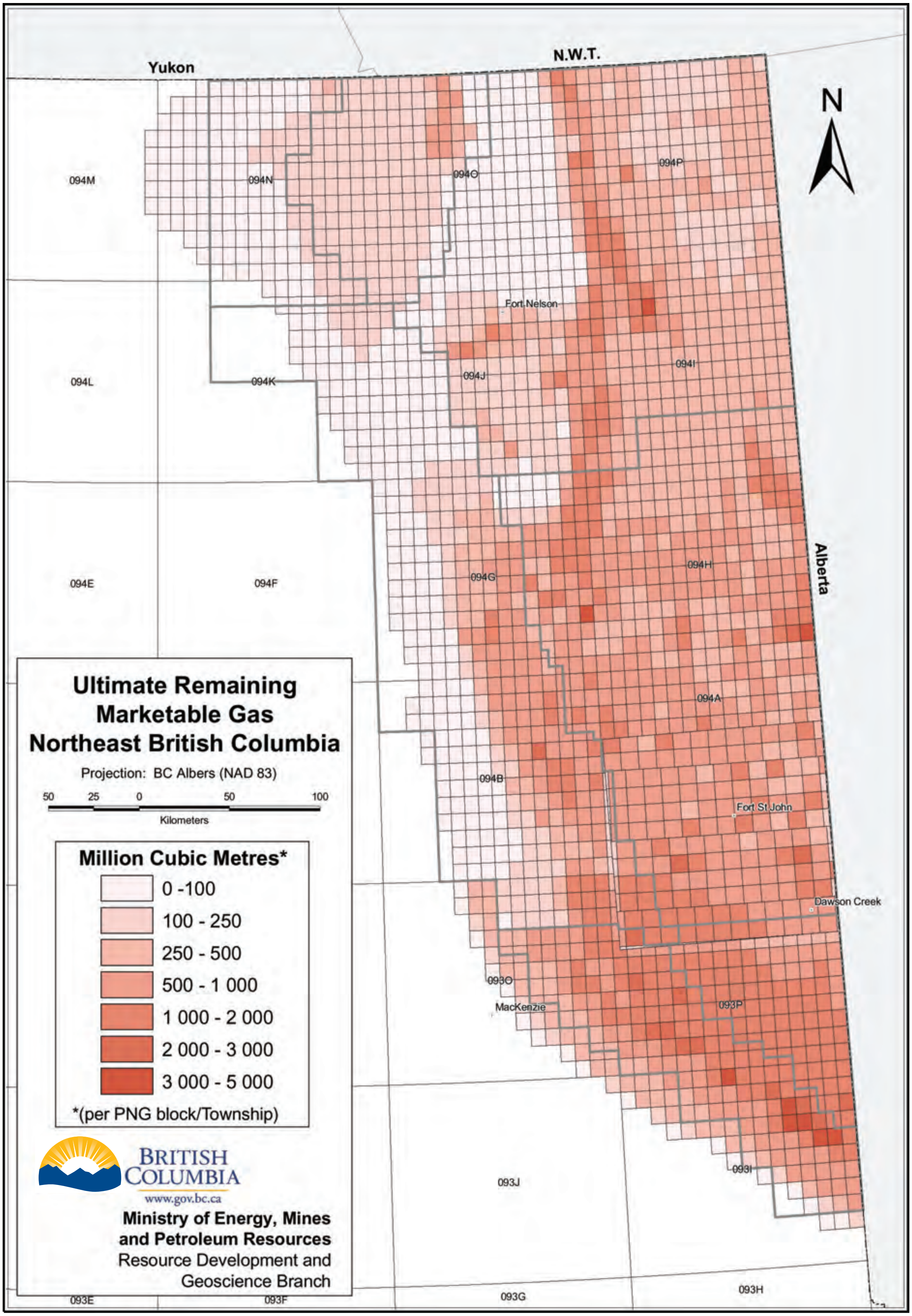
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3.0 Methodology

Values for the aforementioned categories were assigned to PNG grid NTS units (and quarter sections in the Peace River Block) across northeast BC as appropriate. These values were calculated using a mix of tabular and spatial data sources. Reserve data were obtained from the Oil and Gas Commission. These data are structured by Pool Designation Area (PDA). The unique code for each PDA is a composite of the Area (Field) Code, Formation Code and Pool Sequence Code. Values for reserve data were linked spatially to polygons representing PDAs. Where PDA polygons were not found, reserves were attributed evenly across the field in which the PDA was identified. Reserve values for 'other area' PDAs with no corresponding polygon were attributed to the PNG grid cell identified by the PDA Pool Sequence Code.

Production data were gathered from the Oil and Gas Commission in a separate file from the reserve data. These tabular data were linked spatially in the exact same method as described above for reserves data.

Undiscovered gas resources, as provided by project participants, correspond to mapped areas of play potential. As these data represent undiscovered resources, areas corresponding to previously identified pools were removed from each play potential area. Additional areas were removed around the locations of wells that had penetrated the play and not identified reserves. With polygons now representing unexplored areas for each play, resource numbers were applied to the polygons and average values per area-unit were calculated. These polygons were then intersected with the PNG grid and net resource values for each grid unit were subsequently calculated. The PNG grids for each play type were then combined and summarized spatially to calculate the total undiscovered resource value for each grid unit.

Ultimate resource values were calculated by combining the spatial products created from the reserves and undiscovered data and then summarizing by grid unit.

Contributions to Error:

Reserve values for "other area" PDAs were attributed to a single grid unit. This may have been better represented by attributing the reserve and production values to the drill spacing unit representing the well location (*i.e.* four grid units).

As described above, for some PDAs with no corresponding polygons, reserve data were spread evenly across the field in which the PDA was identified. Areas representing the location of these gas reserves could not be removed from the undiscovered play potential areas. It is likely that, for these fields, there are areas where the undiscovered resource potential within fields should be decreased and, in turn, increased elsewhere. With the absence of PDA polygons there is no solution to this problem. There are 87 PDAs for which this is the case, occurring in 60 fields. Given the small number of PDAs, this error is likely not significant when observed regionally.

4.0 Play Descriptions

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4.1 Tertiary / Quaternary

Much of the bedrock in the structurally undeformed portion of northeastern British Columbia is incised by late Tertiary to Quaternary valleys. Irregular bedrock topography and paleovalleys are filled by thick sedimentary successions, typically 150 to 200 metres thick, but in places exceeding 300 metres (e.g. well b-47-L/94-I-5). During the Quaternary glaciations, these valleys were filled with glaciofluvial, glaciolacustrine and morainal sediments.

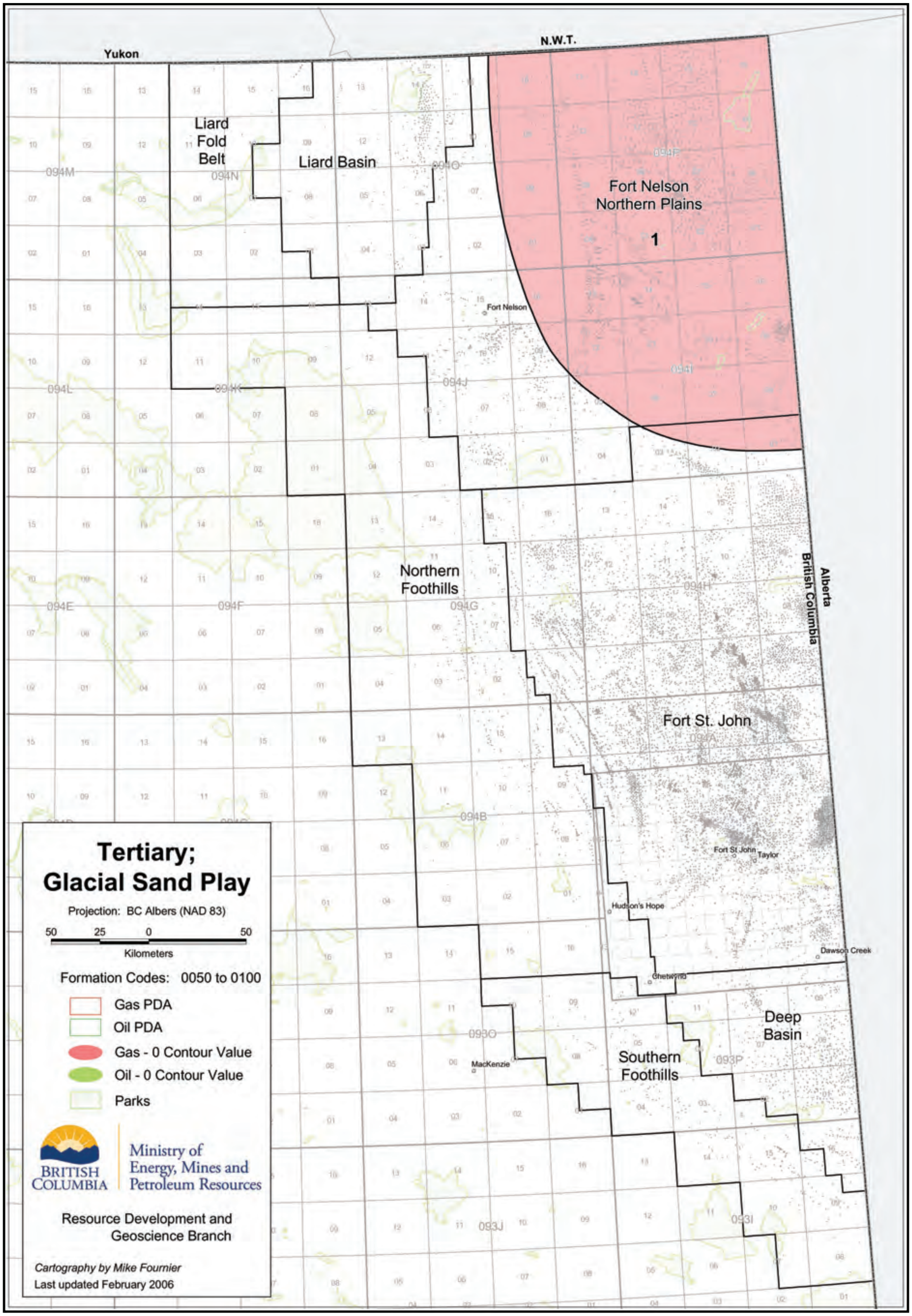
The general stratigraphy of the valley fills can be summarized as preglacial fluvial sand and gravel, overlain by Quaternary glacial sediments, which originated either from the Cordilleran Ice Sheet to the west or from the westward-advancing Laurentide Ice Sheet. Ice-advance glaciofluvial sand and gravel, and glaciolacustrine silt and clay are overlain by clay-rich till and retreat phase glaciolacustrine silt, sand and clay and glaciofluvial sand and gravel.

Buried glaciofluvial and preglacial sand and gravel may be potential reservoirs where over-consolidated, impermeable clay-rich till and glaciolacustrine sediment provide a seal. Gas may charge the reservoirs from biogenic or thermogenic (bedrock seep) sources.

There is no reported production from Quaternary pools in British Columbia. Pressurized aquifers and gas blow-outs from valley-fill successions have been noted in drilling reports (e.g. wells b-93-L/94-P-10, a-94-L/94-I-9). Quaternary gas reservoirs may have been overlooked because they occur in the shallow subsurface, commonly in the depth range in which surface casing is set. Alternatively, producing zones in Quaternary or late Tertiary sediments may be misidentified as Upper Cretaceous channel fills.

Fort Nelson Northern Plains Region

Play 1. Northern Plains Valley Fill Play—Although late Tertiary / Quaternary sediments are found across northeastern B.C., thick valley-fill successions are best developed in the Fort Nelson Northern Plains Region. In addition, gas has been produced from Quaternary reservoirs in nearby northwestern Alberta from the Sousa and Rainbow areas, where the geological setting is similar to that of northeast British Columbia. For example, well 6-13-112-24W5 produced 101 e^6m^3 gas between May 2000 and August 2005 from Quaternary strata, but is misidentified in public databases as a Dunvegan pool.



Tertiary;
Glacial Sand Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 0050 to 0100
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
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Yukon
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Liard Basin
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Southern Foothills
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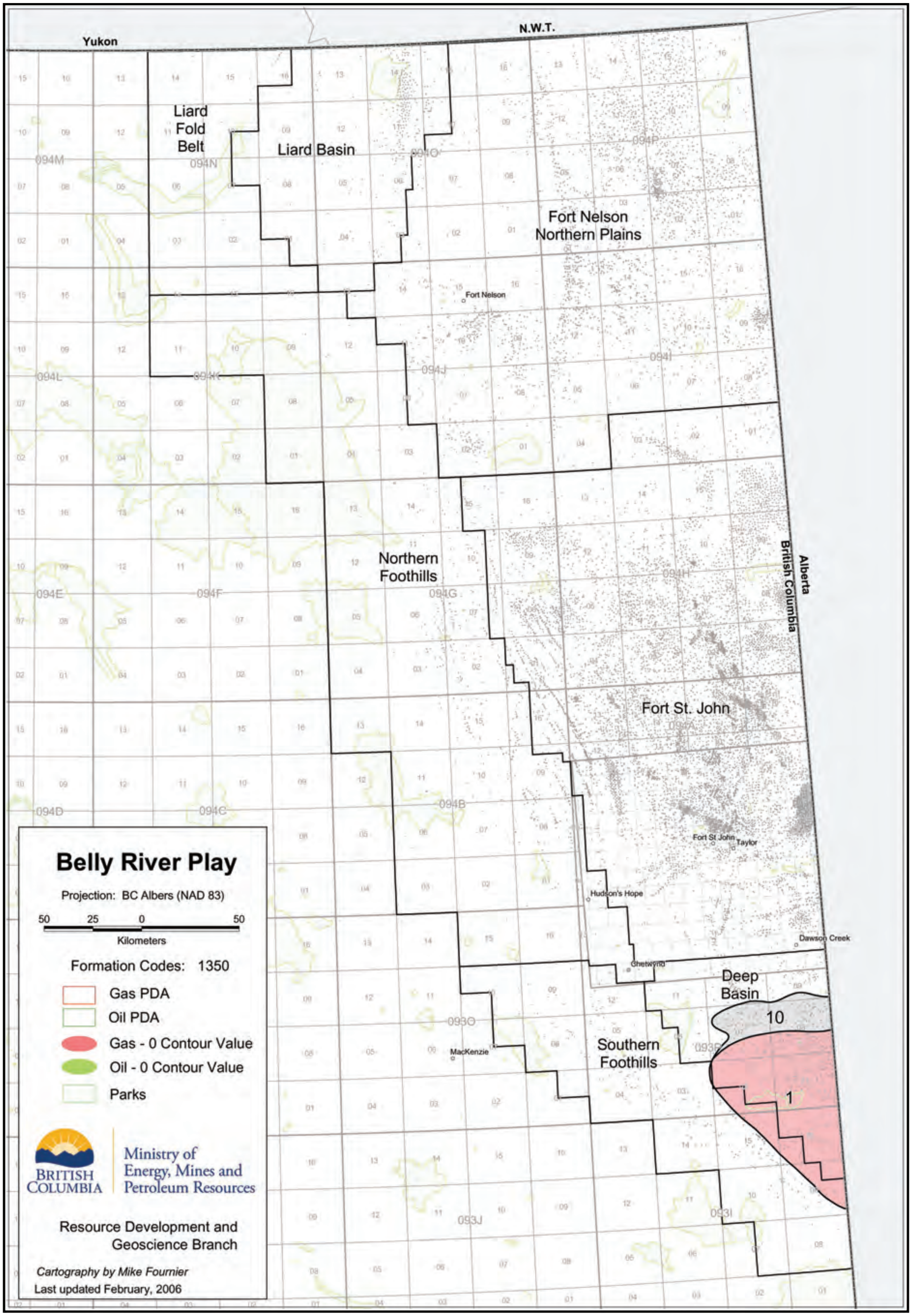
4.2 Belly River

Belly River strata (more correctly termed the Wapiti Group in northeastern B.C.) form a thick, eastwardly-thinning clastic wedge along the western flank of the Western Canada Sedimentary Basin. Fluvial to alluvial plain strata are stacked in thick successions lacking internal stratigraphic markers, conformably overlying Upper Cretaceous Smoky Group shales (Dawson, et. al., 1994). The upper Belly River is exposed at surface in northeastern B.C., limiting prospectivity to more deeply-buried parts of the section.

Deep Basin Region

Play 1. Deep Basin Stratigraphic Play—Belly River prospectivity is limited to the Deep Basin Region, south of the Peace River Block. Potential productive characteristics can be inferred from producing wells in the Elmworth-Wapiti area of west-central Alberta. Gas will be found in stratigraphic traps formed by fluvial channel sandstones encased in impermeable floodplain strata. Along the western edge, Belly River sandstones may be prospective in individual thrust sheets along the eastern margin of the Southern Foothills.

There is no known Belly River production in northeastern B.C.



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Belly River Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1350
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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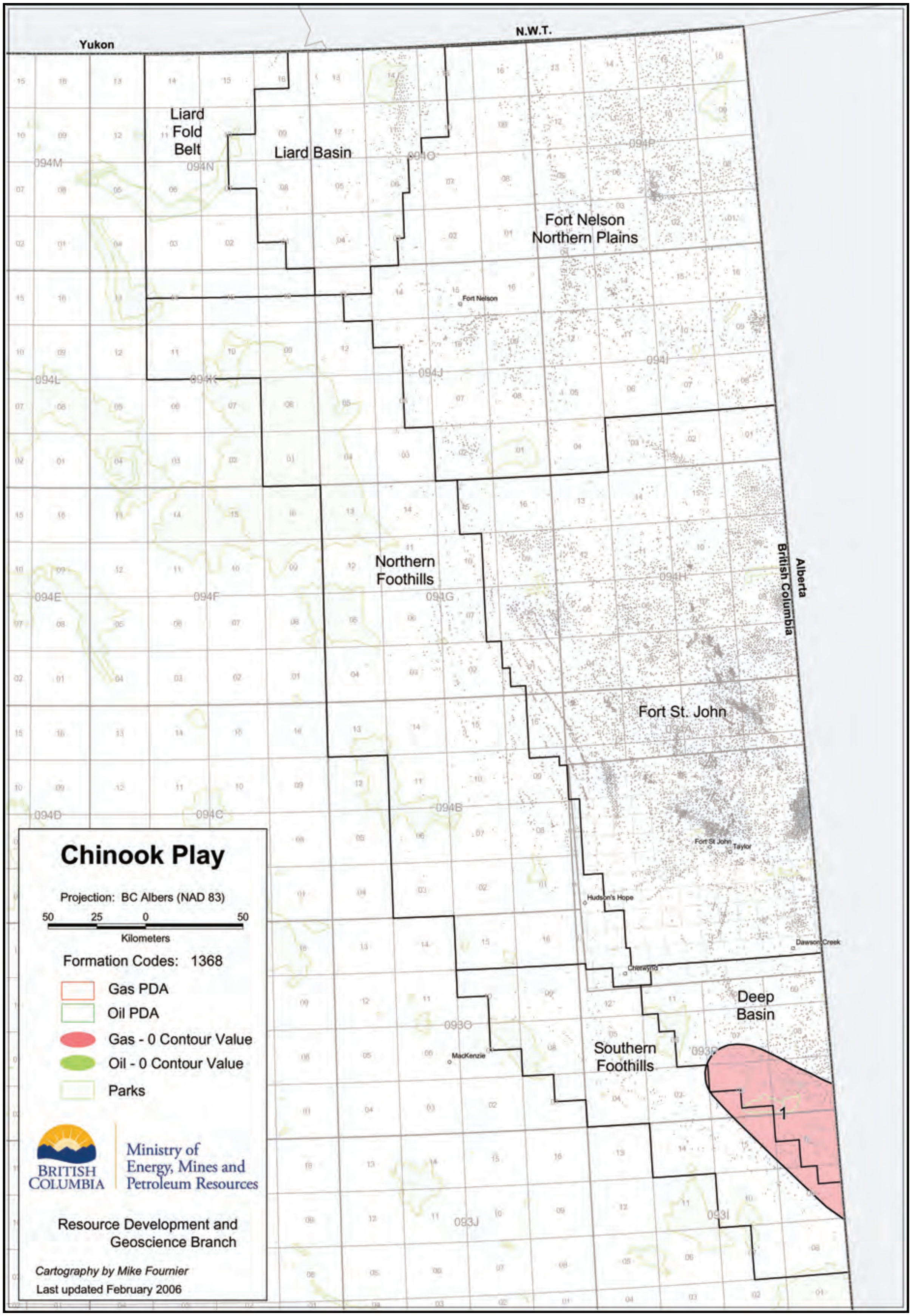
4.3 Chinook Member

The Chinook Member (also known as the Chungo Member) was deposited in shoreface to marginal marine settings on the northwestern flank of the Late Cretaceous Colorado / Smoky seaway (Leckie, et. al., 1994). Northwest-southeast trending coarsening-upward shoreface sandstones are encased in marine shales, forming well-defined stratigraphic traps about 30 metres below basal Belly River / Wapiti sandstones.

Deep Basin Region

Play 1. Deep Basin Stratigraphic Play—The Chinook hosts gas and oil production at Red Rock and Chicken in west-central Alberta, and the trend can be extrapolated northwestward into the southern Deep Basin Region of B.C. Prospectivity will be limited to narrow high-quality reservoir trends within the indicated play area; detailed mapping will be required to identify these trends.

There is no known Chinook production in British Columbia.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Chinook Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1368
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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4.4 Cardium Formation

Cardium strata comprise a northeasterly-prograding shoreface / alluvial plain complex, mappable along the western flank of the WCSB as far north as Twp. 75-77 (Plint and Walker, 1987). In northeastern B.C., Cardium reservoir potential is confined primarily to the Kakwa Member, which consists of a coarsening-upward sandstone succession from 15 to 50 metres thick (Figure 2). Upper shoreface / foreshore conglomerates cap the succession locally. Overlying Cardium "zone" sands, which are productive in adjacent Alberta, are poorly developed. Marine shales of the underlying Kaskapau Formation and overlying Muskiki Formation are regional seals, isolating the Cardium hydrodynamically from other reservoirs.

A gas-saturated Deep Basin regime within the Cardium is defined in west-central Alberta, and can be extrapolated northwestward into British Columbia. Cardium strata crop out on the eastern flank of the Southern Foothills, and in the northern part of the Deep Basin area, thus confining prospectivity to the south and east.

Deep Basin Region

Play 1. Deep Basin Play —Gas and oil are produced from well-sorted upper shoreface to foreshore sandstones and conglomerates within the hydrocarbon-saturated Deep Basin in west-central Alberta. Prospectivity is determined primarily by presence of economic reservoir quality, although local prospects may occur in overlying Cardium "zone" sands. The Deep Basin play can be traced northwestward into British Columbia, but most production is situated 100 km or more from the B.C. border. The updip play boundary is loosely defined as occurring downdip of the regional aquifer system, where water is the primary reservoir fluid.

The Cardium Deep Basin play contains a large resource of gas in place, but most in strata with subeconomic reservoir quality. This can therefore be regarded as a tight gas play. There is no Cardium production in the Deep Basin Region, but Tupper b-A4-D/93-P-8 tested low-rate gas upon completion.

Play 2. Regional Aquifer Play—Although occurring in the same depositional setting, Cardium sandstones in the regional aquifer contain formation water, as demonstrated by test recoveries and log responses. Gas may occur in small and subtle structural or stratigraphic traps, but no examples have been discovered to date.

Southern Foothills Region

Play 1. Deep Basin Play —This play can be traced westward into the eastern part of the Southern Foothills Region. Structural deformation may give rise to structural trapping opportunities, or reservoir enhancement through fracturing. However, traps may be breached by faulting, particularly in this very shallow reservoir section.

No production has been documented to date.

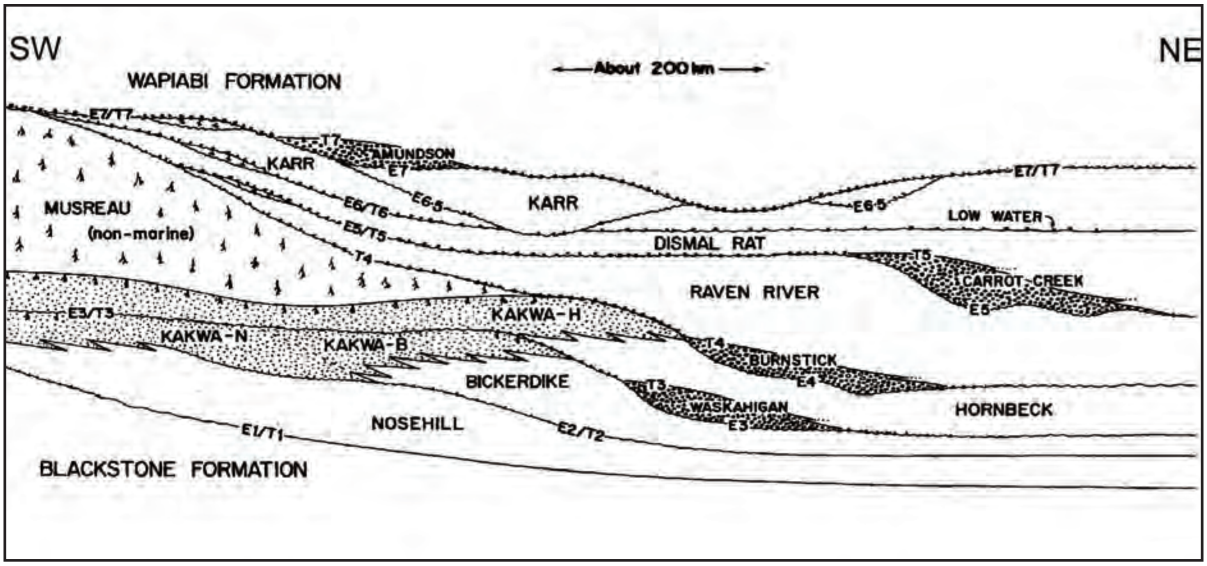
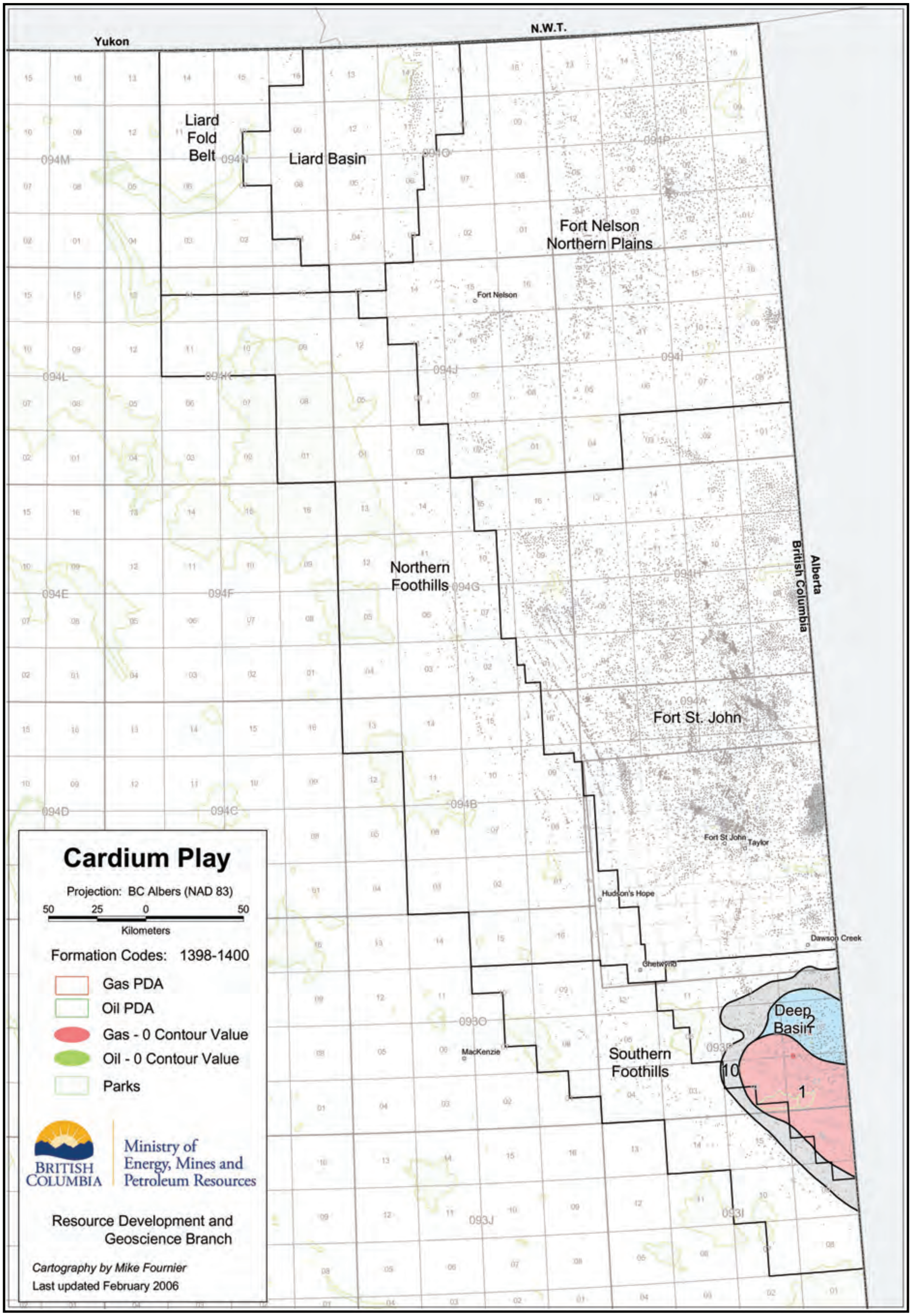


Figure 2. Schematic regional cross-section, Cardium Formation, west-central Alberta and adjacent British Columbia (from Plint and Walker, 1987). Regionally continuous sandstones of the Kakwa Member host large gas resources, but exhibit poor to moderate permeabilities.


Cardium Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1398-1400
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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4.5 Doe Creek Member

Doe Creek sandstones lie within the lower part of the Kaskapau Formation, as part of a transgressive marine package overlying the Dunvegan fluvial / deltaic clastic wedge (Wallace-Dudley and Leckie, 1995) (Figure 3). Reservoir sandstones occur in linear, shoreline-parallel trends, generally less than five metres thick, and exhibiting good conventional reservoir quality. Isolated sandstones in the overlying Pouce Coupe and Howard Creek members may also be included in the Doe Creek play interval.

In Alberta, the Doe Creek produces gas and oil from numerous pools in the Elmworth – Valhalla area. Moving westward into B.C., the interval becomes more gas-prone, and reservoir sandstones become thinner and more isolated.

Deep Basin Region

Play 1. Deep Basin Play—The Deep Basin Play area is defined to occur within the mapped outcrop limits of the Doe Creek, such that the formation is buried sufficiently to be hydrocarbon-charged and isolated from meteoric water influx. Gas is trapped stratigraphically within shallow marine sandstones, encased in impermeable marine shales. One oil producer occurs at Kelly Lake (I/93-P-1).

The Doe Creek Deep Basin play extends northward into the southern fringe of the Fort St. John Play Area, and westward into the eastern part of the Southern Foothills Play Area. However, while the play concept remains identical, it is generally not prospective in these areas because of shallow burial depths.

Doe Creek pools occur in the northeast at Cutbank and Kelly, and to the southwest at Hiding Creek.

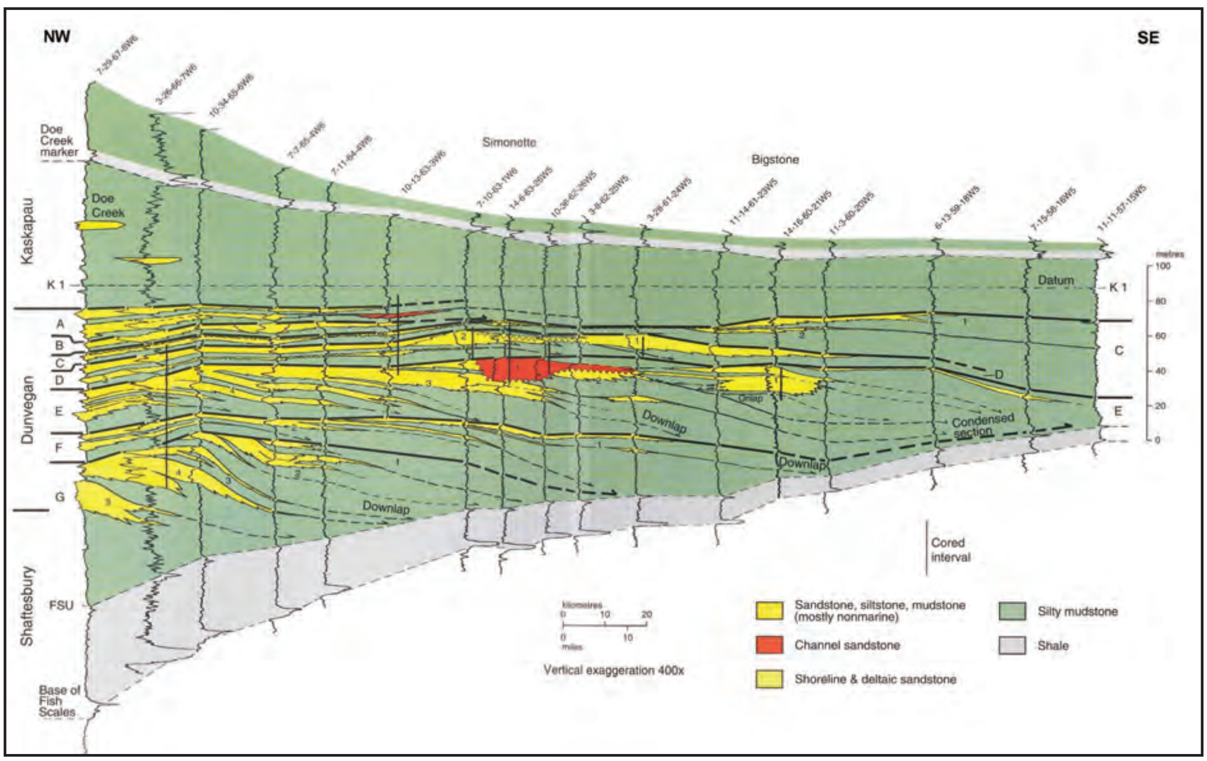
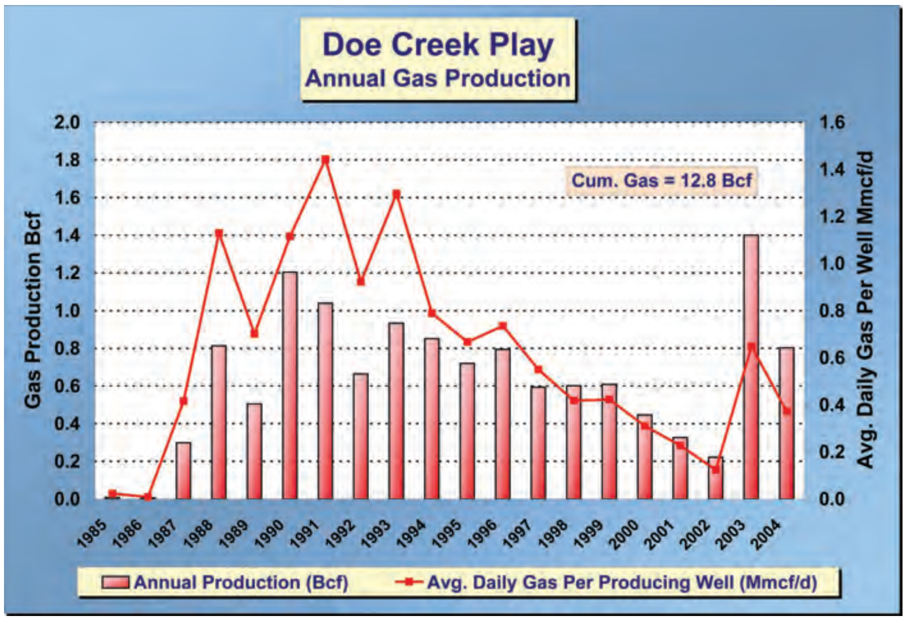
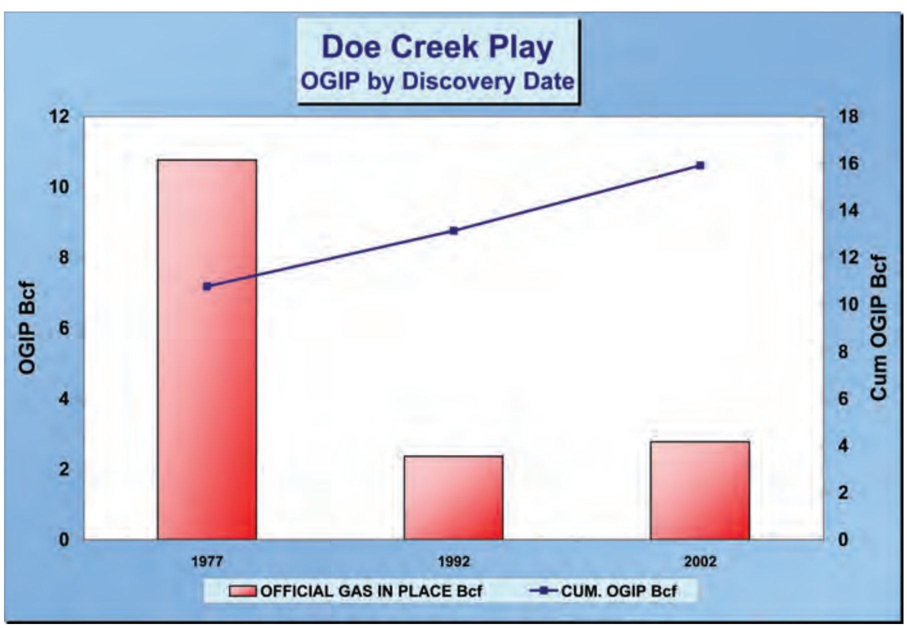
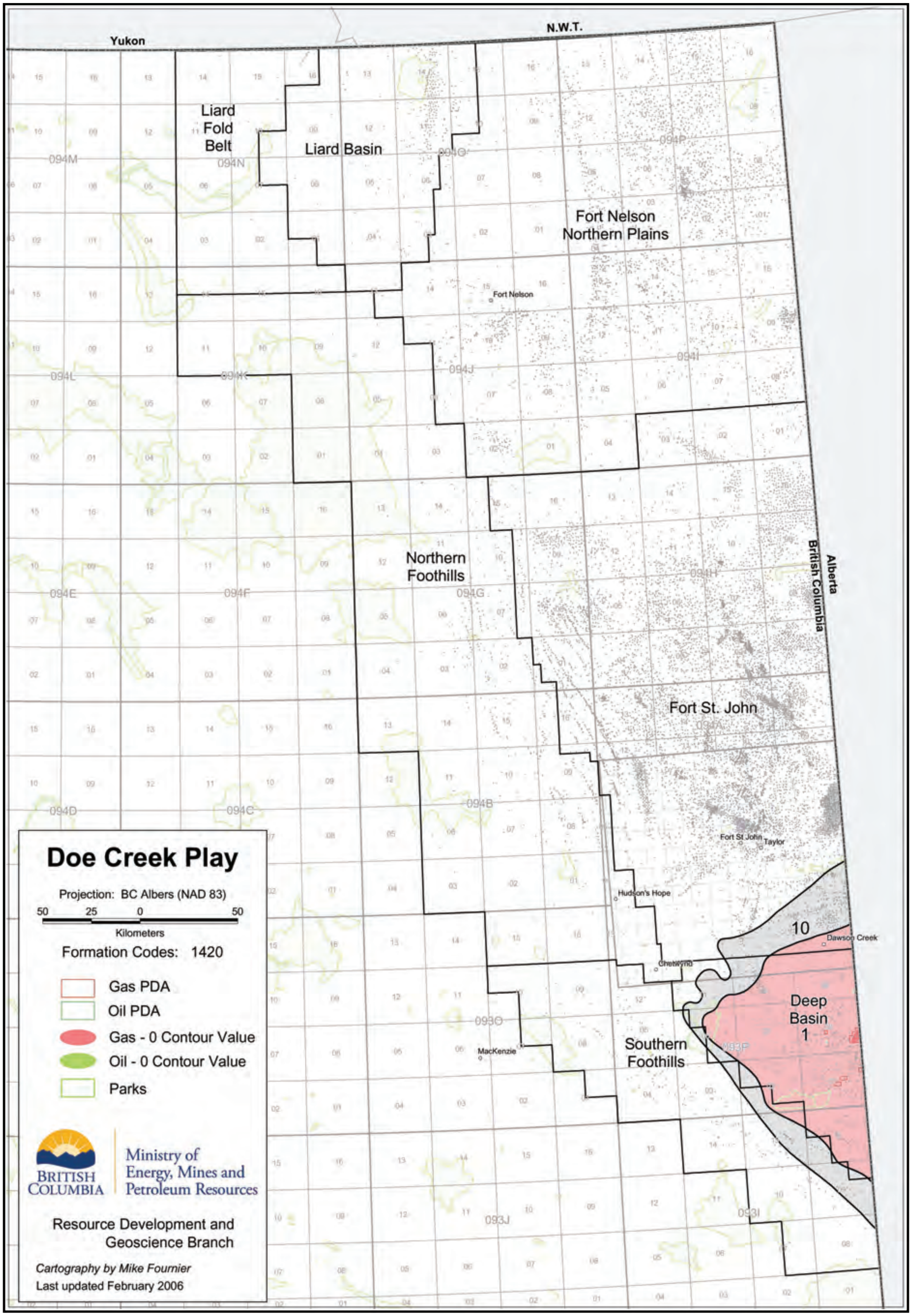


Figure 3. Schematic regional cross-section, Dunvegan Formation and Doe Creek Member, illustrating extensive sandstone reservoir development to the northwest, and basinward (southeastward) shale-out and downlap of individual allomembers (from Bhattacharya, 1994).

Doe Creek Play - All Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Cutbank	Doe Creek	A	305	244	20	11	9	1
Hiding Creek	Doe Creek	A	79	64	35	3	2	1
Kelly	Doe Creek	B	67	57	19	2	2	1
Totals			451	365	73	16	13	3






Doe Creek Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1420
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Yukon
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Liard Fold Belt
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4.6 Dunvegan Formation

Dunvegan strata form a large, southeasterly-prograding wedge of deltaic and shoreface sediments, which originated in far northern B.C. and the Territories, and reached a distal edge in west-central Alberta (Stott, 1982; Bhattacharya, 1994). It lies between marine shales of the Shaftesbury Formation below and the Kaskapau Formation above (Figure 3, page 27). Dunvegan sandstones were deposited in deltaic to shoreface settings at the seaward limit of several regressive subunits, and in associated distributary channels and valley fills.

Dunvegan reservoirs produce over a broad area of west-central Alberta. Reservoir quality generally decreases westward into B.C., largely as the result of compaction associated with significantly deeper paleoburial. North of the Deep Basin, Dunvegan strata crop out or are at such shallow depths that reservoir pressures and effective trapping become significant issues.

Deep Basin Region

Play 1. Deep Basin Play—The Deep Basin Play area is defined to occur within the mapped outcrop limits of the Dunvegan, such that the formation is buried sufficiently to be hydrocarbon-charged and isolated from meteoric water influx. Potential reservoir sandstones are generally fine- to medium-grained, and suffered considerable degradation by burial compaction during Early Tertiary time. Specific play fairways are difficult to map, as most sandstones were deposited in areally-limited fluvial to deltaic bodies; persistent linear shoreline trends are relatively uncommon.

The Dunvegan Deep Basin play extends northward into the southern fringe of the Fort St. John Play Area, and westward into the eastern part of the Southern Foothills Play Area. However, while the play concept remains identical, it is generally not prospective in these areas because of shallow burial depths.

There is only one producing Dunvegan gas well at Kelly Lake (I/93-P-1), although the zone has flowed non-economic gas rates on DST and perforation in several other wells.

Fort St. John Region

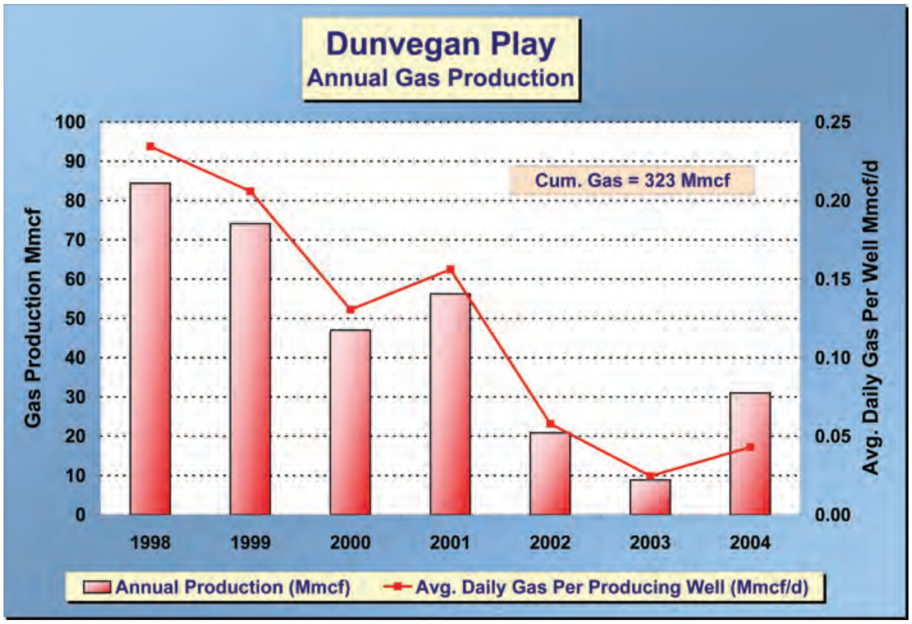
Play 2. Shallow Gas Play (Conceptual)—Dunvegan sandstones exhibit much better reservoir quality in the Fort St. John Region, as they have experienced much less burial compaction than in the Deep Basin. Stratigraphic trapping of gas within channel to marginal marine sandstones may occur, but has not yet been demonstrated. Much of the Dunvegan section in wells in this area will be behind surface casing, and thus has not been adequately evaluated in conventional boreholes.

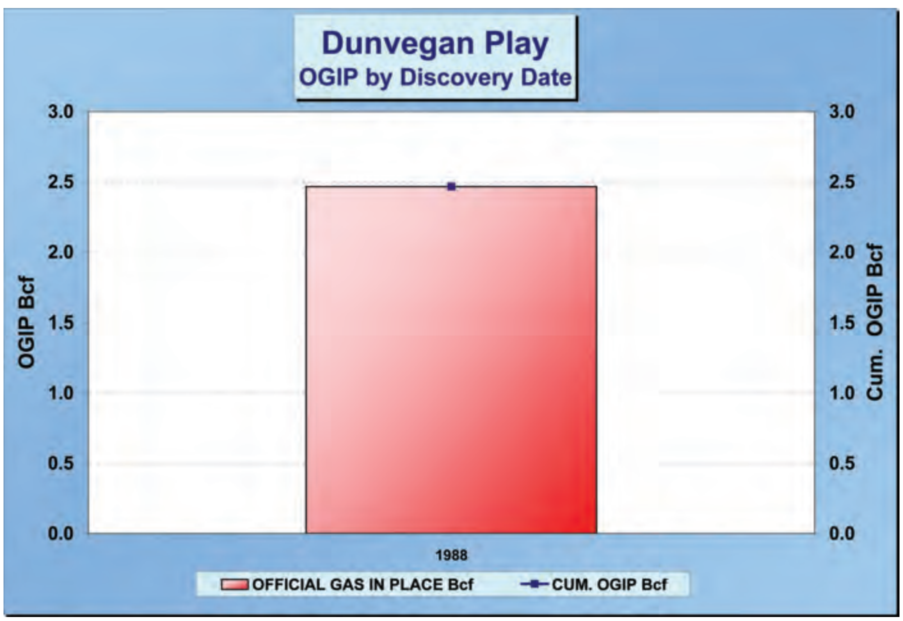
Liard Basin Region

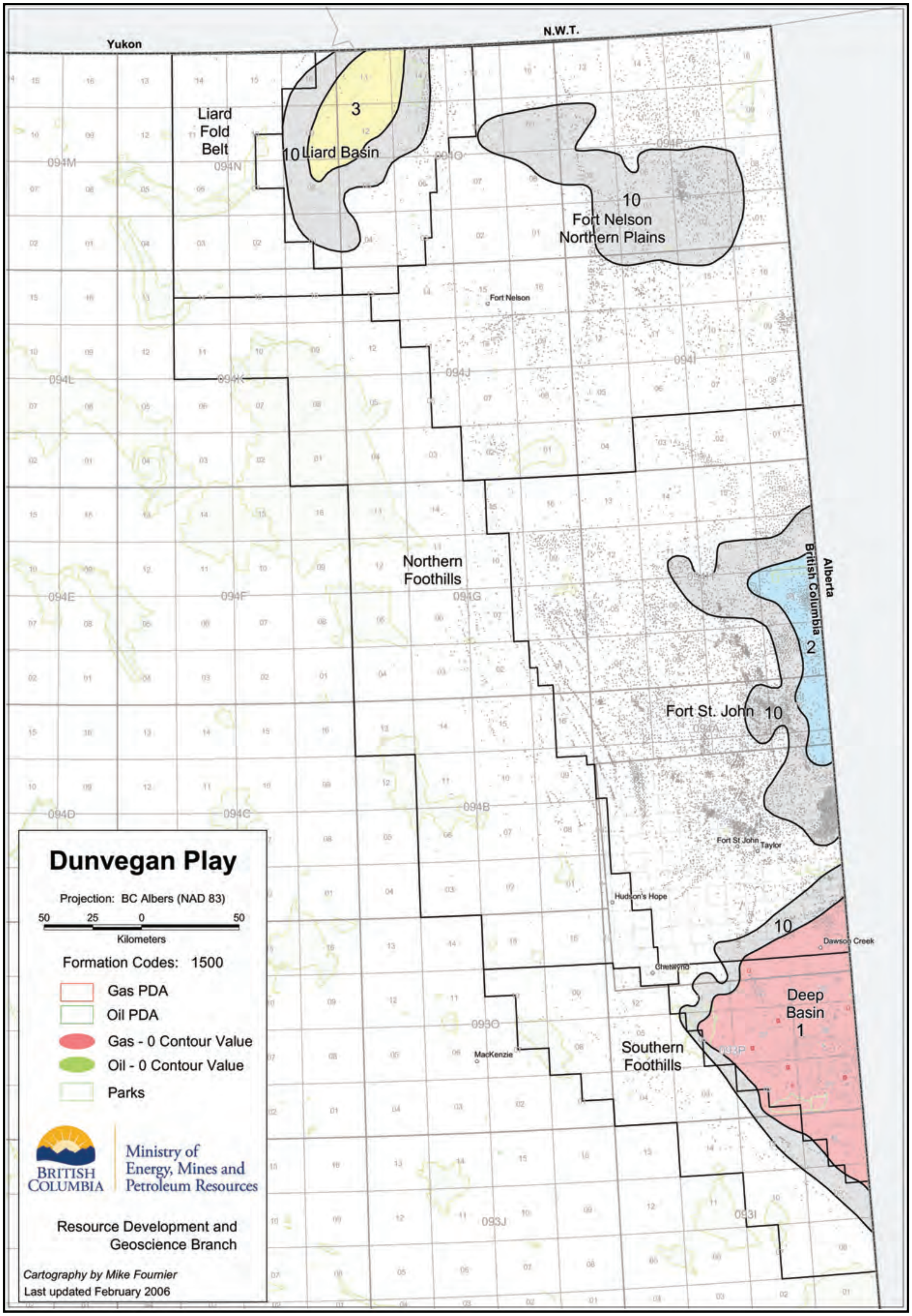
Play 3. Shallow Gas Play (Conceptual)—Massive Dunvegan conglomerates in the Liard Basin offer excellent reservoir potential, but trapping potential is poor because of widespread surface exposure. Toward the centre of the basin, capping Kotaneelee shales may provide adequate seals. The Dunvegan section is very shallow in most existing boreholes, and has not been systematically evaluated.

Dunvegan Play - All Pools by OGIP

Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Kelly	Dunvegan	A	70	51	44	2	2	2
Total			70	51	44	2	2	2


Dunvegan Play
Annual Gas Production
Cum. Gas = 323 Mmcf
Gas Production Mmcf
Avg. Daily Gas Per Well Mmcf/d
100
90
80
70
60
50
40
30
20
10
0
0.25
0.20
0.15
0.10
0.05
0.00
1998
1999
2000
2001
2002
2003
2004
Annual Production (Mmcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Dunvegan Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1988
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Dunvegan Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1500
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Yukon
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Deep Basin
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MacKenzie

4.7 Sikanni / Goodrich Sandstones

Sikanni / Goodrich strata comprise up to seven coarsening-upward deltaic to shoreface successions in northeastern B.C. They overlie marine shales of the Buckinghorse and Hasler formations, and are capped by Cruiser and Sully shales. Sikanni / Goodrich sandstones are predominantly fine-grained, somewhat argillaceous litharenites, petrographically similar to fine-grained Cardium sandstones.

The Goodrich is recognized in outcrop in the Peace and Pine River areas, while the Sikanni has been mapped in the vicinity of Sikanni Chief River and northward (Stott, 1982; Pedersen and Schroder-Adams, 2001). Gross thicknesses up to 240 metres have been recorded, although most sections are substantially less. In the subsurface, the Sikanni / Goodrich occupies a long, narrow trend, bounded to the east by a poorly-defined sandstone progradational limit (Figure 4). Much of the prospective fairway is very lightly explored.

Fort St. John Region

Play 1. Sikanni / Goodrich Play—Sikanni and Goodrich sandstones thin and pinch out over a few tens of kilometres east of outcrop, but one or more sands are consistently developed along the western flank of the Fort St. John area. Traps may occur as stratigraphic pinchouts or structural closures associated with Foothills tectonics. Although penetrated by numerous wells, the Sikanni / Goodrich has been tested in fewer than ten. One well tested gas after frac, but there has been no production.

It appears that the Sikanni / Goodrich contains a large gas in place resource, but that economic reservoir quality and continuity have not yet been established.

The Sikanni / Goodrich play extends into the adjacent Deep Basin, Fort Nelson, and Southern and Northern Foothills Play areas. The main fairway is bounded to the north by the appearance of Sikanni sandstones in outcrop in the Fort Nelson area, but re-appears to the north in the Liard Basin Play area.

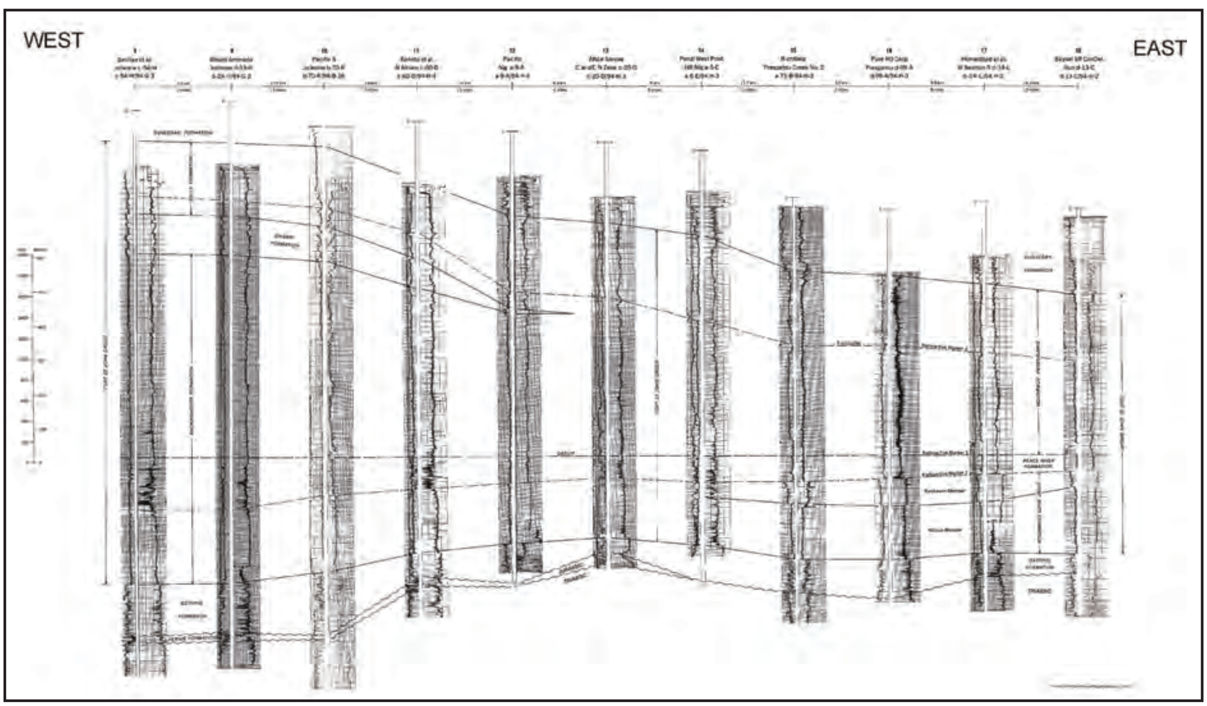
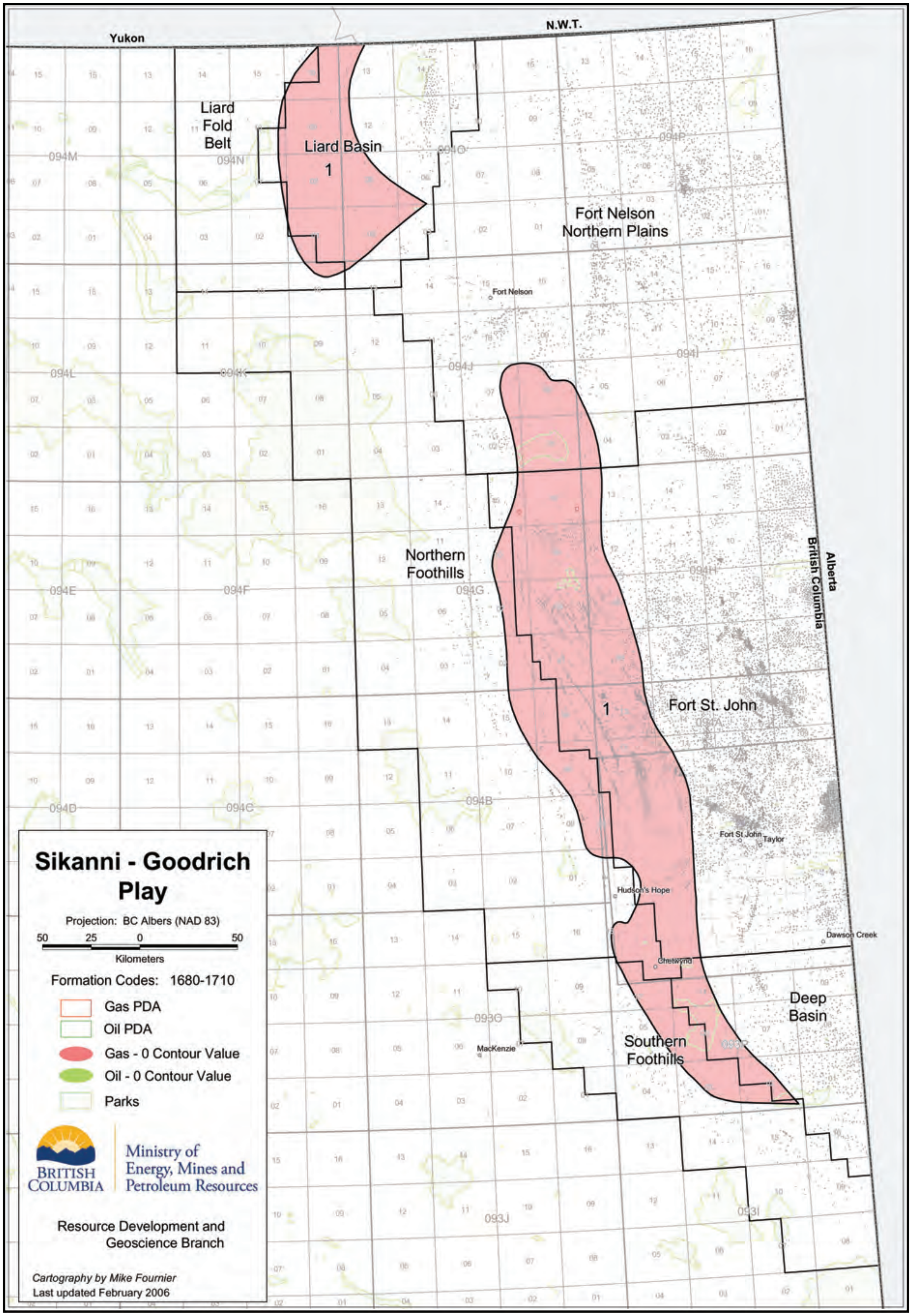


Figure 4. West-east regional cross-section, illustrating eastward pinchout of stacked Sikanni sandstone successions within the uppermost Lower Cretaceous Fort St. John Group marine shales (from Stott, 1982).


Sikanni - Goodrich Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1680-1710
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Yukon
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4.8 Scatter Formation

The Scatter Formation is found in the Liard Basin and northward into the southern Northwest Territories. It was deposited in shallow marine shelf to shoreline settings, and is encased by marine shales of the Garbutt Formation below and the Lepine Formation above (Leckie and Potocki, 1998). From major depocentres to the west and southwest, the Scatter thins eastward, although there is no well-defined eastern sandstone limit.

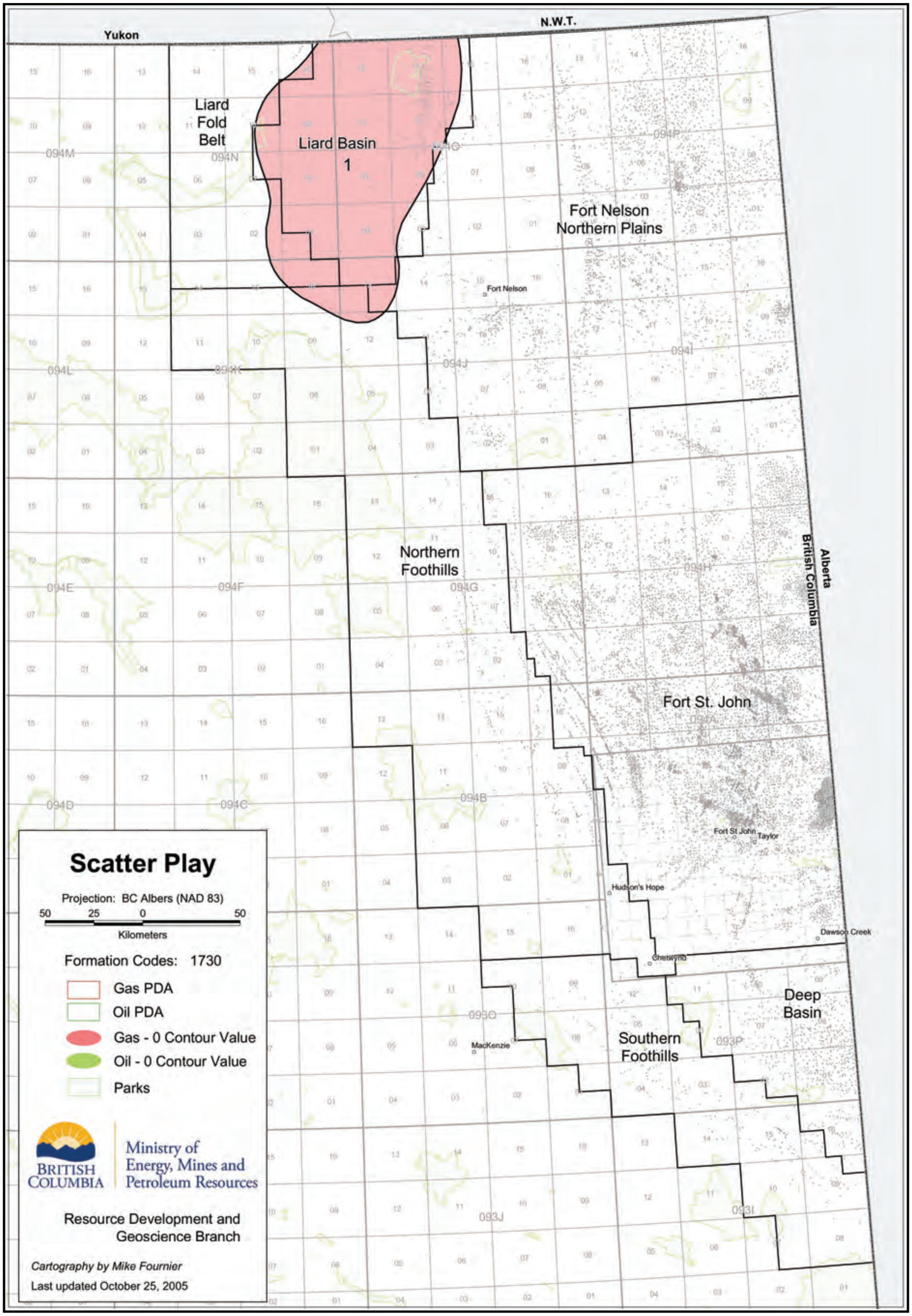
Scatter sandstones are silty to very fine-grained, moderately- to well-sorted, matrix-rich, moderately to poorly porous, glauconitic and lithic. Compaction has greatly reduced porosity and permeability; in addition, locally abundant calcite cement has further reduced reservoir quality.

Liard Basin Region

Play 1. Liard Basin Play—Present-day burial depths range up to about 1700 metres, increasing to the southwest. Considerable gas potential exists for the Scatter in stratigraphic pinchouts and possible fault traps; net sandstone thicknesses exceed 100 metres in the western part of the Liard Basin. However, Scatter sandstones have produced no hydrocarbons to date, and reservoirs are difficult to evaluate on well logs because of their heterolithic bedding.

All Scatter penetrations to date have been targeted for deeper objectives. There has thus been no systematic effort to evaluate the Scatter reservoir with carefully-designed drilling and completion programs. A systematic uphole evaluation of the Scatter over the Maxhamish Field would help to quantify its productive potential.

Scatter play potential laps into the adjacent Liard Fold Belt and Northern Foothills Play areas, where structure may play a greater role in reservoir and trap development.



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Scatter Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 1730
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
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4.9 Paddy Member

Paddy strata were deposited across the southern Deep Basin in alluvial plain to bay/lagoonal environments at the culmination of a widespread regional transgressive/regressive cycle. To the north, the Paddy grades into a regional, southwest-northeast trending sandy shoreface / barrier that can be traced from outcrops in the B.C. Foothills to the Peace River Valley near Peace River town in Alberta.

The Paddy section in the B.C. Deep Basin is dominated by fine-grained clastics and coals, and lacks regional stratigraphic markers (Smith et. al., 1984). Locally, valleys incised from the top of the Paddy are filled with sand-dominated estuarine facies (Leckie and Singh, 1991). Paddy strata cap Cadotte shoreface sandstones and related facies with a subtle unconformity that decreases in magnitude northward. Marine Shaftesbury shales cap the Paddy and provide an excellent upper seal.

Deep Basin Region

Play 1. Estuarine Valley Fill Play—High-quality reservoir sandstones, up to 25 metres thick, occur within north-south trending estuarine valleys at the top of the Paddy (Figure 5). Optimal reservoir facies are medium-grained or coarser sublitharenites to quartzarenites, featuring well-developed primary intergranular and secondary solution porosity. Finer-grained sandstones exhibit poorer quality, with less extensive solution porosity and more tortuous, intricate porosity networks.

The Estuarine Valley Fill Play lies within the hydrocarbon-saturated Deep Basin regime, so that productivity is a function of reservoir quality and volume, without consideration for trapping. The northern limit of the Deep Basin defines the northern boundary of the Play area; this limit is defined in northern 93-P-8 by updip water recoveries, but is poorly defined to the west. Relatively few upper Paddy valley segments are likely to occur west of Cutbank/Tupper, as increasing thickness of the overall Paddy section indicates expanding accommodation space, and thus less likelihood of lengthy valley incisions

Producing gas pools occur at Cutbank, Kelly, Noel, and Tupper Creek, most in a well-defined valley trending north through the middle of 93-P-1 and 93-P-8.

Play 2. Northern Barrier Play—In the northern shoreface / barrier trend, fine-grained Paddy strata grade into more homogeneous, sandier- and coarsening-upward sandstones. In the southern part of the trend, the reservoir is more heterogeneous, with interbedded argillaceous facies. Sandstones are generally fine- to medium-grained with local coarser facies. Reservoir quality is generally good in the east, but degrades westward with burial compaction and associated cementation.

Gas is trapped in subtle structures providing closure within massive shoreface sandstones on the northern flank of the trend. Locally, a stratigraphic component of trapping may occur to the south, as reservoirs are compartmentalized by interbedded argillaceous facies.

Producing pools are found at Dawson Creek, Doe, and Sunrise.

Play 3. Northeast Deep Basin / Backbarrier Play (Conceptual)—This play occupies a position intermediate between Plays 1 and 2, encompassing an area where gas may be trapped stratigraphically in the northern reaches of estuarine valley fills, or in backbarrier splays and channels. There is no established production, although economic reservoir quality has been established in several wells that have tested wet.

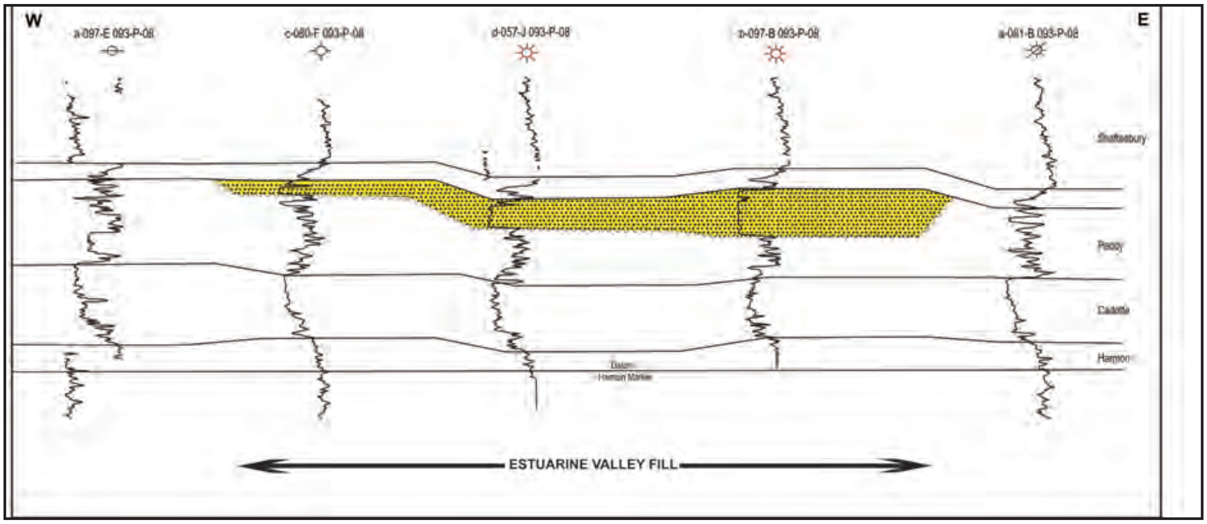
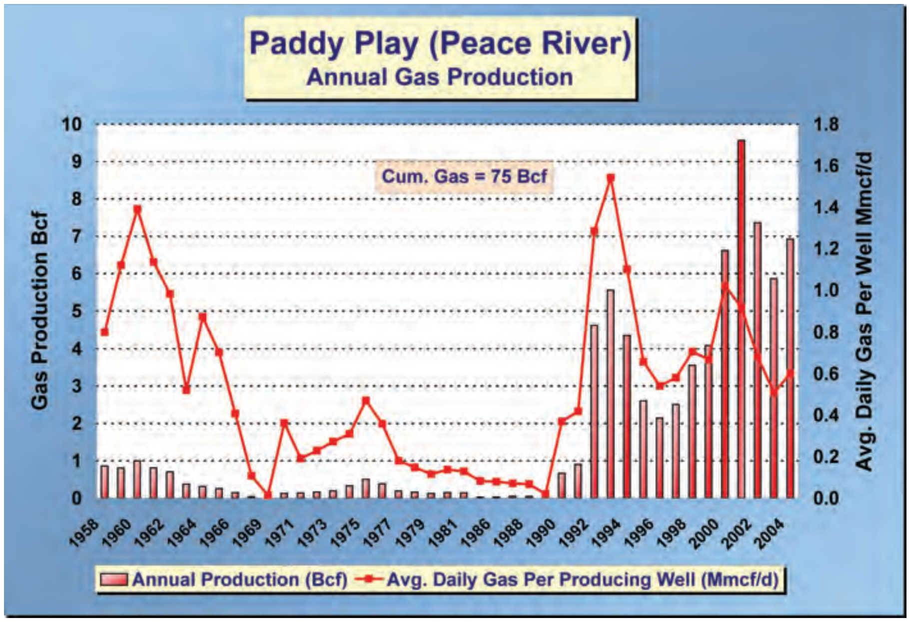
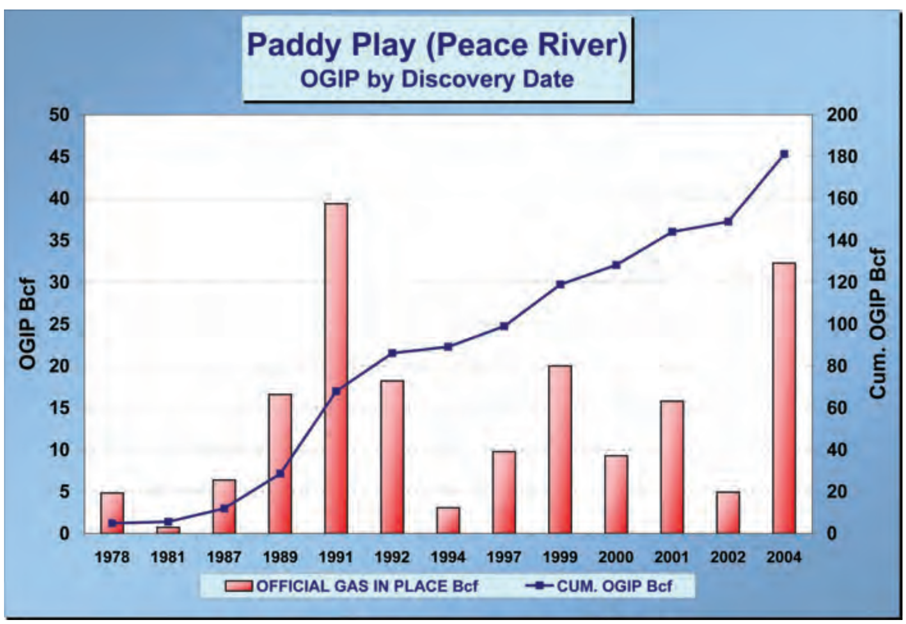


Figure 5. Estuarine valley-fill reservoir development, upper Paddy Member, Tupper Creek area of B.C. Deep Basin. Clean, blocky sandstones in b-97-B and d-57-J wells are highly productive.

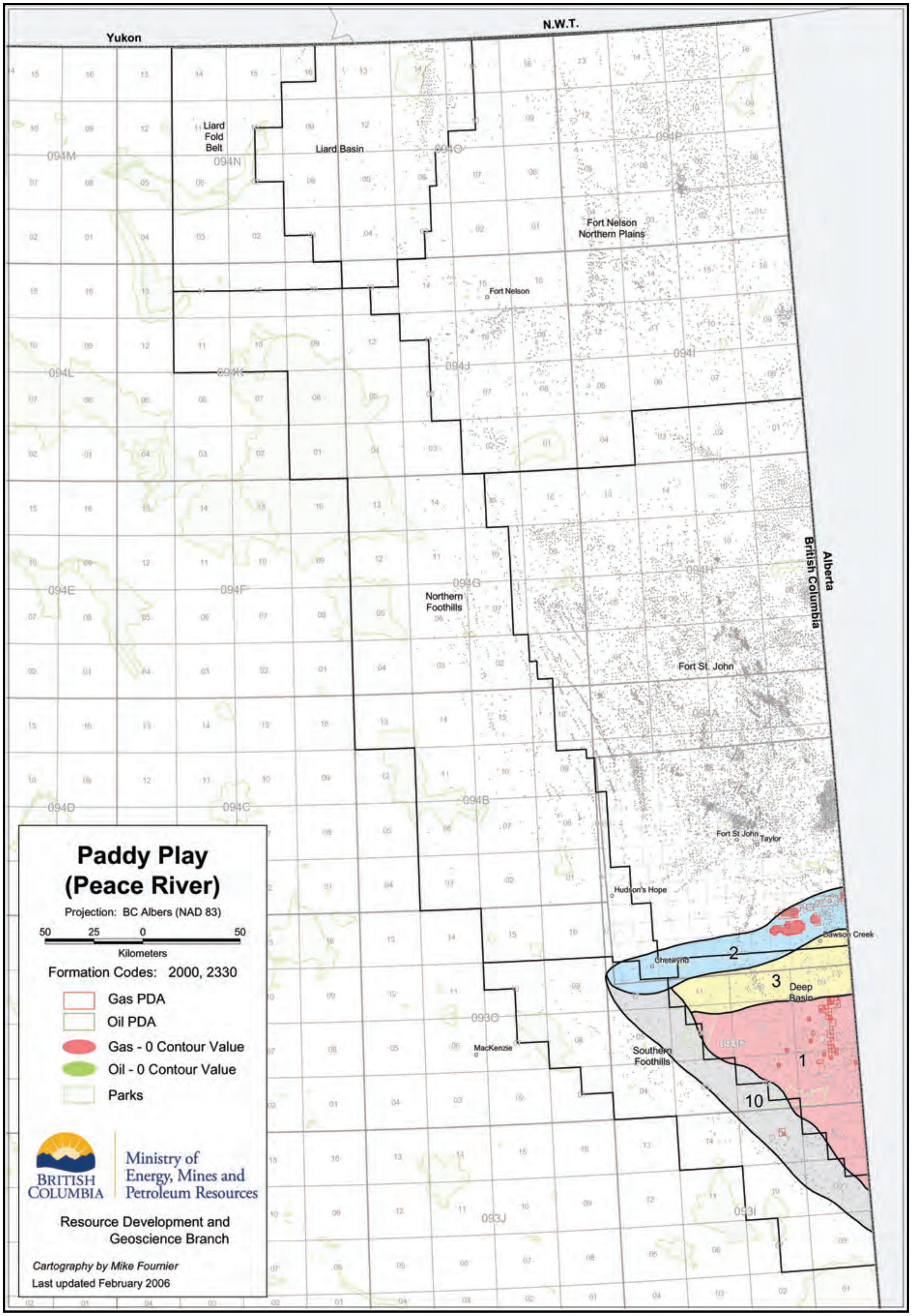
Paddy Play (Peace River) - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Cutbank	Paddy	H	567	491	447	20	17	16
Cutbank	Paddy	B	567	427	91	20	15	3
Tupper Creek	Paddy	A	381	324	83	13	11	3
Noel	Paddy	D	359	249	68	13	9	2
Other Areas	Paddy	A	359	304	232	13	11	8
Cutbank	Paddy	G	348	301	274	12	11	10
Tupper Creek	Paddy	G	277	235	187	10	8	7
Tupper Creek	Paddy	D	275	65	31	10	2	1
Tupper Creek	Paddy	I	263	224	139	9	8	5
Tupper Creek	Paddy	H	244	173	80	9	6	3
Other Pools			1,495	1,026	593	53	36	21
Totals			5,134	3,818	2,225	181	135	79



Paddy Play (Peace River)
Annual Gas Production
Cum. Gas = 75 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Paddy Play (Peace River)
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Yukon
N.W.T.
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Fort St John
Taylor
Hudson's Hope
Chetwynd
Dawson Creek
Deep Basin
Southern Foothills
MacKenzie
British Columbia
Alberta
1
2
3
10
Paddy Play (Peace River)
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2000, 2330
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
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Last updated February 2006

4.10 Cadotte Member

The Cadotte Member was deposited during northerly progradation of coarse clastic shorelines across the west-central portion of the Western Canada Sedimentary Basin. It comprises sandier- and coarsening-upward successions of sandstone and conglomerate, very similar to those of the Falher and Notikewin Members, although generally thicker and more completely developed (Smith et. al., 1984). An erosional edge marks the southern boundary around Township 60 in Alberta. The northern limit is defined by a northerly facies change to more distal fine-grained clastics, approximately coincident with the Paddy northern barrier edge.

Cadotte reservoirs consist of moderately- to well-sorted granule to small pebble conglomerates, deposited in upper shoreface to foreshore environments. Reservoir quality is best in well-sorted upper shoreface to foreshore conglomerates. An immense, almost untapped tight gas resource exists in moderate-porosity, low-permeability fine-grained middle shoreface sandstones.

Deep Basin Region

Play 1. Deep Basin Shoreface Play—East-west trending shoreface to foreshore sandstones and conglomerates host numerous Cadotte gas pools. A subnormally-pressured, gas-saturated Deep Basin regime characterizes this area, so conventional traps are not identified. The northern edge of the Deep Basin demarcates the northern boundary of the Play Area.

Cadotte gas pools are clustered along the northern margin of the Play Area, where reservoir quality is best developed. Optimal reservoir quality occurs in thick, well-sorted conglomerates forming stratigraphic "sweet spots". Increased burial compaction degrades reservoir quality downdip, while a regional valley complex has incised and reworked shoreface strata in the Noel area (Figure 6) (Hayes, 1988).

Cadotte Deep Basin pools occur at Hiding Creek, Jackpine, Kelly, Moose, and Noel.

Play 2. Regional Aquifer Play—Cadotte shoreline clastic reservoirs continue north of the Deep Basin edge, becoming generally thicker and exhibiting greater reservoir quality as far north as Brassey (E/93-P-10). Within the Regional Aquifer Play Area, however, the reservoirs are regionally wet, and gas pools occur in discrete east-west shoreline trends. Trapping appears to be stratigraphic, although specific controls on particular accumulations are poorly understood. Thus, the highly productive Sundown Cadotte 'A' pool was not successfully offset until 17 years after it was first put on production.

Regional Aquifer pools are found at Brassey, Cutbank, Sundown, and Tupper Creek. The northern reaches of the Regional Aquifer play lap into the southeastern corner of the Fort St. John Area.

Southern Foothills Region

Play 3. Foothills Play—Cadotte reservoir trends and quality become less predictable in the Foothills, reflecting proximity to sedimentary source areas and greater sediment accumulation in the foredeep. High-quality, well-sorted conglomerate reservoirs are thus relatively rare and laterally discontinuous. Fracturing associated with structural deformation may locally improve reservoir quality, although this has not been documented conclusively within the Cadotte. Gas-saturated Deep Basin conditions prevail in the eastern reaches of this play area, indicating the presence of a large tight gas resource.

Small Cadotte pools produce at Grizzly North and Ojay.

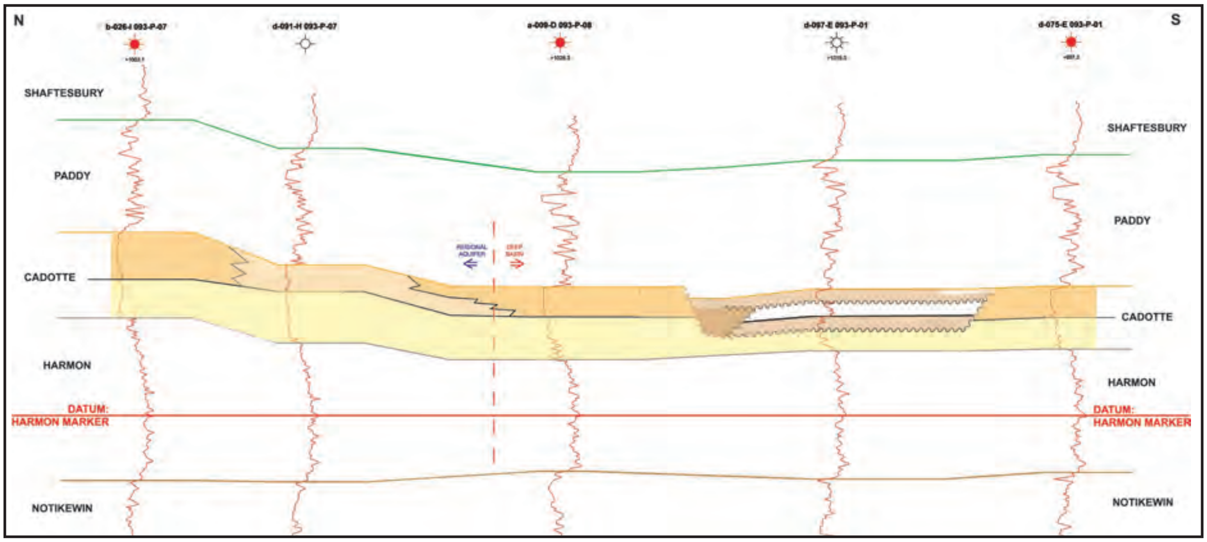
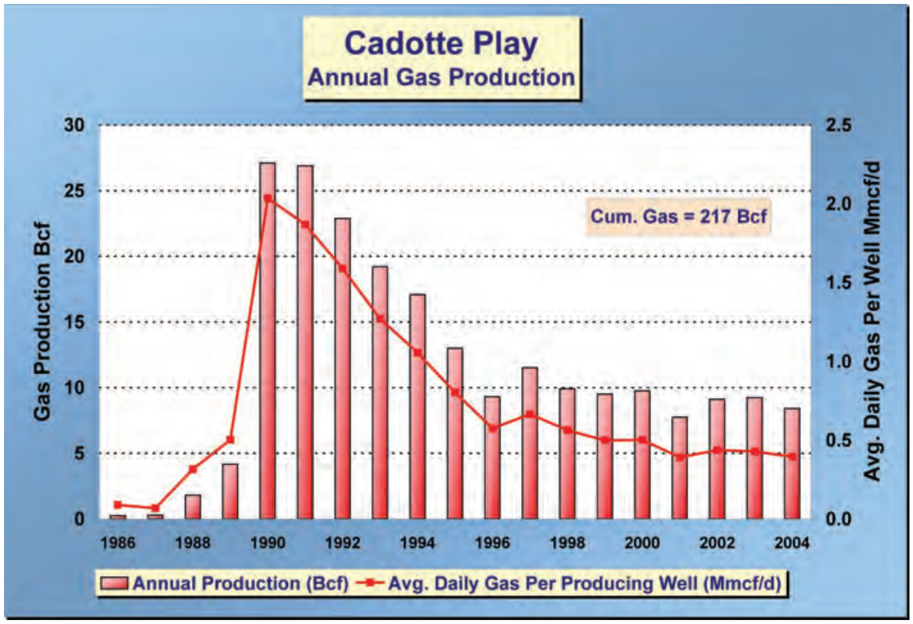
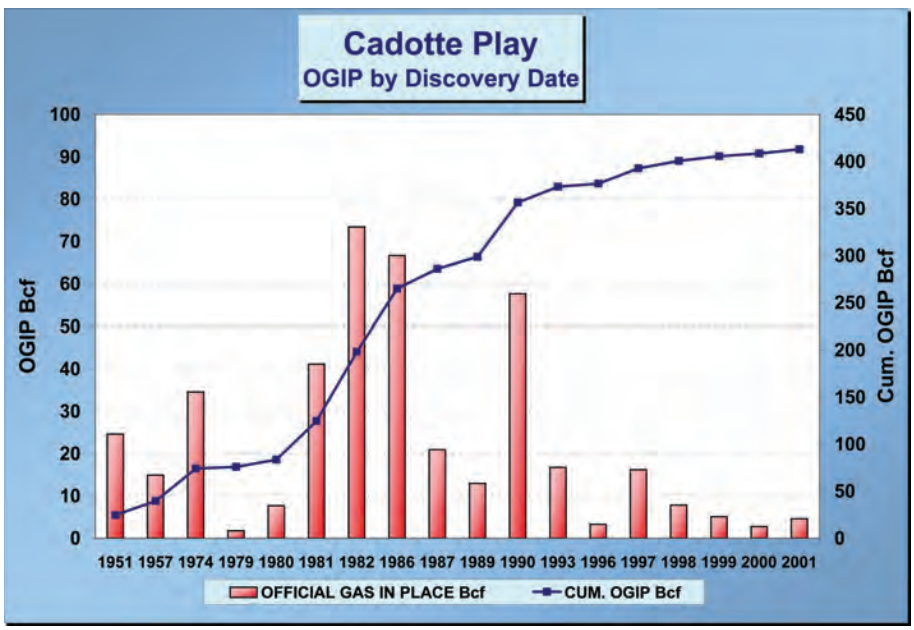
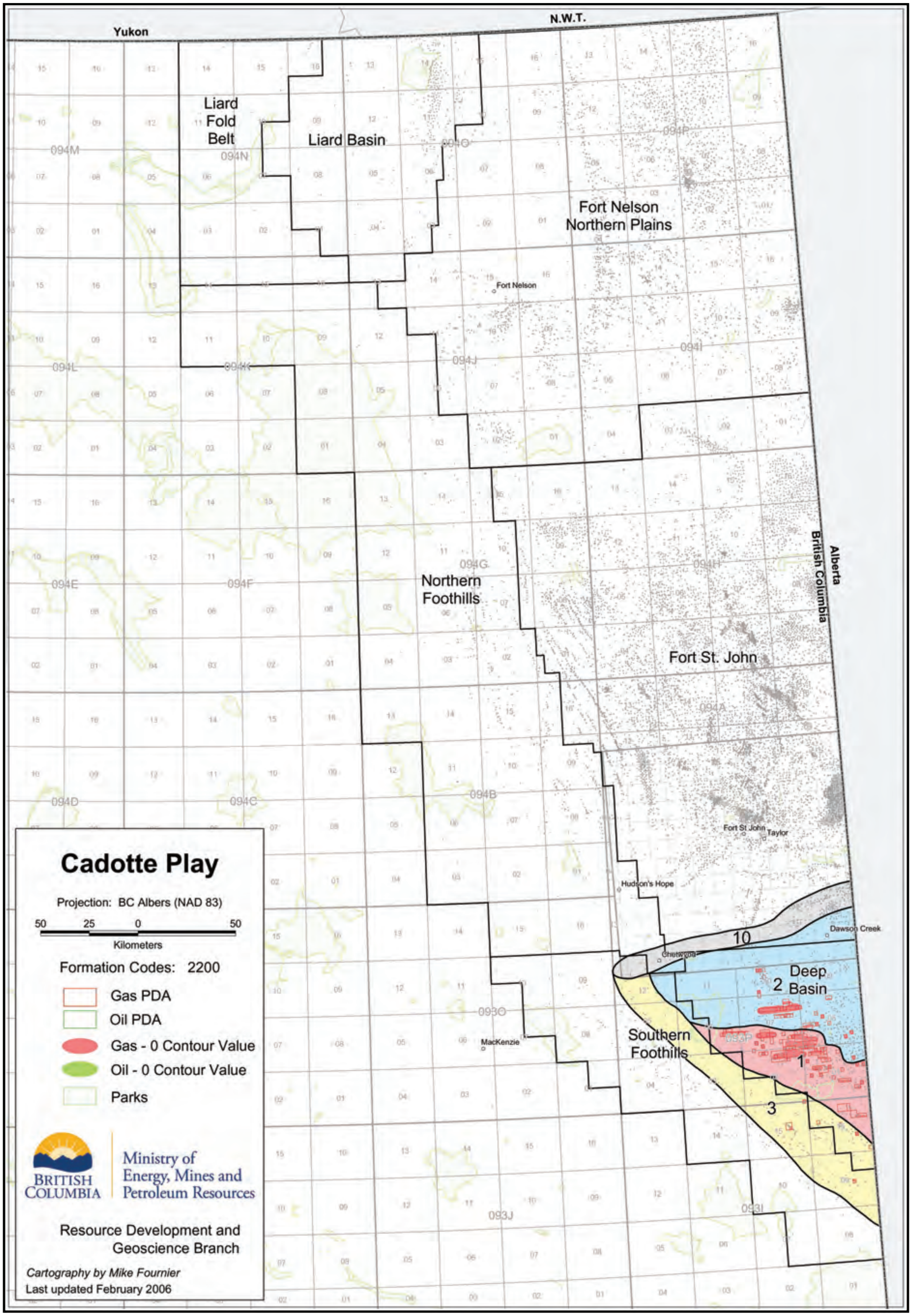


Figure 6. Regional cross-section, Sundown-Noel area. Well b-26-I has produced >23 BCF from a discrete, narrow trend of high-quality shoreface/foreshore conglomerates and sandstones in the Regional Aquifer play area. Well d-91-H penetrates a sand-dominated upper shoreface section with subeconomic permeabilities. Wells a-9-D and d-75-E produce gas from more widely-distributed conglomeratic reservoirs in the Deep Basin play area. Well d-97-E penetrates a regional valley trend incising Cadotte shoreface strata.

Cadotte Play - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Sundown	Cadotte	A	2,080	1,764	87	73	62	3
Noel	Cadotte	A	1,417	1,198	205	50	42	7
Noel	Cadotte	M	1,140	852	212	40	30	7
Doe	Cadotte	A	979	627	627	35	22	22
Moose	Cadotte	A	788	664	182	28	23	6
Sunrise	Cadotte	A	698	137	63	25	5	2
Noel	Cadotte	L	529	398	20	19	14	1
Dawson Creek	Cadotte	A	423	332	128	15	12	5
Jackpine	Cadotte	A	348	261	91	12	9	3
Noel	Cadotte	D	327	242	88	12	9	3
Other Pools			2,971	2,079	1,035	105	73	37
Totals			11,701	8,553	2,739	413	302	97


Cadotte Play
Annual Gas Production
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
Cum. Gas = 217 Bcf
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
2.0
2.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Cadotte Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150
200
250
300
350
400
450
1951 1957 1974 1979 1980 1981 1982 1986 1987 1989 1990 1993 1996 1997 1998 1999 2000 2001
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Yukon
N.W.T.
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Alberta
British Columbia
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
10
Deep Basin
2
Southern Foothills
1
3
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094A
094D
094C
094B
093O
093P
093J
093I
Cadotte Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2200
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
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Last updated February 2006

4.11 Spirit River Formation

The Spirit River Formation is the product of a basinwide progradational episode during mid-Albian time. In the B.C. Deep Basin, it comprises six major stacked shoreface successions, termed (from the top down) Notikewin, Falher A, B, C, D, and F (Figure 7) (Smith et. al., 1984). An individual cycle typically consists of a coarsening-upward succession, passing from very fine-grained sandstones to coarse sandstone or conglomerate, capped by continental mudstones and coals. Recent work has illustrated more complex internal stratigraphic relationships, which can be important at field development scale (e.g., Casas and Walker, 1997).

To the north, Spirit River shorefaces grade to finer-grained, more distal facies. Individual Notikewin and Falher submembers lose their identity, as capping conglomerates and coals pinch out seaward. North of about Township 87, only the uppermost sandstone remains, overlying a succession of shelfal siltstones and shales. This unit has been recognized as an important gas reservoir only since the late 1990's.

Spirit River sandstones grade up from underlying Wilrich Member marine shales, and are capped by transgressive marine shales of the Harmon Member in the south and Buckinghorse Formation in the north.

Deep Basin Region

Play 1. Deep Basin Falher / Notikewin Play—Falher and Notikewin cycles typically coarsen upward from very fine- to fine-grained, swaley cross-stratified middle shoreface sandstones, to cross-bedded conglomeratic sandstones and sandy conglomerates of the upper shoreface (Figure 8). In map view, each is characterized by a southerly transgressive limit, north of which conglomeratic sweet spot reservoirs are optimally developed along trends up to tens of kilometres long. Sweet spots occupy only a small proportion of the overall reservoir volume; low-permeability sandstones are volumetrically very dominant.

Falher and Notikewin pools lie within the subnormally-pressured, gas-saturated Deep Basin regime. The northerly limit of the Deep Basin varies for each submember, but none are well defined, as each

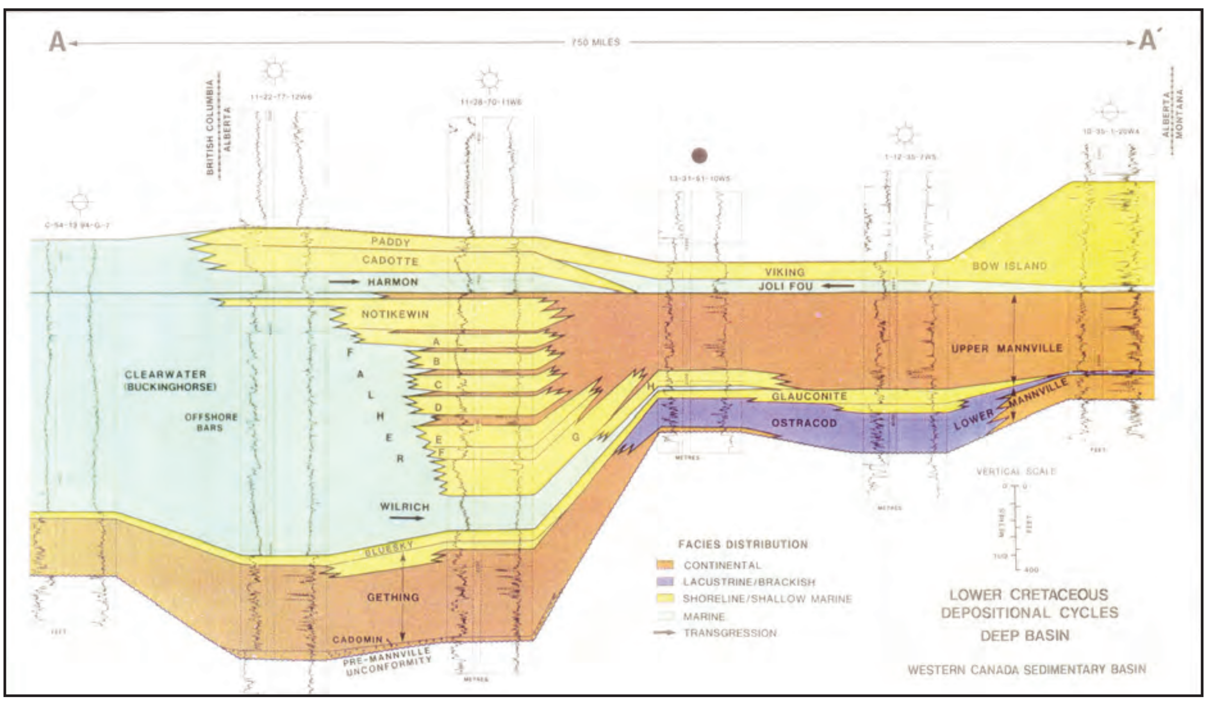


Figure 7. Regional stratigraphic framework, Spirit River Formation. Falher and Notikewin shoreline/shallow marine reservoir sandstones and conglomerates prograde across the west-central Alberta and British Columbia Deep Basin area (from Jackson, 1984).

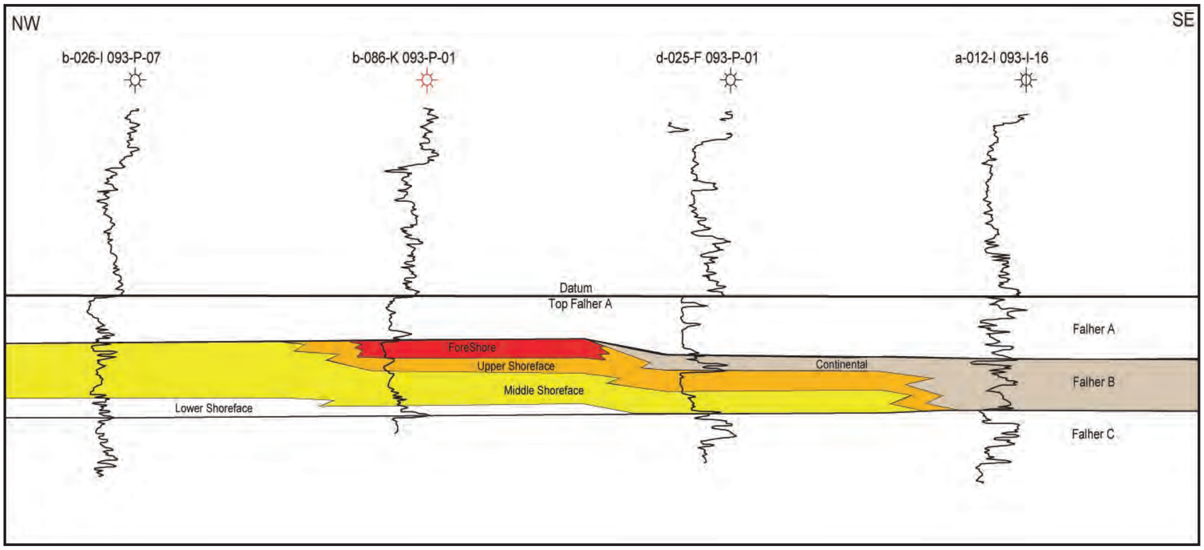


Figure 8. Cross-section illustrating progradation of the Falher B submember across the B.C. Deep Basin. Continental facies in the south pass northward to shoreface sandstones and conglomerates, which in turn grade to distal shoreface and offshore fine-grained clastics. Well b-86-K has produced >7 BCF from well-sorted foreshore and upper shoreface strata.

lies within poorer-quality, more distal sandstone facies north of the conglomerate reservoir trends. A generalized northerly limit demarcates the play area.

Pools in the Deep Basin Falher / Notikewin Play occur at Hiding Creek, Jackpine, Kelly, and Noel.

Fort St. John Region

Play 2. Northern Shoreface Play—North of the Deep Basin, the Spirit River comprises sandier- and coarsening-upward successions deposited in shoreface to deltaic settings. Feldspathic litharenites are the dominant rock type; they range from lower fine- to upper medium-grained, are poorly- to moderately-sorted, and comprise angular to subrounded grains. Kaolinite, chlorite, and carbonate minerals are the primary cements. Conventional log analysis does not adequately evaluate these reservoirs, as feldspars, clays, and partially dissolved grains elevate gamma log readings, and produce wide density-neutron separation and low resistivity readings in reservoir-quality sandstones.

Spirit River northern shoreface reservoirs produce gas with relatively little water. There are very few tests outside of the main producing pools, and most of these have recovered mud or flowed low-rate gas. No regional aquifer has been documented, and a regional gas-saturated (Deep Basin) regime may exist.

The first major discovery in the northern shoreface play was made in 1997 at Pickell, through evaluation of the uphole section in a well targeted for deeper Cretaceous targets. Similarly, the Ladyfern and Drake pools were discovered during development of the Ladyfern Slave Point play in 2001/2002. Both areas are now under active development.

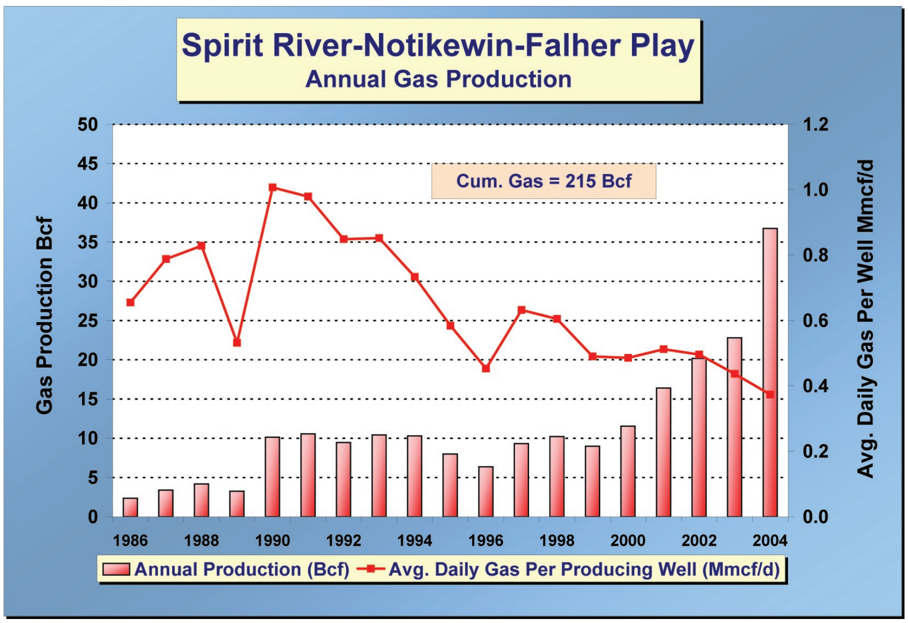
Spirit River Northern Shoreface pools occur at Buick Creek, Buick Creek North, Drake, Milligan Creek West, Pickell, and Velma.

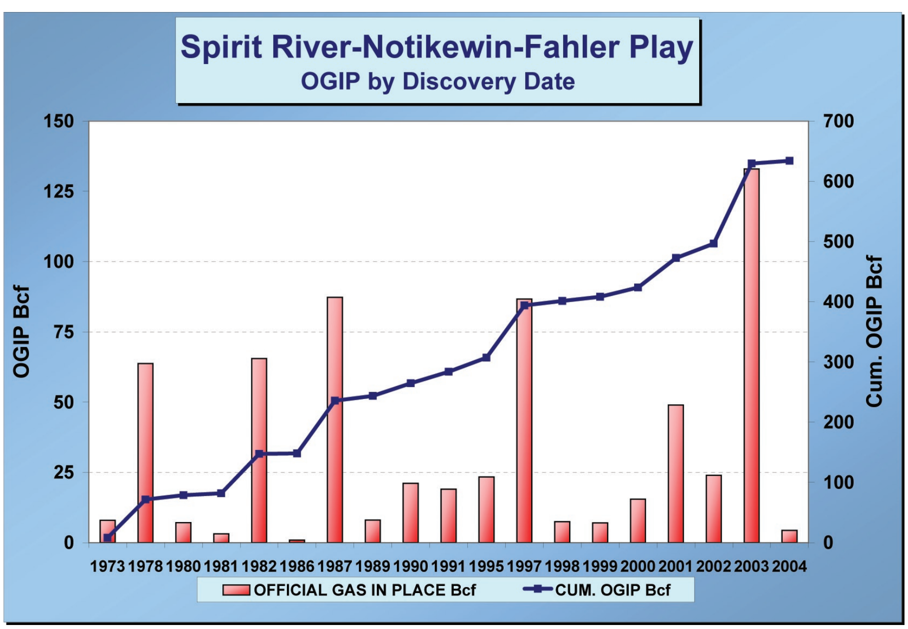
Southern Foothills Region

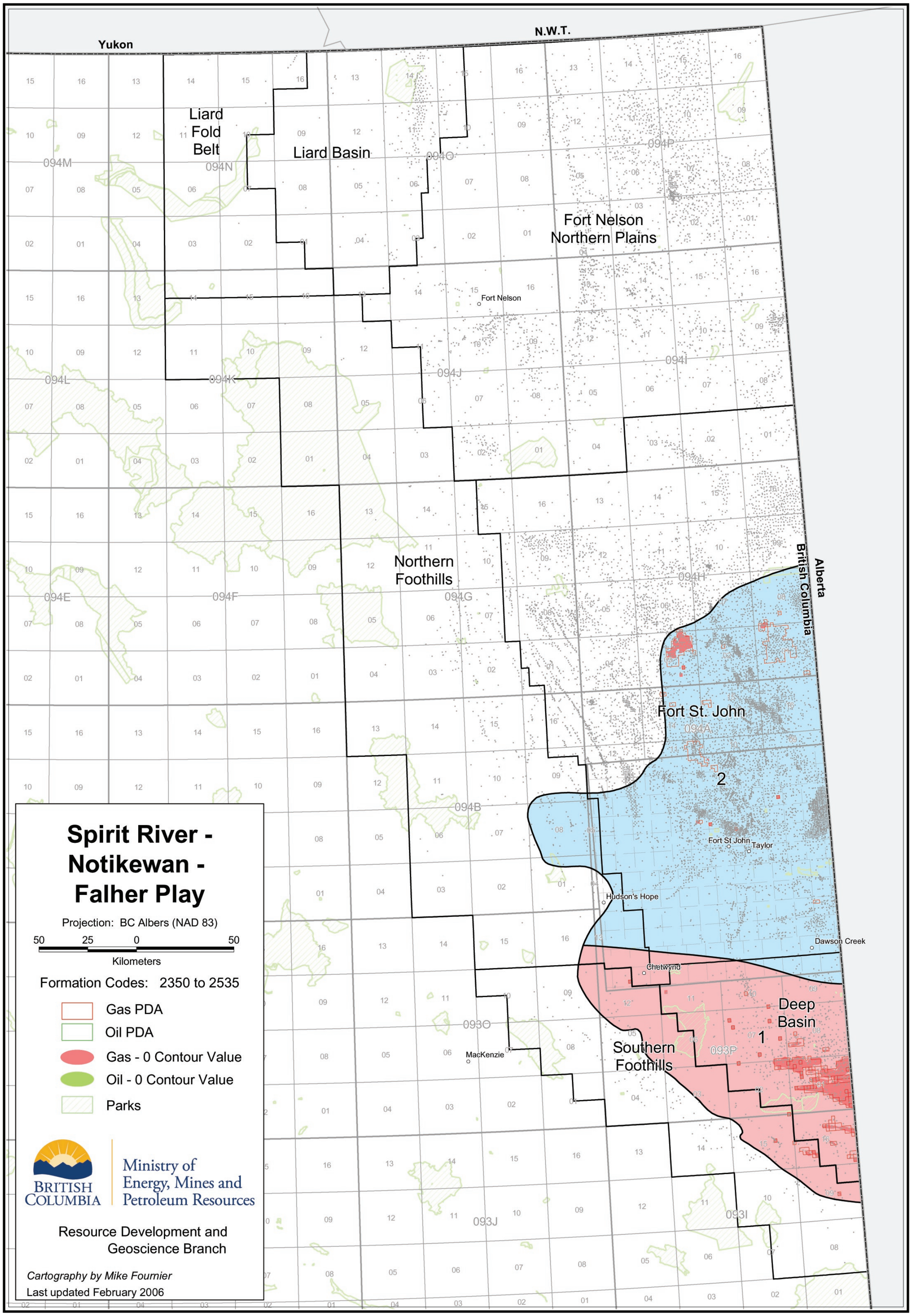
Play 1. Foothills Falher / Notikewin Play—This play represents the westerly continuation of the Deep Basin Falher / Notikewin Play into the Southern Foothills Area. Isolated production appears to be governed by the same stratigraphic controls as in the Deep Basin, but reservoir quality and continuity is generally poorer. Structural overprint is apparently minor, although fracture enhancement of stacked sandstone / conglomerate reservoirs may occur.

Foothills Falher / Notikewin pools occur at Ojay, Grizzly North, and Redwillow River.

Spirit River-Notikewin-Fahler Play - Top 10 Pools by OGIP								
AREA	FORMATION	POOL SEQ	OFFICIAL GAS IN PLACE (MM3)	INIT EST GAS MKT (MM3)	REM GAS MKT (MM3)	OFFICIAL GAS IN PLACE BCF	INIT EST GAS MKT BCF	REM GAS MKT BCF
Drake	Notikewin	A	2,914	2,244	2,193	103	79	77
Noel	Fahler B	C	2,473	1,867	656	87	66	23
Pickell	Notikewin	A	2,256	1,642	1,236	80	58	44
Kelly	Falher B	A	1,186	859	444	42	30	16
Kelly	Falher A	B	1,143	869	336	40	31	12
Buick Creek North	Notikewin	A	852	357	354	30	13	12
Hiding Creek	Notikewin	B	818	666	568	29	24	20
Kelly	Falher A	A	662	484	91	23	17	3
Hiding Creek	Falher C	B	662	544	263	23	19	9
Hiding Creek	Falher D	A	598	447	324	21	16	11
Other Pools			4,395	2,947	1,923	155	104	68
Totals			17,960	12,926	8,388	634	456	296






Spirit River - Notikewan - Falher Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2350 to 2535
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Deep Basin
Southern Foothills
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094A
094B
093O
093P
093J
093I
1
2

4.12 Bluesky Formation

The Bluesky encompasses a wide variety of reservoir sandstone bodies associated with mid-Albian transgression and subsequent regression of the Boreal Sea across the Western Canada Sedimentary Basin (Jackson, 1984). Deposition occurred primarily adjacent to southwesterly source areas, and on the southerly flank of the Keg River Highlands in the north.

Marine shoreface, deltaic, and estuarine reservoirs occur in discrete areas across northeastern British Columbia. Excellent reservoir quality occurs in thin, well-sorted, coarse-grained, areally-limited shoreface sandstones and conglomerates, while widespread deltaic and finer-grained shoreface sandstones generally exhibit poorer reservoir quality.

Although the Bluesky hosts gas in most areas, light oil is produced from several pools in the Fort St. John Area, and at Hay River in 94-I-9. In many of these cases, oil has migrated from underlying Triassic or Mississippian reservoirs subcropping beneath the pre-Cretaceous unconformity.

Deep Basin Region

Play 1. Deep Basin Play—A broad, coarsening- and sandier-upward deltaic wedge of argillaceous sandstones is assigned to the Bluesky in the Deep Basin subsurface, but has been mapped in outcrop as the Chamberlain Member of the Gething Formation (Figure 9). To the south and west, the deltaic complex merges with the Gething Formation, while to the north, it shales out seaward. Isolated low-rate gas shows have been noted, but there is no production.

Underlying the deltaic wedge, relatively narrow north-south trending estuarine valleys are incised into upper Gething alluvial plain facies. Good reservoir quality is found locally in coarse-grained estuarine channel to marginal marine facies, which are known informally as the basal Bluesky (Figure 9). Gas-saturated Deep Basin conditions occur throughout the play area, although the northern margin is poorly defined.

Basal Bluesky production occurs at Brassey, Cutbank, Kelly, and Noel.

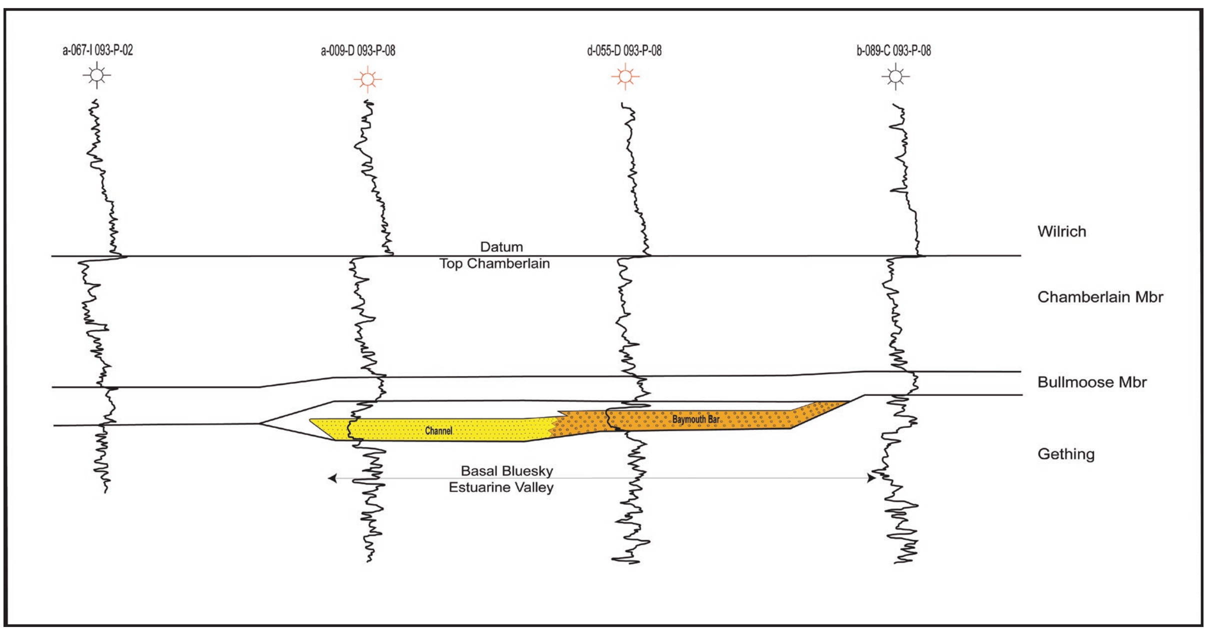


Figure 9. Bluesky Formation reservoirs, Deep Basin area. Estuarine valley-fill sandstones and conglomerates are productive in narrow, sharply-defined trends. Chamberlain Member sandstones are widespread, but exhibit poor to marginal permeability.

Fort St. John Region

Play 2. Peace River Shoreface Play—Over much of the Fort St. John area, Bluesky strata consist of thin shoreface sandstones and conglomerates. Deposition occurred primarily along east-west shoreline trends, although more widespread accumulations (e.g., Velma / Dahl) appear to be influenced by topography on the underlying pre-Cretaceous unconformity (Hayes, 2005). Sediment was supplied by reworking of older Bluesky valley-fill deposits, and locally (e.g., Wargen, Buick Creek), north-south trends reflect orientations of the older valleys.

South of the Peace River, coarse sediment supply and hence reservoir quality are much reduced, although fine-grained shoreface successions locally reach 20 metres or more thick. Near the northern boundary of the Fort St. John Area, the Bluesky shales out basinward.

Gas (and limited oil) occurs in conventional stratigraphic traps, although more regionally pervasive gas dominates in the west.

Bluesky gas pools range from one-well producers to 100+ BCF accumulations, while scattered oil pools occur in the central to northern parts of the Region. Producing pools include Airport, Beatton River, Beatton River West, Beavertail, Bernadet, Birch, Birley, Blueberry, Boundary Lake, Bubbles, Bubbles North, Buick Creek, Buick Creek North and West, Cache Creek, Conroy Creek, Currant, Dahl, Doe, Doig Rapids, Elm, Firebird, Fireweed, Fort St. John, Goose, Hunter, Ladyfern, Lapp, Laprise Creek, Martin, Mercury, Mike, Milligan Creek, Milligan Creek West, Montney, Nig Creek, Nig Creek North, Osborn, Osprey, Owl, Peejay, Pickell, Rigel, Silver, Siphon East, Tommy Lakes, Two Rivers, Umbach, Velma, Wargen, Weasel, Weasel West, Wildmint, Willow, and Zaremba.

Play 3. Altares – Aitken Valley Play—The Altares - Aitken Bluesky valley ranges up to 50 metres thick, and can be traced for up to 90 kilometres in the subsurface along the margin of the foredeep, where greater subsidence has allowed continuous preservation. Blocky cross-bedded sandstones and conglomerates indicate primarily fluvial fill, although muddy facies and limited ichnofauna at Aitken Creek demonstrate estuarine conditions locally (Figure 10) (Alway and Moslow, 1997). Reservoir quality is low-grade conventional to tight throughout most of the play trend, as sandy facies are diagenetically degraded, but high-quality conglomeratic sweet spots occur locally.

At the updip edge of the play trend, high-quality conglomeratic outliers produce oil at Aitken Creek and gas at Aitken Creek North. Further west, lower-grade reservoirs produce gas on outer Foothills structural trends, as at Beg. Very few wells have been drilled between structures, however, and it is unclear whether more regional productive potential might exist.

Northern Foothills Region

Both the Peace River Shoreface and Altares – Aitken Play trends straddle the Fort St. John / Northern Foothills area boundary. Foothills fold/fault structures and associated reservoir fracturing may play a greater role in Northern Foothills, but this has not been demonstrated conclusively. The Altares – Aitken Play produces gas at Altares and Daiber.

Fort Nelson Northern Plains Region

Play 4. Keg River Shoreface Play—Near the northern limit of the basin, Bluesky shoreface sandstones were deposited off the southwestern flank of the Keg River Highlands. Proximal facies, consisting of 10 to 15 metres of well-sorted very fine- to fine-grained sands are excellent reservoirs, producing medium-grade oil at Hay. Westward and southwestward, more distal sands exhibit poorer reservoir quality at deeper burial depths, and are potential tight gas reservoirs over large areas with few tests.

Northward, Bluesky Keg River Shoreface sandstones lap onto the Keg River Highlands, while southward (seaward), they pass laterally into the Buckinghorse Shale.

The Keg River Shoreface Play includes Bluesky pools at Gunnell Creek, Hay River, Helmet, Kotcho Lake East, Thetlaandoa, and Yoyo.

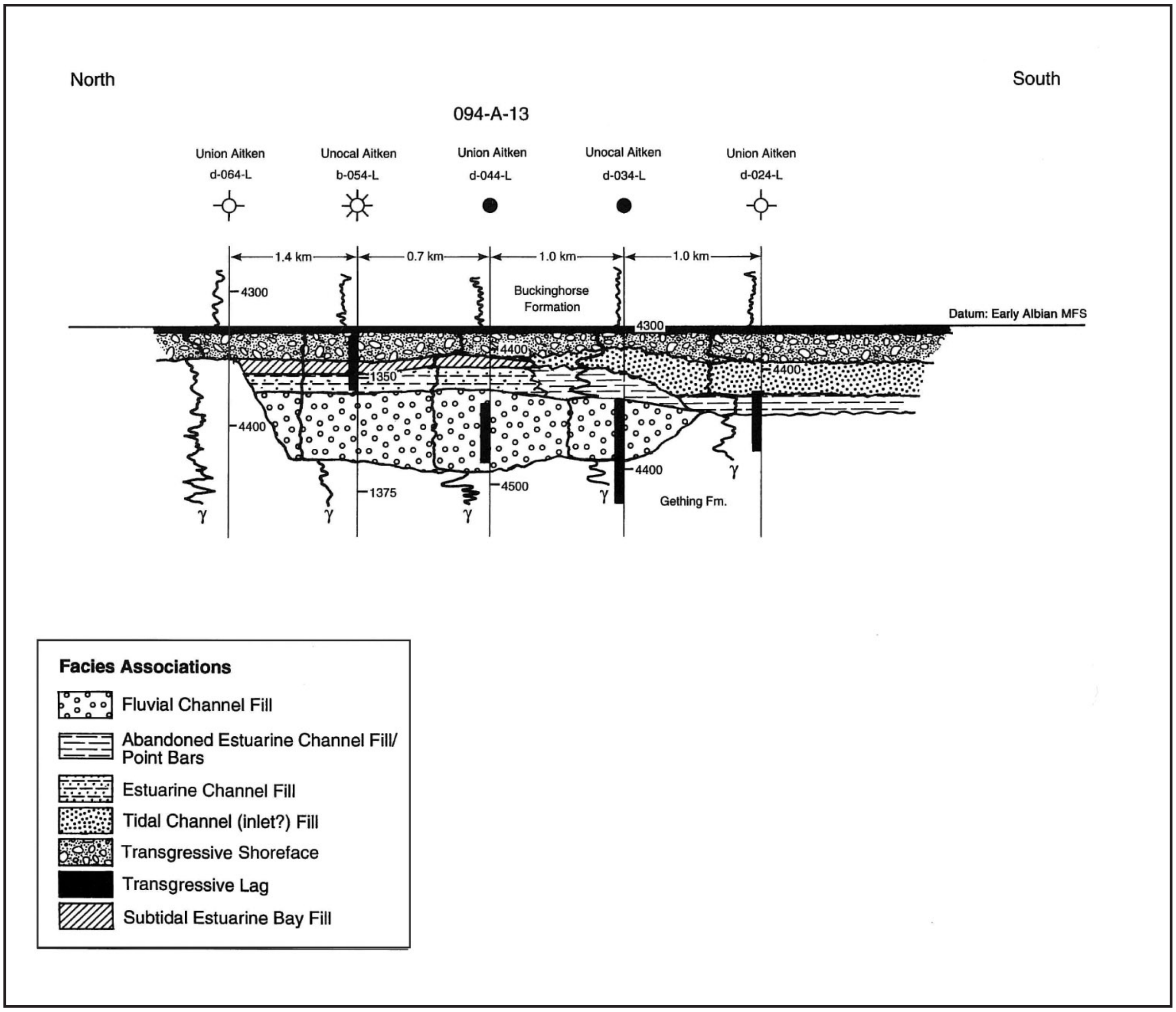
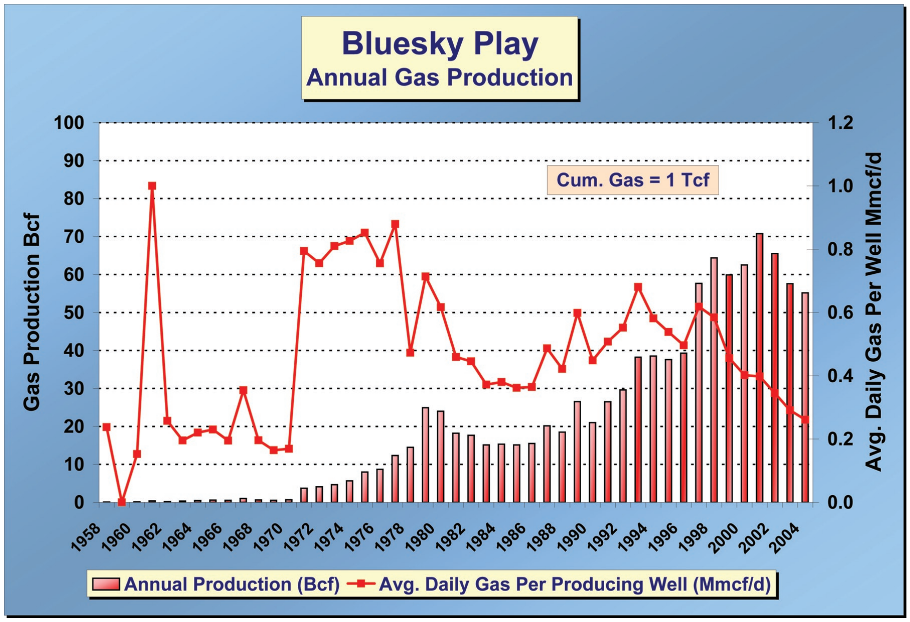


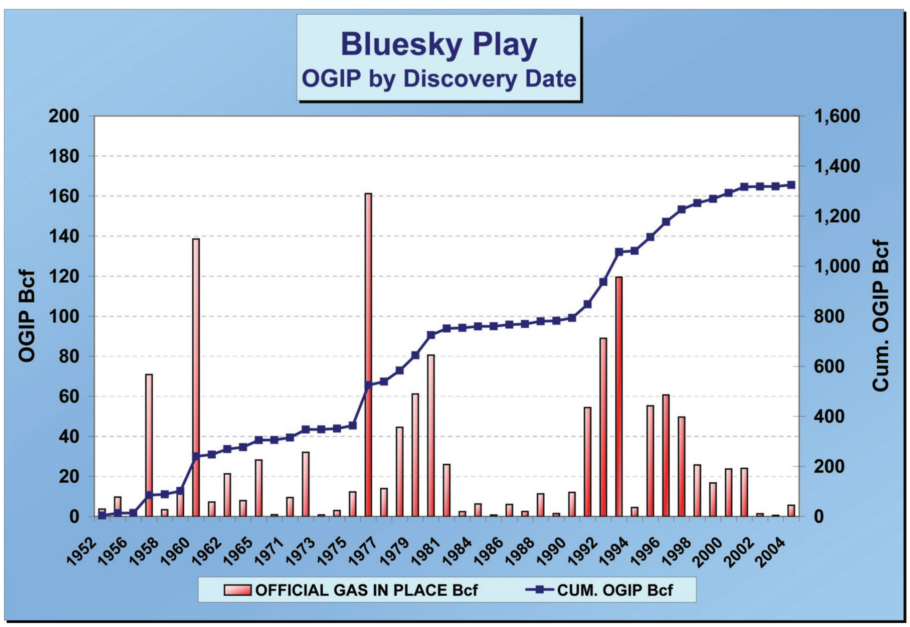
Figure 10. Cross-section across Bluesky estuarine valley fill at Aitken Creek. Fluvial channel conglomerates exhibit optimal reservoir quality; finer-grained estuarine to fluvial clastics are locally productive as well (from Alway and Moslow, 1997).

Bluesky Play - Top 10 Pools by OGIP

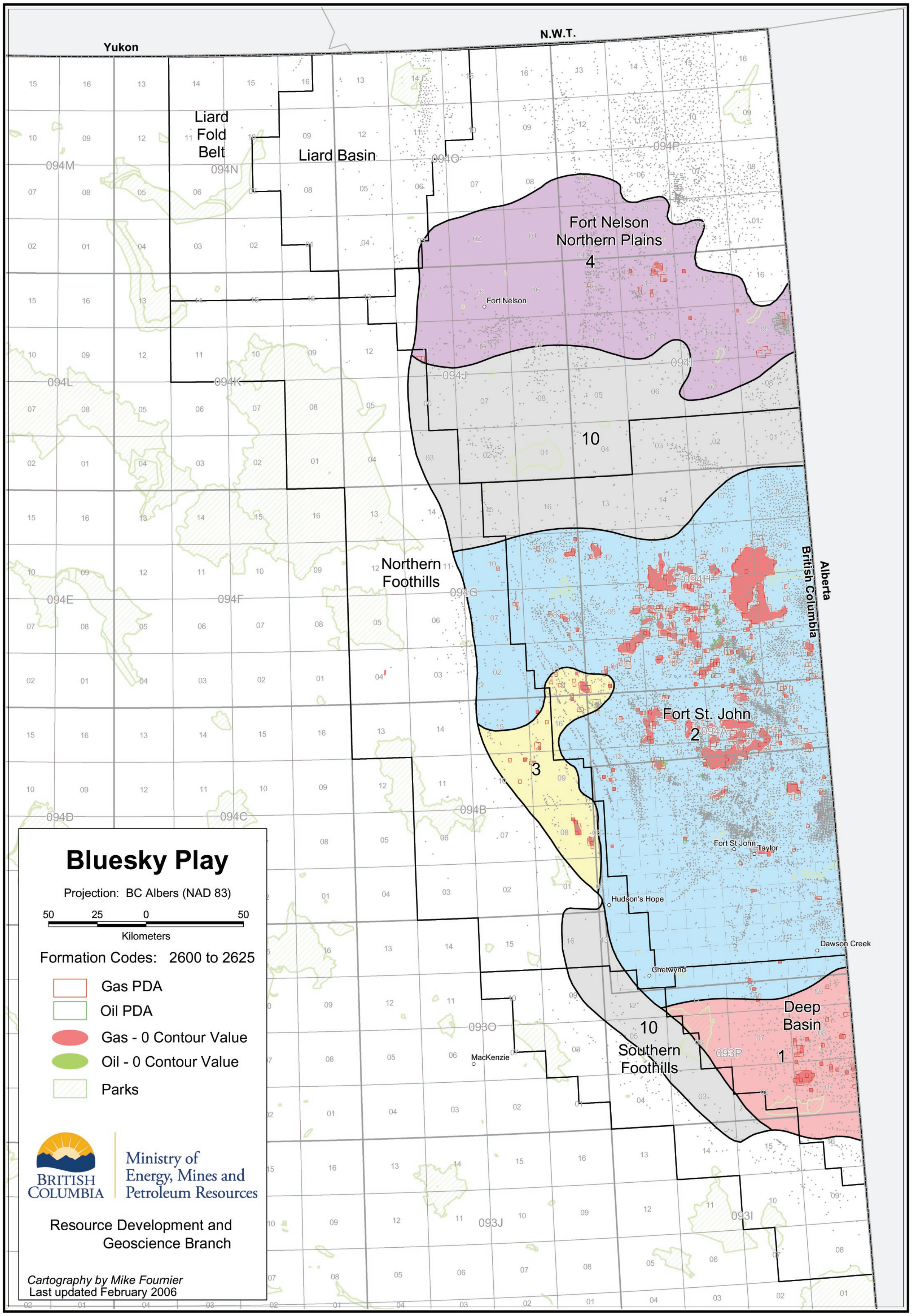
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Buick Creek	Bluesky	C	5042	3659	1163	178	129	41
Silver	Bluesky	A	3924	2817	573	139	99	20
Nig Creek North	Bluesky	A	3208	2049	341	113	72	12
Beavertail	Bluesky	A	1922	1454	32	68	51	1
Aitken Creek North	Bluesky	A	1411	1166	354	50	41	12
Siphon East	Bluesky	A	907	639	50	32	23	2
Buick Creek West	Bluesky	A	901	640	76	32	23	3
Buick Creek North	Bluesky	A	776	519	47	27	18	2
Noel	Basal Bluesky	A	714	231	95	25	8	3
Birley Creek	Bluesky-Gething	A	615	462	386	22	16	14
Other Pools			18,092	11,562	6,243	639	408	220
Totals			37,512	25,197	9,361	1,324	889	330



Bluesky Play
Annual Gas Production
Cum. Gas = 1 Tcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
100
90
80
70
60
50
40
30
20
10
0
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1958 1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Bluesky Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
200
180
160
140
120
100
80
60
40
20
0
1,600
1,400
1,200
1,000
800
600
400
200
0
1952 1956 1958 1960 1962 1965 1971 1973 1975 1977 1979 1981 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Bluesky Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2600 to 2625
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
4
Fort Nelson
10
Northern Foothills
Fort St. John
2
3
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
1
10
Southern Foothills
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.13 Gething Formation

Gething deposition took place in response to eustatically-rising sea level and strong sediment supply from the westerly Columbian Orogen. In the south, fine-grained clastics and coal were deposited in alluvial plain and coal-swamp settings, cut locally by fine- to medium-grained fluvial channel sandstones. To the north, the lower Gething comprises sandy fluvial facies deposited in well-defined valleys, while the upper Gething includes deltaic to alluvial plain facies laid down over broader areas. Gething deposition was terminated with the first major Cretaceous transgression of the Boreal (northerly) sea (Stott, 1975).

Deep Basin Region

Play 1. Fluvial / Alluvial Plain Play—Fine-grained clastics dominate the Gething section in the Deep Basin Region. Reservoir sandstones are fine- to medium-grained litharenites, occurring as channelized bodies up to 10-15 metres thick (Smith et. al., 1984). Typically only the basal few metres attain conventional reservoir quality, as the sediments become finer-grained and muddier upward. Channel sandstones have very limited areal extent, as there has been little success in correlating them from well to well. As well, reservoir performance indicates limited reservoir volumes – most Gething producers have cumulative production volumes of less than 20 e^6m^3, even though some have been on production for more than ten years.

Gething channel sandstones are generally tested where logged, but have been put on production in relatively few wells. Productive trends related to deposition, diagenesis or structure are not evident. Lack of formation water on tests supports the existence of a Gething Deep Basin throughout the area.

The Fluvial / Alluvial Plain Play can be traced continuously into the Southern Foothills Region.

Gething pools produce gas at Brassey, Kelly Lake and Noel in the Deep Basin Region.

Fort St. John Region

Play 1. Fluvial / Alluvial Plain Play—Deep Basin Gething strata grade continuously northward to the Fort St. John Region, where the basin-scale Spirit River and Edmonton Valley systems cut northwesterly across the middle of the Region, producing dramatic relief on the pre-Gething unconformity surface (Hayes, 2005) (Figure 11). Stacked fluvial sandstones, assigned to the lower Gething, fill the deepest parts of the valleys. Reservoir quality is fair to locally good, and gas and oil occur locally in stratigraphic traps, although limited testing suggests potential for a Deep Basin regime to the west.

Overlying upper Gething strata accumulated in more widespread alluvial plain to deltaic settings, less constrained by pre-Gething unconformity relief. Fluvial and distributary channel sandstone reservoirs can be mapped over small areas, hosting gas and oil pools up to a few sections in size. Reservoir quality degrades markedly westward, as these sandstones are generally finer-grained and more argillaceous.

The Fluvial / Alluvial Plain Play can be traced continuously westward into the Northern Foothills Region, where it produces at Graham. In the Fort St. John Region, it produces gas at: Beatton River West, Beavertail, Birley Creek, Boundary Lake, Boundary Lake North, Cecil Lake, Currant, Currant West, Doe, Doig Rapids, Drake, Eagle, Elm, Firebird, Flatrock, Flatrock West, Inga, Jedney, Laprise Creek, Martin, Milligan Creek West, Muskrat, Nig Creek, Oak, Osborn, Osprey, Parkland, Peejay, Peejay West, Pickell, Prespatou, Rigel, Siphon, Siphon East, Stoddart West, Tommy Lakes, Umbach, Wargen, Weasel, Wildmint, and Zaremba.

Fort Nelson Northern Plains Region

Play 2. Northern Isolated Valley Fills (Conceptual)—North of 94H, Gething strata thin and lap out onto the Keg River Highland. Relatively thin fluvial to estuarine / marginal marine strata are preserved in low-relief valleys. Sediment was derived locally from erosion of Triassic and Mississippian strata, and thus is relatively fine-grained and poor-quality. Stratigraphic and structural traps may exist, but subcropping Mississippian aquifers will limit trap size in some areas.

Several tests have recovered water, but there is no gas production.

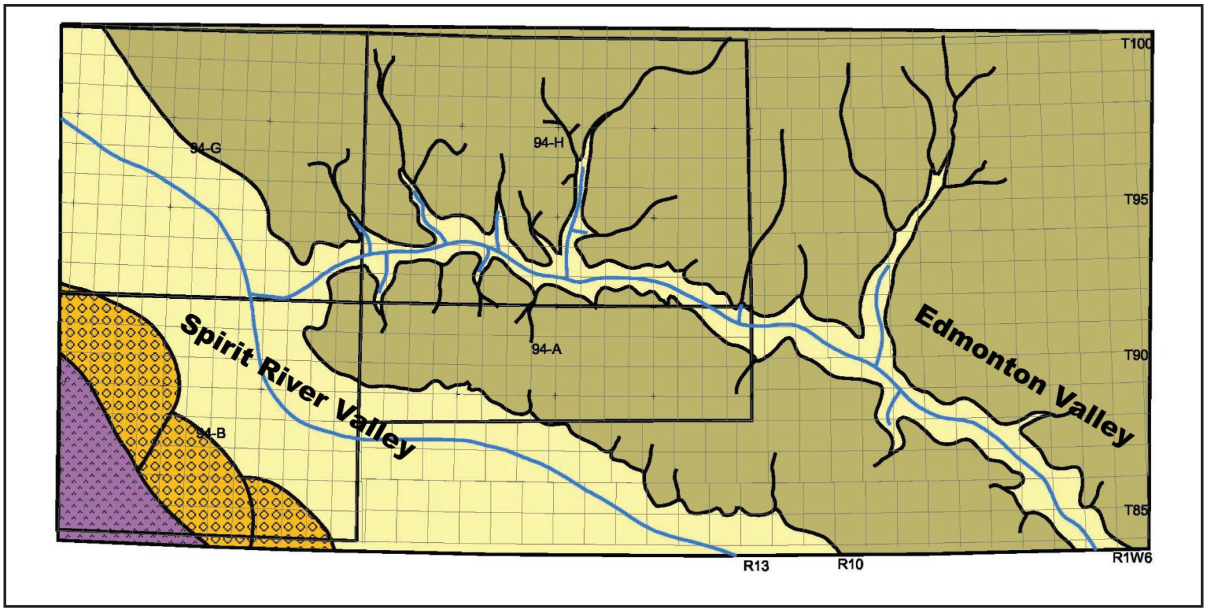
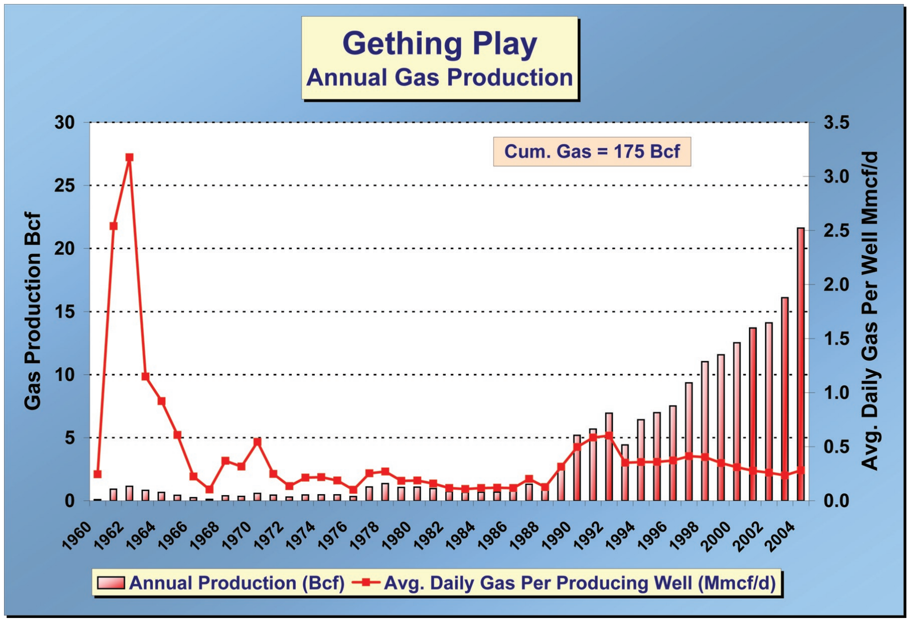
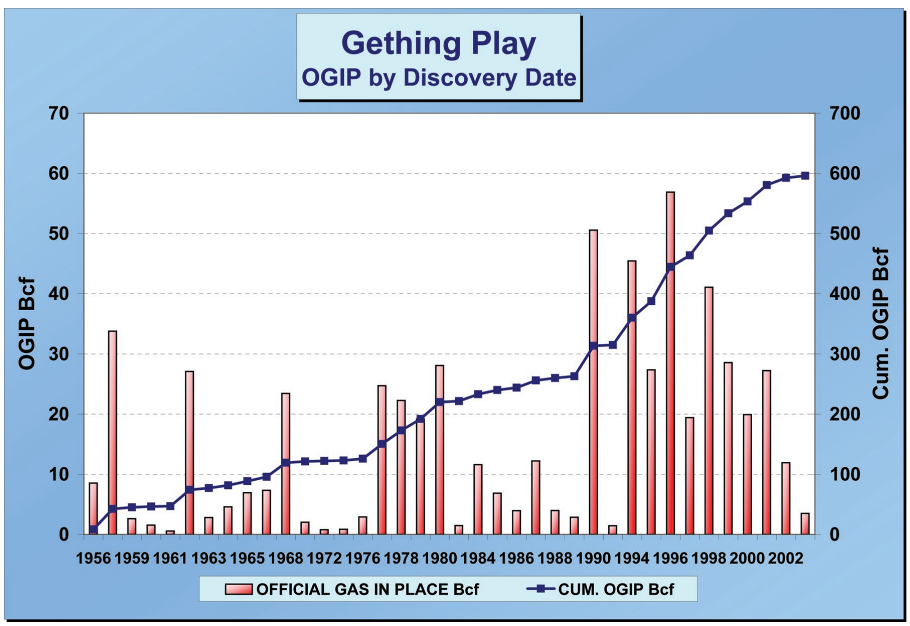


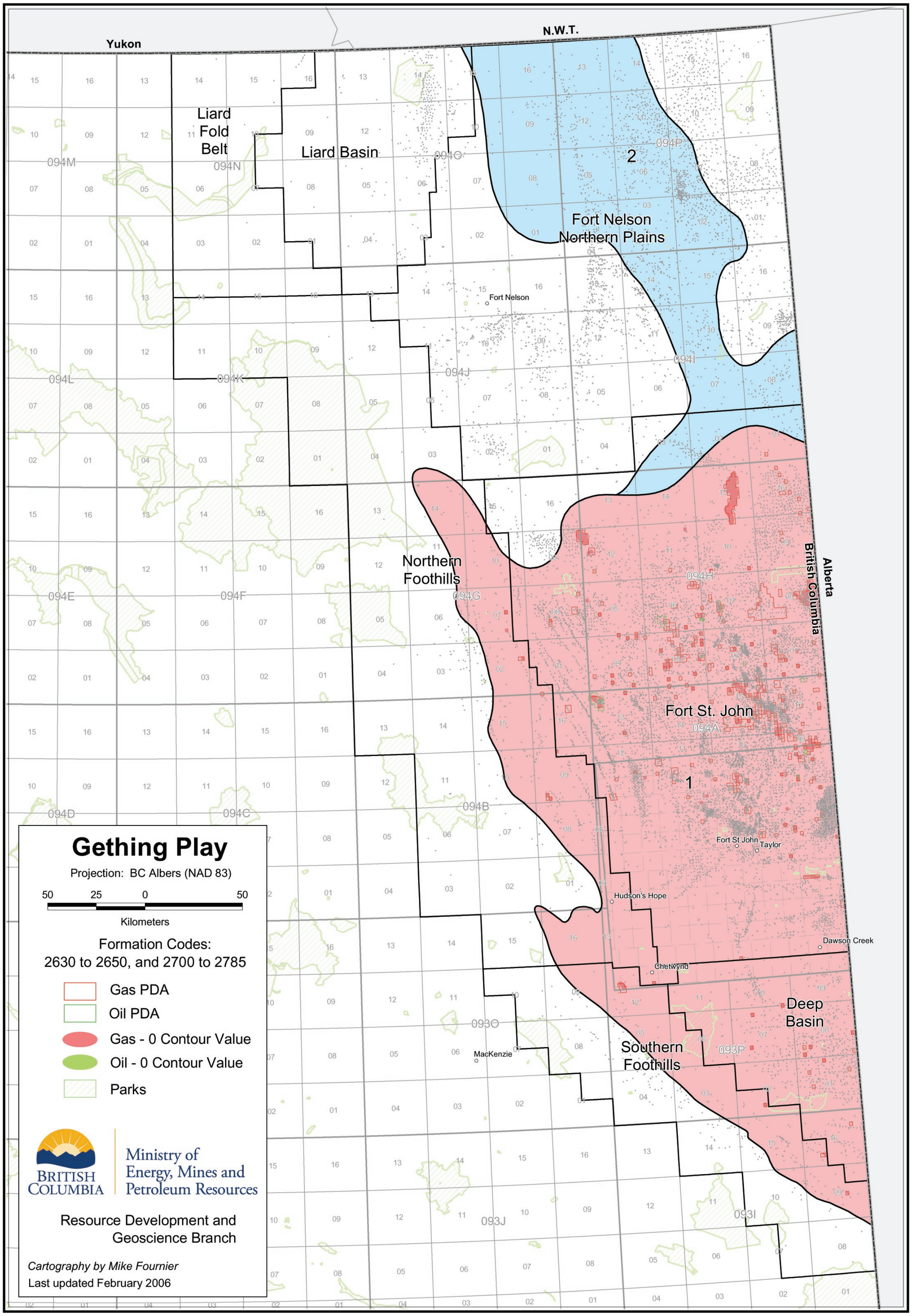
Figure 11. Lower Gething paleogeography, Buick Creek area, northeastern British Columbia (from Hayes, 2005). Northwestern reaches of Spirit River and Edmonton valley systems incise Triassic through lowermost Cretaceous (Buick Creek sandstone) strata. Valley relief constrained deposition and distribution of lower and upper Gething sediments.

Gething Play - Top 10 Pools by OGIP

Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Rigel East	Gething	A	1,239	895	240	44	32	8
Wargen	Gething	A	664	475	22	23	17	1
Osborn	Gething	A	620	434	348	22	15	12
Doe	Gething	B	486	416	367	17	15	13
Peejay	Gething	F	384	240	196	14	8	7
Doe	Gething	A	378	297	297	13	10	10
Tommy Lakes	Gething	A	361	255	155	13	9	5
Flatrock	Gething	C	359	177	108	13	6	4
Boundary Lake	Gething	A	337	284	-12	12	10	0
Osprey	Gething	A	301	188	17	11	7	1
Other Pools			11,755	6,803	5,024	415	240	177
Totals			16,885	10,465	6,760	596	369	239


Gething Play
Annual Gas Production
Cum. Gas = 175 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
30
25
20
15
10
5
0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1960 1962 1964 1966 1968 1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Gething Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
70
60
50
40
30
20
10
0
700
600
500
400
300
200
100
0
1956 1959 1961 1963 1965 1968 1972 1976 1978 1980 1984 1986 1988 1990 1994 1996 1998 2000 2002
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Gething Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes:
2630 to 2650, and 2700 to 2785
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Southern Foothills
Deep Basin
1
2
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie

4.14 Cadomin / Chinkeh Formations

Cadomin strata were deposited as an outwash of alluvial fan to alluvial plain sedimentation in Early Cretaceous time, following renewed uplift of the Columbian orogenic highlands to the west (Stott, 1975; Gies, 1984). Widespread sandstones and conglomerates range from five to more than 25 metres thick, thickening locally to 100 metres or more near depocentres in the Foothills. They lie sharply on the pre-Mannville unconformity, and are sharply or gradationally overlain by Gething strata. The Cadomin reaches a northern depositional limit in northern 94A and B.

Poorly-sorted fine- to coarse-grained sandstones and chert pebble conglomerates characterize the Cadomin. There are no characteristic depositional sequences or internal stratigraphic markers, and specific reservoir trends have not been mapped. Reservoir quality is generally poor. Pervasive silica cement occludes most sand-supported porosity, while white (kaolinitic) clays fill much pebble-supported porosity, although interpebble pores are found in isolated patches.

In the Liard Basin, the Chinkeh Formation occupies the same stratigraphic position atop the pre-Cretaceous unconformity (Leckie et. al., 1991). Conglomerates are limited to a basal lag unit, and as a component of overlying valley-fill and channel deposits. Existing production and most reservoir potential exists in the upper part of the Chinkeh, consisting of widespread coarsening- and sandier upward marine shoreface successions, culminating in fine- to medium-grained sandstones with moderate to good reservoir quality.

Deep Basin Region

Play 1. Deep Basin Alluvial Fan / Fluvial Play—A well-defined, gas-saturated Deep Basin regime characterizes this play. Widespread Cadomin conglomerates and sandstones produce gas where reservoir quality is sufficient to support economic production levels – primarily along the updip edge of the Deep Basin, where fluvial sorting is best and burial compaction is less extreme. Pervasive fracturing augments permeability, and appears to be focused within the Cadomin because of its highly siliceous, brittle nature. Further downdip, extensive fracturing also occurs, but reservoir quality is very poor, and only a few wells have been production tested.

The updip Deep Basin limit is well defined by abundant drilling and testing in 93P, but is much less constrained through the southwestern Peace River Block. An extensive "resource play" development program began along the Deep Basin updip margin in the Cutbank Ridge – Brassey fairway (northeastern 93P) in 2003.

Cadomin strata in the Deep Basin Alluvial Fan / Fluvial Play produce gas at Brassey, Cutbank, Jackpine, Kelly Lake, Noel, and Sundown. The play area laps into the southwestern corner of the Fort St. John Region, and continues westward into the Southern and Northern Foothills Regions.

Southern Foothills Region

Play 1. Deep Basin Alluvial Fan / Fluvial Play—The Deep Basin Alluvial Fan / Fluvial Play continues westward from the Deep Basin Region into the Southern Foothills. Reservoir quality is generally very poor because of deep paleo-burial, although the formation thickens towards western depocentres. There would appear to be abundant opportunity for high-relief Foothills structures to fracture the brittle Cadomin reservoir, thus improving gas flow rates, but this has been documented in only a few wells to date.

Limited Cadomin production occurs at Ojay in the Southern Foothills.

Fort St. John Region

Play 2. Spirit River Valley Play—Updip of the Deep Basin edge, the Cadomin is characterized by a regional aquifer with relatively small, isolated stratigraphic and structural gas traps. Reservoir quality generally increases updip with improved sorting, as the result of increased fluvial reworking of sediments in the Spirit River Valley, and with lesser burial compaction and silicification. Low-relief outer Foothills structure plays a more significant role in trapping along the western margin of the Fort St. John Region.

The Cadomin and lower Gething have not been consistently differentiated toward the northeastern margin of the Spirit River Valley system. In addition, most databases lump Cadomin and older Buick Creek / Nikanassin strata together as the Dunlevy Formation in the northern Peace River Block. This obscures profoundly different depositional settings, and the distinct unconformity between the Cadomin and the older units.

The Cadomin produces from small pools at Airport, Bernadet, Blueberry, Boundary Lake, Cecil, Doe, Flatrock, Flatrock West, Fort St. John, Fort St. John Southeast, Montney, Muskrat, Oak, Squirrel, Stoddart West, and Swan Lake.

Northern Foothills Region

Play 2. Spirit River Valley Play—The Spirit River Valley play extends westward from the Fort St. John Region into the Northern Foothills. Reservoir quality generally degrades with increasing burial depth and associated silica cementation. The same correlation issues outlined for Fort St. John Region apply in the Northern Foothills, but overall westward thickening of the Mesozoic section, less extreme incision on the pre-Cretaceous unconformity, and greater structural control on trapping make differentiation of the Cadomin from older strata a less important issue.

Cadomin strata produce gas at Kobes in the Northern Foothills Region.

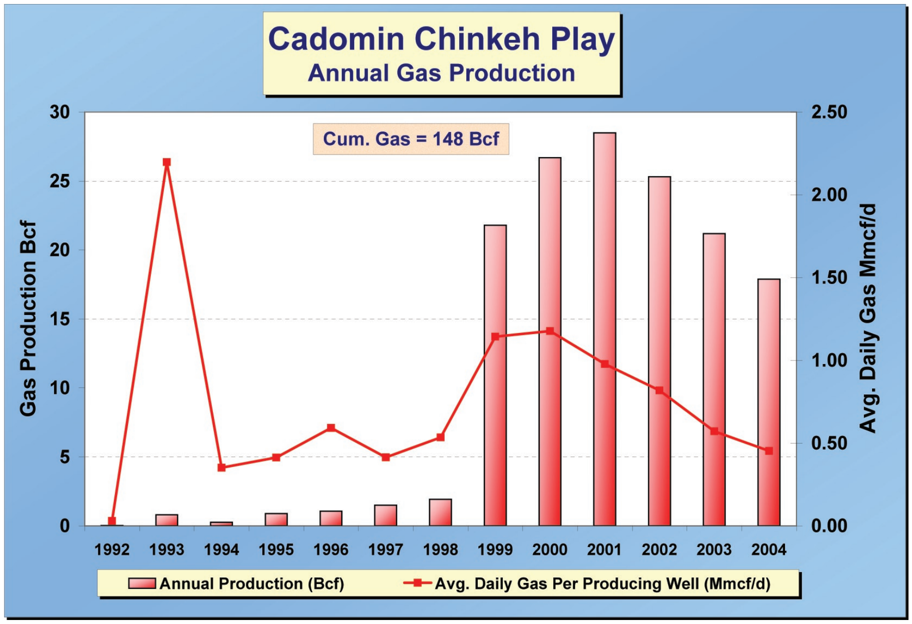
Liard Basin Region

Play 3. Chinkeh Play—Chinkeh strata have been described regionally in outcrop and in the subsurface of the Liard Basin (Leckie et. al., 1991; Frank et. al., 2000). While it is understood that deposition of the Chinkeh was governed by structural relief on the eastern, basin-bounding Bovie Fault, controls on the entrapment of gas have not been documented in detail.

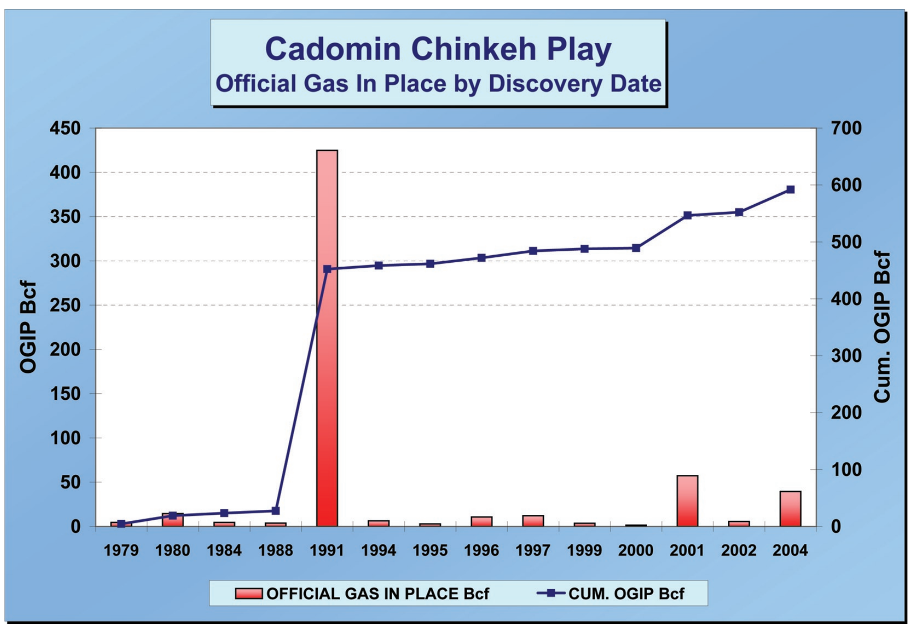
One large pool is on production at Maxhamish Lake; there has been little exploration across the rest of the basin.

Cadomin Chinkeh Play - Top 10 Pools by OGIP

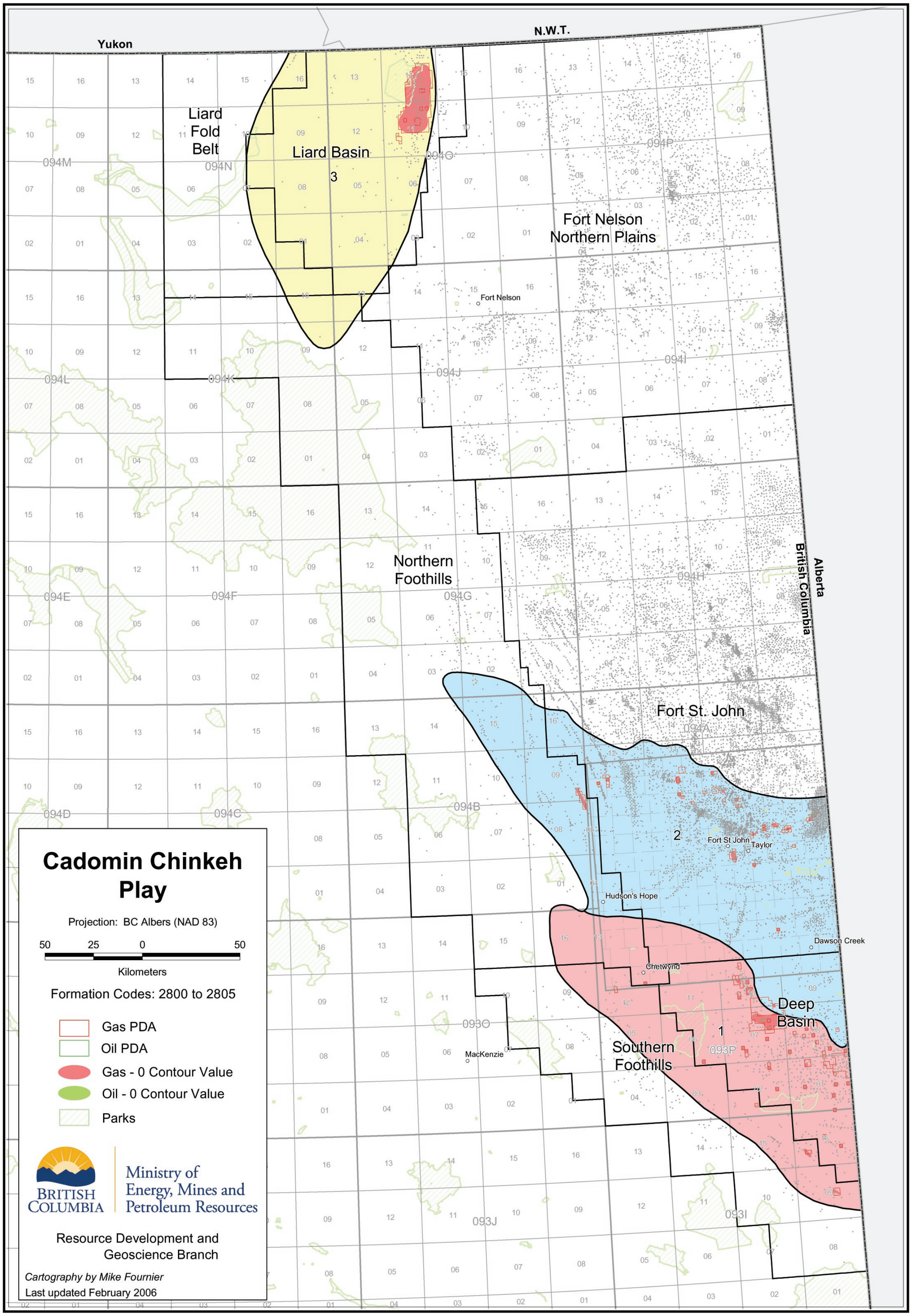
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Maxhamish Lake	Cadomin	A	11,914	7,981	5,266	423	283	187
Kelly	Cadomin	D	1,168	840	717	41	30	25
Hiding Creek	Cadomin	C	1,123	797	797	40	28	28
Flatrock	Cadomin	B	263	108	108	9	4	4
Ojay	Cadomin	A	255	203	199	9	7	7
Sundown	Cadomin	A	244	56	56	9	2	2
Other Areas	Cadomin	-	198	146	136	7	5	5
Oak	Cadomin	A	187	135	66	7	5	2
Kelly	Cadomin	A	129	30	27	5	1	1
Other Areas	Cadomin	A	128	58	58	5	2	2
Other Pools			1,155	711	537	41	25	19
Totals			16,763	11,065	7,967	595	393	283



Cadomin Chinkeh Play
Annual Gas Production
Cum. Gas = 148 Bcf
Gas Production Bcf
Avg. Daily Gas Mmcf/d
30
25
20
15
10
5
0
2.50
2.00
1.50
1.00
0.50
0.00
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Cadomin Chinkeh Play
Official Gas In Place by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
450
400
350
300
250
200
150
100
50
0
700
600
500
400
300
200
100
0
1979
1980
1984
1988
1991
1994
1995
1996
1997
1999
2000
2001
2002
2004
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Cadomin Chinkeh Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2800 to 2805
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
3
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
2
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
1
Southern Foothills
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.15 Nikanassin Formation / Buick Creek Sandstone

Nikanassin strata comprise a thick, easterly-thinning wedge of clastics, deposited during latest Jurassic and earliest Cretaceous time (Stott, 1998). Equivalent strata include the Minnes Group in the Foothills, and the Buick Creek sandstone to the north. During Nikanassin time, the Jurassic Fernie Sea retreated northward from the Western Canada Sedimentary Basin, in response to eustatic sea level fall and immense volumes of sediment being shed from the rising Columbian Orogen to the west. Additional sediment supply from the craton to the east is evident in the highly quartzose nature of Buick Creek sandstones in the Rigel-Buick Creek areas. With further marine retreat and orogenic uplift, deposition was terminated and uppermost Nikanassin strata were eroded.

Nikanassin strata grade up from marine Fernie shales at the base, and are capped by the basin-scale pre-Mannville unconformity. Blocky to fining-upward sandstone bodies are interbedded with siltstones, shales, and minor coal; net sandstone/gross thickness ratios may exceed 50%, resulting in sections with up to 500 metres of net clean sandstone where the Nikanassin is thickest. Deposition took place in marginal marine to continental settings, resulting in an absence of regional stratigraphic markers and mappable depositional trends.

On the northern flank of the Peace River Block, Buick Creek strata comprise highly quartzose sandstones, shales, and coals, deposited in a southwesterly-prograding deltaic setting (Hayes, 2005). Pre-Gething valleys incise the Buick Creek to the north and south, leaving it as almost an erosional outlier. In this area, the term "Dunlevy" has been applied to Buick Creek, Cadomin, and Gething strata, causing considerable confusion in correlations and pool assignments. Dunlevy is thus not used in this report.

Southern and Northern Foothills Regions

Play 1 & Play 4. Foothills Nikanassin and Buick Creek—The Nikanassin/Buick Creek stratigraphic package thickens sharply westward into the depositional foredeep area now occupied by the Southern and Northern Foothills. Depositional settings and reservoir characteristics are similar to those described in the Plains areas to the east, although reservoir quality tends to be poorer in the Foothills, with additional burial compaction and silica cementation.

Gas is produced in several small pools where high-relief Foothills structures have extensively deformed the Nikanassin section, causing extensive fracturing and hence permeability. Many wells have targeted Triassic fractured carbonates, and thus have not penetrated the Nikanassin in optimal positions or orientations. Considerable exploration potential thus remains.

The Nikanassin produces gas in the Southern Foothills at Grizzly (North and South), Ojay, Redwillow River, and Wolverine. Buick Creek sandstones are productive on outer Foothills structures along the western margin of the Fort St. John Region, but do not produce in the Northern Foothills Region.

Deep Basin Region

Play 2. Peace River Play—Reservoir sandstones consist primarily of fine- to medium-grained siliceous litharenites, deposited as channelized bodies on the order of 5 to 15 metres thick, although individual channels may stack into composite bodies. Regional shoreline or valley-fill trends have not been mapped. There appears to be a gas-saturated Deep Basin regime, but there are too few tests to define its updip limit with certainty.

Reservoir quality is very poor – sandstones are glassy and brittle, and break across individual grains, indicating strong and pervasive cementation. Hairline fractures in thin section raise the possibility that natural fracturing may enhance reservoir quality.

In the Deep Basin Region, there is only one well at Cutbank which has produced substantial gas, although there are several sub-economic shows.

Fort St. John Region

Play 2. Peace River Play—Nikanassin strata thin northeastward from the Deep Basin Region into the southern part of the Fort St. John Region, reaching an erosional edge beneath the Spirit River Valley. Where the Mesozoic section thickens to the west, Nikanassin and Buick Creek strata interfinger along a gradational, poorly-defined boundary.

There is very little test information or production in this area, although one can speculate that reservoir quality is generally somewhat better than in the Deep Basin Region, and that there may be a regional aquifer system.

There is no clearly defined Nikanassin gas production in this play area.

Play 3. Buick Creek Sandstone Play—The Buick Creek was deposited as a southwesterly-prograding deltaic complex, sourced from the Canadian Shield to the northeast, fronting on the narrow seaway occupying the foredeep during latest Jurassic and earliest Cretaceous time (Hayes, 2005). Buick Creek sandstones are excellent conventional reservoirs, consisting of medium-grained or coarser quartzarenites with excellent secondary solution porosity and minor bitumen. To the west and southwest, however, they grade to finer, more distal delta front and prodeltaic facies, featuring abundant silica cement, bitumen, clays, and minor carbonate cements.

Gas and some oil are produced from stratigraphic and structural traps. Syndepositional and Laramide-reactivated block faulting influenced reservoir sand deposition and present-day structural configuration (Figure 12). At Buick Creek and westward, water occurs only in isolated pockets, and a Deep Basin regime is evident.

Buick Creek sandstones produce gas at Beg, Blueberry, Blueberry West, Buick Creek, Buick Creek North and West, Fireweed, Gundy Creek, Gundy Creek West, Inga, Lagarde, Rigel, and Siphon.

Nikanassin - Buick (Dunlevy) Play - Top 10 Pools by OGIP

Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Rigel	Dunlevy	F	16,584	12,256	1,266	585	433	45
Buick Creek	Dunlevy	C	4,606	3,352	563	163	118	20
Blueberry	Dunlevy	A	4,572	2,936	1,601	161	104	57
Buick Creek	Dunlevy	A	3,522	2,539	159	124	90	6
Buick Creek	Dunlevy	B	3,175	2,273	514	112	80	18
Blueberry	Dunlevy	B	3,048	2,121	781	108	75	28
Siphon	Dunlevy	A	2,779	1,181	44	98	42	2
Buick Creek West	Dunlevy	A	2,254	1,644	45	80	58	2
Grizzly North	Dunlevy	A	2,017	1,321	568	71	47	20
Fireweed	Dunlevy	A	2,000	1,422	634	71	50	22
Other Pools			26,700	17,771	9,125	943	627	322
Totals			71,257	48,816	15,301	2,515	1,723	540

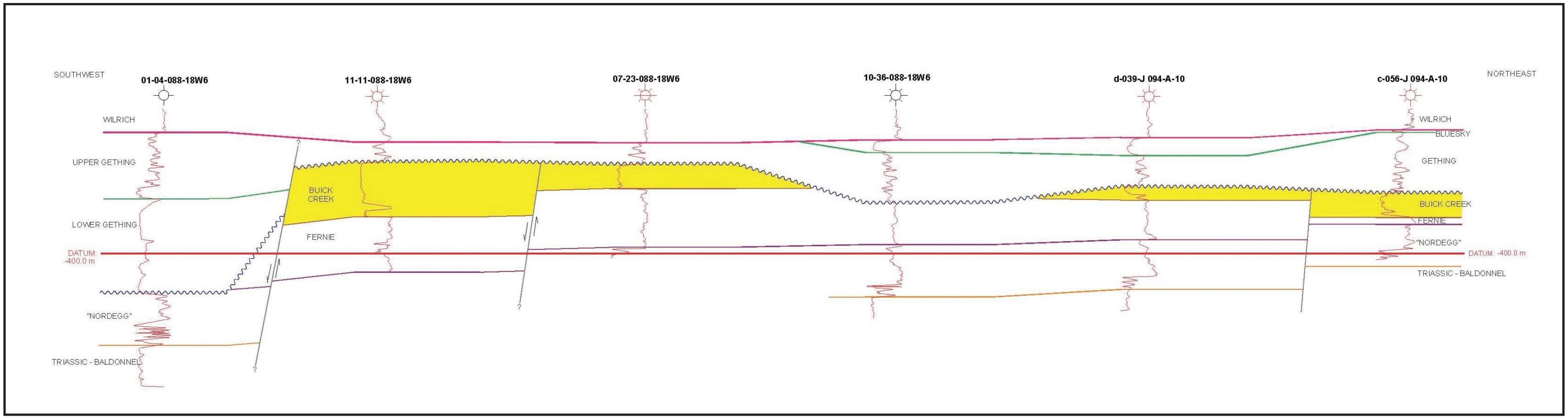
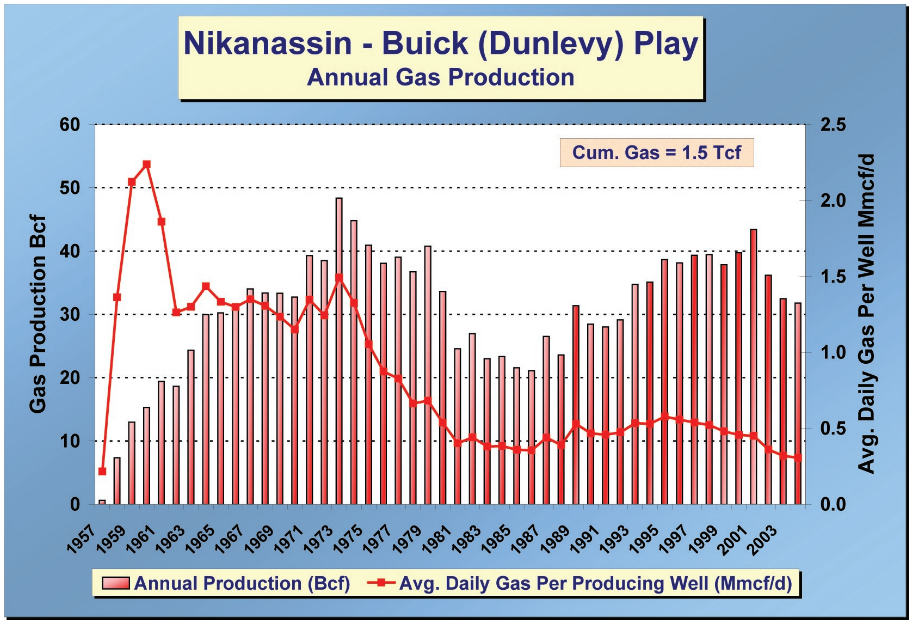
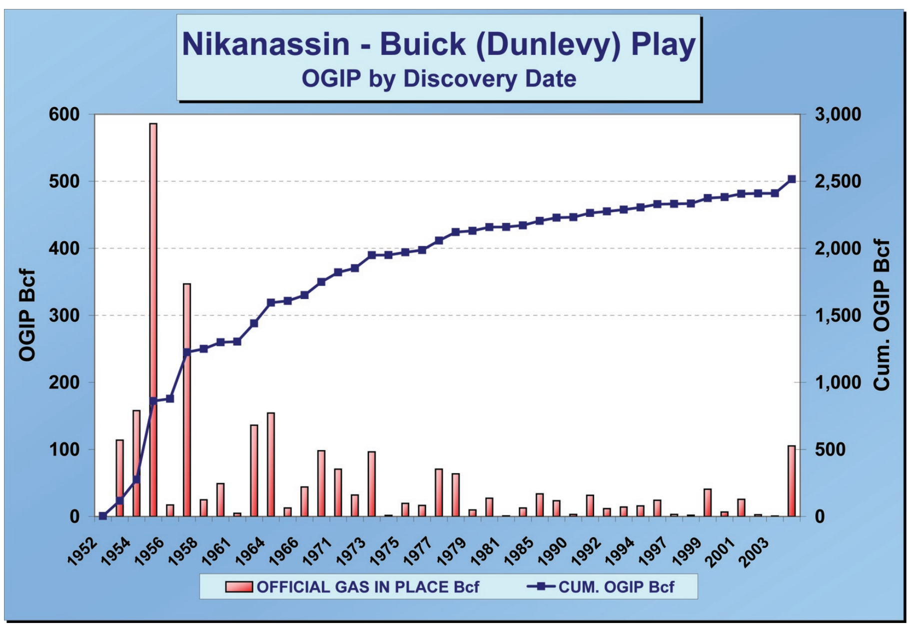
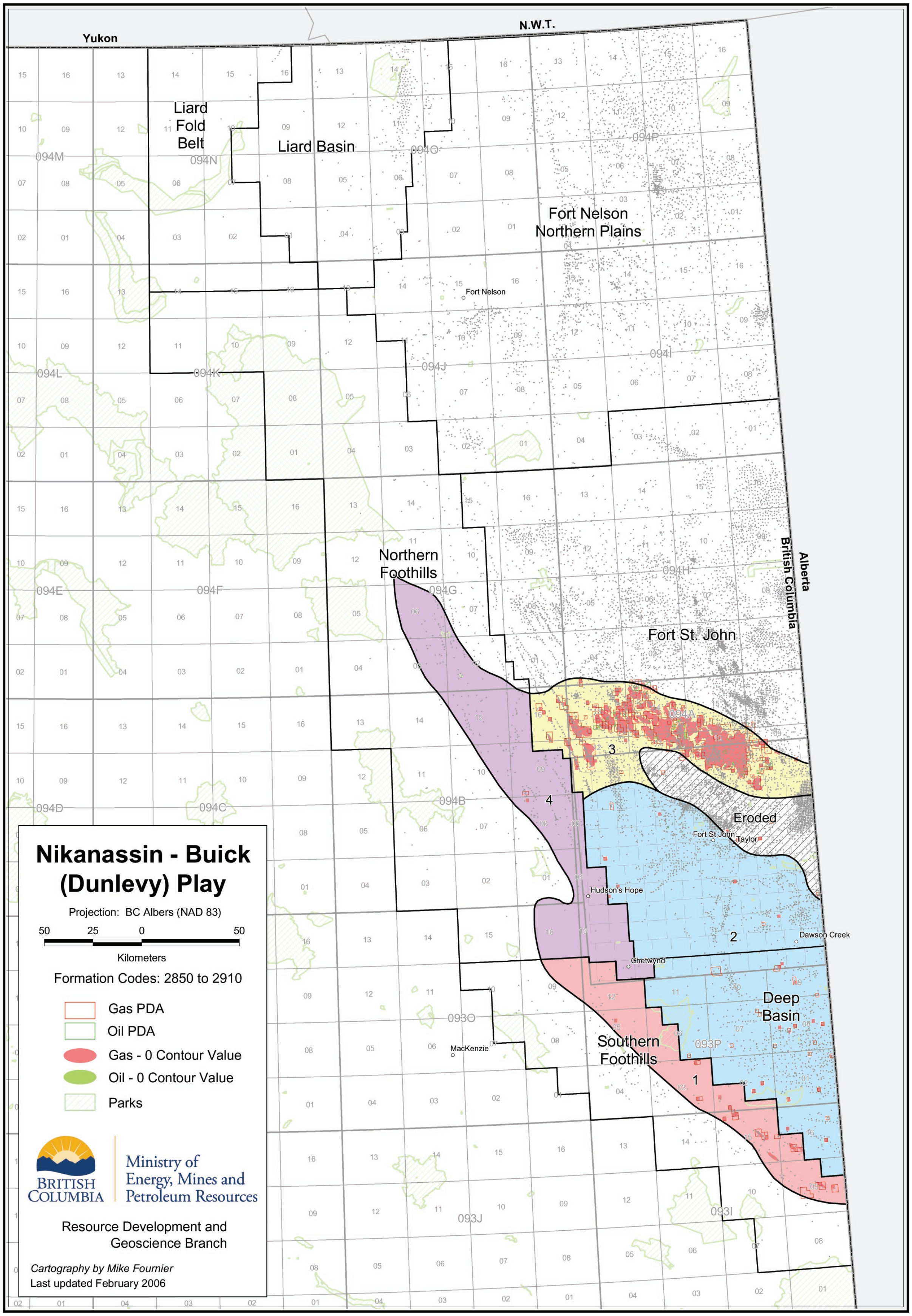


Figure 12. Cross-section illustrating effects of block faulting on Buick Creek sandstone deposition, preservation, and trapping situation in the Rigel area. Note abrupt changes in Buick Creek section across faults.


Nikanassin - Buick (Dunlevy) Play
Annual Gas Production
Cum. Gas = 1.5 Tcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Nikanassin - Buick (Dunlevy) Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Nikanassin - Buick (Dunlevy) Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 2850 to 2910
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Eroded
Deep Basin
Southern Foothills
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
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094D
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4.16 Pardonet / Baldonnel / Upper Charlie Lake

Pardonet / Baldonnel strata are widespread shallow marine to shelfal carbonates, deposited during a regional transgression which drowned Charlie Lake arid coastline environments (Davies, 1997b). Reservoir rocks are primarily dolomitized skeletal calcarenites, with considerable variation in reservoir quality arising from an interplay of depositional facies, diagenesis, and structural overprint. The Baldonnel can be mapped continuously from the southern Deep Basin to a northern subcrop edge in 94G and 94H. It lies more or less conformably on the Charlie Lake Formation, while the Pardonet (and Baldonnel east of the Pardonet subcrop edge) is unconformably overlain by Jurassic marine shales.

The Baldonnel is one of only two tight gas plays in northeastern B.C. (along with the Jean Marie) in which tight gas potential has been recognized and systematically exploited. The Pardonet/Baldonnel has two pure tight gas plays, with numerous large, high-productivity gas pool discoveries within both the Bullmoose/Sukunka and Cypress play trends. Both are structurally-controlled dual porosity systems.

Fort St John Region

Play 1. Baldonnel Stratigraphic & Subcrop Play —In the north, pools and prospects occur in dominantly stratigraphic traps, with some structural component arising from Laramide deformation, in coquinas and algal carbonates of the Baldonnel and Pardonet Formations (Bever, 1990; Bird et. al., 1994) (Figure 13). To the north and east the play is limited by the Baldonnel erosional edge. In the south, pools and prospects occur in dominantly stratigraphic traps, with structural influences due to

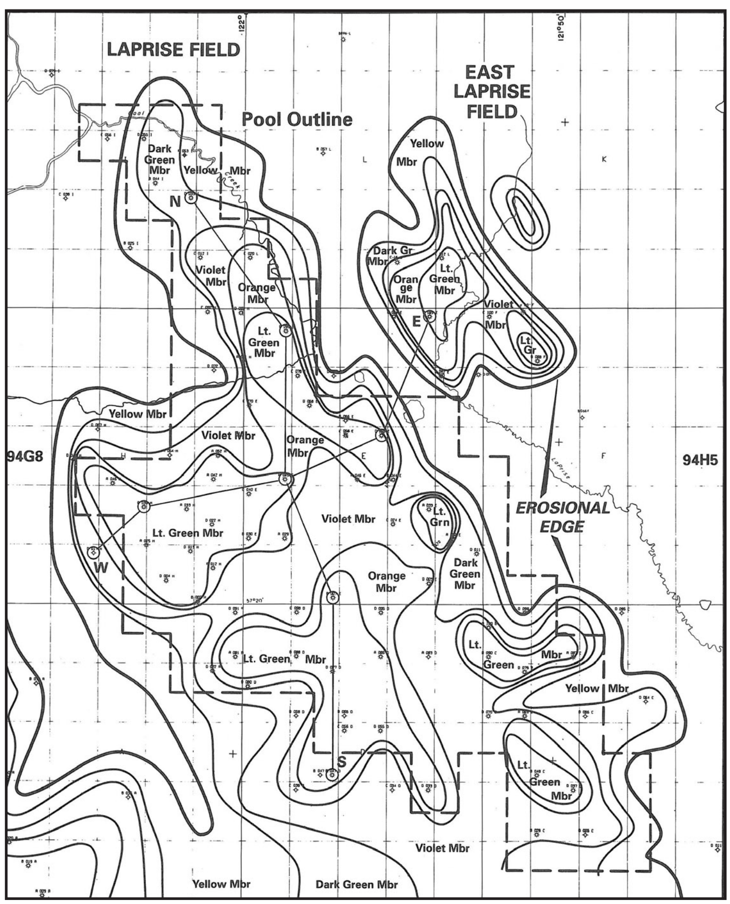


Figure 13. Situation map illustrating distribution of subcrop edges of members within Baldonnel Formation, Laprise and East Laprise areas (from Bever, 1990). Laprise and East Laprise are good examples of Baldonnel subcrop traps, preserved beneath the pre-Cretaceous unconformity, and sealed primarily by Cretaceous marine shales.

the Peace River Arch (PRA). Drape of Baldonnel reservoirs over PRA structures is the dominant trapping mechanism. More profound structural overprinting by Laramide folding marks the western boundary of the play.

The play includes Baldonnel pools in the Airport, Birch, Boundary Lake, Buick Creek, Cecil Lake, Doe, Ft. St. John, Laprise Creek, Laprise Creek West, Martin, Montney, Nig Creek, Osborn, Paradise, Peejay, Siphon, Siphon East, Sojer, Stoddart, Stoddart West, Two Rivers, and Weasel Fields.

Play 2. Baldonnel Laramide Structural Play—Baldonnel prospects in this play are dominated by low-relief Laramide structural controls. The northern boundary is defined by the erosional edge. To the east, stratigraphic controls or PRA structural influences dominate trapping. In some instances, intervals within the Upper Charlie Lake are deemed to be in reservoir communication with the Baldonnel via significant fracture development. Bird (1994) has summarized additional information on Plays 1 and 2.

The play includes Attachie, Beg, Bubbles, Fireweed, Inga, Jedney, and Sikanni Fields.

Deep Basin Region

Play 1. Baldonnel Stratigraphic & Subcrop Play—Pardonet and Baldonnel shallow marine reservoir facies are mapped southward into the Deep Basin Region. However, well control is very poor, and porosity/permeability may be challenged by deep burial diagenesis. There are insufficient data to ascertain whether a gas-saturated Deep Basin regime is present. Prospectivity is therefore conceptual in the Deep Basin Region at this time.

Southern Foothills Region

Play 3. Fracture-dominant Foothills Structural Play—Fault-propagation folds involving Upper Triassic carbonates, formed during Laramide thrusting, are the principal traps (Figure 14) (Barss and Montandon, 1981). Reservoir rocks have low matrix porosities (less than 4%), and permeabilities less than 0.1 md. They are buried to depths of 2400 to 3000 metres where productive. Fracturing is the key element to productivity, producing initial flow rates up to 2400 e^3m^3/d.

In the past, these accumulations have been treated as conventional plays, with usually only the fracture-induced porosity being recognized, and the tight matrix gas component generally discounted. This has resulted in a significant underestimation of original gas-in-place for discovered pools. Water is a significant risk, as there is no regionally-extensive gas-saturated Deep Basin regime. The play area is bounded to the northwest by a transition to deeper-water facies, and structural changes where the Foothills intersect the Fort St. John Graben.

Pools and prospects of this play occur at Boulder, Brazion, Bullmoose, Burnt River, Commotion, Grizzly North, Gwillim, Murray, Ojay, Redwillow River, Stone Creek, and Sukunka.

Northern Foothills Region

Play 4. Foothills Structural Play, Cypress Area —Although similar to the Bullmoose/Sukunka play, pools in this play trend are shallower (675 to 1500 metres), in less complex structures, and produce from both matrix porosity and fractures. Optimal matrix porosity and fracturing occur where the Baldonnel is dolomitized. All discoveries to date have taken place north of the Fort St. John Graben trend.

This play produces gas at Butler, Chowade, Cypress, Daiber, Graham, Green Creek, Gundy Creek West, Julienne Creek, and Julienne Creek North.

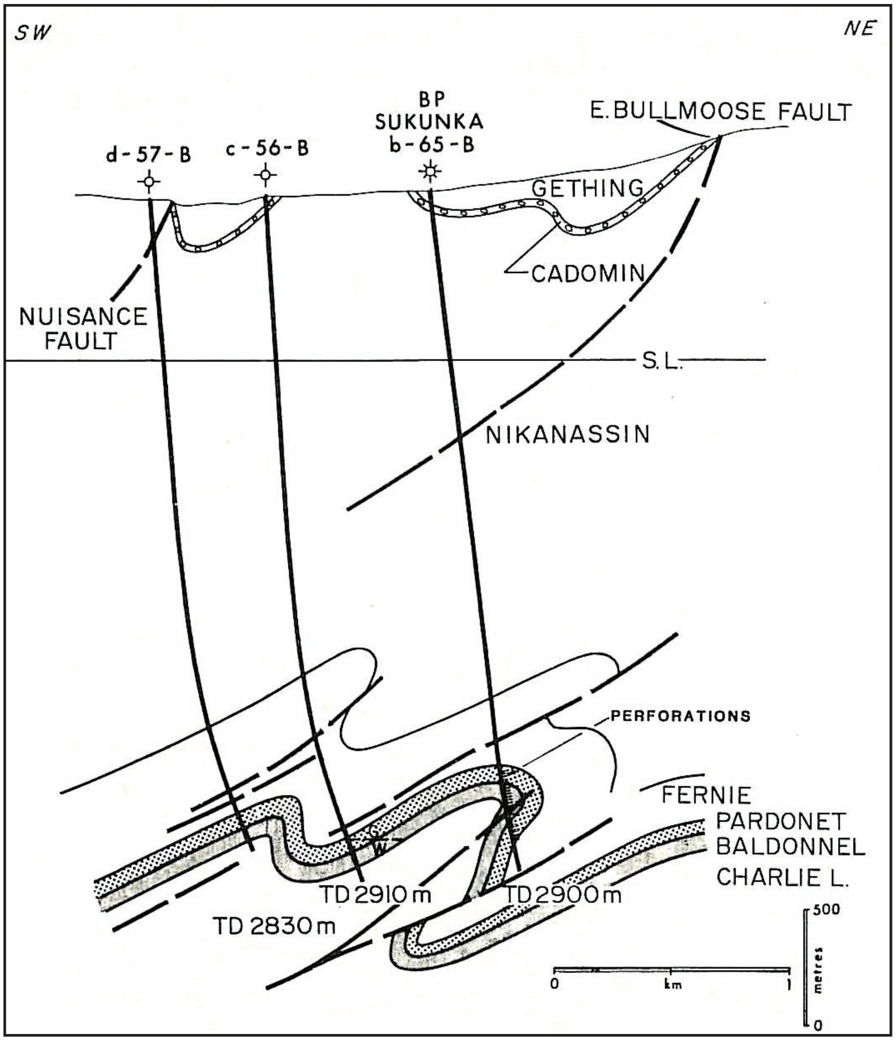
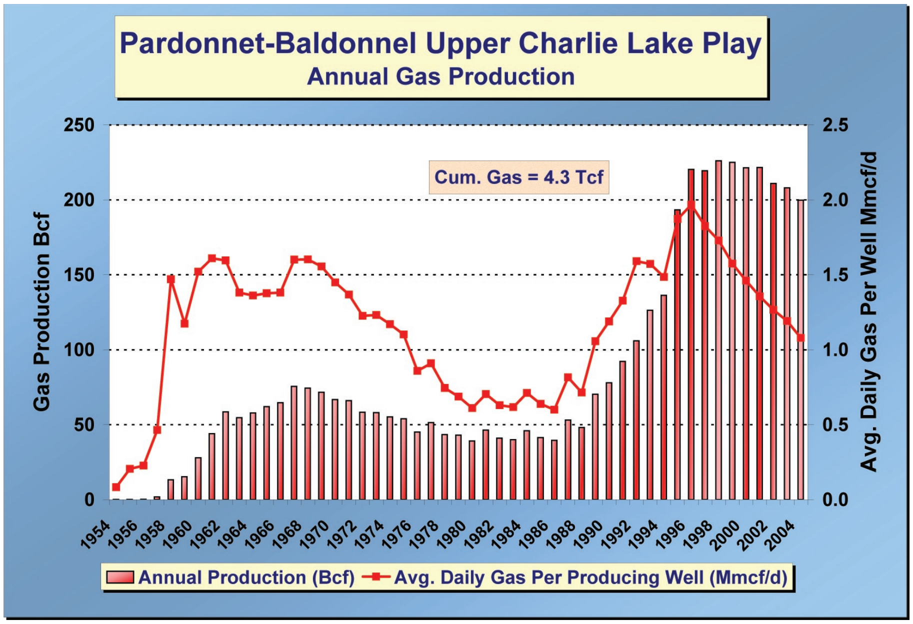
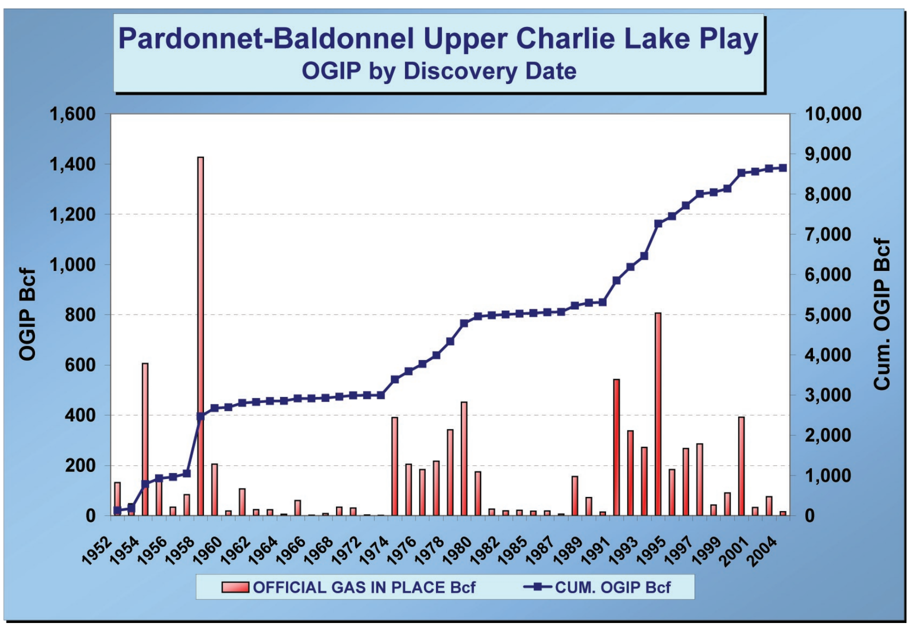


Figure 14. Baldonnel Fracture-dominant Foothills Structural Play at Sukunka, Southern Foothills Region (from Barss and Montandon, 1981). Tight Pardonet/Baldonnel strata are intensively fractured where extensional stresses are exerted over Foothills folds and faults. Wells penetrating fracture systems (as at b-65-B) feature high deliverabilities and reserves.

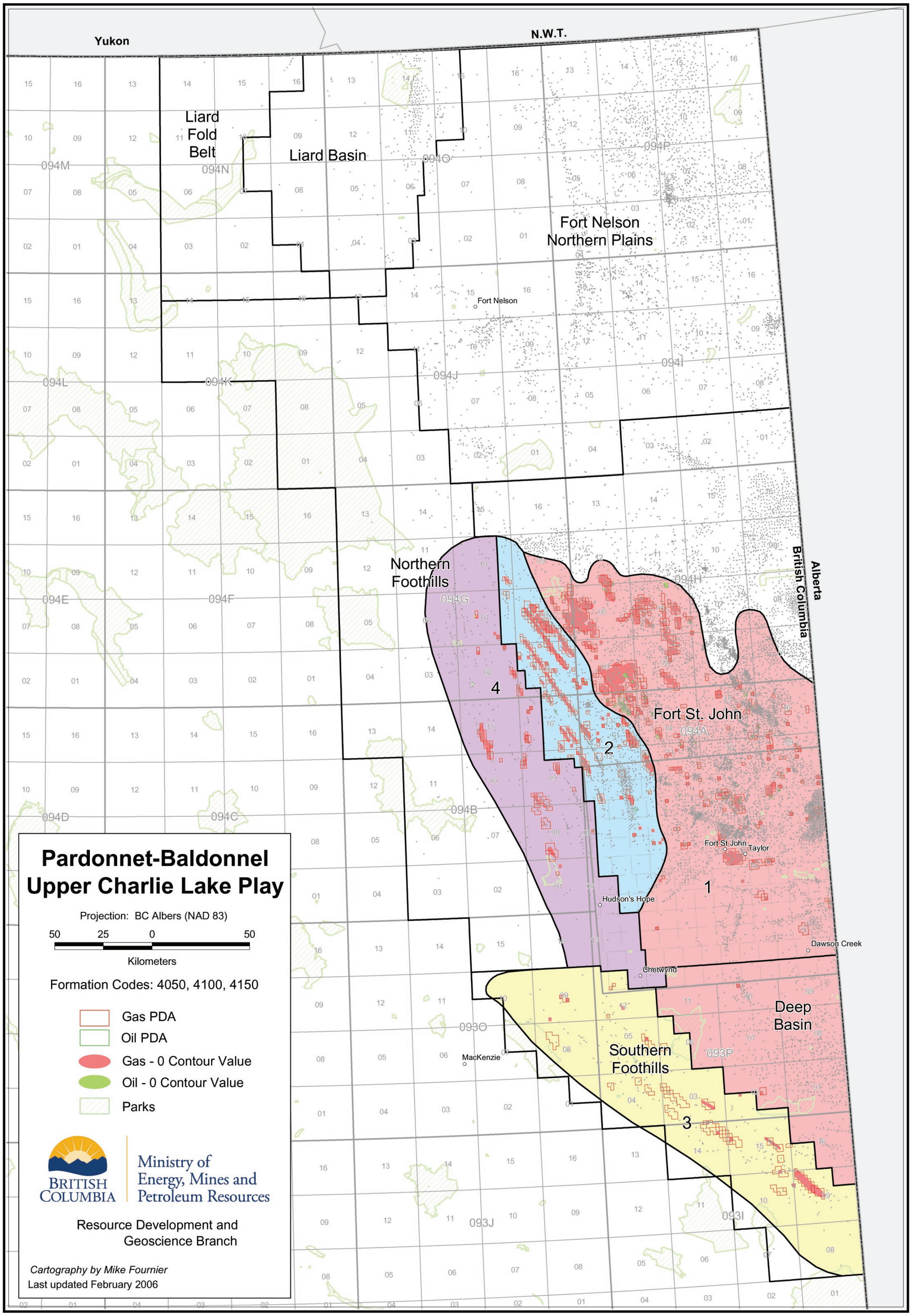
Pardonnet Baldonnel Upper Charlie Lake Play - Top 10 Pools by OGIP									
AREA	FORMATION	POOL SEQ	OFFICIAL GAS IN PLACE (MM3)	INIT EST GAS MKT (MM3)	REM GAS MKT (MM3)	OFFICIAL GAS IN PLACE BCF	INIT EST GAS MKT BCF	REM GAS MKT BCF
Laprise Creek	Baldonnel/Upper Charlie Lake	A	26,362	17,906	2,014	931	632	71
Nig Creek	Baldonnel	A	15,852	8,601	1,114	560	304	39
Jedney	Baldonnel/Upper Charlie Lake	A	12,798	9,455	867	452	334	31
Sukunka	Pardonnet-Baldonnel	E	12,477	6,929	1,480	440	245	52
Ojay	Baldonnel	A	11,060	6,353	6,349	390	224	224
Murray	Baldonnel/Upper Charlie Lake	A	8,452	5,369	2,119	298	190	75
Grizzly South	Baldonnel	B	7,791	6,152	5,455	275	217	193
Laprise Creek	Baldonnel/Upper Charlie Lake	B	5,197	3,732	960	183	132	34
Bubbles	Baldonnel	A	4,849	3,533	399	171	125	14
Boulder	Pardonnet-Baldonnel	A	4,413	2,908	1,387	156	103	49
Other Pools			135,916	79,135	36,147	4,798	2,794	1,276
Totals			245,167	150,072	58,291	8,655	5,298	2,058



Pardonnet-Baldonnel Upper Charlie Lake Play
Annual Gas Production
Cum. Gas = 4.3 Tcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Pardonnet-Baldonnel Upper Charlie Lake Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Pardonnet-Baldonnel
Upper Charlie Lake Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4050, 4100, 4150
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
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Deep Basin
Southern Foothills
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
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4.17 Upper Charlie Lake Formation

The Charlie Lake Formation comprises a thick succession of interbedded siliciclastic, carbonate, and evaporitic rocks, deposited at the culmination of a major transgressive-regressive cycle encompassing the Doig, Halfway, and Charlie Lake (Davies, 1997a). Reservoir units include very fine- to medium-grained sandstones, deposited in arid coastline to shallow marine settings, and crystalline to skeletal limestones and dolostones, primarily of shallow marine origin.

Stratigraphic markers can be correlated regionally with confidence in the Charlie Lake, reflecting very widespread, low-relief deposition. Several internal unconformity surfaces can also be traced throughout northeastern B.C. One of these, the Coplin unconformity, serves as the boundary between lower and upper Charlie Lake. It progressively truncates all lower Charlie Lake members, as well as the Halfway, Doig, and Montney, in a northeasterly direction, and thus records a major early Late Triassic tectonic and erosional event (Davies, 1997c).

The Charlie Lake is overlain by the Baldonnel Formation. The contact is locally disconformable, but can be difficult to identify consistently on logs because of lithological similarities between the two units.

Charlie Lake reservoirs host both oil and gas in northeastern B.C. Individual pools tend to be thin and areally small, reflecting low-relief environments of deposition and truncation by unconformities. Tight evaporitic facies provide effective seals throughout the Charlie Lake.

Fort St. John Region

Play 1. Peace River Plains Play—Major upper Charlie Lake reservoirs in the Peace River Plains include the Coplin, Nancy, and Siphon sandstones, and the Boundary Member carbonate. Traps are formed by facies pinchouts, diagenetic boundaries, and erosional truncation by intra- or post-Triassic unconformities (Bird et. al., 1994; Sherwin, 2003). Gentle Laramide fold structures may also influence trapping to the west. To the south, block faulting associated with the Peace River Arch / Fort St. John Graben locally plays an important role in trap formation (Figure 15).

In the east, the large Boundary Lake pool is found where Boundary Member carbonates are preserved as a large erosional outlier beneath the post-Boundary unconformity. Reservoir quality was enhanced by exposure at the unconformity surface, and also by fluid movements associated with extensive faulting.

Upper Charlie Lake Peace River Plains pools include Beatton River, Beavertail, Boundary Lake, Boundary Lake North, Bubbles North, Buick Creek, Cache Creek, Cecil Lake, Eagle, Eagle West, Flatrock, Flatrock West, Fort St. John, Fort St. John Southeast, Groundbirch, Halfway, Inga, Lagarde, Laprise Creek, Martin, Mercury, Mica, Montney, Muskrat, Oak, Osprey, Owl, Peejay, Pintail, Pluto, Red Creek, Rigel, Saturn, Silver, Siphon, Stoddart, Stoddart South, Stoddart West, Sunset Prairie, Two Rivers, Velma, Weasel, Wilder, and Zaremba.

Deep Basin Region

Play 1. Peace River Plains Play—Upper Charlie Lake reservoirs can be mapped southward into the Deep Basin region, but are deeply buried and tend to be more diagenetically degraded than to the north. There is also less potential for structural trapping south of the Peace River Arch. However, the primary reason for the lack of discoveries to date is poor well control, particularly as the thin Charlie Lake reservoirs are best identified using intensive stratigraphic mapping.

Northern Foothills Region

Play 2. Foothills Structural Play—Laramide fold and fault structures play a more important role in defining upper Charlie Lake traps in the Northern Foothills Region. The Charlie Lake stratigraphic framework, including depositional and diagenetic trends, is less clearly defined, however, because well control is relatively sparse. Most future discoveries will likely take place in wells targeted for structural closures that happen to encounter a Charlie Lake reservoir unit.

Upper Charlie Lake Foothills pools occur at Altares, Cypress, and Kobes.

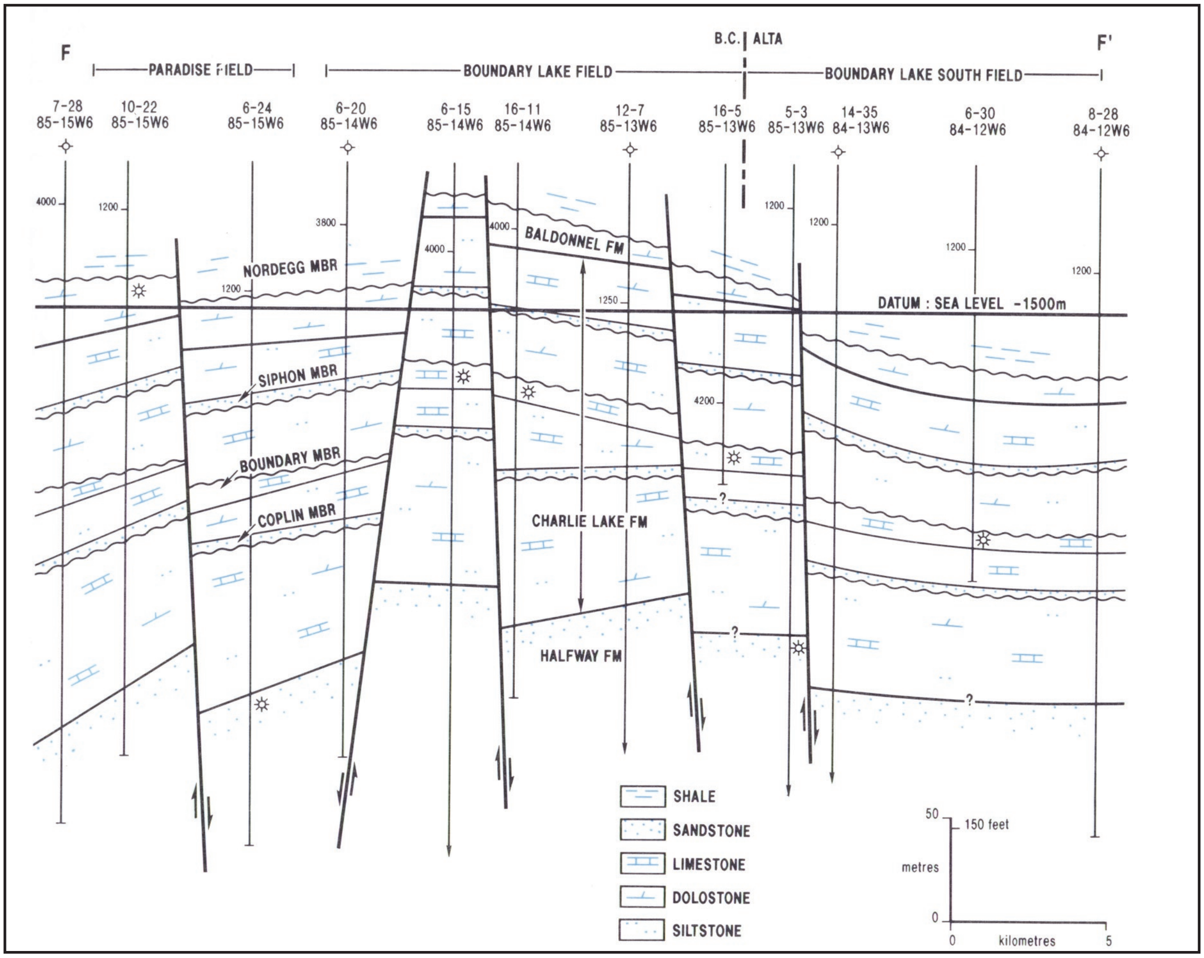
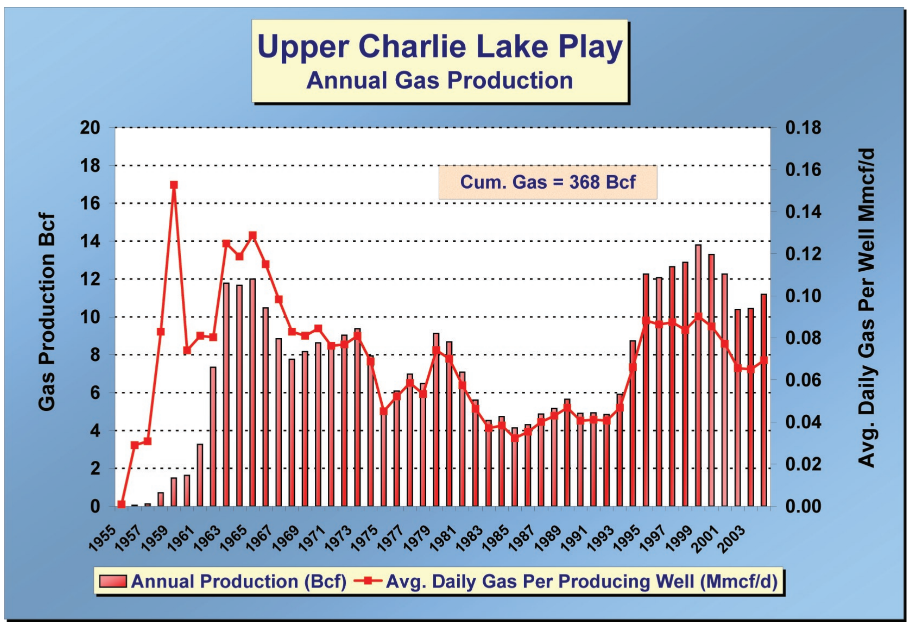


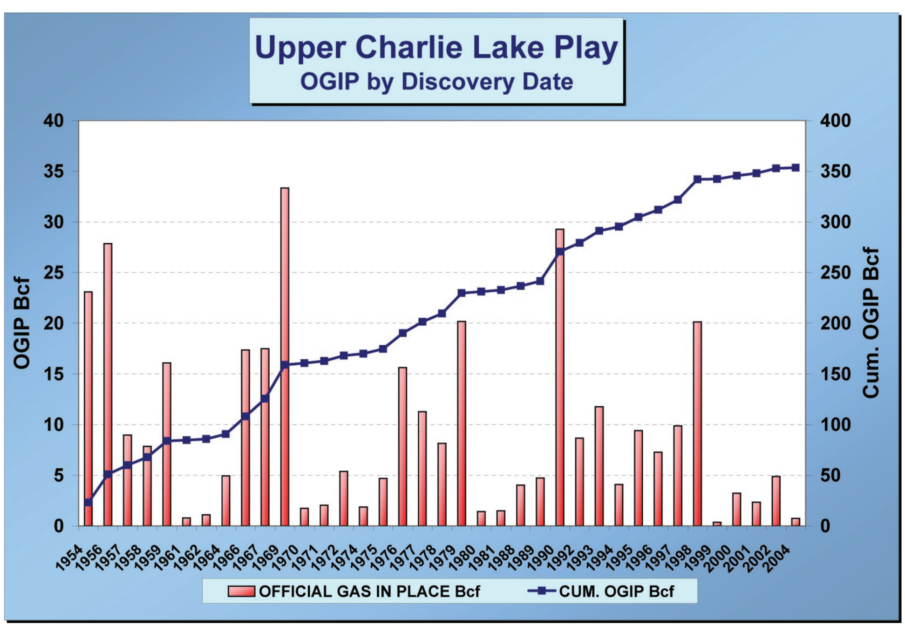
Figure 15. Structural cross-section through Charlie Lake Formation across the Fort St. John Graben area. Note development of reservoir sandstones and carbonates associated with regional unconformities within the Charlie Lake, and importance of faults as structural traps.

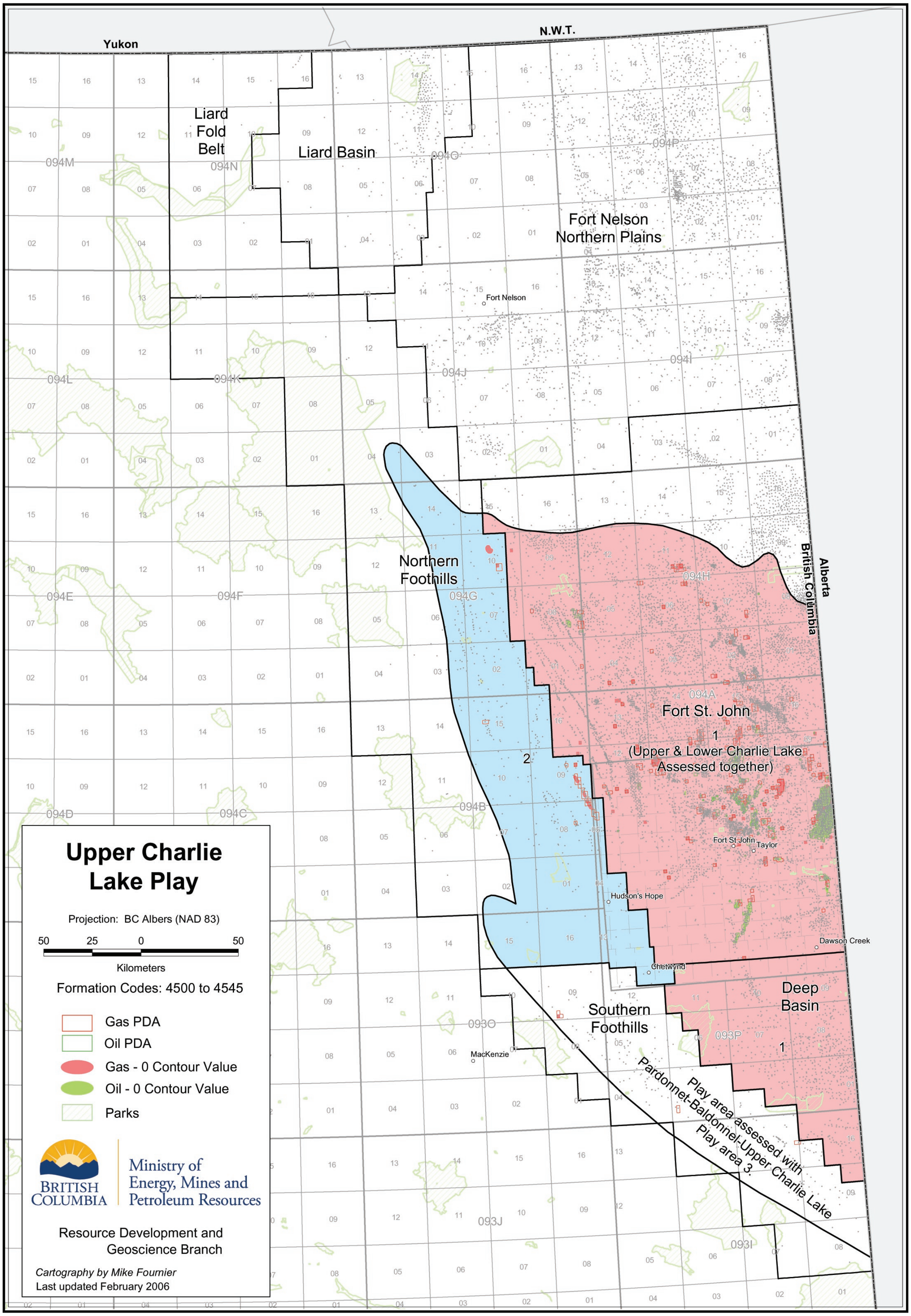
Southern Foothills Region

Gas production from upper Charlie Lake strata cannot be distinguished with confidence from Pardonet / Baldonnel production in the Southern Foothills Region. Upper Charlie Lake prospectivity is thus included within Pardonet / Baldonnel / Upper Charlie Lake Play 3 (Fracture-dominant Foothills Structural Play).

Upper Charlie Lake Play Pool List - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Cache Creek	Coplin	A	875	659	85	31	23	3
Kobes	Charlie Lake	B	648	483	33	23	17	1
Rigel	Cecil	A	548	411	61	19	14	2
Siphon	Siphon	A	456	255	2	16	9	0
Boundary Lake	Coplin	A	446	313	204	16	11	7
Cache Creek	Coplin	B	443	283	27	16	10	1
Wilder	Cecil	-	368	15	0	13	1	0
Kobes	Charlie Lake	E	316	209	15	11	7	1
Buick Creek	Cecil	A	283	204	146	10	7	5
Kobes	Charlie Lake	C	254	189	27	9	7	1
Other Pools			5,377	3,133	2,040	190	111	72
Totals			10,014	6,153	2,639	353	217	93






Upper Charlie Lake Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4500 to 4545
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
1
(Upper & Lower Charlie Lake Assessed together)
2
Deep Basin
1
Southern Foothills
Play area assessed with Pardonnet-Baldonnel-Upper Charlie Lake Play area 3.
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
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4.18 Lower Charlie Lake Formation

Lower Charlie Lake sandstone and carbonate reservoirs occur below the Coplin unconformity. Like the upper Charlie Lake, they consist of thin arid coastline to shallow marine sandstones and restricted to shallow marine carbonates, occurring in highly-correlative stratigraphic successions. The lower Charlie Lake overlies the Halfway Formation with a contact that is generally sharp in the east, but assumes a more interfingering nature to the west as the lower Charlie Lake succession becomes sandier, and grades to more homogeneous marine facies.

Fort St. John Region

Play 1. Peace River Plains Play—Major lower Charlie Lake reservoirs in the Peace River Plains include the Artex, "A" Marker, North Pine, Inga, Farrel, Blueberry and Kobes members. Traps are formed by facies pinchouts, diagenetic boundaries, and erosional truncation by intra- or post-Triassic unconformities (Higgs, 1990; Bird et. al., 1994). Gentle Laramide fold structures may also influence trapping to the west. To the south, block faulting associated with the Peace River Arch / Fort St. John Graben locally plays an important role in trap formation.

Lower Charlie Lake pools are found at Airport, Bear Flat, Beatton River, Beg, Bernadet, Birley Creek, Blueberry, Buick Creek, Cecil Lake, Cypress, Dahl, Doig Rapids, Drake, Eagle, Eagle West, Fireweed, Flatrock, Flatrock West, Fort St. John, Goose, Groundbirch, Gundy Creek, Halfway, Inga, Inga North and South, Mica, Moberly Lake, Monias, Montney, North Pine, Osborne, Pickell, Red Creek, Red Creek North, Saturn, Septimus, Silverberry, Squirrel, Stoddart, Stoddart West, Sunset Prairie, Tommy Lakes, Tower Lake, Velma, Wargen, Wilder, and Zaremba.

Deep Basin Region

Play 1. Peace River Plains Play—Lower Charlie Lake reservoirs can be mapped southward into the Deep Basin region, but are deeply buried and tend to be more diagenetically degraded than to the north. There is also less potential for structural trapping south of the Peace River Arch. However, the primary reason for the lack of discoveries to date is poor well control, particularly as the thin Charlie Lake reservoirs are best identified using intensive stratigraphic mapping. The notable exception is at Brassey, where a gas show in the Artex Member was offset, resulting in discovery of a major oil pool.

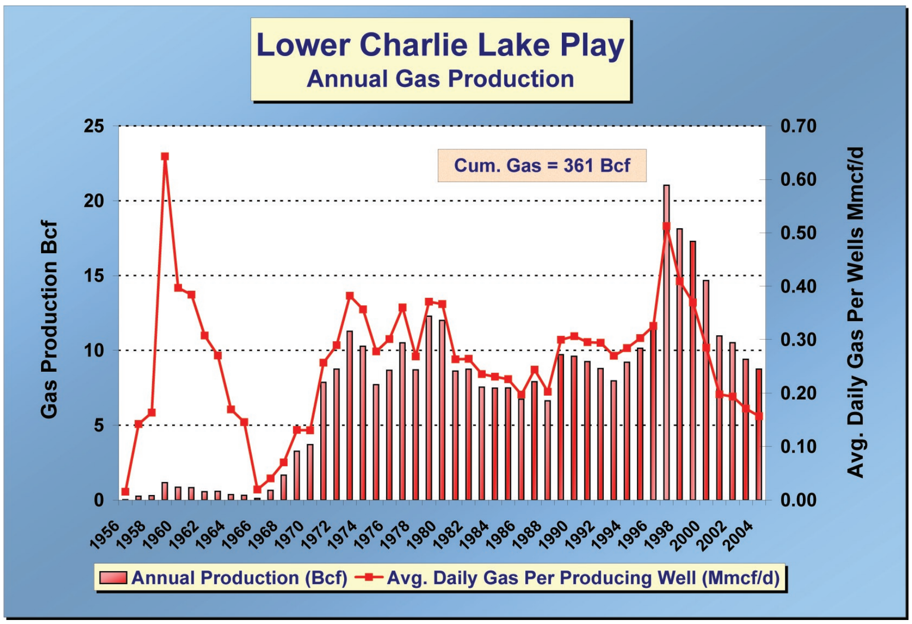
The only producing pool in the lower Charlie Lake in this region is at Brassey.

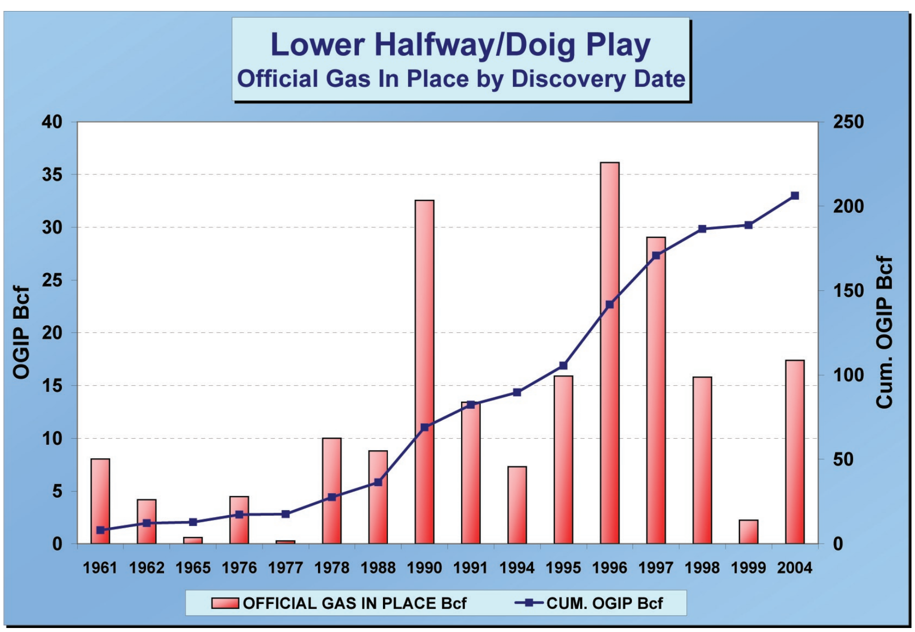
Southern and Northern Foothills Regions

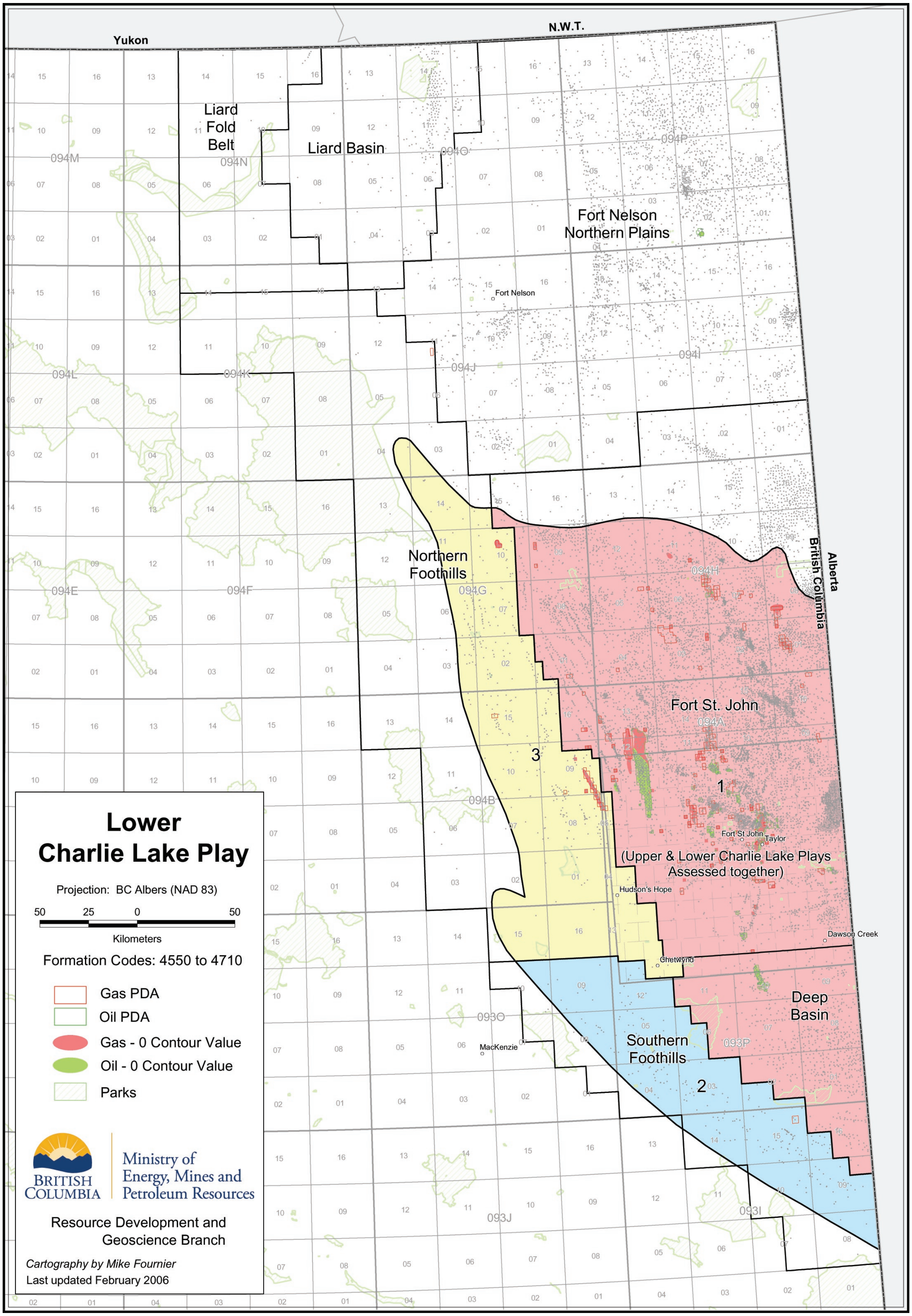
Play 2 & Play 3. Foothills Structural Play—Laramide fold and fault structures play a more important role in defining lower Charlie Lake traps in the Southern and Northern Foothills Regions. The Charlie Lake stratigraphic framework, including depositional and diagenetic trends, is less clearly defined, however, because well control is relatively sparse. Most future discoveries will likely take place in wells targeted for structural closures that happen to encounter a Charlie Lake reservoir unit.

Lower Charlie Lake Foothills production occurs at Cypress, Graham, Kobes, Kobes West, and Thunder Mountain.

Lower Charlie Lake Play - Top 10 Pools by OGIP								
AREA	FORMATION	POOL SEQ	OFFICIAL GAS IN PLACE (MM3)	INIT EST GAS MKT (MM3)	REM GAS MKT (MM3)	OFFICIAL GAS IN PLACE BCF	INIT EST GAS MKT BCF	REM GAS MKT BCF
Inga	Inga	A	4,619	2,982	418	163	105	15
Cecil lake	North Pine	A	1,138	834	172	40	29	6
Buick creek	North Pine	A	536	402	66	19	14	2
Drake	A Marker/Base of Lime	A	385	255	65	14	9	2
Red creek	Bear Flat	A	380	260	91	13	9	3
North pine	North Pine	B	360	269	21	13	9	1
Silverberry	North Pine	A	353	279	0	12	10	0
Buick creek	North Pine	B	339	179	19	12	6	1
Birley creek	A Marker/Base of Lime	A	295	193	162	10	7	6
Fort st john	North Pine	A	294	221	21	10	8	1
Other pools			5,641	2,957	1,709	199	104	60
Totals			14,339	8,830	2,745	506	312	97






Lower Charlie Lake Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4550 to 4710
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
(Upper & Lower Charlie Lake Plays Assessed together)
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
Deep Basin
Southern Foothills
1
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094M
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093I

4.19 Halfway Formation

The Halfway encompasses shallow marine sandstone parasequences, deposited along the western margin of the North American craton in barrier island, shoreface, and tidal inlet channel environments. Halfway reservoir bodies are stratigraphically isolated in updip areas, but pass southwestward into a broad, continuous shelfal sandstone complex.

Halfway sandstones are primarily quartzarenites and sublitharenites, with local bioclastic (shell debris) sandstones and coquinas. Grain sizes generally range from very fine to fine, as most clastic sediment was derived through aeolian transport from the craton. Major cements include silica, carbonates, and anhydrite. The best (and volumetrically dominant) reservoir facies in many pools in the updip "discontinuous Halfway" regime are tidal channel fills. To the south and west in the "continuous" Halfway, reservoir quality generally deteriorates, although secondary solution of lithic and bioclastic grains can create significant reservoir sweet spots.

Fort St. John Region

Play 1. Discontinuous Halfway Barriers and Tidal Channels—In this play area, the Halfway is preserved discontinuously as individual barrier island / shoreface sand bodies, cut by numerous tidal channels (Caplan and Moslow, 1997) (Figure 16). Facies changes provide abundant stratigraphic trapping opportunities, while local structural traps have been created by faulting associated with the Peace River Arch and Fort St. John Graben. The play is bounded updip by the erosional edge of the Halfway, and downdip by the transition to continuous shelfal sandstones.

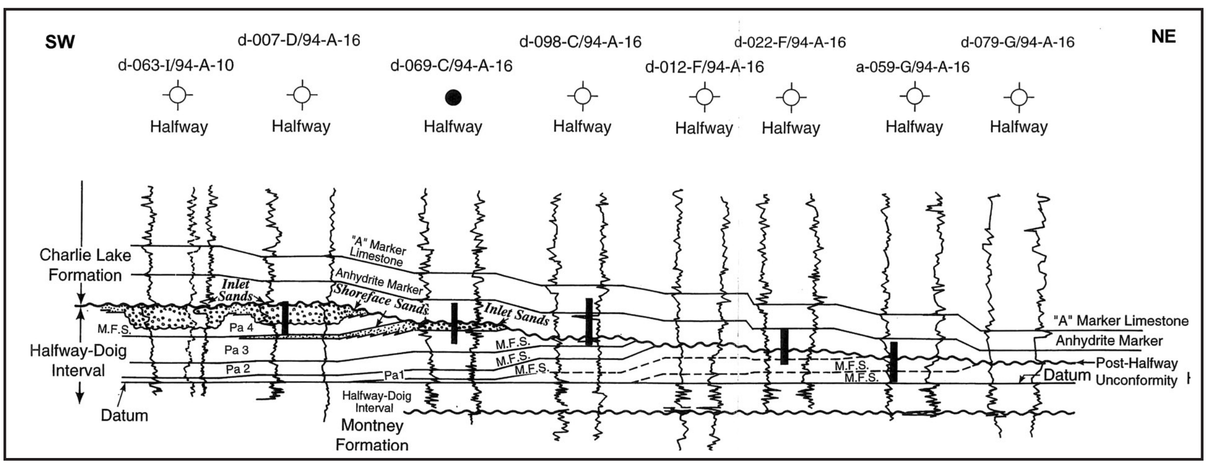


Figure 16. Stratigraphic cross-section at Peejay, illustrating discontinuous preservation of Halfway tidal channel and shoreface sandstone reservoirs (from Caplan and Moslow, 1997).

There are numerous oil and gas pools in the discontinuous Halfway play area, including Beaverdam, Beatton River, Beavertail, Birley Creek, Bulrush, Crush, Currant, Dahl, Doe, Doig Rapids, Drake, Elm, Lapp, Laprise Creek, Martin, Mercury, Milligan Creek, Montney, Muskrat, Nig Creek, Peejay, Pickell, Pluto, Redeye, Silver, Tommy Lakes, Velma, Wargen, Weasel, Wildmint, Wolf, Woodrush, and Zaremba.

Play 2. Continuous Halfway Shoreface – Plains—Halfway reservoirs become more gas-prone moving westward and deeper into the basin, but there are some oil pools in the updip areas of the continuous shoreface regime. Trapping is primarily structural, as illustrated by well-defined block faulting associated with the Fort St. John Graben at Monias, and by outer Foothills anticlinal trends in the Beg-Jedney-Bubbles area (Bird et. al., 1994; Norgard, 1997). However, local thinning and cementation, as well as local development of secondary solution porosity, provide some stratigraphic trapping elements.

Halfway pools over much of the Peace River Block have conventional water legs. To the south, and to the northwest in the outer Foothills, the presence of regional formation water has not been documented, and gas-saturated Deep Basin conditions may exist.

The continuous Halfway shorefaces produces oil and gas at Airport, Altares, Bear Flat, Beg, Bernadet, Birch, Blueberry, Boundary Lake, Bubbles, Buick Creek, Cache Creek, Cecil Lake, Eagle, Fireweed, Flatrock, Fort St. John, Gopher, Halfway, Hunter, Inga, Jedney, Julienne Creek, Monias, Oak, Osborn, Osprey, Paradise, Parkland, Rigel, Septimus, Siphon, Tower Lake, Town, Two Rivers, West Stoddart, Wilder, and Willow.

Deep Basin Region

Play 2. Continuous Halfway Shoreface – Plains—Continuous Halfway shoreface sandstones are found throughout the Deep Basin Region. Burial depths are generally greater and reservoir quality consequently poorer than in the Fort St. John Region, but there are relatively few penetrations and tests. Structural trapping potential is lacking, so any production would likely be from stratigraphic traps related to solution porosity or differential cementation. Insufficient data exist to document the presence of a gas-saturated Deep Basin.

Continuous Halfway sandstones produce gas at Redwillow River, Sundown, and Swan Lake.

Southern Foothills Region

Play 4. Halfway – Foothills—Halfway shoreface sandstones occur throughout the Foothills, thickening and grading westward to finer-grained outcrop equivalents (Liard Formation). Lower Halfway and Doig reservoirs are included as part of this play. Cementation, particularly by carbonates, increases westward, making the Halfway a thick, brittle unit, susceptible to fracturing. In high-relief Foothills structures, fractured Halfway reservoirs can produce gas at high rates. As most Southern Foothills exploration has targeted the Pardonet/Baldonnel, however, the Halfway produces from only a few wells. Considerable Halfway potential therefore remains.

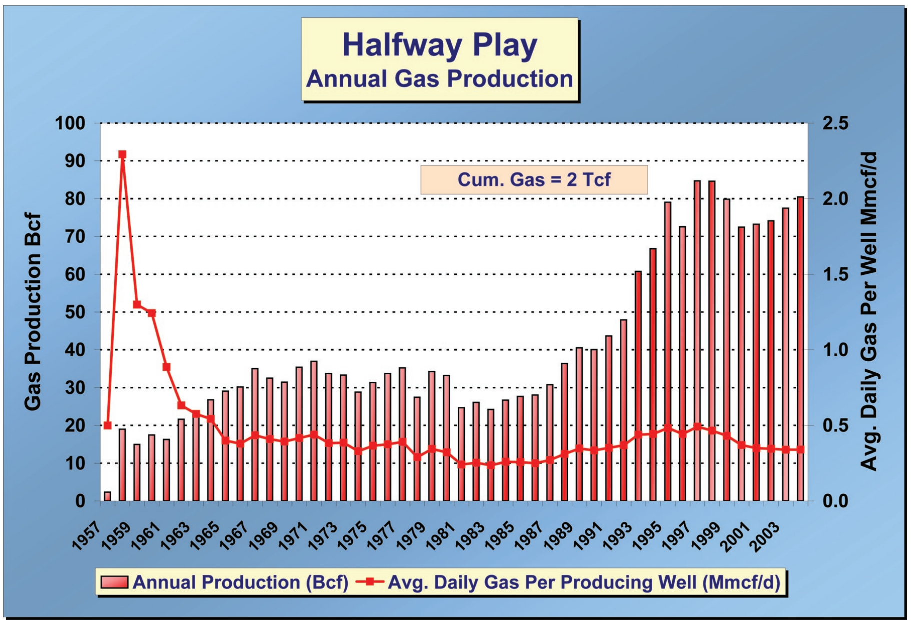
Halfway gas pools occur in the Southern Foothills at Grizzly.

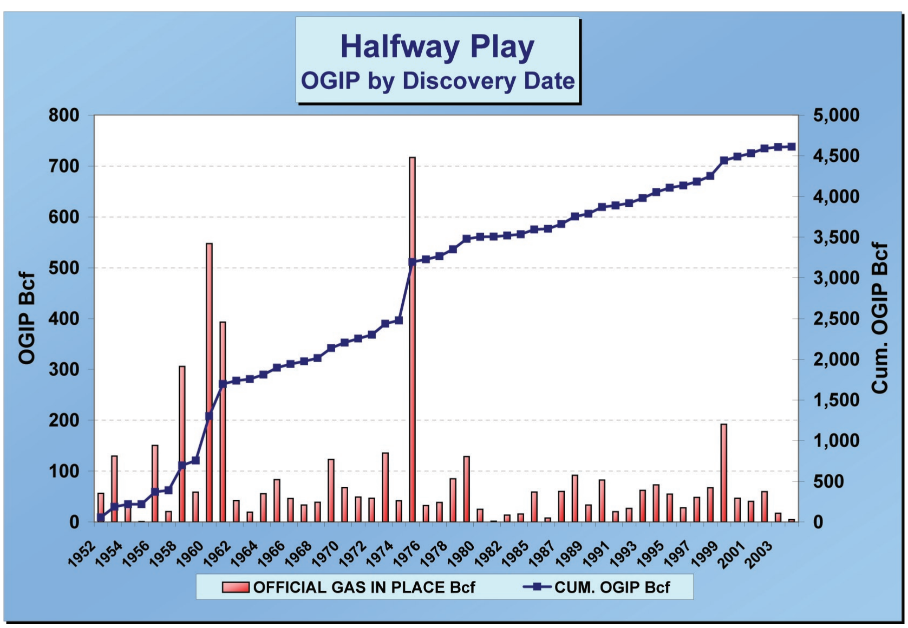
Northern Foothills Region

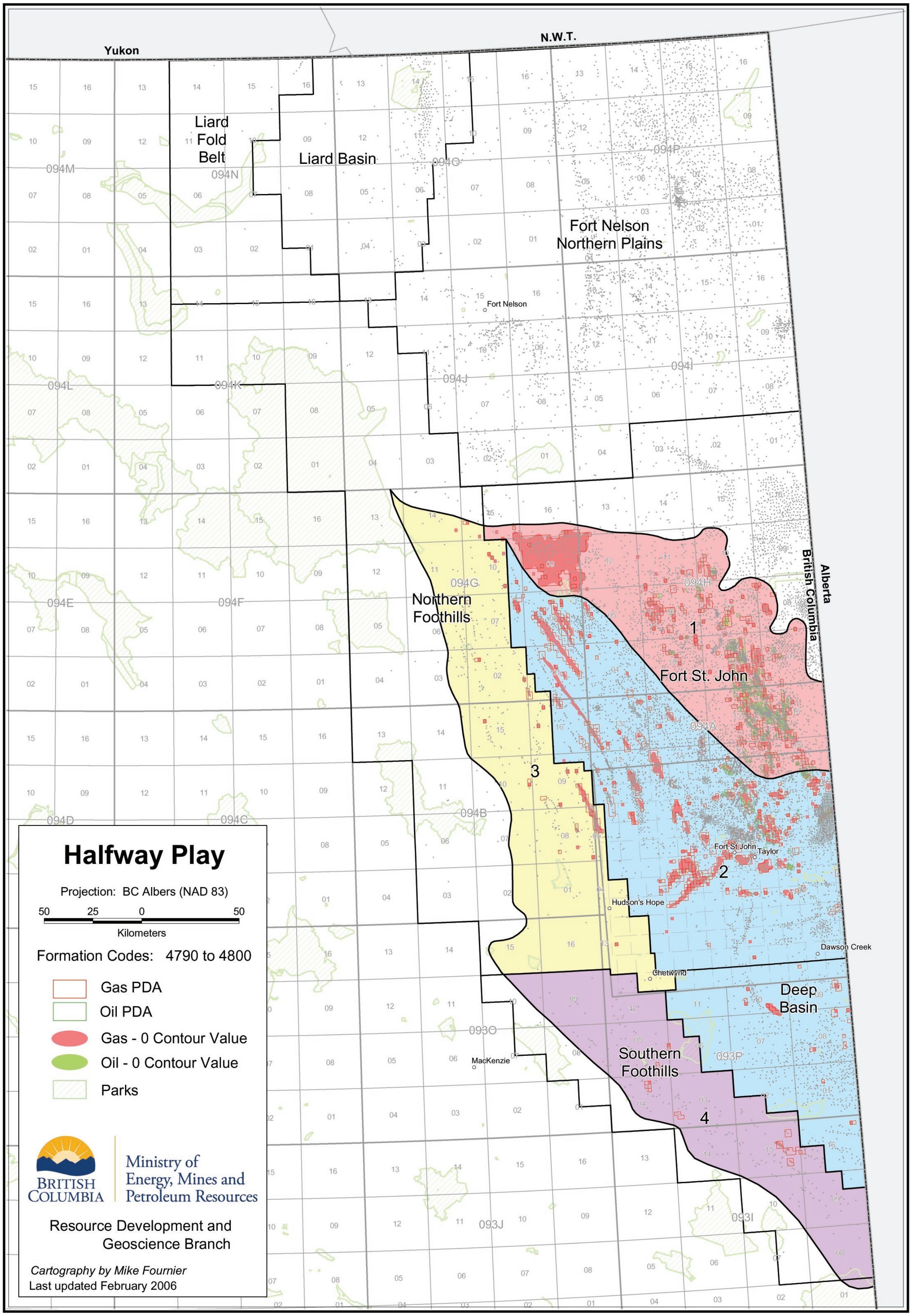
Play 3. Halfway – Foothills—Fractured Halfway (including lower Halfway and Doig) sections are prospective in the Northern Foothills, much as they are in the Southern Foothills, although the formation thins northward towards the northern erosional limit. In the south, west of the Peace River Block, prospective structures have not been defined. To the north, anticlinal closures are more abundant. However, the high-relief structure associated with fractured reservoirs in the south is less pronounced in the north.

Halfway gas pools occur in the Northern Foothills at Cypress, Green Creek, and Kobes.

Halfway Play - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Monias	Halfway	-	20,098	9,801	2,221	709	346	78
Tommy Lakes	Halfway	A	12,517	7,526	4,076	442	266	144
Beg	Halfway	A	7,525	4,785	1,220	266	169	43
Jedney	Halfway	A	7,521	4,829	183	265	170	6
Kobes	Halfway	A	4,100	3,037	305	145	107	11
Wilder	Halfway	A	2,849	1,619	45	101	57	2
Cache Creek	Halfway	A	2,249	1,063	259	79	38	9
Bubbles North	Halfway	A	2,063	832	639	73	29	23
Fort St John	Halfway	A	2,000	1,398	3	71	49	0
Green Creek	Halfway	A	1,962	1,606	1,605	69	57	57
Other Pools			67,719	40,644	20,380	2,391	1,435	719
Totals			130,603	77,140	30,936	4,610	2,723	1,092







Yukon
N.W.T.
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Deep Basin
Southern Foothills
1
2
3
4
Hudson's Hope
Chetwynd
Dawson Creek
Taylor
MacKenzie
British Columbia
Alberta
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I
Halfway Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4790 to 4800
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006

4.20 Lower Halfway / Doig Formations

The Doig and Halfway Formations were deposited within a prograding clastic coastal system along the western margin of the North American craton, in proximal to distal marine environments. They are preserved across the southern Deep Basin and Peace River areas, thinning to a northeasterly subcrop edge. The Doig comprises offshore to lower shoreface shales, siltstones, and sandstones, with thick, cleaner, more proximal sandstones in isolated bodies and linear trends. In places, it is difficult to separate parasequences in the lower part of the Halfway from the Doig, so plays included here may contain some strata genetically related to the Halfway, but lumped lithostratigraphically with the Doig. Westward, Doig and Halfway sandstones cannot be consistently differentiated as the section thickens; consequently, all Halfway and Doig prospects in the Foothills regions are lumped within the Halfway.

Doig exploration and development activity has historically focused upon thick, clean sandstones, which range up to 60 metres thick, and occur in linear trends running approximately north-south (Evoy, 1997). Thick or interbedded mudstone bodies occur within some of these trends. Three depositional settings have been proposed:

- Shelf margin sand bodies, fed by sediment gravity flows off an equivalent Halfway shoreface, and localized by listric normal faulting
- Lowstand shoreface sands, reflecting short-lived falls in relative sea level
- Transgressive barrier to estuarine sands, with associated estuarine mud bodies

Doig sandstones are well-sorted, very fine- to fine-grained sublithic to quartz arenites, with interbedded bioclastic (coquinoid) packstones and grainstones. A complex diagenetic history has produced highly variable reservoir quality.

An emerging tight gas play at Groundbirch has targeted more argillaceous siltstone facies in the Doig, in which small-scale fracturing appears to play a role in generating permeability.

Fort St. John Region

Play 1. Doig Regional Shoreface—Thick Doig sandstone reservoirs produce oil in the northern Peace River Block and northward. To the south, the basal Doig phosphate source rock is more mature, and has charged reservoirs with gas. Trapping is predominantly stratigraphic, controlled by reservoir quality within linear sandstone trends (Evoy and Moslow, 1995) (Figure 17). A gas discovery at Groundbirch in 2003 appears to produce from argillaceous siltstones, but further information is required to assess this play more completely.

The Doig / Lower Halfway produces oil and gas at Beavertail, Bernadet, Blueberry, Boundary Lake, Briar Ridge, Buick Creek, Cache Creek, Fireweed, Groundbirch, Inga, Muskrat, Red Creek, Rigel, Siphon, Tommy Lakes, Weasel, West Stoddart, and Wildmint.

Deep Basin Region

Play 1. Doig Regional Shoreface—The Regional Shoreface Play can be traced southward into the Deep Basin, where there are relatively few penetrations or tests. There are scattered gas shows, and production has recently been established at Swan Lake.

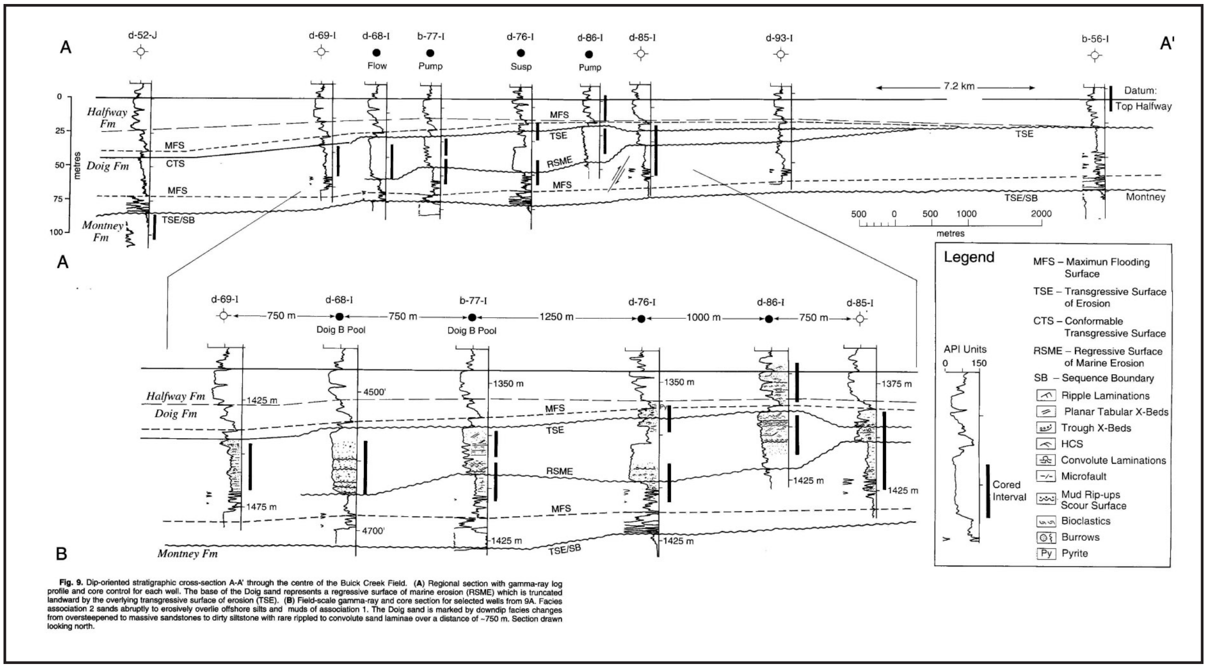
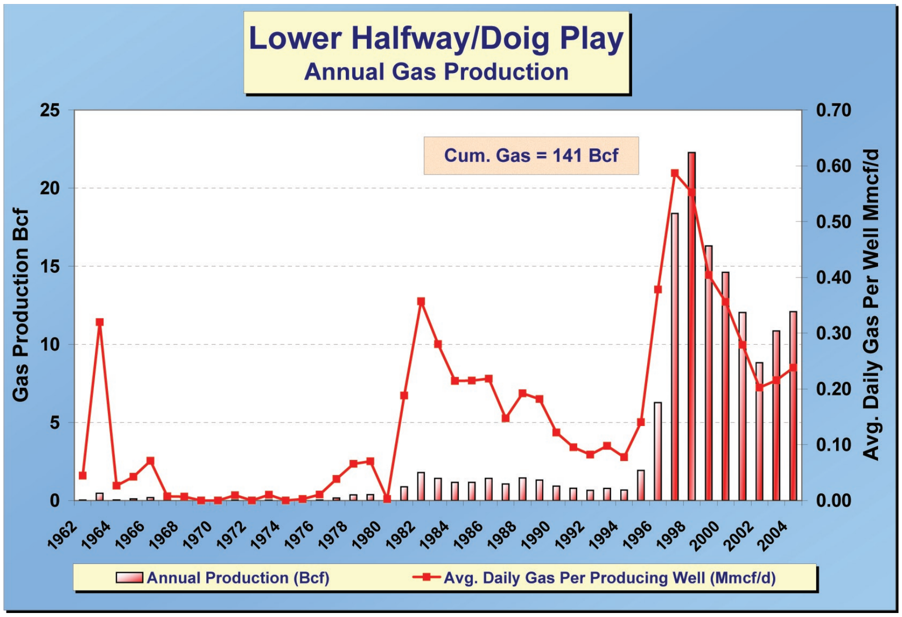
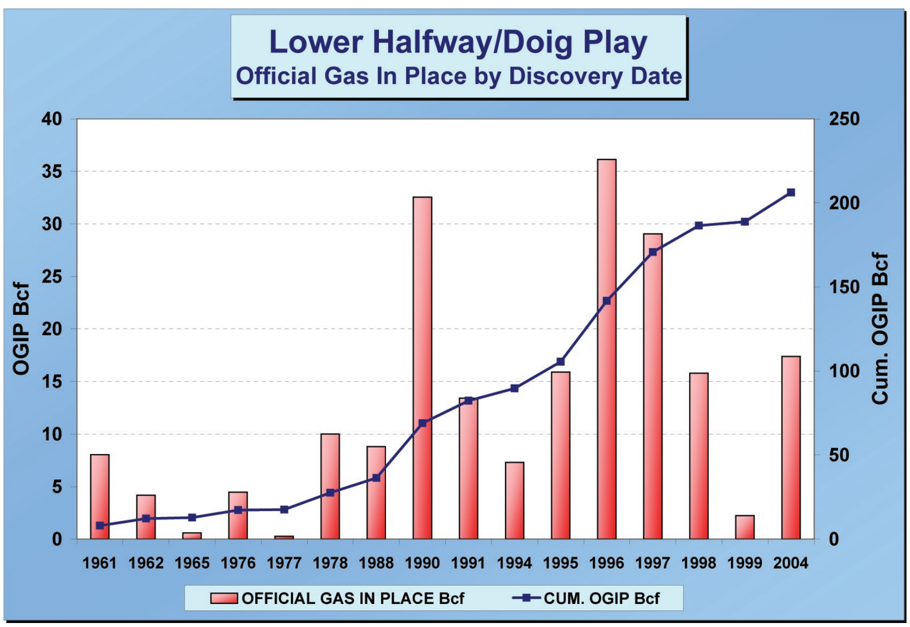
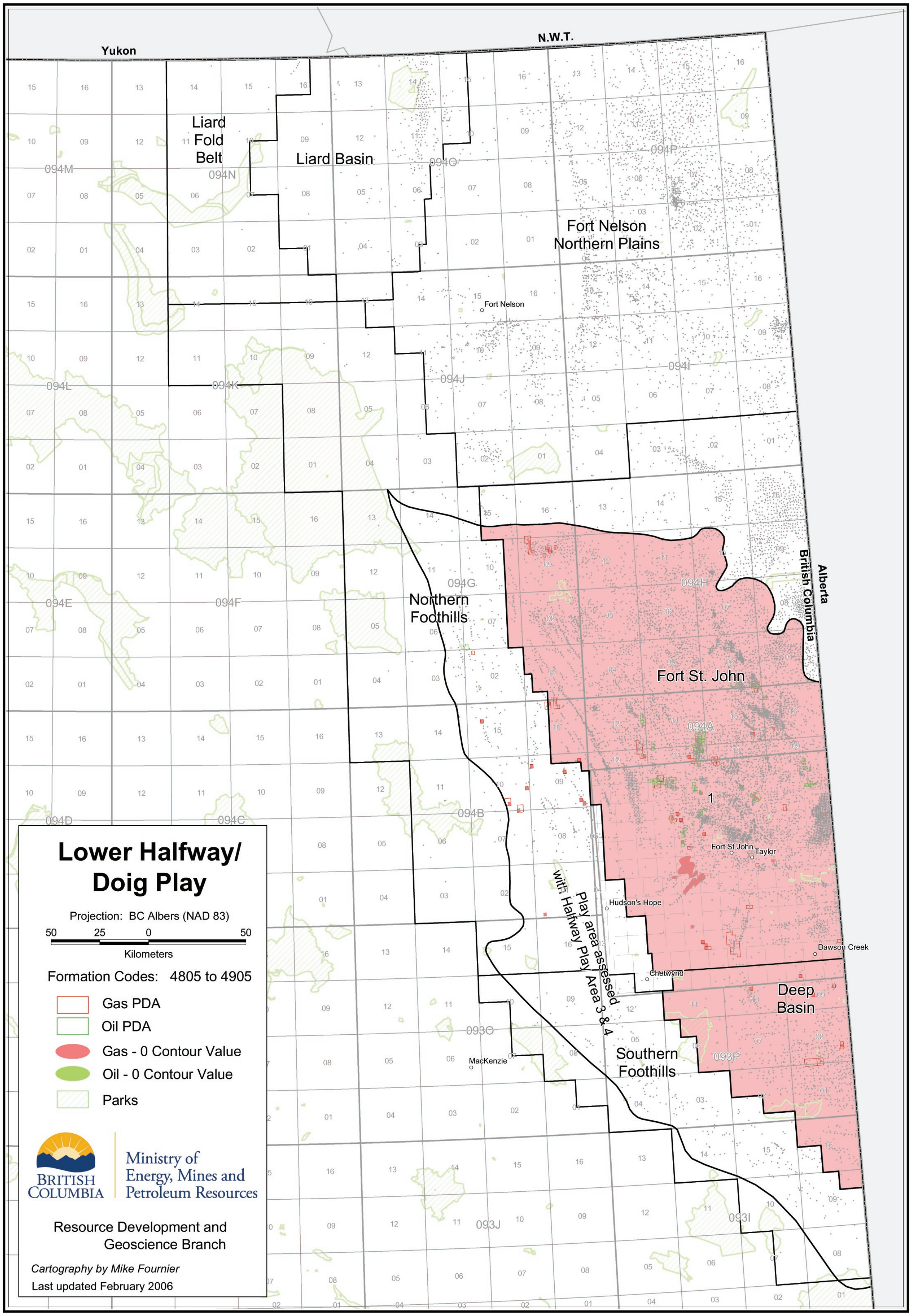


Figure 17. Stratigraphic cross-section at Buick Creek, illustrating clean, blocky Doig sandstone reservoirs, deposited above a regressive surface of marine erosion (RSME), and overlain by a transgressive surface of erosion (TSE) (from Evoy and Moslow, 1995).

Lower Halfway Doig Play Pool List - Top 10 Pools by OGIP									
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Stoddart West	Doig	E	742	354	466	26.2	12.5	16.5
Buick Creek	Lower Halfway	C	586	394	230	20.7	13.9	8.1
Brassey	Doig	A	490	374	366	17.3	13.2	12.9
Buick Creek	Lower Halfway	E	331	169	214	11.7	6.0	7.6
Siphon	Doig	A	312	230	229	11.0	8.1	8.1
Buick Creek	Lower Halfway	D	292	192	128	10.3	6.8	4.5
Cache Creek	Doig	A	282	0	0	9.9	0.0	0.0
Cache Creek	Doig	D	260	83	78	9.2	2.9	2.8
Buick Creek	Lower Halfway	B	248	141	66	8.8	5.0	2.3
Tommy Lakes	Doig	A	234	178	126	8.2	6.3	4.4
Other Pools			2031	1206	1326	71.7	42.6	46.8
Totals			5,808	3,322	3,229	205	117	114


Lower Halfway/Doig Play
Annual Gas Production
Cum. Gas = 141 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
25
20
15
10
5
0
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Lower Halfway/Doig Play
Official Gas In Place by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
40
35
30
25
20
15
10
5
0
250
200
150
100
50
0
1961
1962
1965
1976
1977
1978
1988
1990
1991
1994
1995
1996
1997
1998
1999
2004
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Lower Halfway/ Doig Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4805 to 4905
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Fort St John
Taylor
Hudson's Hope
Chetwynd
Dawson Creek
Deep Basin
Southern Foothills
MacKenzie
Play area assessed with Halfway Play Area 3 & 4
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.21 Montney Formation

Montney strata accumulated on a broad continental ramp on the western flank of the North American craton. They comprise stacked, prograding highstand parasequences, interrupted by a medial transgressive event (Davies et. al., 1997). Aeolian processes provided most of the sediment supply. Shoreface to subtidal facies in the east grade westward to more argillaceous basinal facies, cut by turbidite deposits associated with lowstand events (Figure 18). Major structural features, particularly within the Fort St. John Graben, exerted considerable influence upon transport and deposition of turbidite facies (Moslow and Davies, 1997).

Montney reservoirs are predominantly coarse siltstones to very fine-grained sandstones, with true shales being relatively rare. Shoreface sandstones and associated dolomitic coquinas in the east exhibit good conventional reservoir quality. Lower shoreface to shelfal equivalents of the uppermost parasequences, however, are buried sufficiently deeply in the west to form sand-dominated but low-permeability reservoirs.

Montney turbidite reservoirs exhibit both turbidite channel and lobe facies associations in densely-developed pools in west-central Alberta (Moslow and Davies, 1997). Modest reservoir quality in west-central Alberta is expected to become poorer westward, although gas production has now been extended into northeasternmost 93-P in B.C.

Fort St. John Region

Play 1. Subcrop Edge – Proximal Sandstone Play—Clean sandstones deposited in proximal shoreface environments host large gas pools in subtle stratigraphic / structural traps. Reservoir quality is very good to excellent where enhanced by shallow burial depths and solution of labile grains and cements beneath the pre-Cretaceous unconformity. The Montney subcrop edge forms the updip boundary of the play trend, while Cretaceous marine shales provide a regional top seal along the subcrop edge of individual reservoir sandstones (Fig. MONT1). Downdip, proximal sandstones grade to lower-quality, more distal facies, but the boundary has not been mapped in detail.

Montney proximal sandstone reservoir produce gas at Chinchaga River, Dahl, Kahntah River, and Ring.

Play 2. Distal Shoreface and Turbidite Plays—Oil and gas production from Montney turbidite channels and lobes is well established in west-central Alberta. Outcrop equivalents in the B.C. Foothills allow the play fairway to be extrapolated across the southern Fort St. John and Deep Basin Regions. To date, however, only a small number of gas wells have been drilled in B.C., immediately along the Alberta border. Reservoir quality is expected to become poorer with greater burial depth, but there are very few penetrations or tests to test this assumption.

Heterolithic middle to lower shoreface strata at the distal margin of nearshore sandstone bodies in the upper Montney produce from scattered wells in west-central Alberta, but are currently being developed systematically at Dawson Creek. Reservoir and trapping controls on this play type are not well understood.

The distal shoreface and turbidite play is productive at Dawson Creek, Flatrock, and Saturn.

Deep Basin Region

Play 2. Distal Shoreface and Turbidite Plays—Turbidite plays are expected to be prospective across the Deep Basin Region, linking to outcrop analogues in the B.C. Foothills. Although the parameters of distal shoreface production are not well understood, it is expected this play will become less prospective westward, away from paleo-shoreline sand supply.

Montney turbidites produce gas at Cutbank and Swan Lake in the Deep Basin Region.

Fort Nelson Northern Plains Region

Play 1. Subcrop Edge – Proximal Sandstone Play—The Montney subcrop edge can be mapped northwestward, but prospective proximal sandstone reservoirs become less common, as the subcrop edge appears to deviate westward from the overall Montney paleoshoreline trend. There are no pools producing from this play in the Fort Nelson Region.

Liard Basin Region

Play 3. Toad / Grayling Play—Distal Montney equivalents in the Liard Basin have been mapped as the Toad and Grayling Formations. Fine-grained marine sandstones and siltstones have been noted to occur, and some have tested gas at low flow rates. However, prospective reservoir trends have not been outlined, and there is no production.

Southern and Northern Foothills Regions

Play 4. Distal Turbidite / Foothills Play (Conceptual)—As Montney-equivalent turbidite facies have been noted in outcrop, it is expected that more proximal turbidites may retain economic reservoir quality where optimally developed in the Southern and Northern Foothills Regions. High-relief Foothills structure may assist in generating natural fractures in the reservoir, thus elevating deliverability. However, neither production nor shows have been noted from the Montney in these regions.

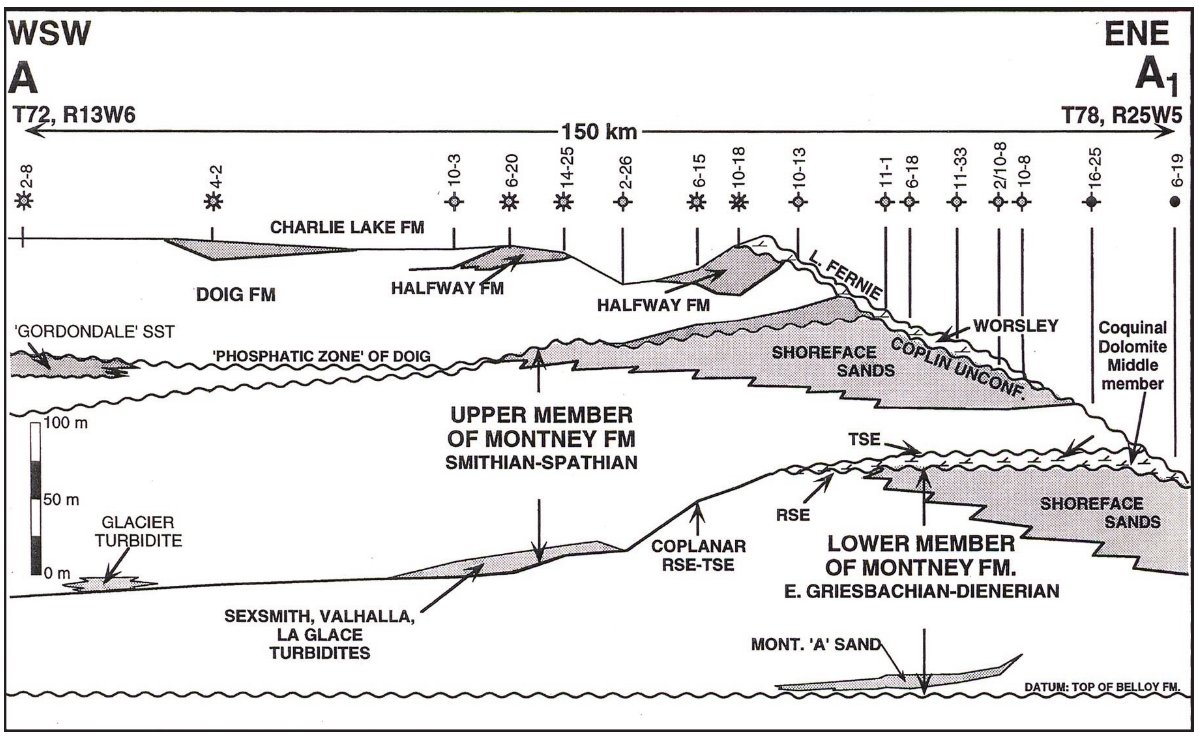
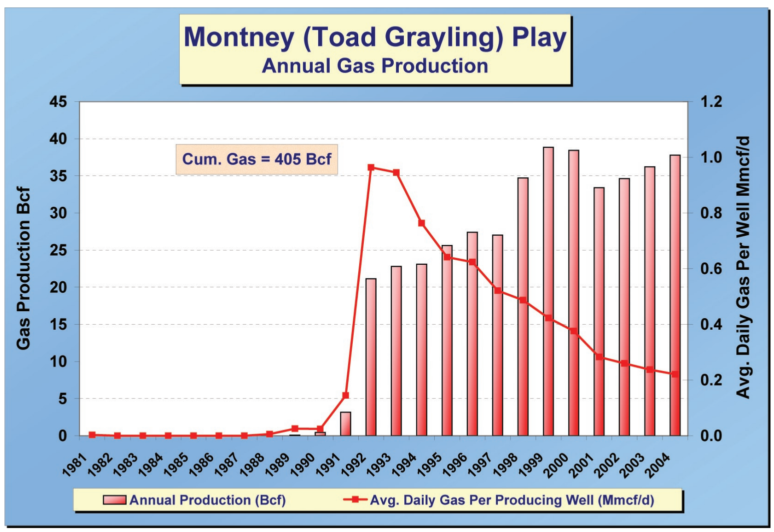
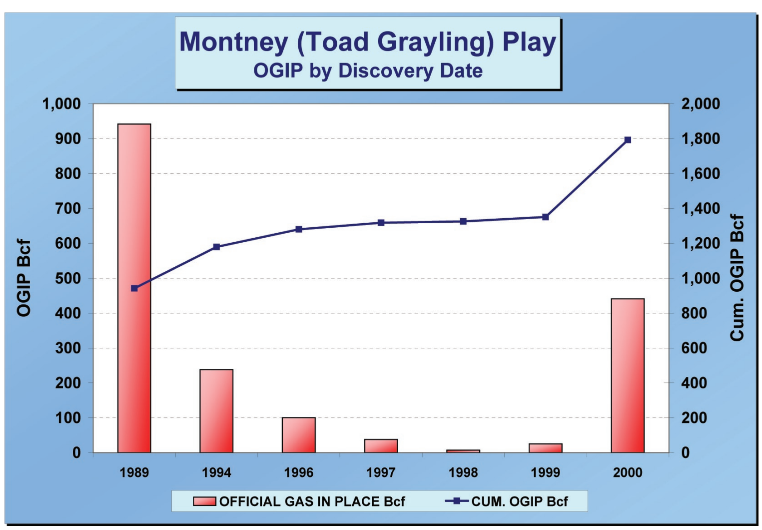
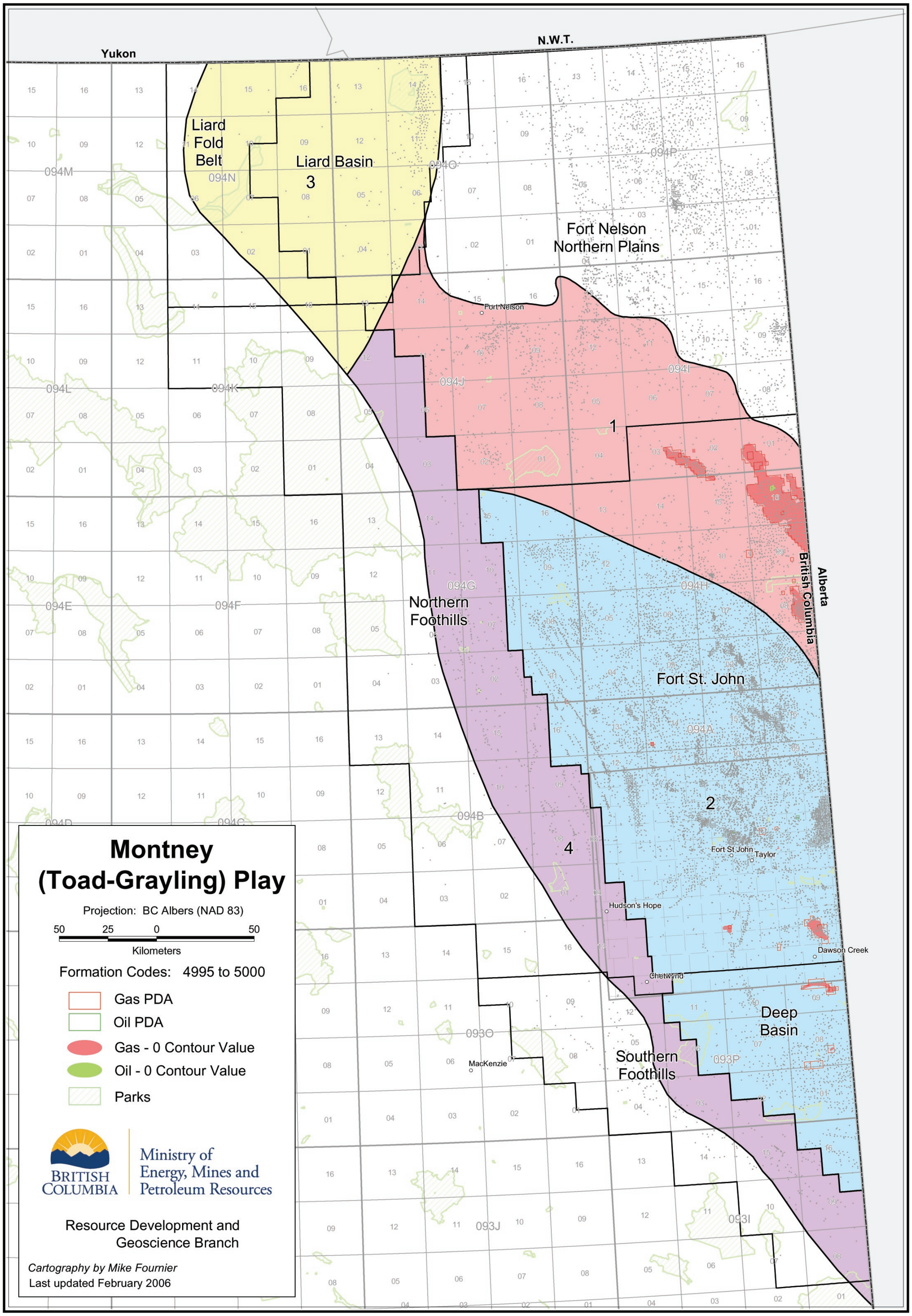


Figure 18. Schematic regional cross-section, Montney Formation (from Moslow and Davies, 1997). Shoreface sandstone reservoirs to the east produce in the Subcrop Edge – Proximal Sandstone Play in the Fort St. John and Fort Nelson Regions. Further basinward, distal shoreface (not specified) and turbidite sandstone plays are current exploration targets in B.C.

Montney (Toad Grayling) Play - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Ring	Bluesky-Gething-Montney	A	26,684	18555	11536	942	655	407
Dawson Creek	Montney	A	10,220	3345	3175	361	118	112
Chinchaga River	Lower Charlie Lake/ Montney	A	4,422	2800	2081	156	99	73
Kahntah River	Bluesky-Gething-Montney	A	1,275	731	688	45	26	24
Chinchaga River	Bluesky-Gething-Detrital	A	1,238	697	215	44	25	8
Kahntah River	Montney	A	1,076	616	240	38	22	8
Flatrock West	Montney	A	295	187	185	10	7	7
Dahl	Montney	A	252	166	69	9	6	2
Flatrock	Montney	A	207	83	83	7	3	3
Cutbank	Montney	A	198	146	146	7	5	5
Other Pools			4,900	2,850	2,524	173	101	89
Totals			50,767	30,175	20,942	1,792	1,065	739






Montney
(Toad-Grayling) Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 4995 to 5000
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
3
Fort Nelson Northern Plains
Fort Nelson
1
Northern Foothills
Fort St. John
2
4
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
Southern Foothills
MacKenzie
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4.22 Belloy / Taylor Flat / Fantasque Formations

Upper Carboniferous through Permian strata of the Belloy / Taylor Flat / Fantasque succession exhibit highly variable depositional patterns and lithologies throughout northeastern British Columbia. Although each formation is bounded by unconformities, regional correlations are generally questionable because of a lack of well and core control. Only the Belloy has been systematically explored.

The Taylor Flat accumulated within the Peace River Embayment as a poorly-developed carbonate ramp (Barclay et. al., 1990). Reservoir facies are relatively small skeletal carbonate and fine-grained sandstone bodies. The overlying Belloy Formation is best developed in the Peace River Embayment / Fort St. John Graben. It consists of several stacked regressive sequences, grading from siltstones and fossiliferous carbonates typical of outer shelf to distal carbonate platform settings in the west, eastward to shoreface and tidal to fluvial channel sandstones and dolostones (Leggett et. al., 1993). Reservoir quality is best developed on the embayment margins, where the section consists primarily of cleaner, better-sorted sandstones (Figure 19). The Fantasque Formation is recognized primarily in the north, where it consists of bedded cherts, shales, and siltstones; these rocks are generally highly siliceous, with poor reservoir quality (Henderson, 1989).

Prospectivity in the Belloy / Taylor Flat / Fantasque succession is focused within and on the margins of the Fort St. John Graben, where economic reservoir quality is reasonably consistently developed.

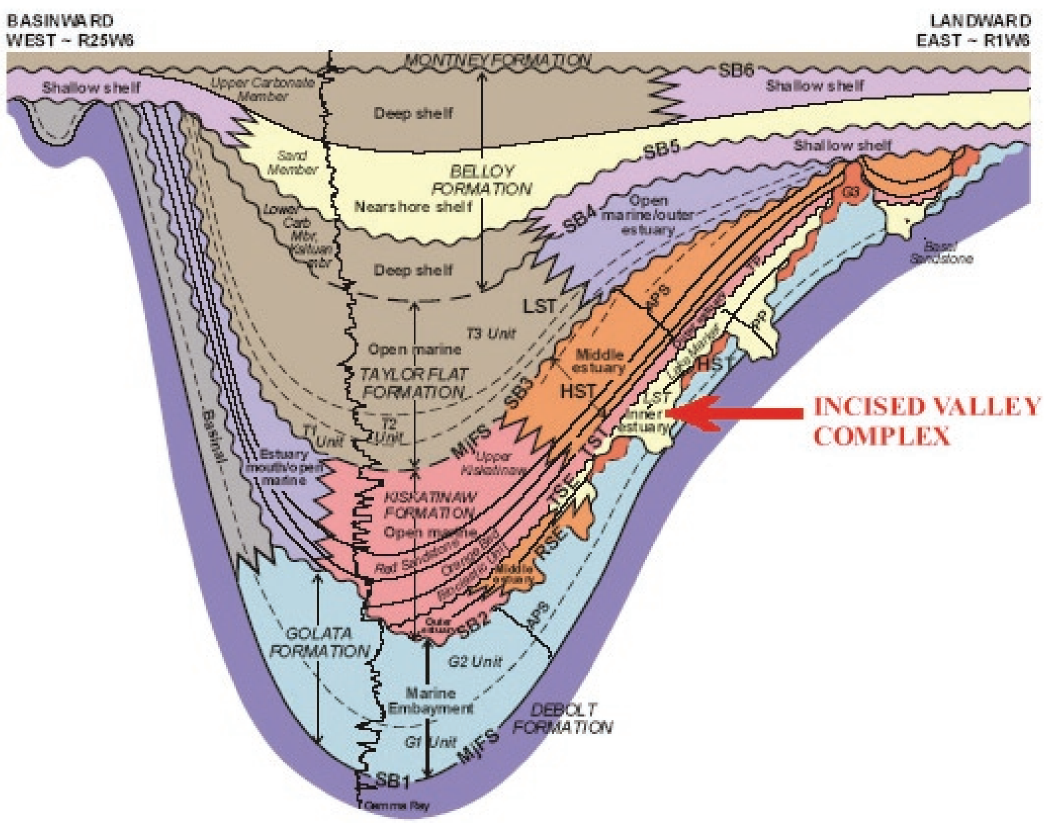


Figure 19. Schematic regional cross-section of Carboniferous – Permian strata across Fort St. John Graben area (from Barclay et. al., 2002). Belloy reservoirs are best developed in shallow marine sandstone and carbonate units deposited on the flanks of the graben complex. Taylor Flat strata consist of open marine carbonate and fine clastic strata, with relatively poor and discontinuous reservoir development. Fluvial to estuarine sandstones of the Kiskatinaw are locally important reservoirs.

Fort St. John Region

Play 1. Fort St. John Graben Play—Belloy and Taylor Flat reservoir section are fully developed within the Fort St. John Graben. Production and prospectivity occur primarily in shallow marine sandstone and carbonate reservoirs of the upper Belloy, in structural traps associated with block faulting. Channel-fill sandstones generally exhibit the best reservoir quality (Leggett et. al., 1993). Erosional relief at the upper unconformable contact locally plays a role in trapping, particularly in relatively thin sandstones at the margin of the graben complex. Reservoir quality is affected locally by variations in cementation. Overlying Triassic shales provide effective seals.

Taylor Flat and Belloy strata are not consistently correlated or distinguished, and there is likely some Taylor Flat production incorrectly assigned to the Belloy. In general, however, Taylor Flat reservoirs produce from small stratigraphic and faulted structural traps.

North of the Fort St. John Graben, Belloy strata are patchily distributed, with variable but poor reservoir quality, and are generally regarded as non-prospective (area 10 on play map).

Belloy and Taylor Flat production occurs at Airport, Bear Flat, Blueberry West, Boudreau, Boundary Lake, Eagle, Eagle West, Flatrock, Fort St. John, Fort St. John Southeast, Mica, Monias, Osborn, Parkland, Red Creek South, Ring, Stoddart, Stoddart West and South, Two Rivers, and Wilder.

Southern and Northern Foothills, Liard Fold Belt Regions

Play 2 & Play 3. Foothills Play—Upper Carboniferous and Permian strata produce from primarily structural traps in the Southern and Northern Foothills. Stratigraphic correlations become questionable as the section thickens westward, and well and core control become more scarce. Mattson and Kiskatinaw equivalent strata are included in this play, as they are not reliably differentiated.

Recent exploration in the Southern Foothills appears to be focused on fractured reservoirs developed over high-relief structures, analogous to the fracture-dominated Bullmoose-Sukunka play in the Pardonet / Baldonnel. In the Northern Foothills, pools are isolated, although some production may be mis-assigned to the underlying Debolt Formation. In the Liard Fold Belt, reservoir quality in the cherty Fantasque Formation is highly suspect, although there is conceptual fractured reservoir potential.

Foothills production is found at Grizzly South, Gwillim, Lily Lake, Ojay, and Sukunka.

Deep Basin Region

Play 4. Deep Basin Play (Conceptual)—South of the Fort St. John Graben, the Belloy / Taylor Flat section retains appreciable thickness, but is very poorly understood, as there are very few penetrations. Prospectivity may occur in stratigraphic traps, with structural elements toward the Foothills in the west. Reservoir quality is a substantial risk because of extreme burial diagenesis and a predominance of fine-grained, distal facies.

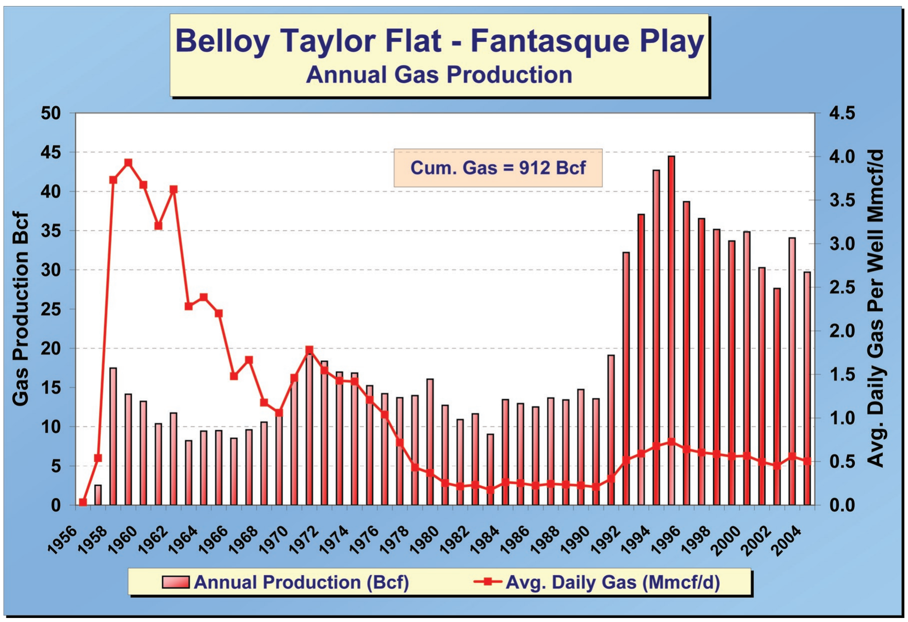
There is no known production in this play, and prospectivity is conceptual.

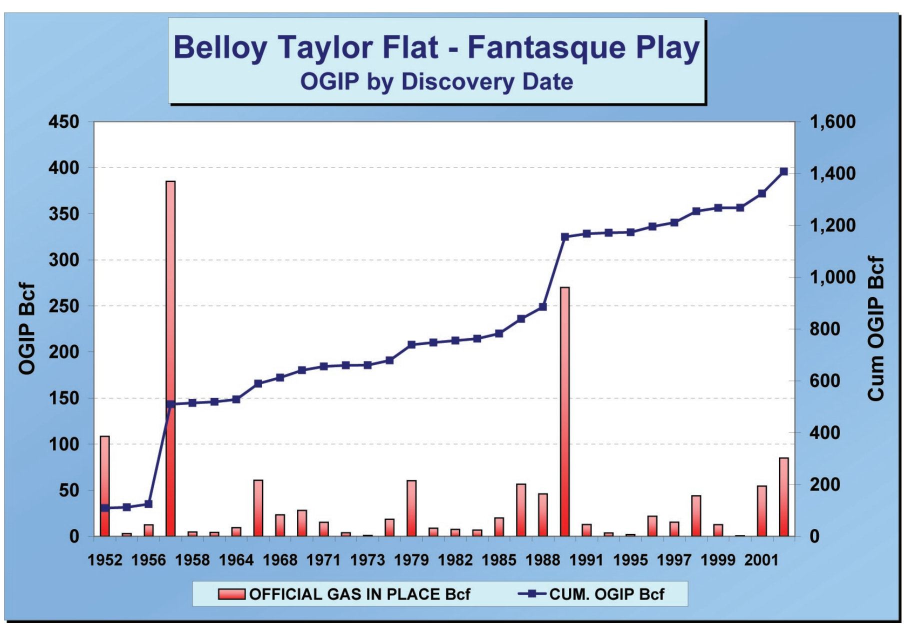
Liard Basin Region

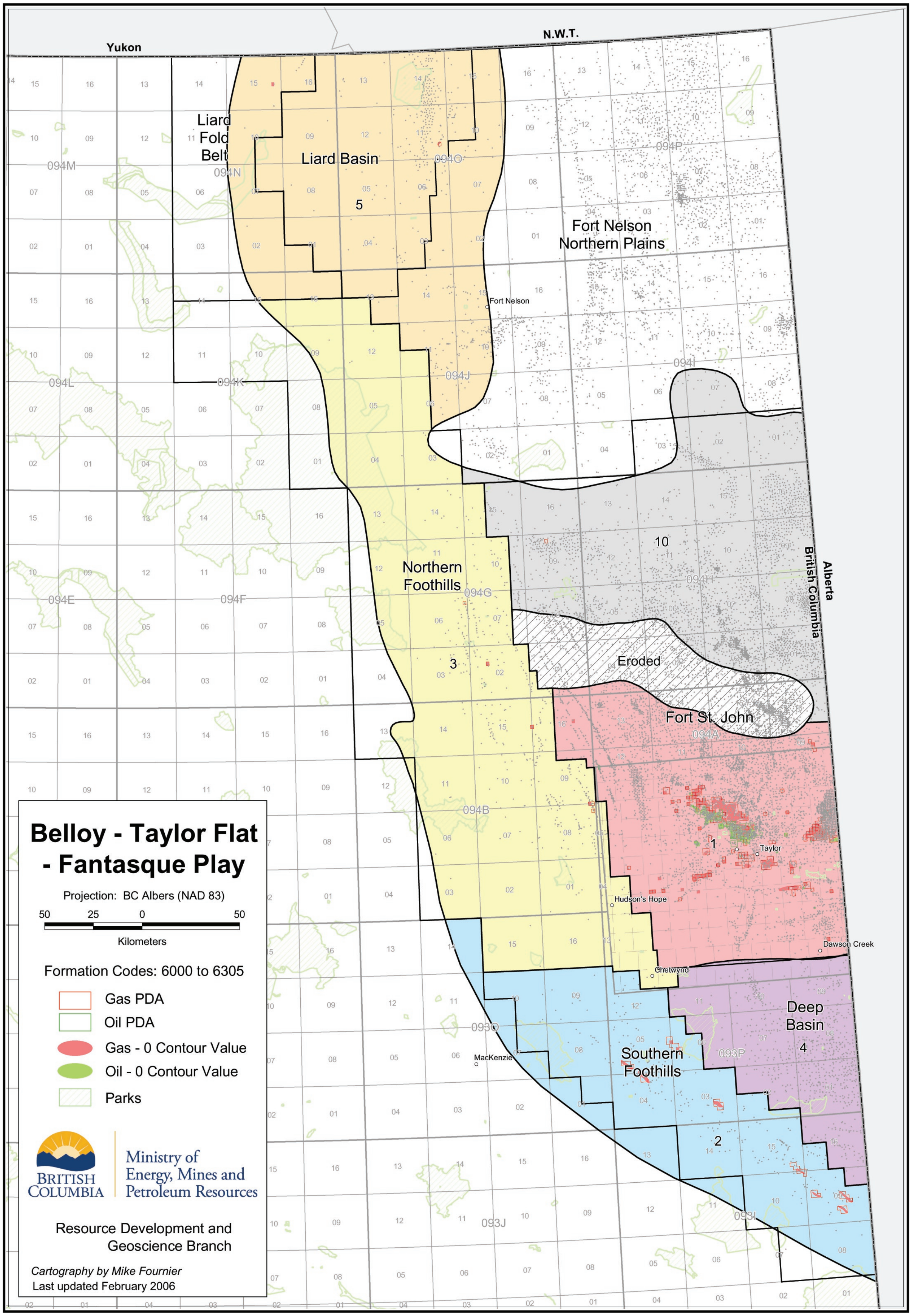
Play 5. Fantasque / Liard Basin Play—Thin (up to 50 metres) cherts, shales, and siltstones of the Fantasque occur as an unconformity-bounded package across the Liard Basin, and lap into the surrounding Liard Fold Belt and Fort Nelson Northern Plains regions. Prospectivity is judged to be very low because of poor reservoir quality, although fractured reservoir quality may be associated with structure locally.

One pool produces at Windflower, along the faulted eastern margin of the Liard Basin.

Belloy-Taylor Flat-Fantasque Play - Top 10 Pools by OGIP									
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Stoddart	Belloy	A	10,911	8,145	681	385	288	24
Boundary Lake	Belloy	J	4,380	3,463	613	155	122	22
Fort St John Se	Belloy	A	2,536	2,009	82	90	71	3
Ojay	Taylor Flat	C	1,545	1,165	1,133	55	41	40
Boundary Lake	Belloy	I	1,479	1,242	127	52	44	4
Boundary Lake	Belloy	B	1,315	1,099	196	46	39	7
Boundary Lake	Belloy	K	1,282	1,068	83	45	38	3
Grizzly South	Taylor Flat	A	1,257	582	582	44	21	21
Ojay	Taylor Flat	A	1,244	836	693	44	30	24
Stoddart West	Belloy	A	1,170	779	28	41	28	1
Other Pools			12,732	8,337	5,122	449	294	181
Totals			39,851	28,725	9,339	1,407	1,014	330







Yukon
N.W.T.
Liard Fold Belt
Liard Basin
5
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
3
10
Eroded
Fort St. John
1
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
4
Southern Foothills
2
MacKenzie
British Columbia
Alberta
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094B
094A
093O
093P
093J
093I
Belloy - Taylor Flat - Fantasque Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 6000 to 6305
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006

4.23 Mattson / Kiskatinaw Formations

The Mattson Formation is a thick section of sandstones with minor shales and coals, deposited in deltaic to prodeltaic environments. Its depocentre is in the southwestern District of Mackenzie, from which it grades westward to basinal shales of the Besa River Formation, and southward to more carbonate-rich, fine-grained strata of the Stoddart Group (Richards, 1989). However, it has not been described in detail in the subsurface. The Mattson truncates abruptly against the Bovie Lake Structure in the east, and thus is confined to the Liard Basin and adjacent fold belt.

In the Peace River Plains area, the Kiskatinaw Formation was deposited in the Peace River Embayment in a variety of fluvial, estuarine, and marginal marine environments (Barclay et. al., 2002). Normal faulting associated with formation of the Fort St. John Graben provided structural relief and influenced depositional patterns. Fluvial to estuarine channel fill sandstones are the primary reservoirs in the Kiskatinaw.

Fort St. John Region

Play 1. Kiskatinaw – Peace River Embayment—Kiskatinaw sandstones occur in a variety of fluvial, estuarine, and marginal marine settings, and produce gas from a number of pools (Barclay et. al., 2002) (Figure 19, page 90). Normal faulting in the Fort St. John Graben had a large influence on depositional geometries and later trap formation (Figure 20). Thus, although depositional systems can be mapped continuously through the area, individual pools tend to be relatively small and isolated because of intricate fault control. Reservoir quality is variable, primarily because of local diagenetic degradation.

The play area is bounded to the north by the depositional limit of the Kiskatinaw. A southern boundary has not been defined, in part due to scanty well control. The westerly extent of the Kiskatinaw depositional system has not been defined.

The Kiskatinaw produces gas at Alces, Attachie, Bear Flat, Briar Ridge, Boundary Lake, Doe, Eagle, Eagle West, Flatrock West, Mica, Monias, Paradise, Parkland, and Two Rivers. There is one oil pool at Stoddart South.

Deep Basin Region

Play 1. Kiskatinaw – Peace River Embayment—Kiskatinaw sandstones generally thin southward from the axis of the Fort St. John Graben, but a southerly boundary has not been defined, largely as the result of poor well control.

The Kiskatinaw produces gas at Swan Lake.

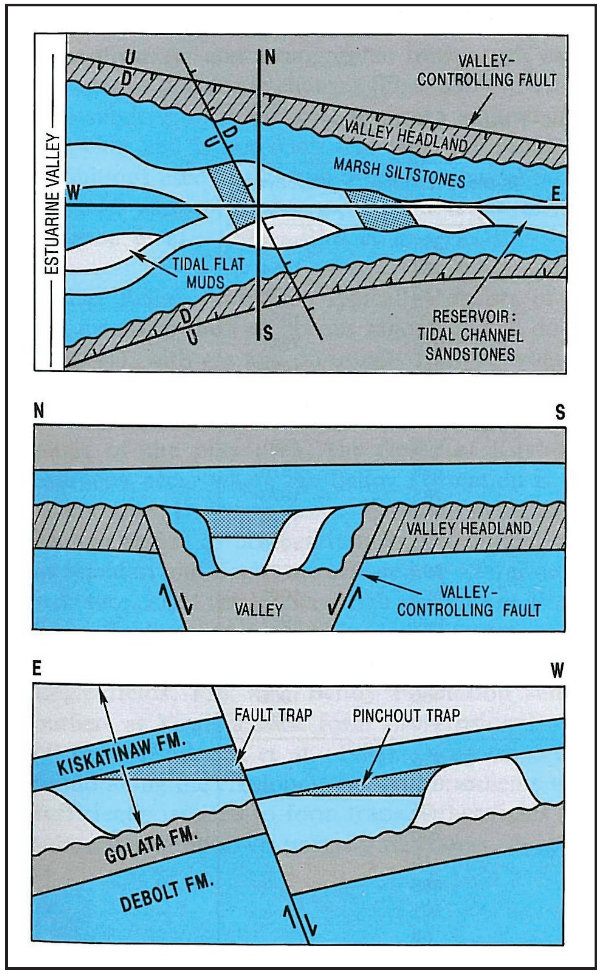


Figure 20. Normal faulting within the Fort St. John Graben complex played an important role in deposition of Kiskatinaw tidal/estuarine reservoir sandstones, and in formation of structural traps (from Barclay et. al., 1997).

Liard Basin and Liard Fold Belt Regions

Play 2. Mattson – Liard Basin / Fold Belt Play—Deltaic and prodeltaic sandstones prograding southwestward demonstrate good reservoir quality along the northern flank of the Liard Basin and Fold Belt Regions, and locally along the Bovie Lake Structure in the east. Fault traps are developed locally along the Bovie Lake Structure (Figure 21), and in larger-scale Laramide folds in the Liard Fold Belt. Poor well control precludes systematic mapping of stratigraphic trap potential in the central part of the Liard Basin. Locally, however, reservoir degradation by silica cementation and pyrobitumen has been observed.

Mattson sandstones produce gas at Beaver River, Maxhamish Lake, Tattoo, and Windflower.

Southern and Northern Foothills Regions

Mattson / Kiskatinaw prospectivity in these regions is included in the assessment of Belloy / Taylor Flat plays, as the stratigraphic intervals have not been reliably differentiated.

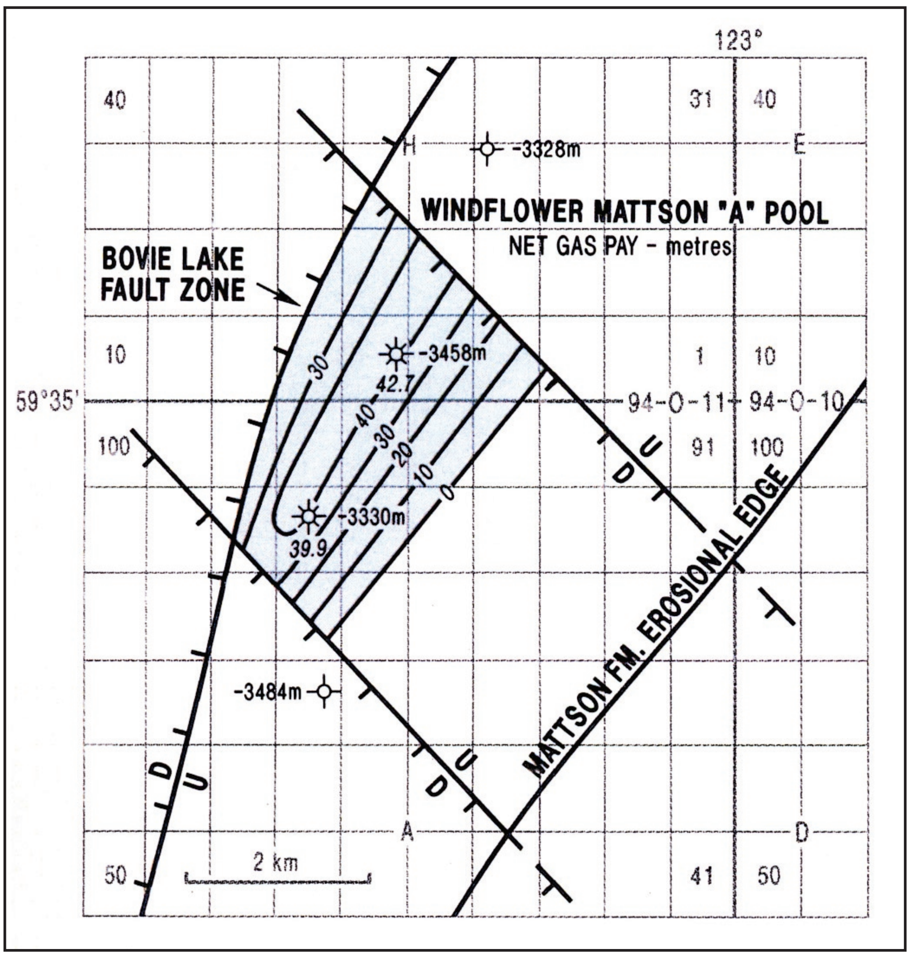
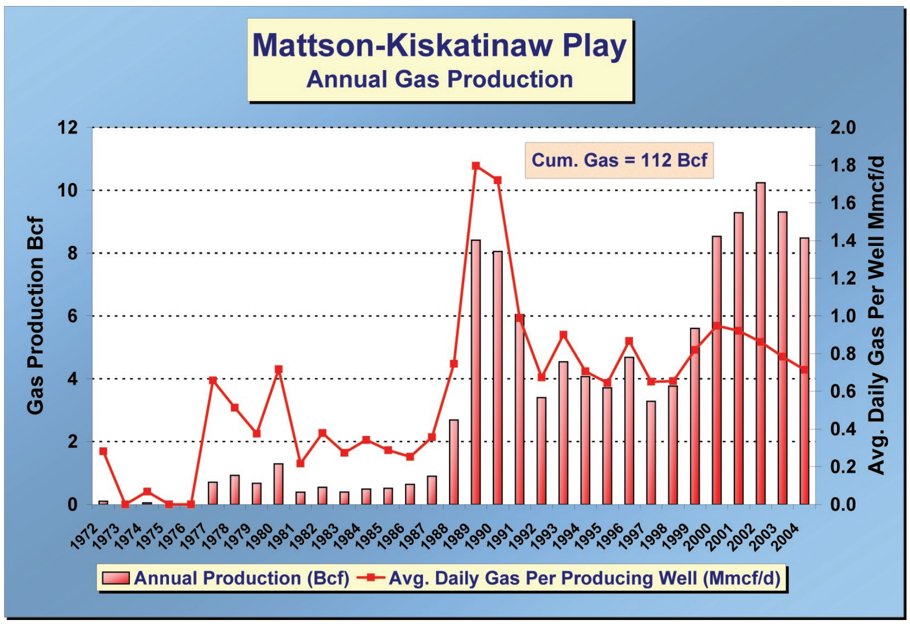
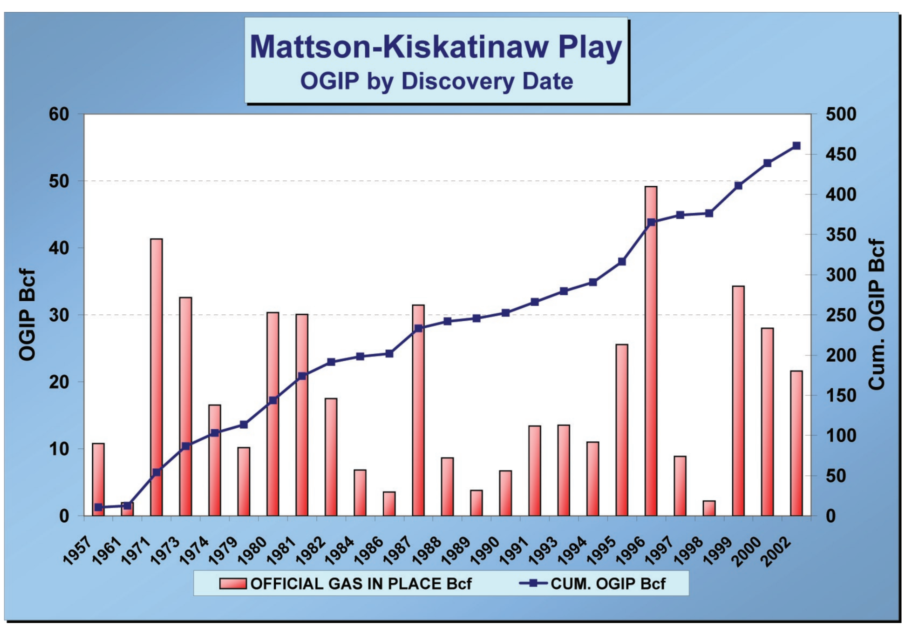
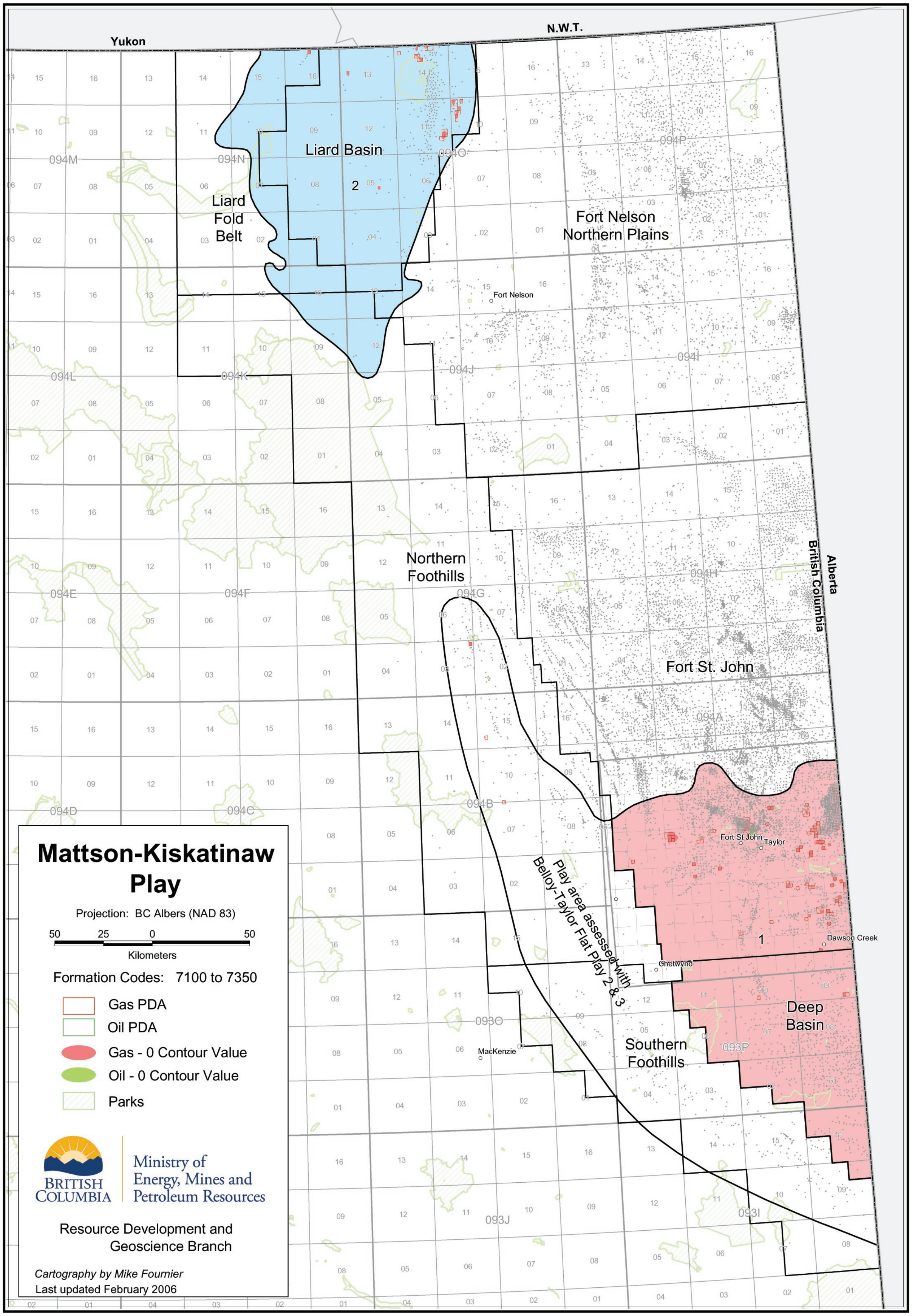


Figure 21. Structural trap in Mattson sandstones along the Bovie Lake Fault Zone, eastern margin of Liard Basin (from Barclay et. al., 1997).

Mattson-Kiskatinaw Play - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Boundary Lake	Lower Kiskatinaw	B	1,319	449	332	47	16	12
Attachie	Basal Kiskatinaw	A	1,058	722	97	37	25	3
Boundary Lake	Basal Kiskatinaw	-	892	458	108	31	16	4
Alces	Kiskatinaw	A	852	101	13	30	4	0
Boundary Lake	Basal Kiskatinaw	N	725	539	485	26	19	17
Windflower	Mattson	A	684	376	262	24	13	9
Parkland	Basal Kiskatinaw	C	481	422	399	17	15	14
Sikanni	Kiskatinaw	A	372	5	0	13	0	0
Maxhamish Lake	Mattson	E	338	271	259	12	10	9
Briar Ridge	Kiskatinaw	A	313	76	73	11	3	3
Other Pools			6,010	3,697	2,669	212	131	94
Totals			13,044	7,114	4,698	460	251	166







Mattson-Kiskatinaw Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 7100 to 7350
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Basin
2
Liard Fold Belt
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Fort St John
Taylor
Dawson Creek
1
Chetwynd
Deep Basin
Southern Foothills
MacKenzie
Play area assessed with Belloy-Taylor Flat Play 2 & 3
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.24 Debolt Formation

The Debolt is the youngest of three major Mississippian carbonate successions mappable throughout northeastern B.C. and adjacent Alberta (Law, 1981). Each was deposited during a long-term, basinwide transgressive-regressive cycle, and all stack to form a carbonate ramp complex spanning the entire WCSB. Lithologies range from intertidal dolomitic mudstones to open shelf packstones and wackestones, deposited within higher-order transgressive-regressive cycles mappable within each formation. The entire ramp grades northwestward to outer ramp to basin margin lime mudstones (Richards et. al., 1994).

Higher-order T/R cycles can be traced as distinctive log markers locally to subregionally; for example, in adjacent northwestern Alberta, the lower Elkton Member of the Debolt is mapped separately because of its distinctive character. To the west, syndepositional faulting related to Antler orogenic events disrupts log marker continuity, and makes correlation of individual cycles more difficult.

Debolt reservoirs are classified within two general settings:

1. Cretaceous subcrop margin reservoirs – extensive diagenetic modification, including solution and dolomitization, enhances reservoir quality in facies with substantial original porosity, particularly shelfal / bank grainstones and carbonate sands. These reservoirs are best developed beneath the pre-Cretaceous unconformity, where very long-term exposure occurred (Figure 22).
2. Downdip reservoirs – Downdip from the pre-Cretaceous subcrop edge, diagenetic enhancement is less common and less extensive. Primary depositional facies play a larger role in productivity – banks and shoals are traditionally viewed as the optimal targets. In addition, significant dolomitization and reservoir enhancement occurs in association with faulting in the Fort St. John Graben and along the Foothills. As well, Antler orogenic events may have elevated some block-faulted areas during Debolt time, allowing deposition of shallower-water facies.

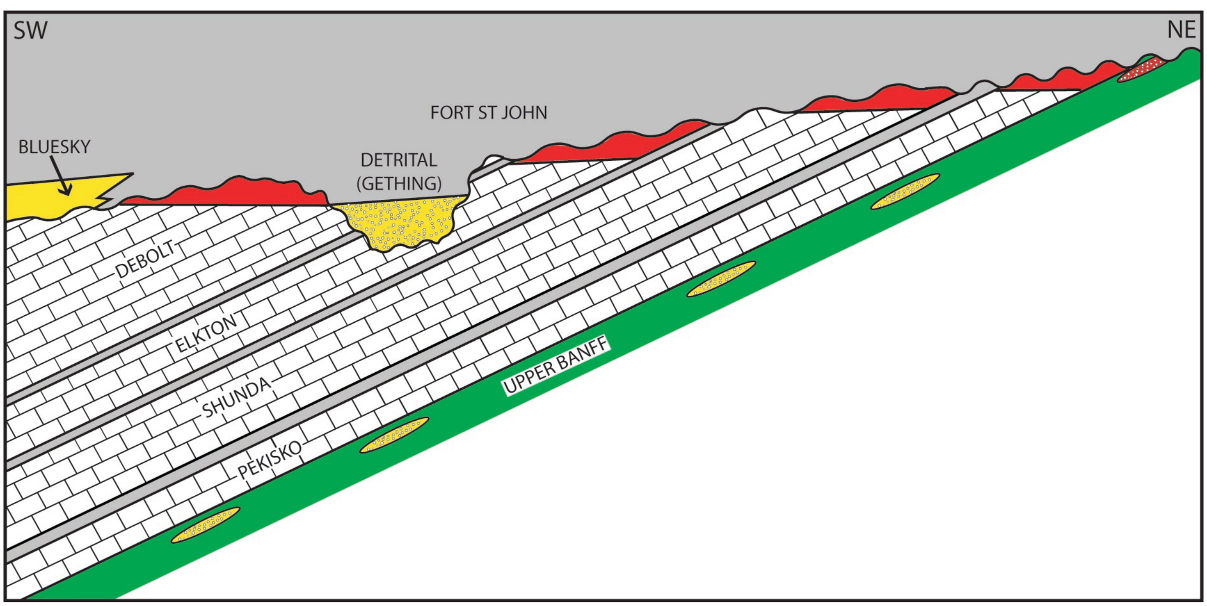


Figure 22. Schematic regional cross-section illustrating traps along Debolt and older Mississippian subcrop edges. Reservoir quality is enhanced diagenetically beneath the pre-Cretaceous unconformity, and regional seals are provided by overlying Fort St. John marine shales. Detrital or Gething valley fill strata are of variable reservoir quality, and may locally form a component of subcrop edge gas pools. Transgressive strata at the base of each carbonate unit exhibit poor reservoir quality, and assist in separating discrete subcrop reservoir trends.

Fort Nelson Northern Plains Region

Play 1. Cretaceous Subcrop Margin Play—Debolt carbonates were incised extensively by pre-Cretaceous erosion, forming numerous stratigraphic traps along the subcrop margin (Barclay et. al., 1997). Diagenetic reservoir enhancement was extreme, particularly along trends where the most susceptible shallow-water facies were deposited. High-relief karst occurs locally. Cretaceous marine shales form an effective top seal, although Debolt carbonate debris is incorporated into a basal Cretaceous "detrital zone" in places.

The Cretaceous Subcrop Margin Play is bounded updip by the erosional edge of the Debolt, and downdip by the erosional edge of overlying Belloy and Montney strata. It is extensively developed in northwestern Alberta, but has seen much less drilling in northeastern B.C. The play laps into the northeasternmost corner of the Fort St. John Region.

Producing pools are at Bivouac, Desan, Helmet, Kotcho Lake, Kyklo, and Thetlaandoa.

Play 2. Debolt Regional Platform Play—Reservoir quality is relatively poor across much of the platform area, as diagenesis was generally less extreme. Low-relief, shorter-term erosion on the upper unconformity surface did not allow the extensive diagenetic reservoir enhancement and high-relief trapping potential that exists beneath the pre-Cretaceous unconformity. Depositional facies gradually deepen northwestward approaching the ramp edge. Local structural traps do exist, however, and enhanced dolomitization has been linked to fluid movement along fault planes.

Debolt productive potential in basinal facies to the northwest is addressed in the discussion of Shunda/ Pekisko/Banff plays.

Debolt Regional Platform pools are found at Klua.

Fort St. John Region

Play 2. Debolt Regional Platform Play—The Debolt Regional Platform continues southeastward into the Fort St. John Region. Most discoveries are associated with structural traps and limited reservoir enhancement in the outer Foothills, along the western flank of the Region. At Blueberry, reservoir quality has been enhanced sufficiently to host an oil-producing reservoir. Despite extensive Paleozoic block faulting, little Debolt production has been established in the Fort St. John Graben of B.C., although several large pools occur on block-faulted structures to the east in Alberta.

The Debolt Regional Platform Play produces oil and/or gas at Attachie, Beg, Blueberry, Blueberry East and West, Fireweed, Fort St. John, Halfway, Inga, Parkland, Ring, and Tommy Lakes.

Deep Basin Region

Play 2. Debolt Regional Platform Play—The regional platform can be traced southward into the Deep Basin Region, but there are very few penetrations and no published mapping with which to assess its prospectivity. Better reservoir quality may be found along the western margin of the Region, associated with outer Foothills structure, as in the Fort St. John Region. There is no known production, and prospectivity must be regarded as conceptual.

Northern Foothills Region

Play 3. Northern Foothills Play—Structural traps generated by Laramide deformation are common throughout the region, and have been most intensely developed in the Sikanni-Pocketknife area. As noted in other regions, reservoir quality is locally enhanced in association with fluid movements along faults. It has also been suggested that shallow-water facies may have been deposited preferentially atop structural blocks elevated during Late Devonian – Early Mississippian Antler deformation. Seals are provided by overlying Mississippian through Triassic shales. However, where the Debolt is overlain by porous Belloy facies, particularly on the flanks of the Fort St. John Graben, hydrocarbons have escaped into overlying units. Gas potential in the underlying Shunda / Pekisko / Banff units is included within the Debolt Northern Foothills Play, as there appears to be little potential for stratigraphic control on entrapment.

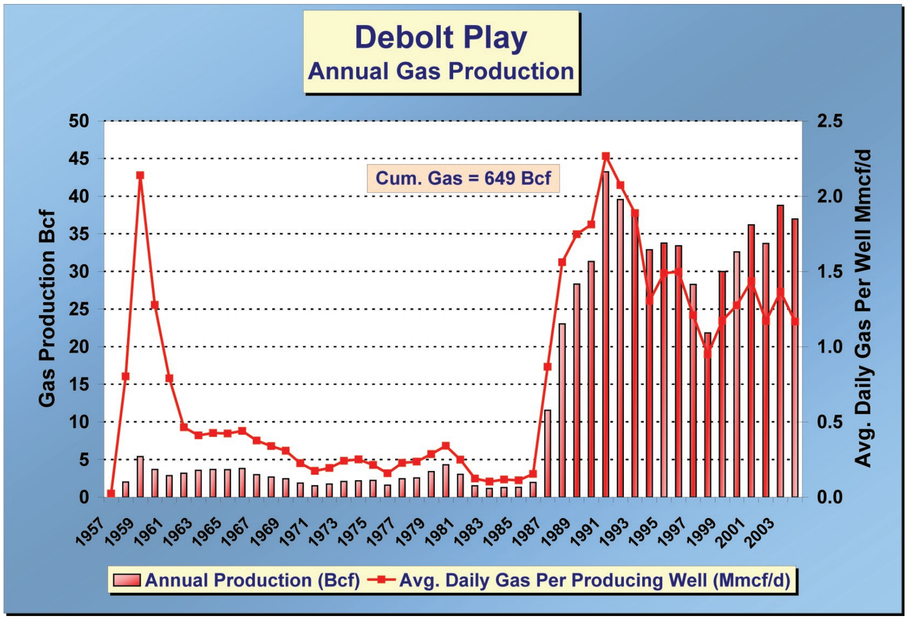
The Debolt Northern Foothills Play is productive at Bougie, Buckinghorse, Caribou, Cypress, Elbow Creek, Graham, Grassy, Julienne Creek (North and South), Kobes, Lily Lake, Pocketknife, Sikanni, and Townsend.

Southern Foothills Region

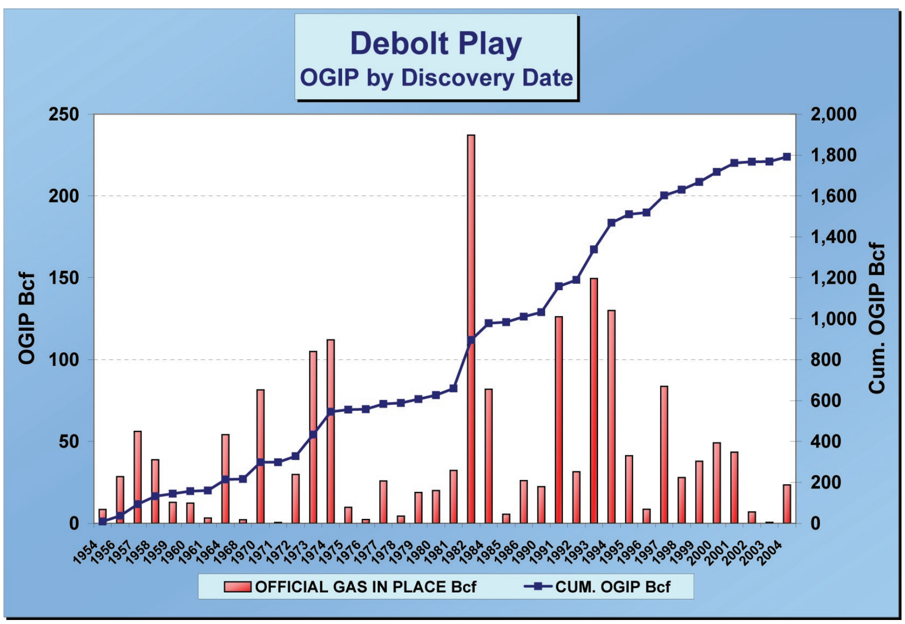
Play 4. Southern Foothills Play—Structural traps like those in the Northern Foothills occur throughout the Southern Foothills Region, but there are relatively few Debolt penetrations. Similar reservoir quality and trapping situations should apply, with the potential for the Debolt to become somewhat more dolomitized toward the southern limit of the region. Gas potential in the underlying Shunda / Pekisko / Banff units is included within the Debolt Southern Foothills Play, as there appears to be little potential for stratigraphic control on entrapment.

The only Debolt Southern Foothills Play production is at Ojay.

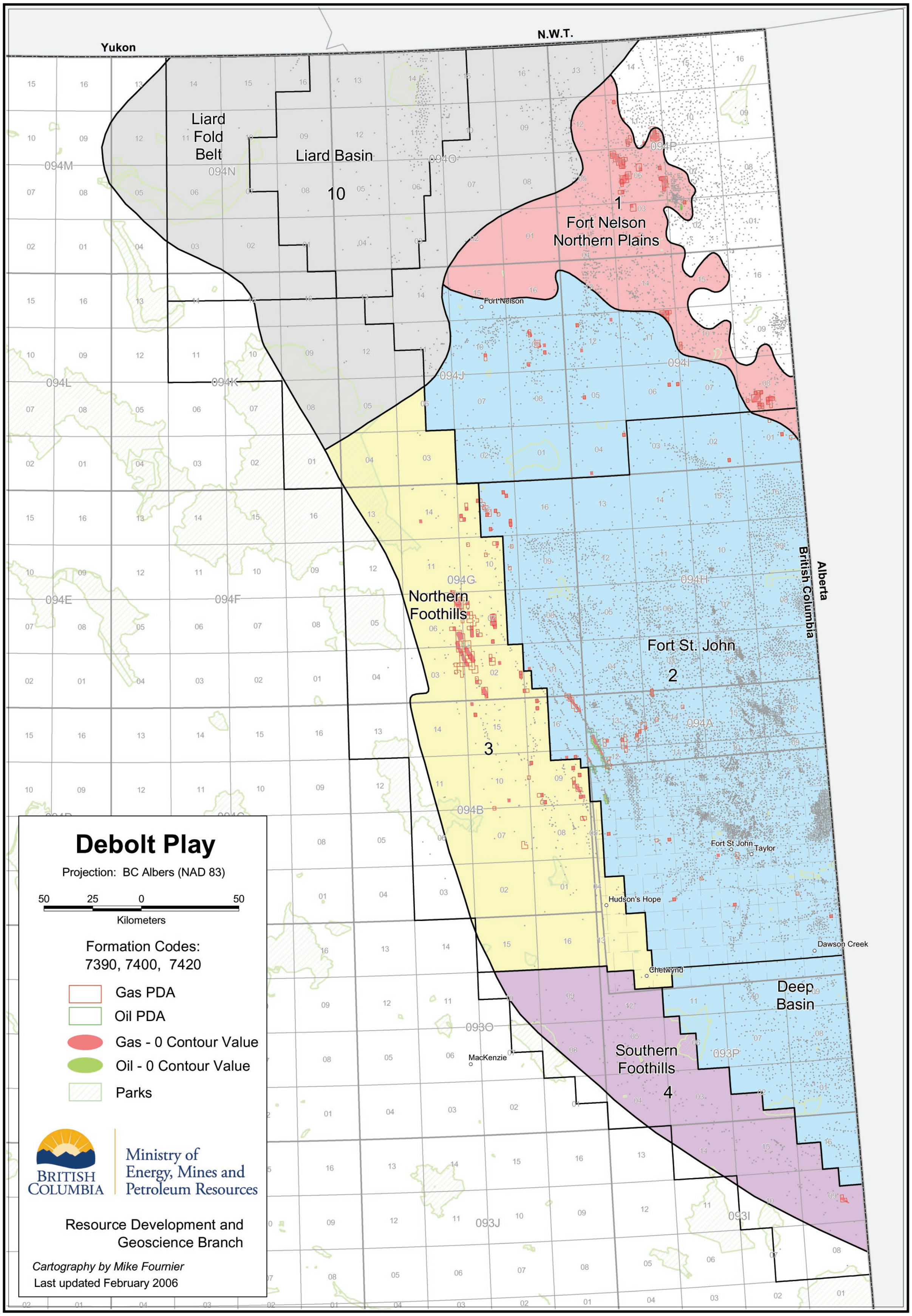
Debolt Play - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Sikanni	Debolt	C	5440	2742	54	192	97	2
Sikanni	Debolt	H	3361	2984	306	119	105	11
Sikanni	Debolt	G	3050	1507	485	108	53	17
Thetlaandoa	Debolt	A	2645	2002	1100	93	71	39
Pocketknife	Debolt	C	2319	1008	47	82	36	2
Grassy	Debolt	A	2309	1141	494	81	40	17
Other Areas	Debolt	B	1857	1430	510	66	50	18
Other Areas	Debolt	D	1600	1010	1008	56	36	36
Pocketknife	Debolt	A	1535	328	1	54	12	0
Other Areas	Debolt	A	1515	1184	1089	53	42	38
Other Pools			25,124	11,160	5,981	887	394	211
Totals			50,754	26,495	11,074	1,792	935	391



Debolt Play
Annual Gas Production
Cum. Gas = 649 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
0
5
10
15
20
25
30
35
40
45
50
0.0
0.5
1.0
1.5
2.0
2.5
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Debolt Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
0
50
100
150
200
250
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Debolt Play
Projection: BC Albers (NAD 83)
Kilometers
Formation Codes:
7390, 7400, 7420
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
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Southern Foothills
4
Deep Basin
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie

4.25 Shunda / Pekisko / Banff Formations

The Pekisko and Shunda Formations are the older two of three units making up a carbonate ramp that prograded northwestward across the WCSB during Mississippian time (Law, 1981). Like the overlying Debolt, each was deposited during a long-term, basinwide transgressive-regressive cycle. Lithologies range from intertidal dolomitic mudstones to open shelf packstones and wackestones, deposited within higher-order transgressive-regressive cycles mappable within each formation. The entire ramp grades northwestward to outer ramp to basin margin lime mudstones (Richards et. al., 1994).

Higher-order T/R cycles can be traced as distinctive log markers locally to subregionally. To the west, syndepositional faulting related to Antler orogenic events disrupts log marker continuity, and makes correlation of individual cycles more difficult. In northeastern B.C., the Pekisko and Shunda differ significantly from their type areas in west-central Alberta, but their bounding surfaces can be correlated with a high degree of confidence.

Pekisko and Shunda reservoirs are classified within three general settings:

1. Cretaceous subcrop margin reservoirs – extensive diagenetic modification, including solution and dolomitization, enhances reservoir quality in facies with substantial original porosity, particularly shelfal / bank grainstones and carbonate sands. These reservoirs are best developed beneath the pre-Cretaceous unconformity, where very long-term exposure occurred (Figure 22, page 98).
2. Downdip reservoirs – Downdip from the pre-Cretaceous subcrop edge, diagenetic enhancement is less common and less extensive. Primary depositional facies play a larger role in productivity – banks and shoals are traditionally viewed as the optimal targets. Dolomitization and other reservoir quality enhancement is less common than in the Debolt, as the Debolt conformably overlies the Shunda.
3. Ramp margin and basinal facies – Argillaceous, more distal ramp facies grade basinward to basinal Prophet Formation shales and cherts. Isolated reservoir quality may occur where shallower-water facies and/or diagenetic enhancement have occurred locally. Distal equivalents of the Debolt Formation are included in this play setting.

The Banff Formation is a basinal to slope assemblage of shales and muddy limestones, arranged in stacked shallowing-upward successions Higher-energy, shelfal lime grainstones and muddy tidal carbonates may occur higher in the section. Elsewhere in the WCSB, petroleum reservoirs are preferentially developed in porous grainstones and dolomitized tidal carbonates of the upper Banff, or in Waulsortian mound facies in deeper-water settings lower in the Banff. Although these reservoir facies have not been documented in northeastern B.C., a distinct mixed siliciclastic/carbonate succession caps the Banff, and contains isolated high-quality very fine-grained sandstone reservoirs. These were deposited in tidal flat to shallow marine shoreface settings, and exhibit optimal reservoir quality immediately beneath the pre-Cretaceous unconformity.

Fort Nelson Northern Plains Region

Play 1. Cretaceous Subcrop Margin Play—Pekisko and Shunda carbonates and upper Banff sandstones were incised extensively by pre-Cretaceous erosion, forming stratigraphic traps along the subcrop margin (Barclay et. al., 1997). Where the unconformity cuts down to the upper Banff clastics, Banff sandstones are commonly mistaken for transgressive sandstones in the overlying Cretaceous package, and may be assigned to the Bluesky Formation. Diagenetic reservoir enhancement is observed, particularly along trends where the most susceptible shallow-water facies were deposited. Cretaceous marine shales form an effective top seal.

The Cretaceous Subcrop Margin Play is bounded updip by the erosional edge of the Banff (in Alberta), and downdip by the erosional edge of overlying Debolt strata. It is extensively developed in northwestern Alberta, but has seen much less drilling in northeastern B.C.

Producing pools are at Helmet, Peggo-Pesh, and Tooga.

Play 2. Shunda / Pekisko / Banff Regional Platform Play—Reservoir quality is relatively poor across much of the carbonate platform area, as diagenesis was less extreme beneath Debolt carbonates. Although depositional facies gradually deepen northwestward approaching the ramp edge, the Shunda contains abundant clean, shallow marine carbonate grainstones in the Desan area. Local structural traps may exist.

Shunda / Pekisko / Banff Regional Platform pools are found at Bivouac, Desan (where Shunda grainstones host an extensive oil reservoir), and Ekwan.

Play 3. Distal Ramp Margin Play—Reservoir development is generally lacking in more argillaceous, distal ramp to basin facies equivalent to the Pekisko, Shunda, and Debolt. Waulsortian mounds and turbidite units may offer some deeper-water reservoir potential, while structures such as the Bovie Fault Zone may have nucleated deposition of shallower-water reservoir facies. The southeastern boundary with Plays 1 and 2 is an interfingering facies contact.

There is no production from the Distal Ramp Margin Play in the Fort Nelson Region.

Fort St. John Region

Play 2. Shunda / Pekisko / Banff Regional Platform Play—The Shunda / Pekisko / Banff regional platform can be mapped continuously through the Fort St. John Region. However, there are few penetrations, and no established production.

Deep Basin Region

Play 2. Shunda / Pekisko / Banff Regional Platform Play—The Shunda / Pekisko / Banff regional platform can be mapped southward to the Deep Basin Region. There are very few penetrations, however, and prospectivity must be regarded as speculative.

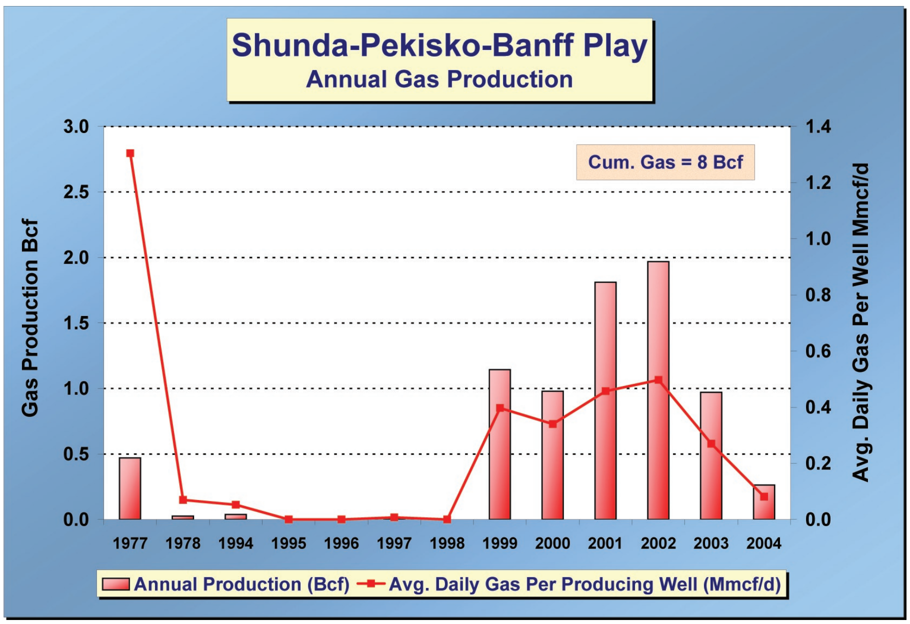
Liard Basin / Liard Fold Belt Regions

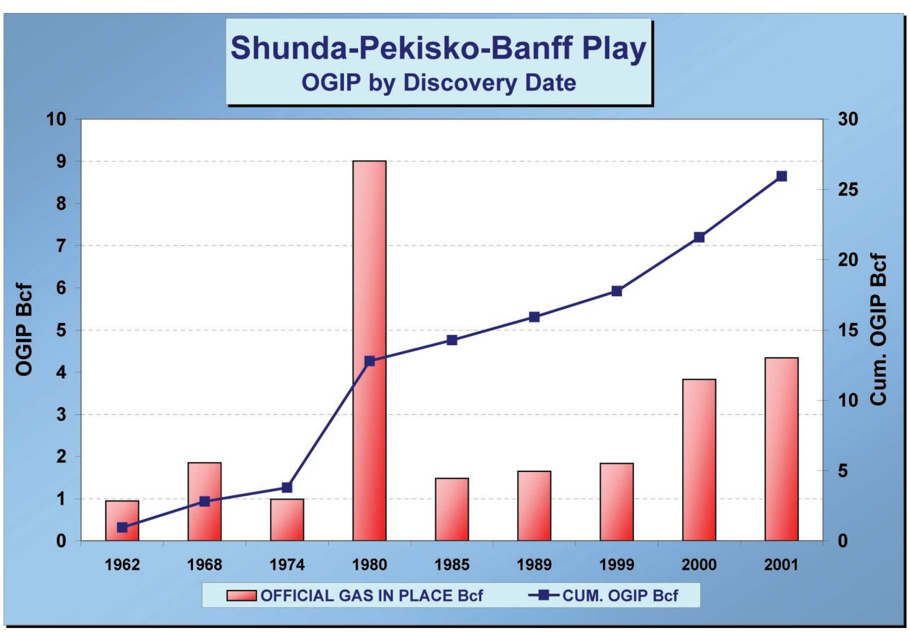
Play 3. Distal Ramp Margin Play—Distal ramp facies (including Debolt equivalents) grade northwestward into basinal facies, which are assigned to the Besa River Formation in the far northwestern reaches of these regions. Isolated gas shows occur at Tattoo (near the Bovie Fault Zone) and at Beaver River (in the Liard Fold Belt), but the nature of these accumulations has not been documented.

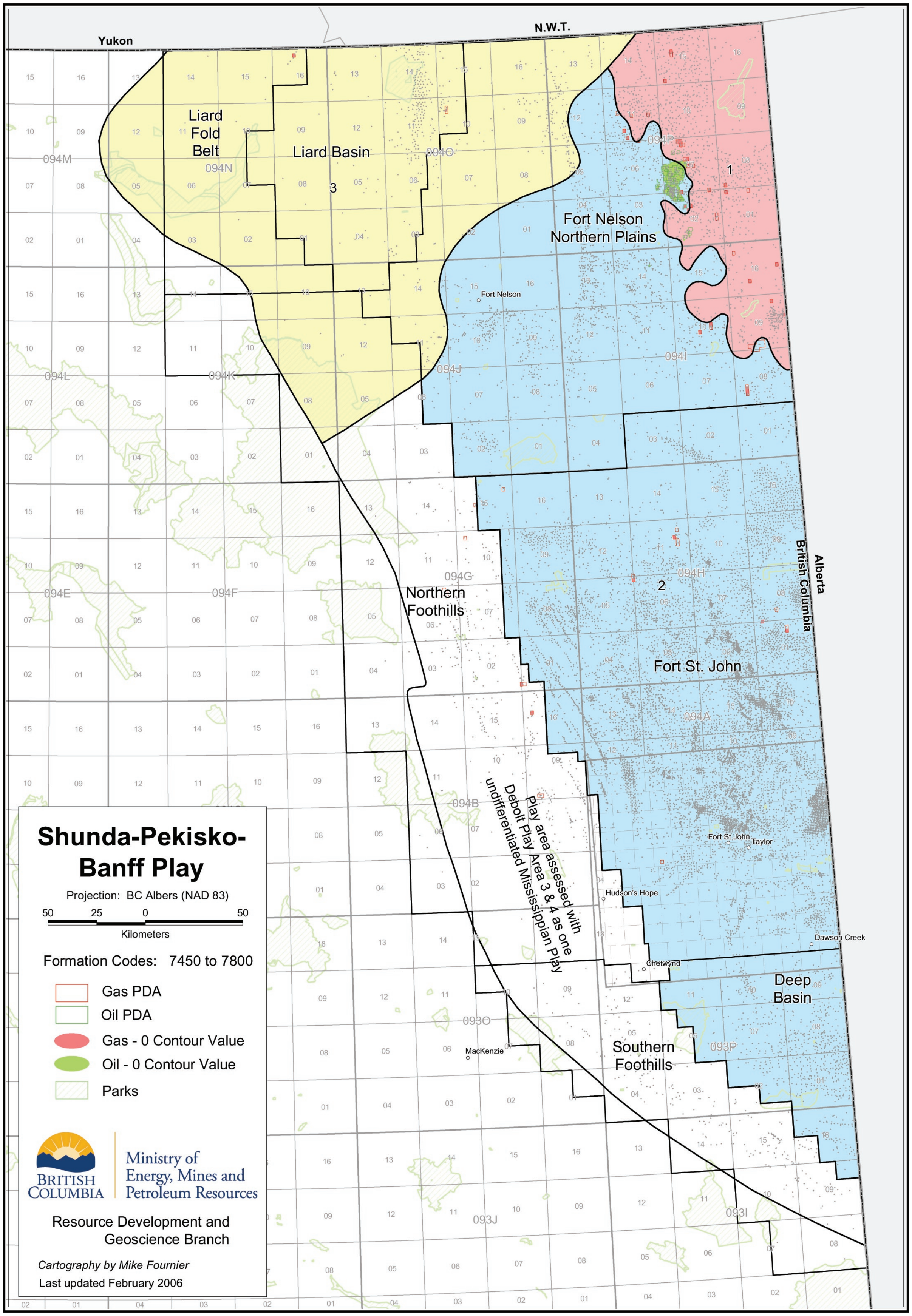
Northern and Southern Foothills Regions

Shunda / Pekisko / Banff prospectivity in these regions has been assigned to the Debolt Formation Northern and Southern Foothills Plays.

Shunda-Pekisko-Banff Play Pool List - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Tattoo	Debolt	A	123	96	72	4	3	3
Helmet	Shunda	B	111	82	43	4	3	2
Peggo-pesh	Bluesky	B	75	53	4	3	2	0
Helmet	Bluesky	A	69	45	45	2	2	2
Helmet	Debolt	C	54	1	0	2	0	0
Other Areas	Banff	D	52	36	36	2	1	1
Peggo-pesh	Bluesky	A	47	18	5	2	1	0
Bivouac	Banff	A	42	30	20	1	1	1
Helmet	Bluesky	B	42	30	3	1	1	0
Peggo-pesh	Banff	A	29	21	6	1	1	0
Other Pools			90	57	20	3	2	1
Totals			734	470	254	26	17	9






Shunda-Pekisko-Banff Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 7450 to 7800
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
3
1
2
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
Fort St. John
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
Southern Foothills
MacKenzie
Play area assessed with Debolt Play Area 3 & 4 as one undifferentiated Mississippian Play
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094A
094B
093O
093P
093J
093I

4.26 Wabamun Group

During Late Devonian time, the Wabamun carbonate ramp complex prograded northwestward across the WCSB, reaching a north-south margin in northeastern British Columbia (Halbertsma, 1994). Ramp facies consist of stacked cleaning- and shallowing-upward successions, deposited during repeated transgressive/regressive cycles, much like those in the overlying Mississippian carbonate ramp. Regionally, these facies grade from highly restricted, evaporitic facies in southeastern Alberta to subtidal / open marine carbonate sands and nodular skeletal mudstones / wackestones in the eastern part of northeast B.C. Further west, the ramp grades to basinal shales of the Kotcho Formation.

Wabamun strata lap onto the Peace River Arch, reflecting its emergent position in Late Devonian time. Subsequent collapse of the Fort St. John Graben complex atop the Arch created high-relief fault traps, and the faults themselves provided fairways for hydrothermal fluids to circulate within the carbonate ramp (Figure 23) (Stoakes, 1987). Hydrothermally karsted and dolomitized Wabamun reservoirs occur in several fields in west-central Alberta. In B.C., however, Packard et. al. (2001) demonstrated that most reservoir capacity at Parkland Field occurs as microintercrystalline porosity in replacement hydrothermal cherts.

Fort St. John Region

Play 1. Peace River Arch / Fort St. John Graben Play—Wabamun reservoirs occur where reservoir quality within the carbonate ramp has been enhanced by hydrothermal fluids. Extensional faulting associated with creation of the Fort St. John Graben complex in Early Mississippian time provided both structural traps and routes for admission of hydrothermal fluids (Packard et. al., 2001) (Figure 23). Prospectivity may generally decrease westward, as Wabamun ramp facies become more distal, and Fort St. John Graben faults become less defined.

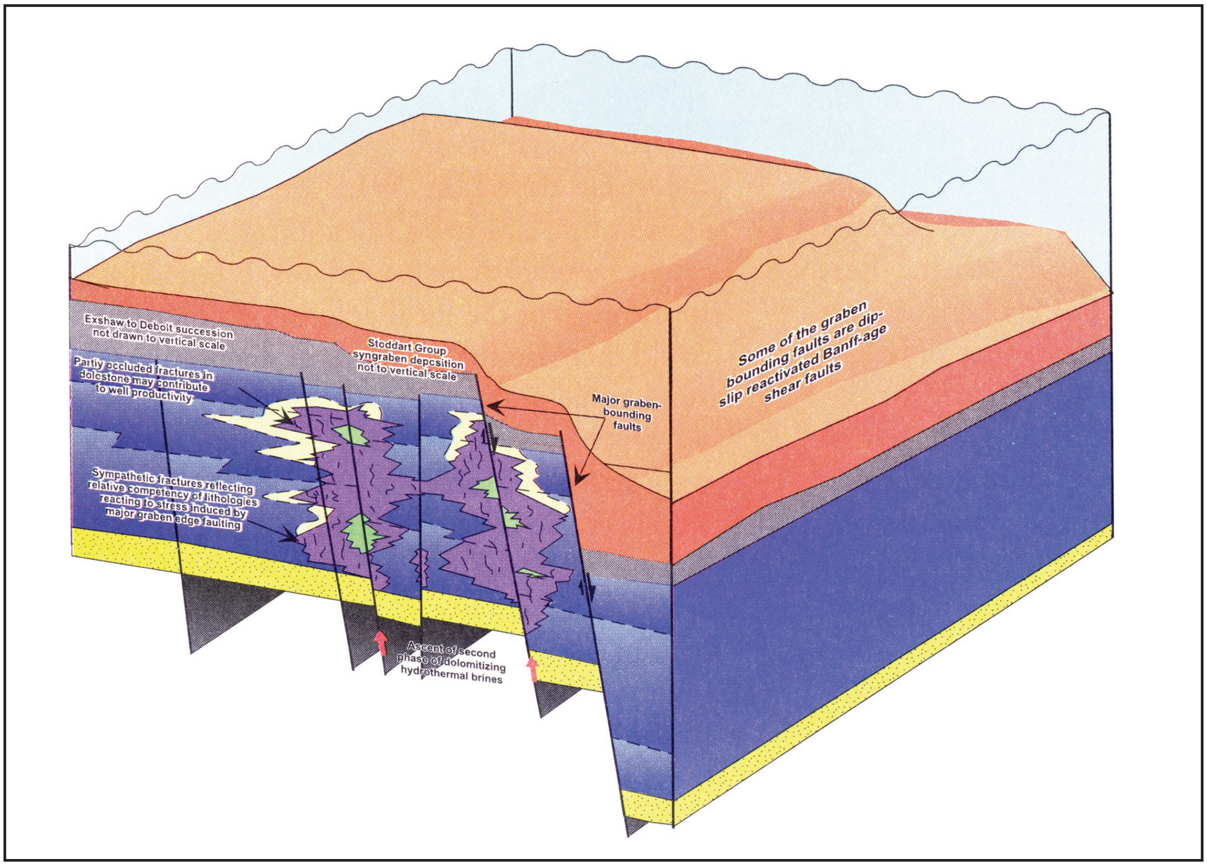


Figure 23. Schematic block diagram illustrating development of hydrothermal carbonate and chert reservoirs within the Wabamun Group, as the result of migration of hydrothermal brines along block faults (from Packard et. al., 2001).

Large gas pools occur in the Wabamun at Parkland and Doe, with smaller accumulations at Two Rivers.

Play 2. Northern Wabamun Platform Play (Conceptual)—Carbonate ramp facies of the Wabamun become increasingly distal to the north and west, reducing opportunities for reservoir formation in primary facies and diagenetically-enhanced rocks. Moving northward from the margin of the Fort St. John Graben, opportunities for reservoir enhancement by hydrothermal processes are generally less, although some may exist along the southwest-northeast Hay River Fault Zone in the Ladyfern area.

There is no gas production from the Northern Wabamun Platform Play

Deep Basin Region

Play 1. Peace River Arch / Fort St. John Graben Play—Wabamun carbonate ramp facies can be mapped southward into the Deep Basin, although there are very few penetrations in this region. As for the Northern Wabamun Platform Play, there are relatively few opportunities for reservoir enhancement by hydrothermal processes moving away from the margin of the Fort St. John Graben complex.

There are no producing pools in Play 1 in the Deep Basin Region.

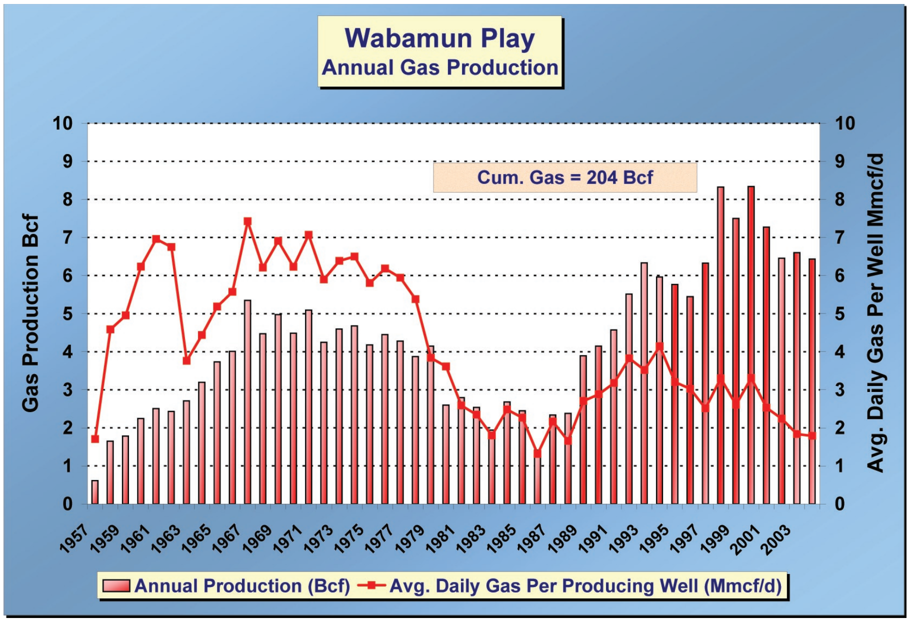
Southern Foothills Region

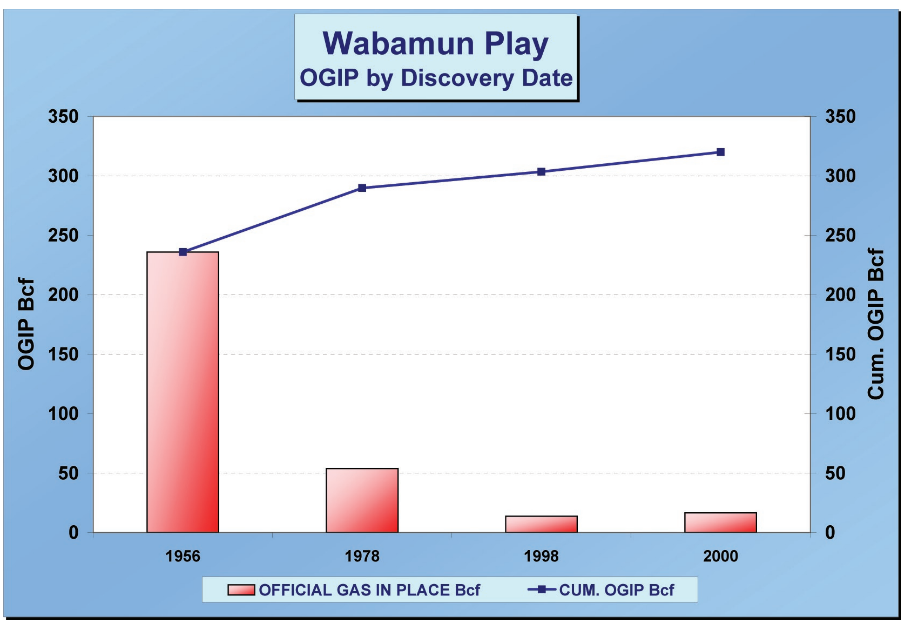
Play 3. Wabamun Foothills Play (Conceptual)—Wabamun reservoir quality is enhanced locally in the southern and central Alberta Foothills through dolomitization and fracturing related to structural deformation. This prospectivity may extend northward into the B.C. Southern Foothills. There are very few Wabamun penetrations, however, and examples of reservoir development are lacking.

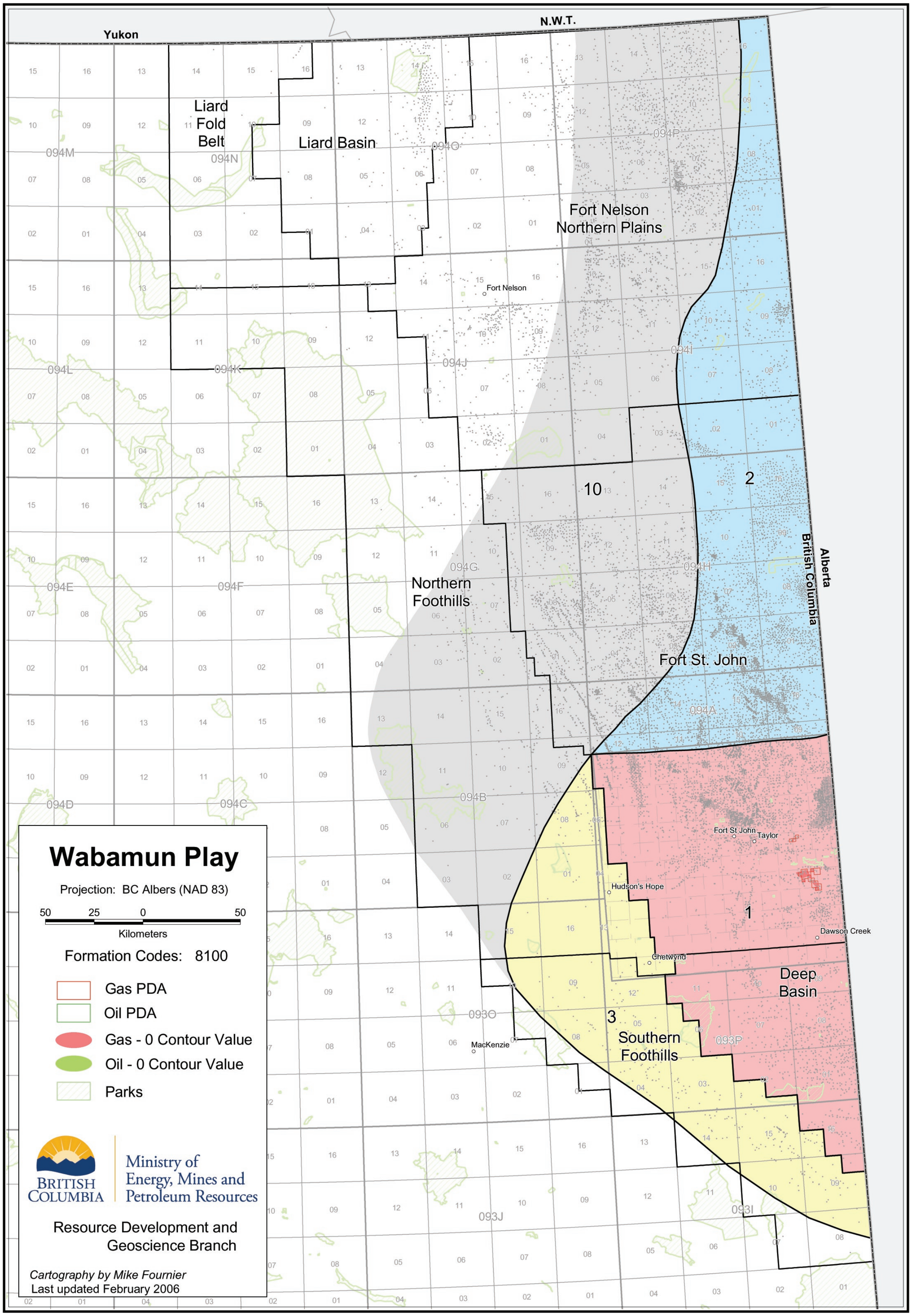
There are no producing pools in this play.

Wabamun Play - All Pools by OGIP

Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Parkland	Wabamun	A	6683	5601	1464	236	198	52
Doe	Wabamun	A	1524	1272	268	54	45	9
Doe	Wabamun	C	469	299	298	17	11	11
Two Rivers	Wabamun	B	389	279	279	14	10	10
Totals			9,064	7,451	2,308	320	263	81


Wabamun Play
Annual Gas Production
Cum. Gas = 204 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
10
9
8
7
6
5
4
3
2
1
0
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)


Wabamun Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
350
300
250
200
150
100
50
0
1956
1978
1998
2000
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf


Wabamun Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8100
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
10
2
Fort St. John
Fort St John
Taylor
Hudson's Hope
1
Dawson Creek
Chetwynd
Deep Basin
3
Southern Foothills
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.27 Kakisa Formation

The Kakisa Formation, equivalent to the Blue Ridge Formation in west-central Alberta, consists of silty, quartzose, dolomitic limestones deposited on a northwesterly-prograding carbonate ramp (Figure 24). It overlies and grades basinward into basinal shales of the Redknife Formation, and is capped by Trout River siliciclastics. Very little work has been published on its stratigraphy and reservoir potential, so controls on the gas pools at Ekwan are poorly understood. There is no platform margin buildup as in the Jean Marie, and no direct evidence of reefal / biostromal reservoir bodies.

Fort Nelson Northern Plains Region

Play 1. Kakisa Carbonate Platform—The Kakisa platform has been mapped only on a very broad scale (Switzer et. al., 1994). There are no local features mapped to suggest controls on the gas production at Ekwan. Because of this lack of knowledge, resource potential has been assigned to the Kakisa only in the Ekwan area; outside of this, the play is regarded as conceptual.

Kakisa carbonates lap onto the Peace River Arch in the south, and grade northwestward into basinal shales (Figure 24).

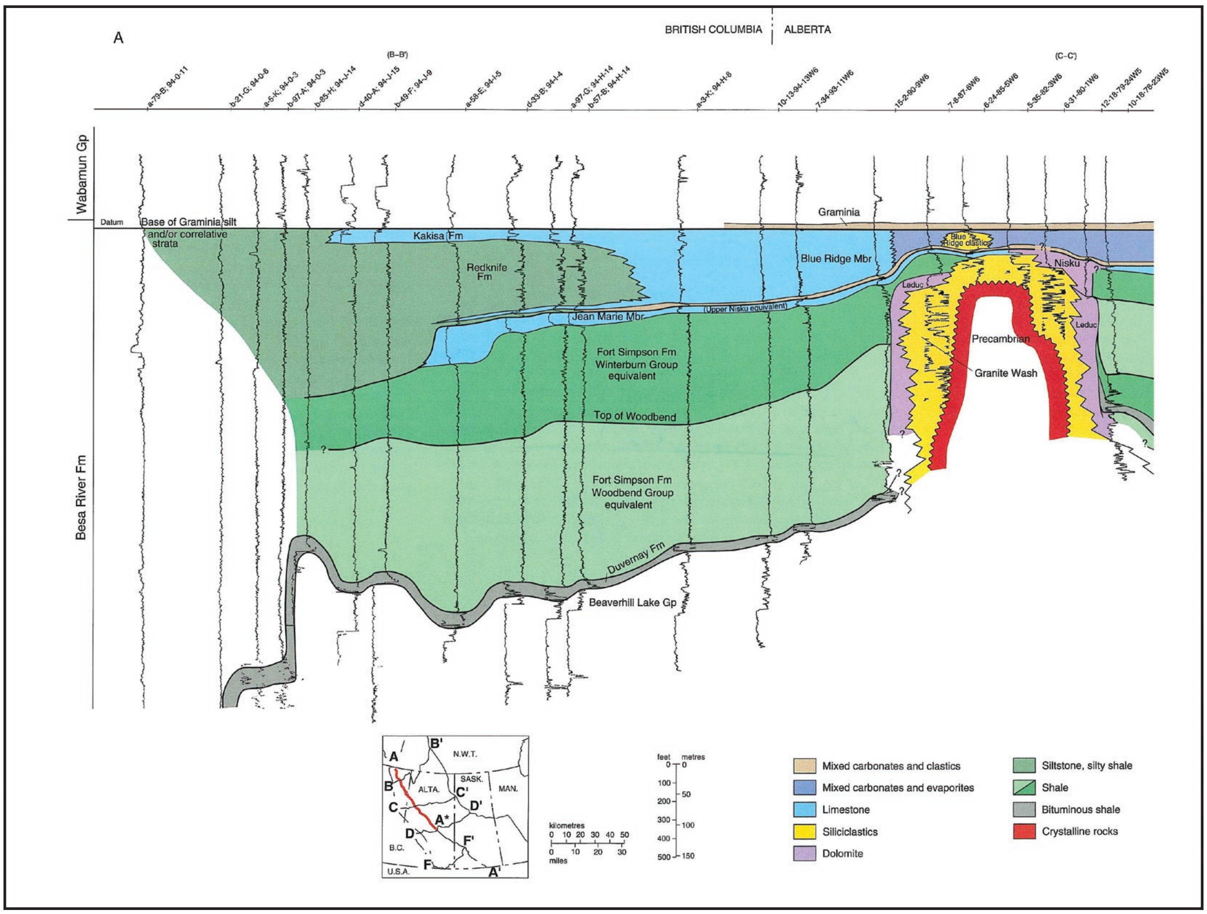
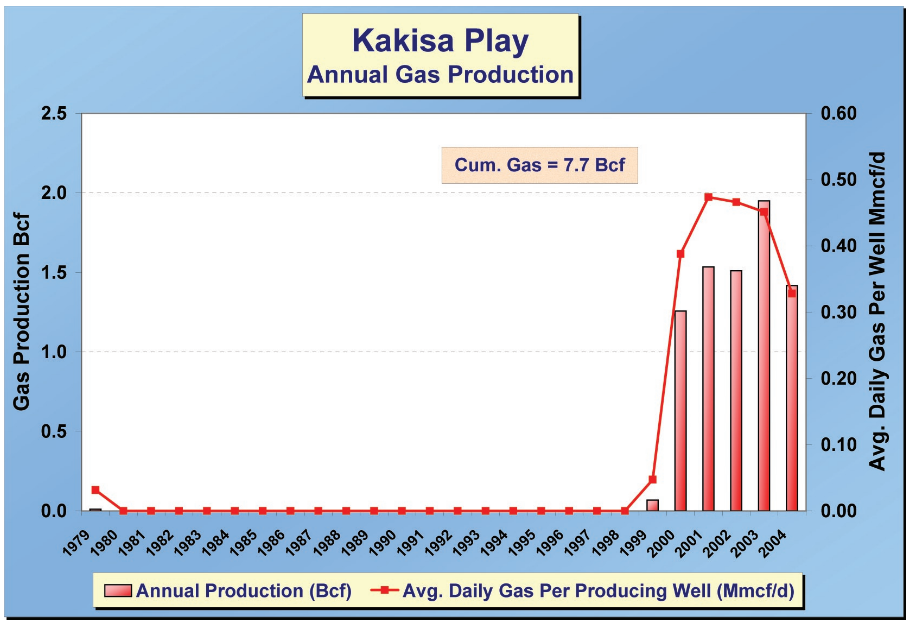
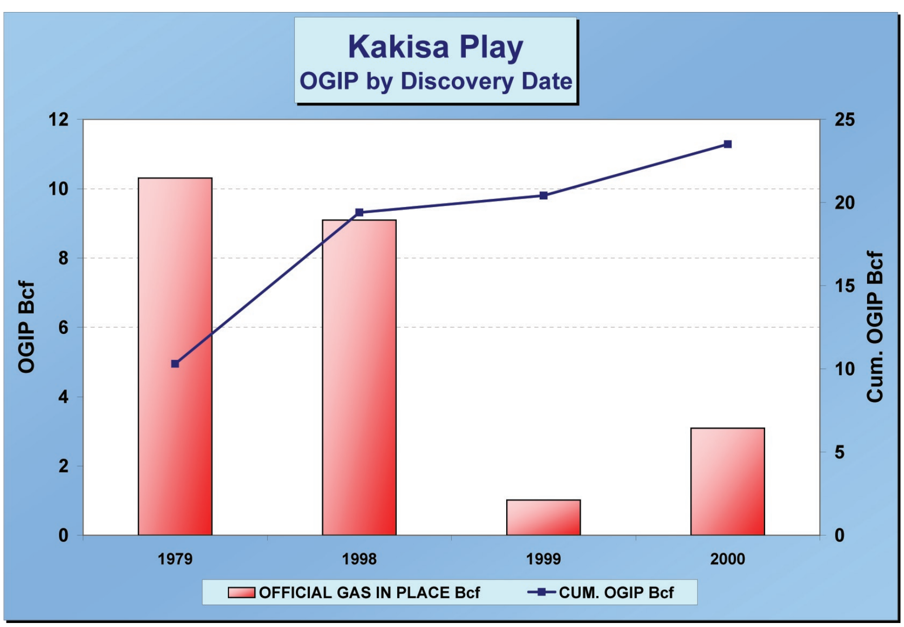
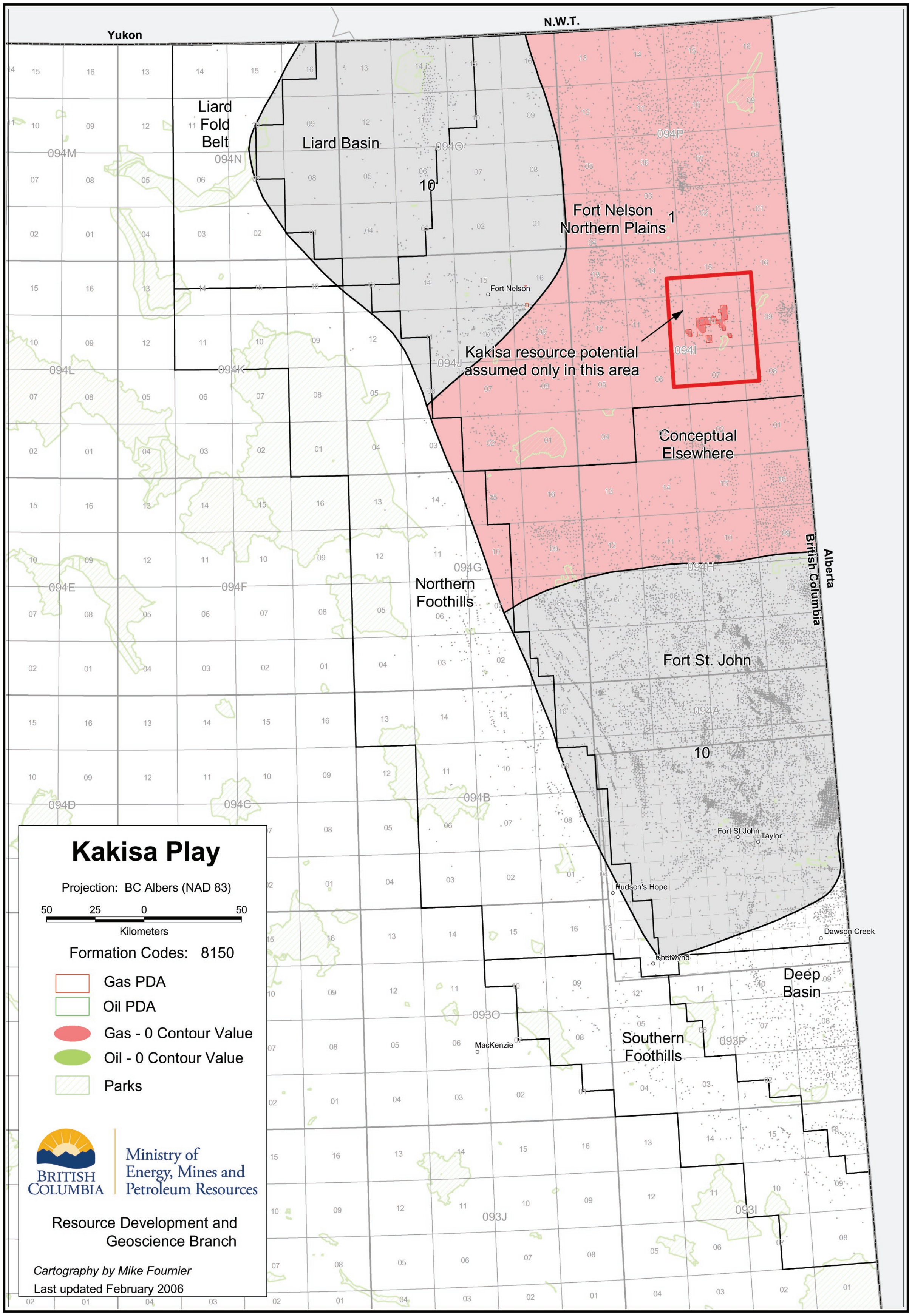


Figure 24. Schematic regional cross-section, illustrating development of Kakisa platform carbonate reservoirs in northeastern British Columbia (from Switzer et. al., 1994).

Kakisa Play - All Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Ekwan	Kakisa	A	292	234	151	10	8	5
Ekwan	Kakisa	D	258	207	165	9	7	6
Ekwan	Kakisa	E	56	45	38	2	2	1
Ekwan	Kakisa	B	31	22	10	1	1	0
Ekwan	Kakisa	C	29	21	7	1	1	0
Totals			666	529	371	24	19	13







Kakisa Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8150
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
10
Fort Nelson Northern Plains
1
Fort Nelson
Kakisa resource potential assumed only in this area
Conceptual Elsewhere
Northern Foothills
Fort St. John
10
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
Deep Basin
Southern Foothills
MacKenzie
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I

4.28 Jean Marie Formation

The Jean Marie was deposited as a broad, shallow marine limestone shelf, under moderate energy conditions. It varies from 10 to 25 metres thick across northeastern British Columbia and adjacent Alberta, thickening abruptly westward to a shelf margin (McAdam, 1993). Overlying a basal crinoidal wackestone ramp, three transgressive-regressive cycles grade from relatively deep-water coralline limestones to shallower-water reefal facies. Patch reefs up to 100 metres across grew with relief of about 7 metres above the sea floor (Figure 25). Thin, platy stromatoporoids created a cavernous framework; within this, shelter cavities hosted the algae *Renalcis*, and were later filled by lime muds (Stoakes, 1992). Matrix capacity was created by dolomitization and solution of *Renalcis*, while permeability was enhanced by selective fracturing of cavity-filling muds.

Reinson et. al. (1993) speculated that larger-scale natural fractures exerted control on Jean Marie productivity, and that fracture intensity could be related to compaction drape over Slave Point bank margins, or to regional tectonism. However, large-scale fractures and enhanced productivity have not been conclusively related.

Wackestones of the basal ramp thicken along the western margin of the Jean Marie platform, where they make up the basal third to half of the formation. Above this, grainstones and broken reefal debris dominate the section, exhibiting relatively low-grade conventional to tight reservoir quality over a section ranging in excess of 50 metres. Although of lower quality than the platform reef "sweet spots", the platform margin reef detritus is consistently developed and highly mappable.

Redknife and Fort Simpson marine shales encase the Jean Marie, producing a closed reservoir system. As a result, a gas-saturated, regionally-underpressured Deep Basin regime characterizes the Jean Marie across northeastern B.C.

Fort Simpson Northern Plains Region

Play 1. Jean Marie Platform Play—Areally-extensive gas pools on the Jean Marie platform have nucleated around discoveries of reefal sweet spots, often in wells drilled for deeper Devonian objectives. In 94-P, stepout development of numerous separate discoveries has resulted in melding of several fields into a continuous productive area. Production from high-quality patch reefs provides high initial rates and substantial longer-term reserves, as gas from the encasing tighter facies is produced with pressure drawdown of the relatively small reef mass. Horizontal wells are the preferred method of development, as they increase wellbore exposure to reservoir facies, and increase the probability of encountering reefal sweet spots. South of 94-P, exploration well control is relatively sparse, but three separate productive areas are under development.

The Jean Marie Platform play is bounded on the west by the Platform Margin play, but is continuous north and east of the B.C. provincial border. Producing pools include Bivouac, Ekwan, Helmet, Helmet North, Midwinter, Peggo-Pesh, Sierra, and Thetlaandoa South. (Note: as of 2005, Helmet North, Midwinter and Peggo-Pesh fields are now included in the Helmet.)

Play 2. Jean Marie Platform Margin Play—Relatively continuous and mappable reef debris facies host large gas reserves along the narrow, north-south trending Jean Marie platform margin. Until recently, however, generally poor reservoir quality has precluded economic development. Rising gas prices and a focused, multi-well development strategy (the "resource play approach) has supported large-scale development by EnCana and other operators. Horizontal drilling and minimal evaluation are keys to maximizing deliverability and minimizing costs.

Although a large area is under active development, the Jean Marie Platform Margin play remains open-ended to the north and south. Producing pools include Cabin, Gunnell Creek, Sahtaneh, Elleh, Eskai and Tsea.

Fort St. John Region

Both the Jean Marie Platform and Platform Margin plays extend southward into the Fort St. John Region. There is very little well control, and consequently minimal knowledge of potential play fairways. An arbitrary southern margin of approximately 2500 metres drill depth has been applied to both plays.

Play 3. Southern Jean Marie Platform and Margin (Conceptual)—South of the Platform and Platform Margin play areas, little is known of the Jean Marie and equivalent strata. Most other Devonian carbonate units interfinger southward with sandstones shed from the emergent Peace River Arch, and it appears likely that the Jean Marie does the same. Stratigraphic and structural traps may occur as products of facies changes and Arch-related tectonism.

There is no production from the Southern Jean Marie Platform play.

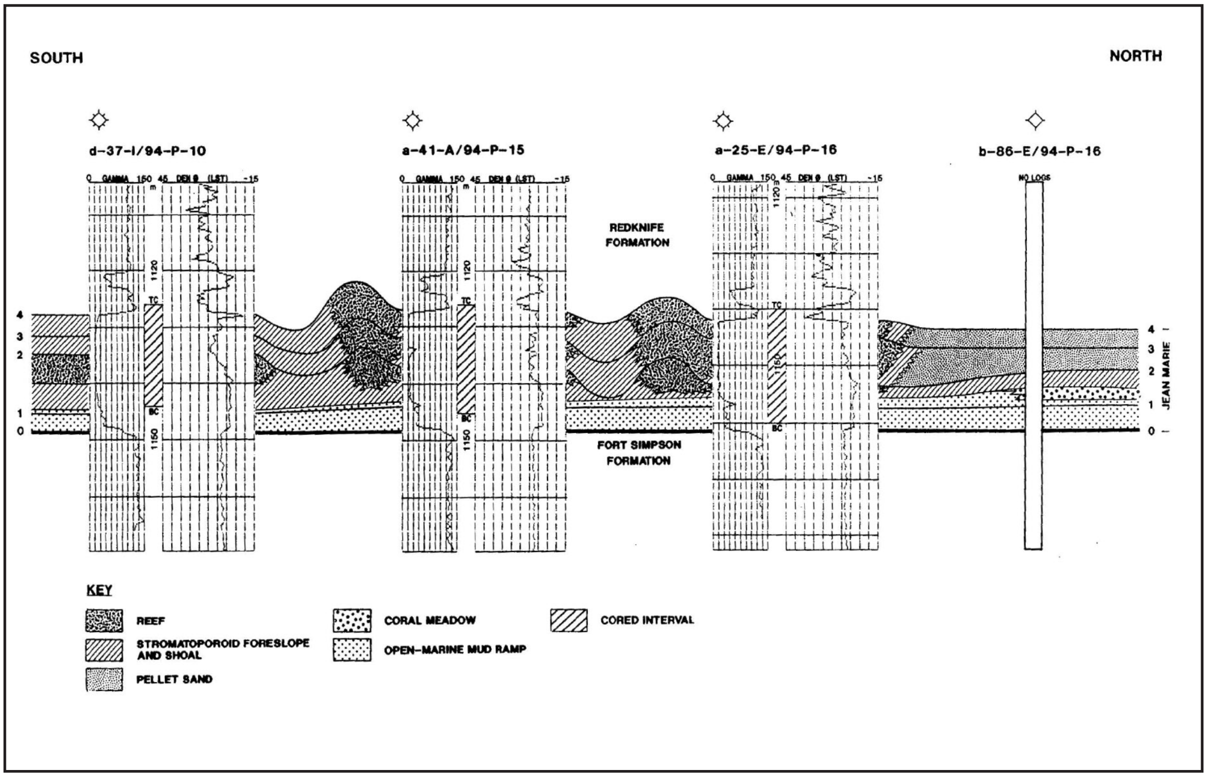
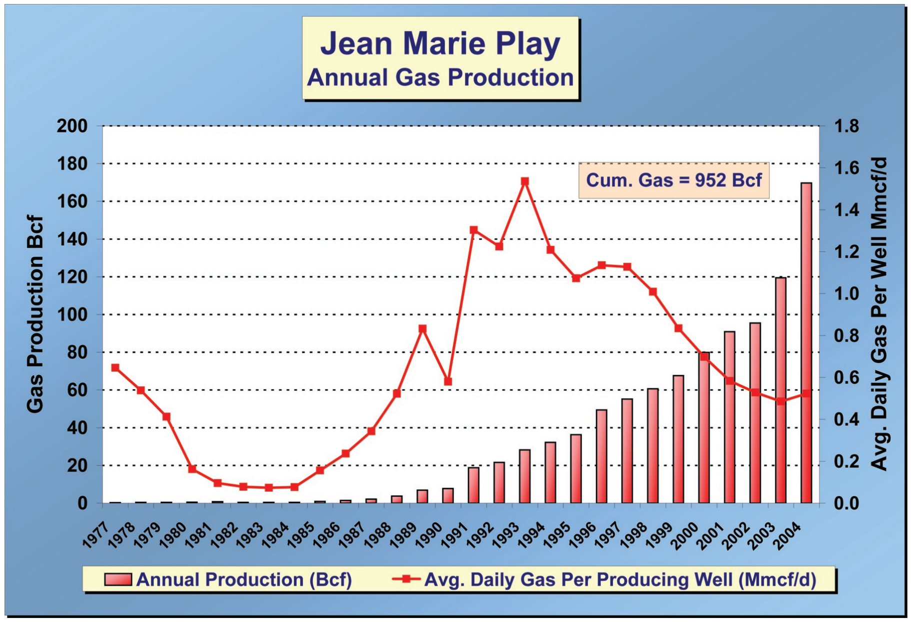
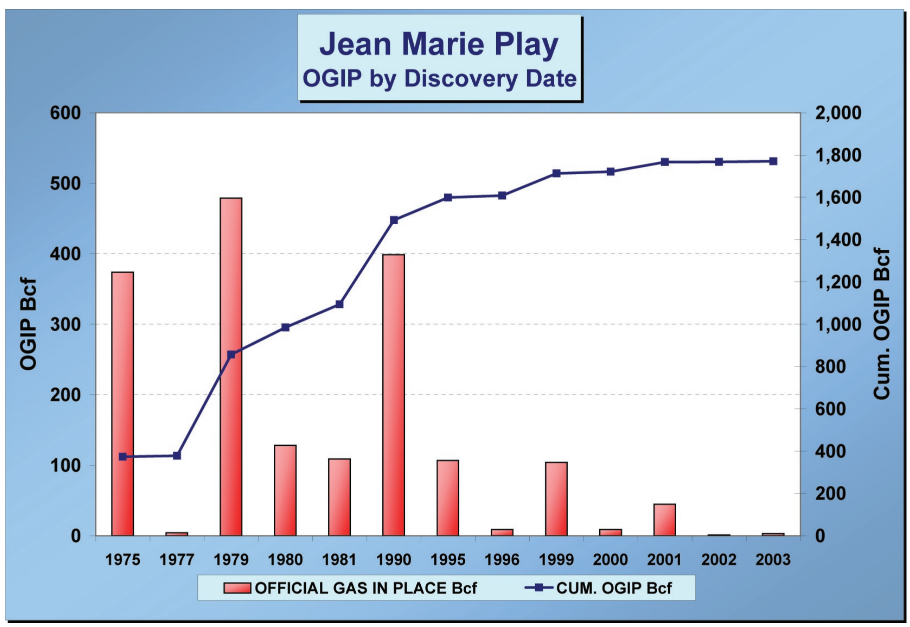


Figure 25. Stratigraphic cross-section, Jean Marie Formation, Helmet area (from Stoakes, 1992). Note patch reef stratigraphic sweet spots developed within different depositional cycles, encased in tighter foreslope and shoal facies.

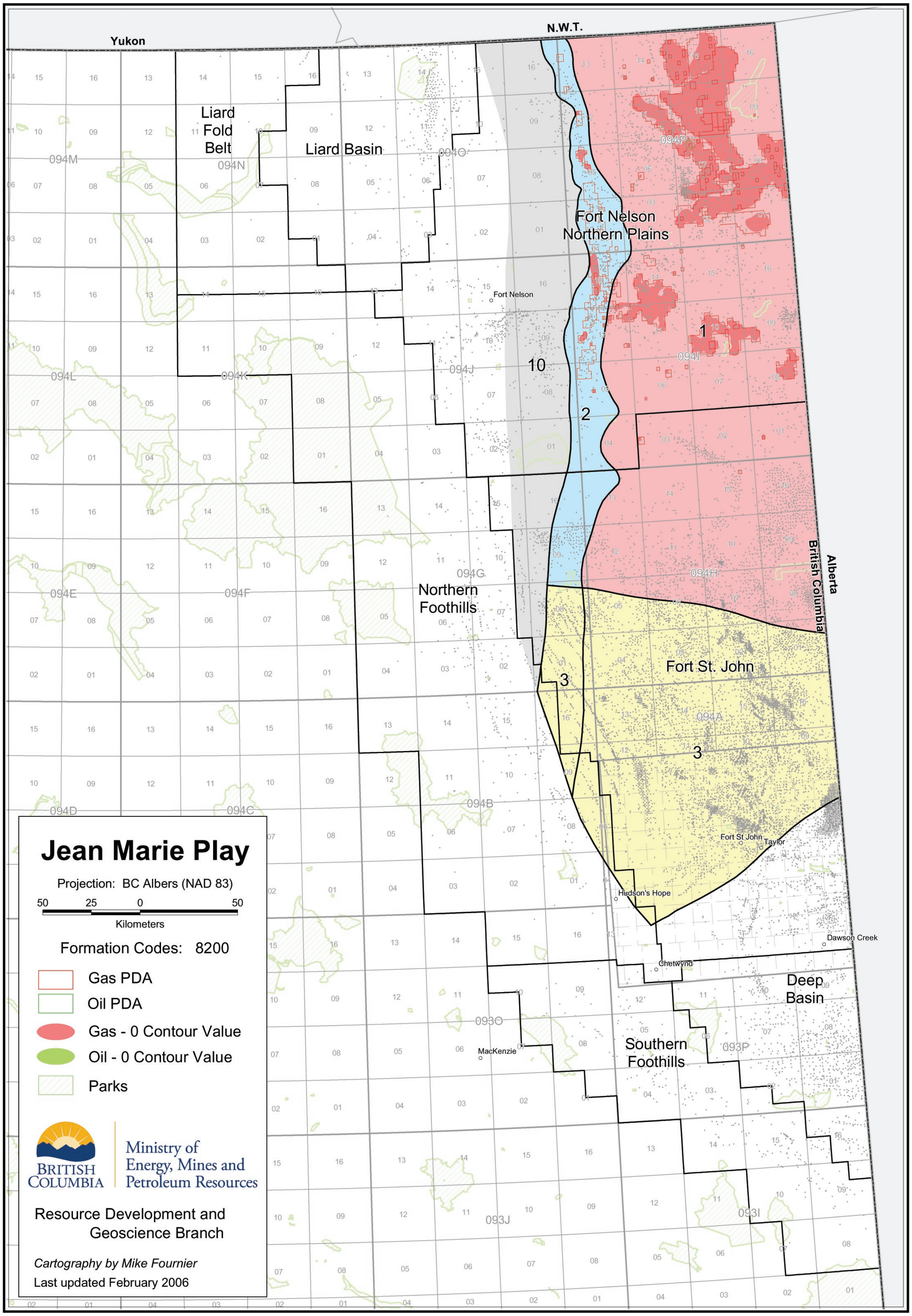
Jean Marie Play Pool List - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Gunnell Creek	Jean Marie	A	13,082	10,389	8,419	462	367	297
Helmet North	Jean Marie	A	11,292	9,637	1,709	399	340	60
Peggo-Pesh	Jean Marie	A	10,590	9,170	3,776	374	324	133
Helmet	Jean Marie	F	3,085	2,328	667	109	82	24
Ekwan	Jean Marie	A	3,032	2,140	1,938	107	76	68
Sierra	Jean Marie	A	2,954	2,241	1,896	104	79	67
Midwinter	Jean Marie	C	2,127	1,643	384	75	58	14
Midwinter	Jean Marie	A	1,489	1,222	277	53	43	10
Bivouac	Jean Marie	A	644	460	410	23	16	14
Sahtaneh	Jean Marie	A	486	374	220	17	13	8
Other Pools			1,391	944	709	49	33	25
Totals			50,171	40,547	20,406	1,771	1,431	720



Jean Marie Play
Annual Gas Production
Cum. Gas = 952 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
200
180
160
140
120
100
80
60
40
20
0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Jean Marie Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
600
500
400
300
200
100
0
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1975
1977
1979
1980
1981
1990
1995
1996
1999
2000
2001
2002
2003
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Jean Marie Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8200
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Deep Basin
Southern Foothills
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
094N
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094P
094L
094K
094J
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3
10

4.29 Leduc Formation

Upper Devonian (Frasnian) reefal buildups of the Leduc Formation are well documented throughout central and southern Alberta, where they grew in isolated to sub-regional reefal complexes and fairways atop the Cooking Lake Platform. A Leduc reef complex fringes the Peace River Arch, and produces hydrocarbons primarily from structural traps generated by block faulting (Figure 26) (Switzer et. al., 1994). The westernmost producing field lies about 70 kilometres east of the B.C./Alberta border, however, and penetrations further west are sparse.

Leduc reefs host hydrocarbons in high-quality, dolomitized stromatoporoid reef buildups. Reservoir geology has been interpreted in detail in a number of the major buildups in Alberta, showing that reef framework and coarse-grained debris facies near the reef margin are generally the best producing rocks.

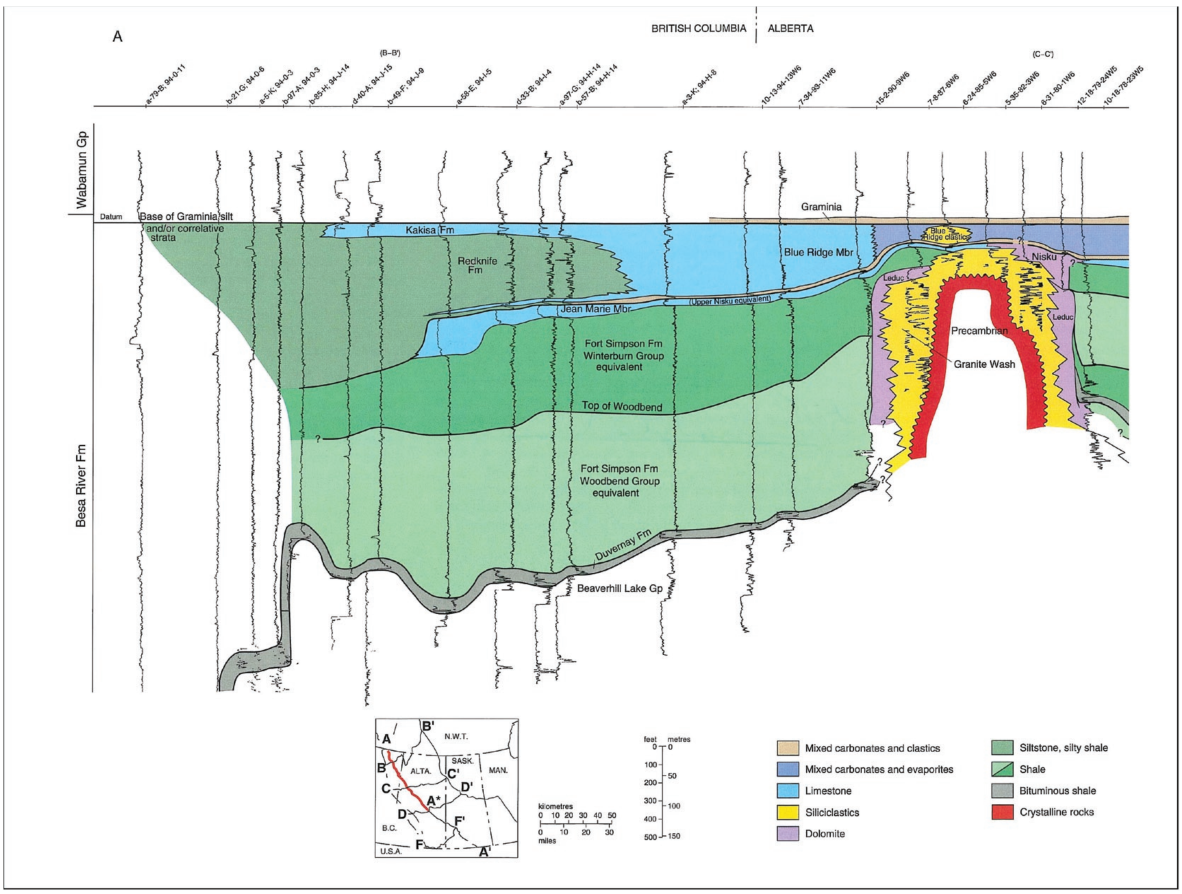


Figure 26. Schematic regional cross-section, illustrating Leduc reefal buildups flanking Peace River Arch in northwestern Alberta and adjacent B.C. (from Switzer et. al., 1994).

Fort St. John Region

Play 1. Peace River Arch Fringing Reef Play (Conceptual)—Leduc strata along the northern fringe of the Peace River Arch may host gas in dolomitized reefal buildups. Peace River Arch-related faulting should provide structural traps, with equivalent and overlying Ireton / Fort Simpson shales providing the seals. This play is conceptual, however, as there are few penetrations and no discoveries.

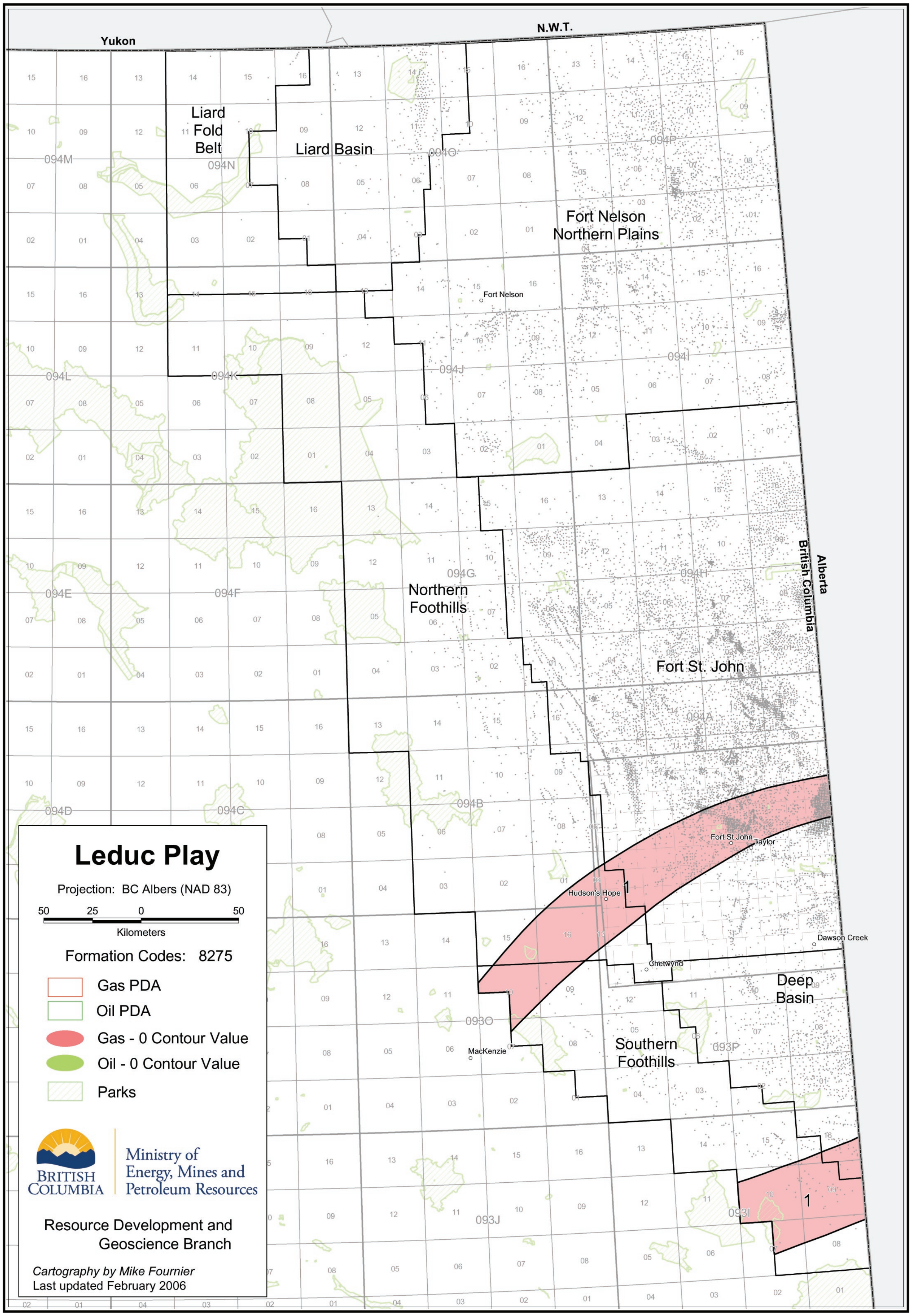
The northern and southern play boundaries are the depositional margins of the Leduc fringing reef. The western boundary is drawn at the western margin of the Southern Foothills Region, approximately where Leduc-equivalent strata come to surface in the thrust belt.

Deep Basin Region

Play 1. Peace River Arch Fringing Reef Play (Conceptual)—The southern limb of the fringing reef play crosses the southeastern corner of the Deep Basin Region. There are no discoveries or penetrations, so the play is considered to be conceptual in this area as well.

Southern Foothills Region

Play 1. Peace River Arch Fringing Reef Play (Conceptual)—The western extension of the Fringing Reef Play crosses the Southern Foothills Region on both its northern and southern limbs. Foothills-related structure may add an additional structural component to play potential, but the play is still conceptual in both areas through lack of drilling.



Leduc Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8275
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Deep Basin
Southern Foothills
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
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093I

4.30 Slave Point Formation

The Slave Point Formation was deposited in the early stages of a basin-wide transgression, which ultimately drowned the Middle Devonian carbonate platforms of northeastern B.C. and Alberta (Oldale and Munday, 1994). Slave Point carbonates form a thick and complex carbonate platform, comprising several stacked shallowing-upward cycles. The lower cycles can be correlated regionally, and consist of nodular brachiopod-crinoid mudstones and wackestones with local carbonate bank developments. High-energy reefal carbonates were deposited primarily along platform-margin banks in upper Slave Point cycles, although some banks are found on the margins of the Hotchkiss Embayment to the south, and along lesser embayments within the main platform (Figure 27). Otter Park marine shales accumulated during Slave Point time in the Horn River and Cordova Embayments to the north, and within the Hotchkiss Embayment and smaller platform embayments to the south.

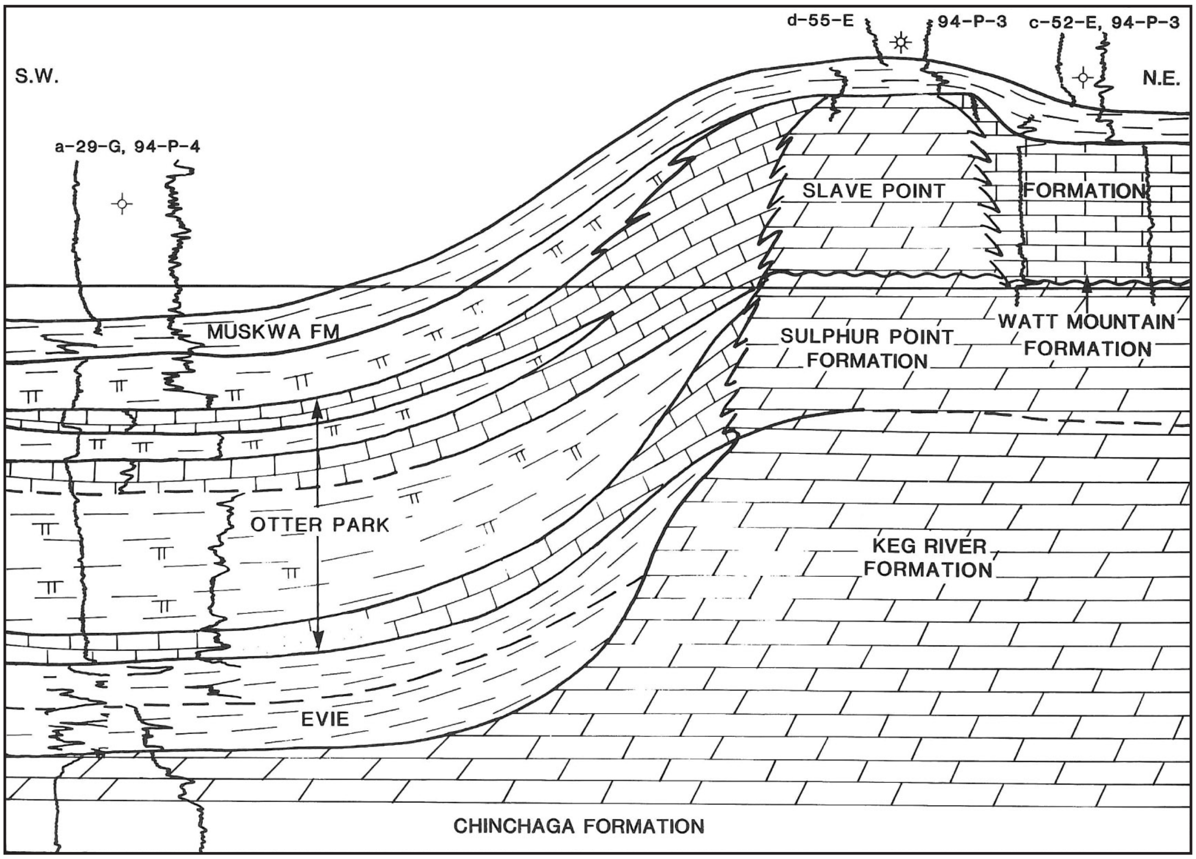


Figure 27. Cross-section illustrating platform margin reef reservoirs in the Slave Point Barrier Reef / Pinnacle Play of the Fort Nelson Region (from Lehto, 1990).

Slave Point gas reservoirs are hosted within dolomitized reefal buildups, which grew on platform- and embayment-margin banks. Slave Point reefs are typically limited to one depositional sequence, and thus are relatively narrow and thin compared to other Devonian reef reservoirs in the WCSB. Dense back-reef limestones and basinal shales provide effective lateral and top seals.

Fort Nelson Northern Plains Region

Play 1. Slave Point Barrier Reef / Pinnacle Play—This play encompasses Slave Point platform margin reef buildups along the edges of the Horn River and Cordova Embayments (Lehto, 1990). Isolated reefs may also occur as pinnacles growing on Keg River platform / reef outliers, but it is difficult to differentiate Slave Point from Keg River carbonate buildups in these situations. Along the platform margin, extensive dolomitization may also obscure the Slave Point / Keg River contact, so the entire dolomite section has been termed "Pine Point" in some areas. Locally, faulting is important in establishing separate reservoir compartments, and in providing conduits for introduction of hydrothermal dolomitizing fluids (Morrow et. al., 2002).

The western boundary of the play area has been set at the western edge of the Fort Nelson Region, which approximates the current westerly limit of production along the platform margin.

Slave Point barrier reefs and pinnacles produce gas at Cabin, Clarke Lake, Dilly, Gote, Helmet, Helmet North, Hoffard, Hossitl, Kotcho Lake, Kotcho Lake East, Louise, Mel, Milo, Peggo-Pesh, Petitot River, Sahtaneh, Tsea, and Yoyo.

Play 3. Slave Point Platform—Within the Slave Point Platform, reefal buildup reservoirs occur in lower Slave Point cycles in various areas, and bordering embayments developed within upper Slave Point cycles. Many areas are only lightly drilled, and mapping of embayment trends is rather speculative, as the result of poor well control and difficulties in interpreting facies where core is lacking. Platform gas pools tend to be smaller than those along platform or major embayment margins because of lower depositional relief and less extensive dolomitization.

The Slave Point Platform play is bounded to the north by the platform margin, to the west by the speculated platform margin, and continues to the south into the Fort St. John Region.

Slave Point Platform gas pools in the Fort Nelson Region include Adsett, Bulldog, Ekwan, Elleh, Elleh North, Junior, Klua, Sextet, Shekilie, and Sierra.

Fort St. John Region

Play 2. Ladyfern / Hotchkiss Embayment Play—Slave Point reef reservoirs occur as isolated reefs within the Hotchkiss Embayment trend, and also as structural/stratigraphic traps in buildups along the embayment margins. Large pools such as Cranberry and Hamburg were discovered a number of years ago in Alberta, but production was not established in B.C. until the discovery of Ladyfern in 2000 (Boreen et. al., 2001). A concerted exploration effort to the west since that time has resulted in limited success, particularly as seismic cannot readily distinguish porous Slave Point reservoir from calcareous embayment-fill shales.

Hydrothermal dolomitization across the Hay River Fault Zone is a major influence on reservoir development in the Slave Point (Boreen et. al., 2001). The Hotchkiss Embayment is bounded to the north by the Slave Point Platform, and to the south by Slave Point platformal carbonates and clastics onlapping the Peace River Arch. It is extrapolated westward into the Northern Foothills Region on very little well control.

Slave Point reservoirs in the Hotchkiss Embayment produce gas at Buick Creek, Chinchaga River, Dahl, Ladyfern, Milligan Creek, Nig Creek, Ring, and Velma.

Play 3. Slave Point Platform—The Slave Point Platform continues southward from the Fort Nelson Region. It is bounded to the south by the Hotchkiss Embayment, and to the west by the (speculative) platform margin in the Northern Foothills Region.

Slave Point Platform pools occur in the Fort St. John Region at Bougie, Bubbles, and Bubbles North.

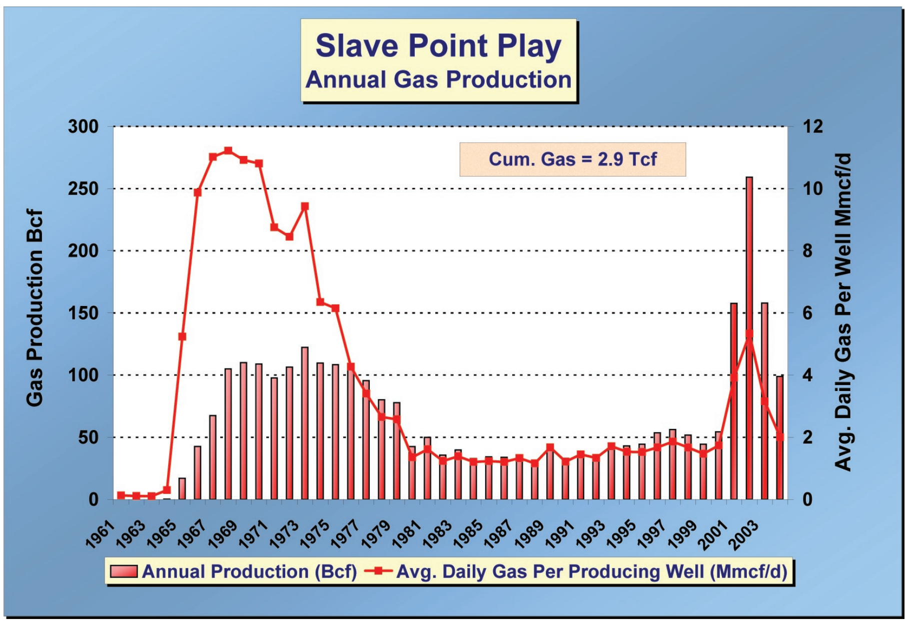
Northern Foothills Region

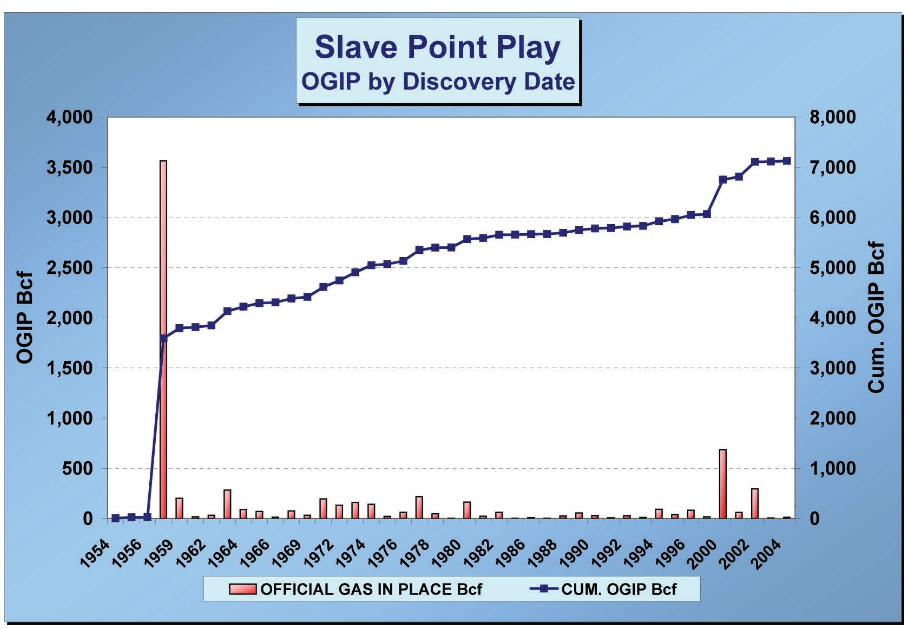
The Northern Foothills includes the westerly extension of Play 2 (Hotchkiss Embayment) and Play 3 (Slave Point Platform), both extrapolated westward on relatively little well control. There is no production in the region from either play.

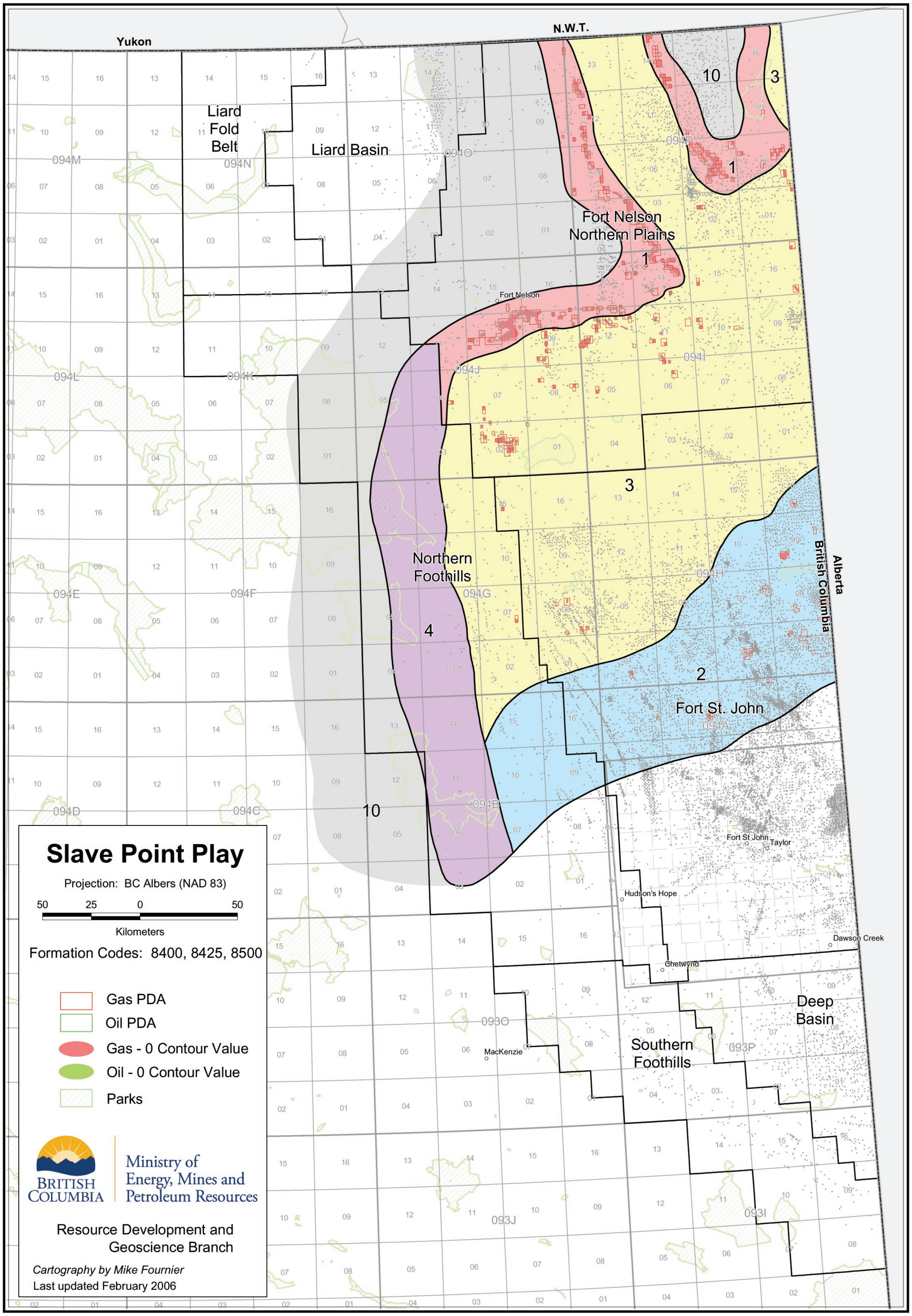
Play 4. Western Platform Margin / Barrier Reef (Conceptual)—The Slave Point platform margin and associated reefal buildups are mapped along a north-south trend in the Northern Foothills Region, based upon the concept that the Slave Point Platform must have had a westerly limit, much like the platform margin to the north. Very scant well control and speculative outcrop-subsurface correlations are not sufficient to define the platform margin trend or characteristics.

Although there are no producing gas pools, one can speculate that Slave Point reservoirs in this play would resemble those of the Barrier Reef / Pinnacle Play, but with a larger structural component because of Laramide structural deformation.

Slave Point Play Pool List - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Clarke Lake	Slave Point	A	101,000	40,893	1,664	3,565	1,444	59
Ladyfern	Slave Point	A	19,438	14,405	6,101	686	509	215
Helmet	Slave Point	A	6,817	3,492	658	241	123	23
Klua	Slave Point	D	5,000	808	189	177	29	7
Klua	Slave Point	B	3,794	1,211	206	134	43	7
Adsett	Slave Point	A	3,347	1,426	307	118	50	11
Kotcho Lake East	Slave Point	C	3,214	766	93	113	27	3
Mel	Slave Point	A	3,000	1,454	171	106	51	6
Kotcho Lake	Slave Point	A	2,950	1,704	394	104	60	14
Petitot River	Slave Point	A	2,786	396	1	98	14	0
Other Pools			50,516	20,989	12,187	1,783	741	430
Totals			201,862	87,543	21,971	7,126	3,090	776






Slave Point Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8400, 8425, 8500
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated February 2006
Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Southern Foothills
Deep Basin
Fort Nelson
Fort St John
Taylor
Hudson's Hope
Dawson Creek
Chetwynd
MacKenzie
094M
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094L
094K
094J
094I
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094F
094G
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094C
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094A
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1
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3
4
10

4.31 Watt Mountain / Gilwood / Granite Wash

This group of formations encompasses Middle Devonian sandstone and conglomerate reservoirs that mantle the Peace River Arch, and grade basinward into equivalent carbonate or shale/evaporitic units. Three distinct clastic wedges – Gilwood, Keg River, and Chinchaga – have been mapped in Alberta (Figure 28) (Reinson et. al., 1993). Depositional environments ranged from alluvial plain to fan delta and shallow marine (e.g., Dec et. al., 1996). However, moving onto the Arch, the clastic units amalgamate into the Granite Wash, the distribution of which was controlled primarily by structural movements on the Arch.

In Alberta, these units are prolific oil reservoirs, and are reasonably well documented and understood. In B.C., however, there are few penetrations and relatively poor regional knowledge. Outcrop relationships suggest that sediments were derived from both westerly (lower Paleozoic sandstones) and local to easterly (PreCambrian crystalline rocks) sources. Traps are formed regionally by depositional pinchout of clastic units against the Arch, and by more local structural controls influencing sandstone depositional geometry and / or present-day structural configuration.

Fort St. John Region

Play 1. Granite Wash / Peace River Arch Play (Conceptual)—Gas potential is projected to occur within structural and stratigraphic traps, in sandstones on the northern and western flanks of the Peace River Arch. The play is bounded southward and eastward by onlap of reservoir units onto the Arch. Northward, sandstones grade to associated platformal carbonates and evaporites, while stratigraphic relationships to the west are poorly understood.

Play 1 is mapped into the Northern and Southern Foothills Regions, as well as over the northwesternmost corner of 93P. However, its lateral extent is poorly known.

There are no known producing pools from the Watt Mountain / Gilwood / Granite Wash unit in British Columbia.

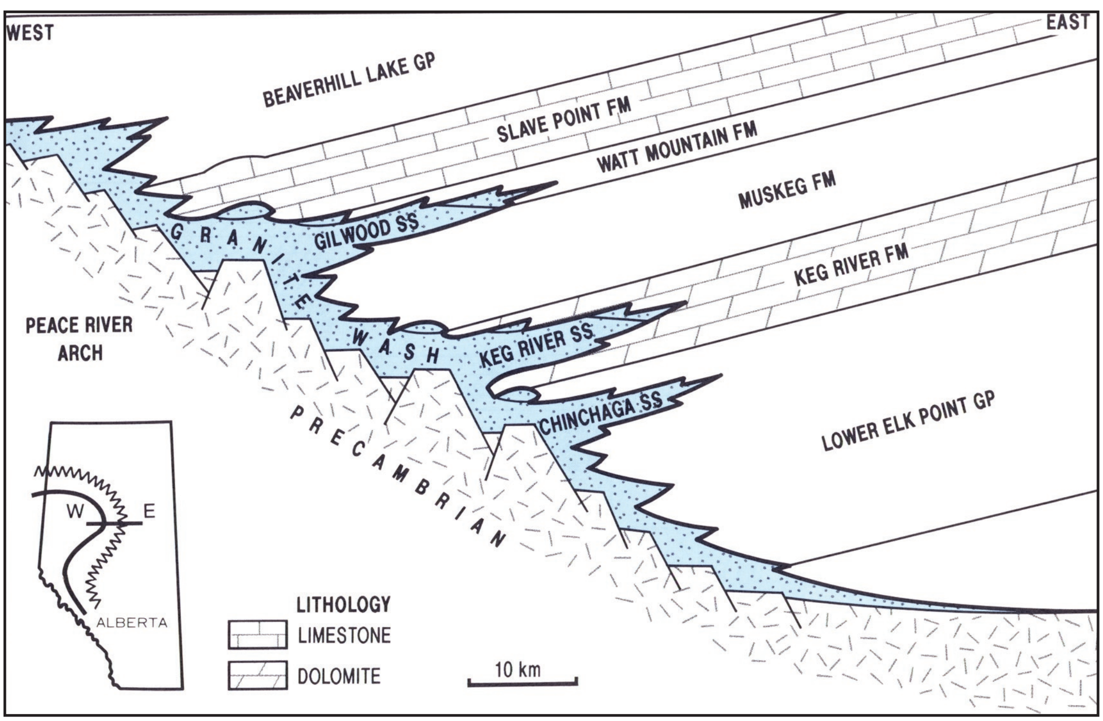
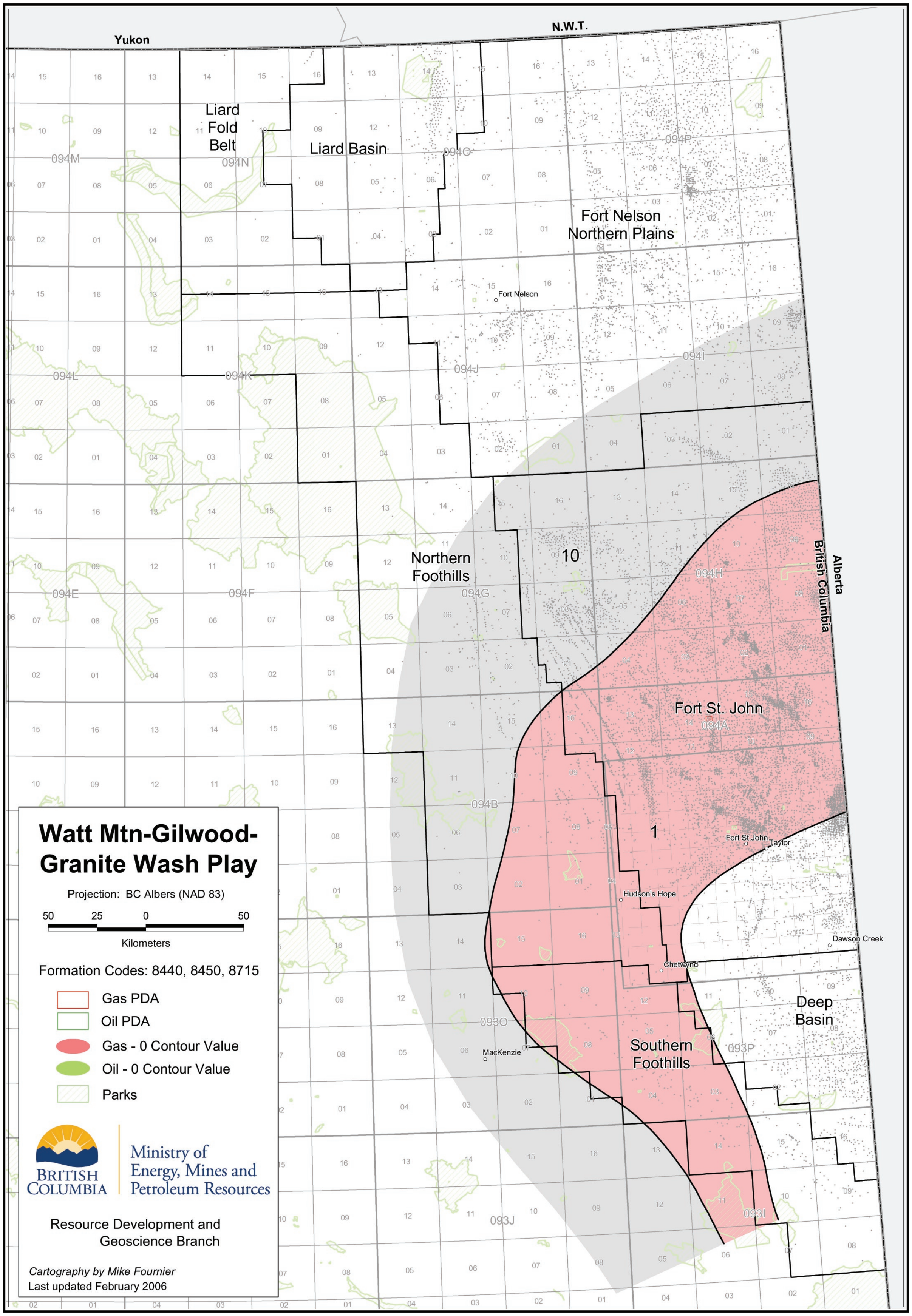


Figure 28. Schematic regional cross-section, illustrating Granite Wash sandstone reservoirs mantling Peace River Arch, with sandstone tongues corresponding to specific regressive pulses correlated basinward (from Reinson et. al., 1993). Reservoir distributions have been mapped in Alberta, but are more speculative in B.C.


Yukon
N.W.T.
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Fort Nelson
Northern Foothills
10
Fort St. John
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Fort St John
Taylor
Hudson's Hope
Chetwynd
Dawson Creek
Deep Basin
Southern Foothills
MacKenzie
British Columbia
Alberta
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093O
093P
093J
093I
Watt Mtn-Gilwood-Granite Wash Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8440, 8450, 8715
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Cartography by Mike Fournier
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4.32 Sulphur Point, Muskeg, Pine Point, Keg River

The primary prospective unit in this interval is the Keg River Formation. "Pine Point" is an outcrop term sometimes applied to Middle Devonian carbonates, particularly dolomitized facies. Its usage in the subsurface has been inconsistent, and it is not used in this report.

The Keg River Formation can be subdivided into lower and upper units. The lower unit consists of relatively deep-water platformal carbonates, deposited near the beginning of a widespread transgressive episode. Lower Keg River carbonates are typically dolomitized, and exhibit a sharp contact over Chinchaga evaporites. Upper Keg River strata consist of stacked shoaling-upward carbonate cycles, capped by high-energy skeletal / reefal debris. These banks reach thicknesses of more than 200 metres, and amalgamate to form the northern wall of the Elk Point restricted basin (Meijer-Drees, 1994). Individual banks are separated by channels and embayments filled with more argillaceous strata. Isolated Upper Keg River buildups occur adjacent to the banks, their growth apparently nucleated over elevated fault blocks.

The Keg River interfingers southward with Muskeg Formation evaporites, and basinward with marine shales of the Evie Formation. To the west, scattered wells and outcrops suggest the presence of a westerly reef margin bounding the Elk Point Basin.

Sulphur Point platform and reefal carbonates cap the Keg River and Muskeg Formations regionally. Although there is a sharp transgressive contact at its base, the Sulphur Point can be difficult to distinguish from the Upper Keg River, particularly where both are dolomitized, and in development wells which do not penetrate the entire Middle Devonian section. Sulphur Point and Keg River prospectivity are thus considered together.

Fort Nelson Northern Plains Region

Play 1. Platform Margin / Pinnacle Fairway Play—Relatively small but high-quality platform margins reservoirs occur where cross-cutting faults create trapping situations along the Keg River platform margin. Some deep-seated faults may also have influenced reef growth and local diagenesis (Morrow et. al., 2002). Several pinnacle reef buildups currently produce gas on elevated structural blocks seaward of the main bank margin, and others remain to be found on the flanks of the Horn River Basin.

The play area is bounded to the west by marine shales, to the south by the transition zone to evaporitic Muskeg strata, and to the east by equivalent argillaceous embayment-fill strata. The Platform Margin is mappable southwestward into the Northern Foothills Region, but its presence there is conceptual.

Keg River Platform Margin / Pinnacle Fairway pools are productive at Clarke Lake, Elleh, Gote, Gunnell Creek, Klua, Kyklo, Mel, Milo, Roger, Sahtaneh, Sierra, Tsea, and Yoyo.

Play 2. Lower Keg River Platform Play—Stratigraphic and structural traps occur in the lower Keg River platform unit, primarily in the Cordova Embayment area. Patchy dolomites are the main reservoirs. There is no upper Keg River reef development in this area, so that overlying Horn River, Evie, and Klua shales form an effective top seal (Figure 29). Play boundaries and paleogeography are not clearly understood, as drilling densities are fairly low, particularly in the adjacent Northwest Territories.

The play area is bounded to the south by the transition to Muskeg evaporites, and to the west by upper Keg River reefs. Lower Keg River Platform pools are found at Helmet North and Peggo-Pesh.

Play 3. Keg River – Muskeg Transition Play (Conceptual)—Stratigraphic traps should occur in the transition zone where upper Keg River reefal carbonates grade to impermeable Muskeg evaporite facies. Local structure may assist in defining trap configurations. There are no producing examples for this play, but much of the play area is very lightly drilled, and accumulations are likely to be fairly small.

The Keg River – Muskeg Transition Play laps into the Fort St. John and Northern Foothills Regions, based on general paleogeography.

Northern Foothills Region

Play 4. Western Platform Margin / Pinnacle Reef Play (Conceptual)—The productive platform margin / pinnacle reef fairway is extrapolated westward into the northern Foothills based on scant well control and limited outcrop mapping. In addition, a western platform margin is inferred to exist in order to separate evaporitic platform interior facies (Muskeg Formation) from basinal shales. Reservoir characteristics should be like those for Play 1, although there is greater potential for structural trapping as the result of Laramide deformation.

Play boundaries are poorly constrained. The southern limit is drawn where Keg River carbonates are projected to lap onto the Peace River Arch. There are no producing pools in this play.

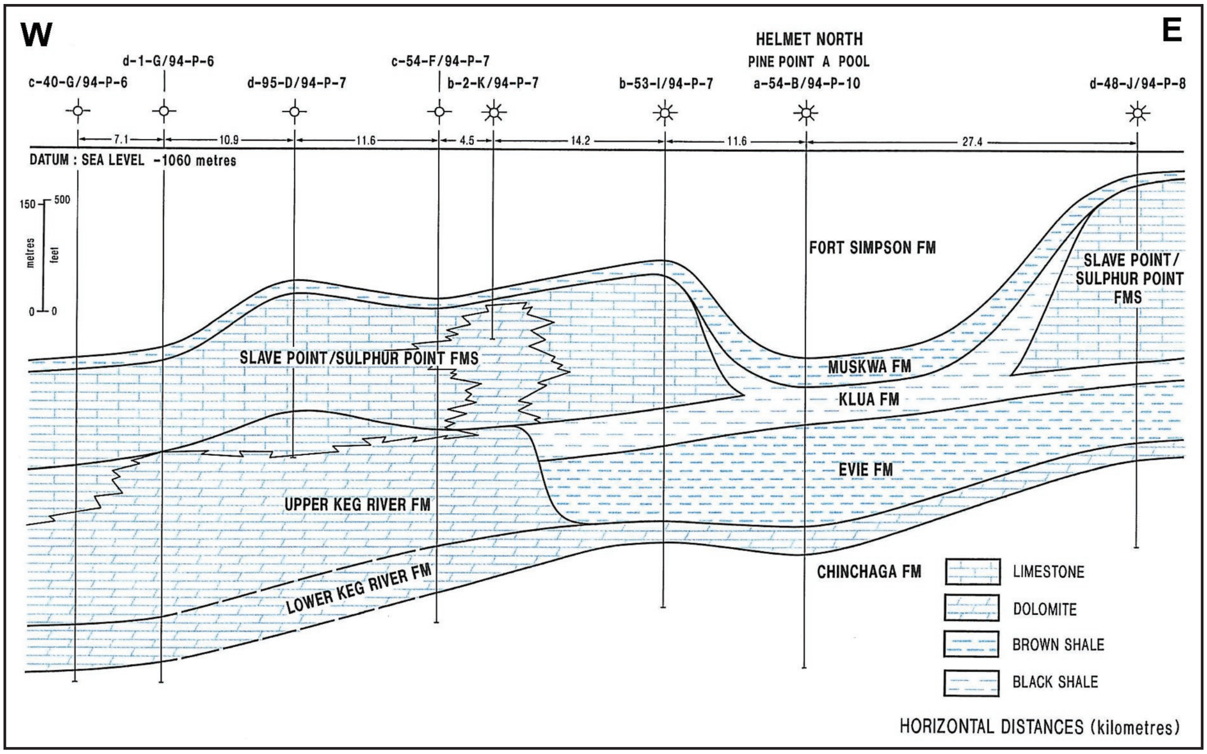
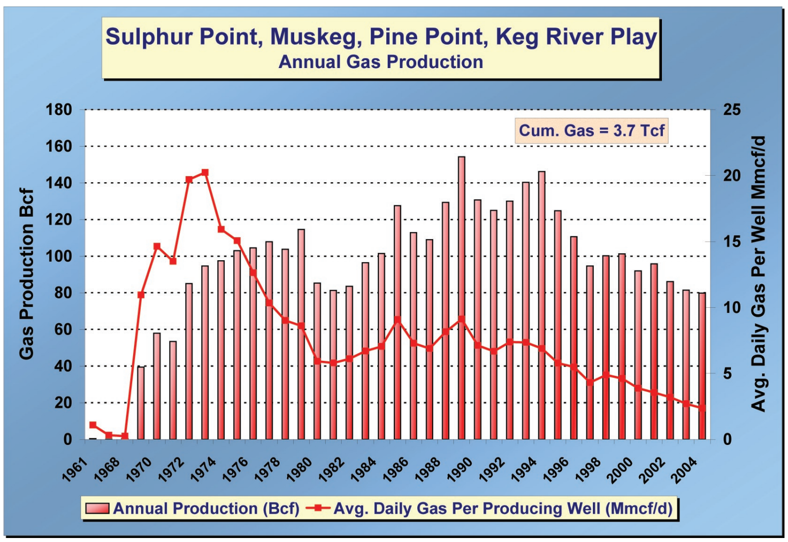
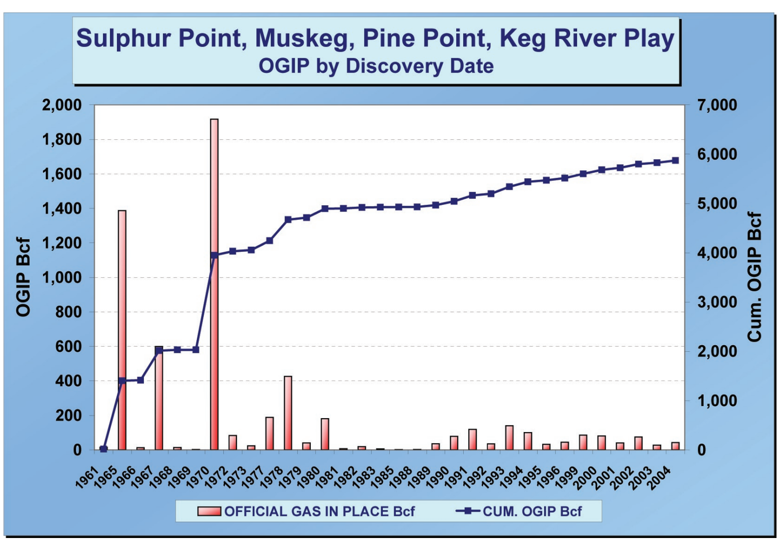
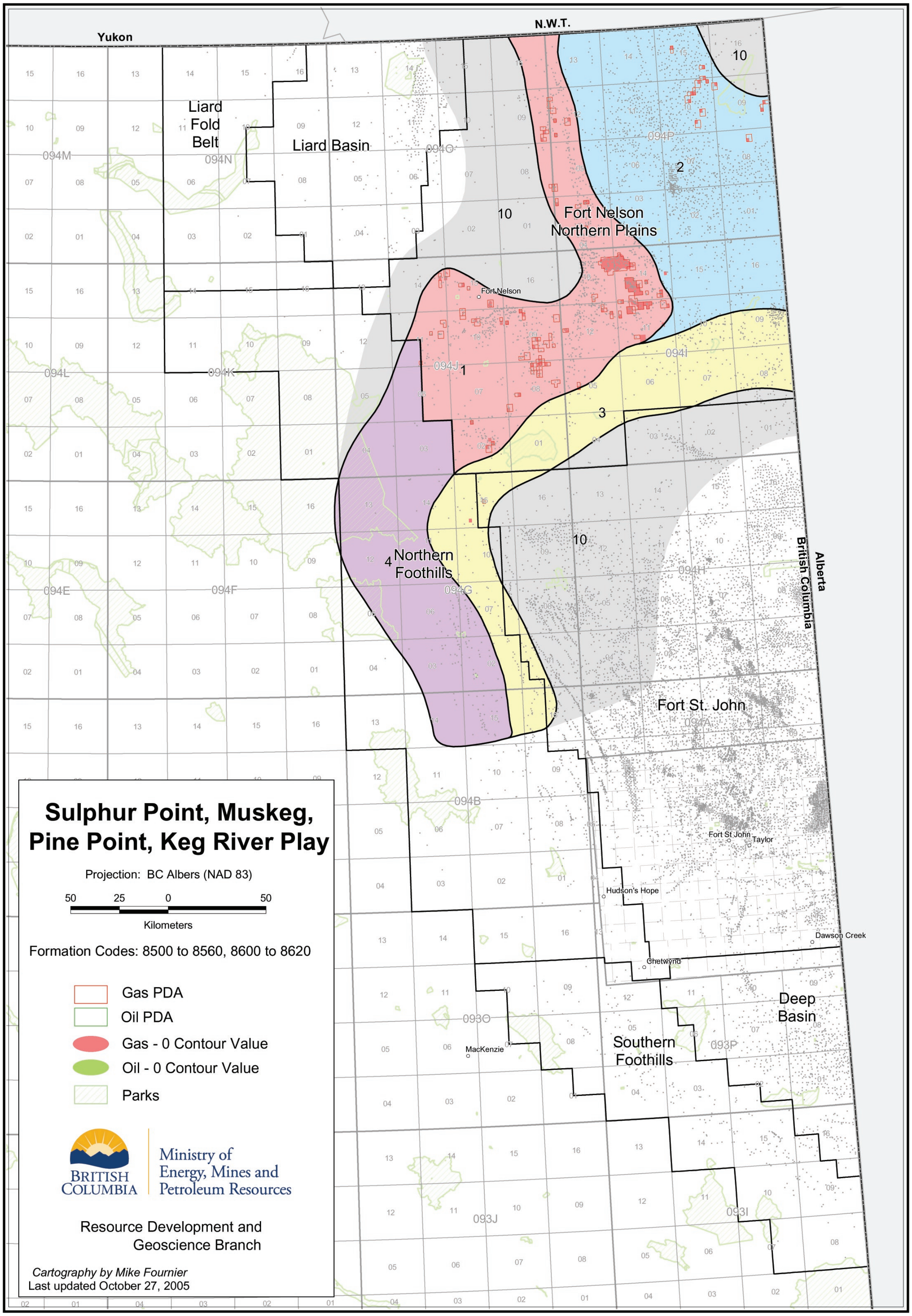


Figure 29. Schematic cross-section of Lower Keg River Platform Play in Helmet area, illustrating production from low-relief platform, basinward of high-relief Upper Keg River and Slave Point platform margins (from Reinson et. al., 1993).

Sulphur Point, Muskeg, Pine Point, Keg River Pool List - Top 10 Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Yoyo	Pine Point	A	54,300	33,383	2,148	1,917	1,178	76
Sierra	Pine Point	A	39,300	26,482	5,289	1,387	935	187
Sierra	Pine Point	B	16,742	10,273	1,765	591	363	62
Sierra	Pine Point	D	11,612	3,562	759	410	126	27
Roger	Pine Point	A	3,425	1,724	31	121	61	1
Sierra	Pine Point	J	2,476	951	265	87	34	9
Gote	Sulphur Point	A	2,360	1,271	210	83	45	7
Sierra	Pine Point	E	2,272	1,448	57	80	51	2
Sierra	Pine Point	F	2,142	1,313	350	76	46	12
Sahtaneh	Pine Point	B	1,477	313	14	52	11	1
Other Pools			30,552	14,830	10,112	1,079	524	357
Totals			166,658	95,549	21,000	5,883	3,373	741






Sulphur Point, Muskeg, Pine Point, Keg River Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8500 to 8560, 8600 to 8620
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
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Resource Development and Geoscience Branch
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Yukon
N.W.T.
Alberta
British Columbia
Liard Fold Belt
Liard Basin
Fort Nelson Northern Plains
Northern Foothills
Fort St. John
Southern Foothills
Deep Basin
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4.33 Nahanni / Headless / Chinchaga

Chinchaga carbonates are the uppermost unit of the lower Elk Point Group, deposited during marine transgression over the Cold Lake evaporite basin. They comprise a variety of platformal carbonate and interbedded clastic facies, generally thinning and becoming more dominated by clastics and evaporites southward toward the Peace River Arch. To the northwest, the Chinchaga becomes more marine, and appears to be equivalent to the Nahanni and Headless carbonates of the Northwest Territories.

Facies characteristics and boundaries are generally speculative, as well control is very limited.

Liard Fold Belt / Liard Basin Regions

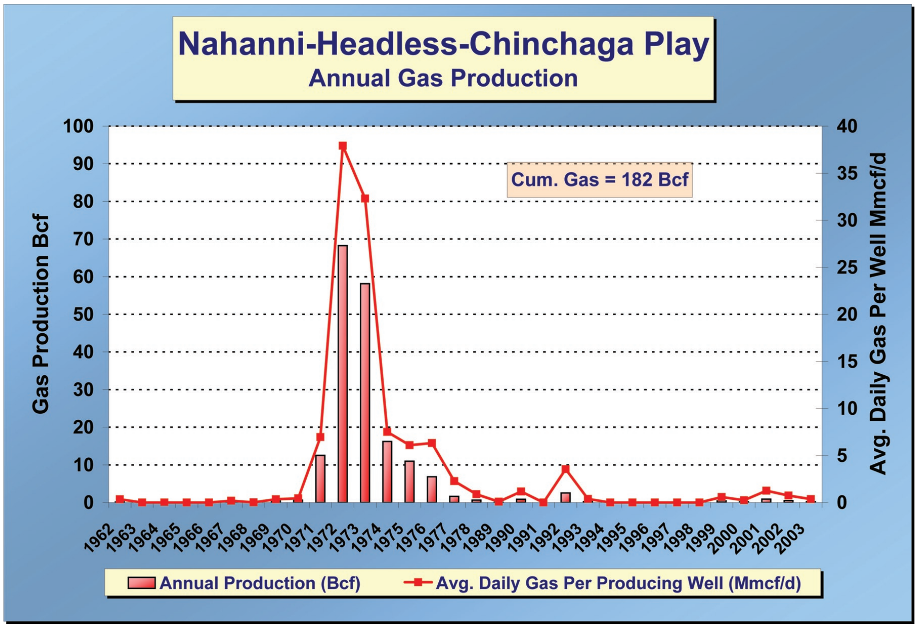
Play 1. Foothills / Fractured Carbonate Shelf Play—The fully-developed Chinchaga carbonate shelf has experienced hydrothermal dolomitization in this area, significantly enhancing the limited reservoir quality present regionally in the shelfal facies. Structural traps occur within the fold belt, and associated fracturing further enhances reservoir permeabilities (Morrow and Potter, 1998). Major structures have been drilled, but additional prospects will be defined with better structural and seismic control.

The Foothills / Fractured Carbonate Shelf Play is productive at Beaver River and Crow River.

Play 2. Chinchaga Carbonate Platform—Fenestral and vuggy porosity occur in platformal facies, and are locally enhanced by leaching and dolomitization associated with fault trends. There are numerous gas shows, particularly along the Bovie Fault Zone at the eastern margin of the Liard Basin, but no production to date.

The Chinchaga Carbonate Platform Play can be traced southeastward into the Northern Foothills and Fort Nelson Northern Plains Regions, where reservoir quality deteriorates with increasing evaporite and clastic content.

Nahanni-Headless-Chinchaga Play - All Pools by OGIP								
Area	Formation	Pool Seq	Official Gas In Place (Mm3)	Init Est Gas Mkt (Mm3)	Rem Gas Mkt (Mm3)	Official Gas In Place Bcf	Init Est Gas Mkt Bcf	Rem Gas Mkt Bcf
Beaver River	Nahanni	A	7,312	4,397	275	258	155	10
Crow River	Nahanni-Headless	A	249	108	107	9	4	4
Totals			7,561	4,505	382	267	159	13



Nahanni-Headless-Chinchaga Play
Annual Gas Production
Cum. Gas = 182 Bcf
Gas Production Bcf
Avg. Daily Gas Per Well Mmcf/d
100
90
80
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
0
1962
1963
1964
1965
1966
1967
1968
1969
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1971
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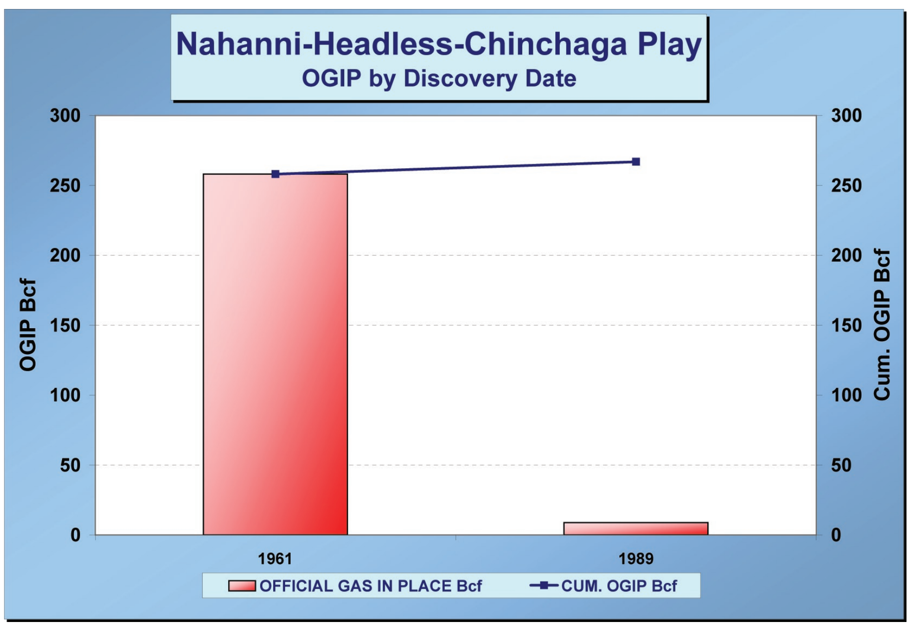
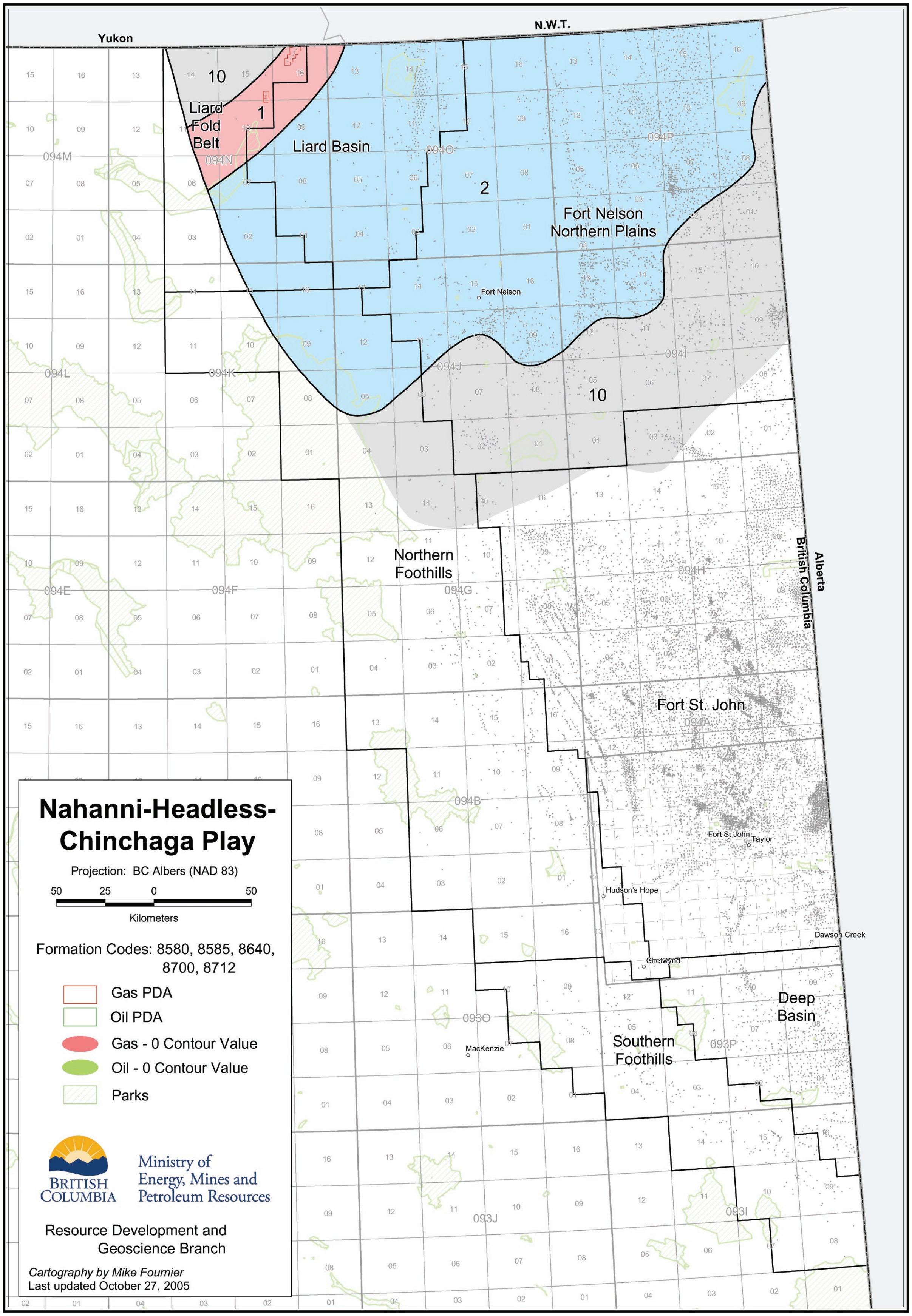
Annual Production (Bcf)
Avg. Daily Gas Per Producing Well (Mmcf/d)



Nahanni-Headless-Chinchaga Play
OGIP by Discovery Date
OGIP Bcf
Cum. OGIP Bcf
300
250
200
150
100
50
0
1961
1989
OFFICIAL GAS IN PLACE Bcf
CUM. OGIP Bcf



Nahanni-Headless-Chinchaga Play
Projection: BC Albers (NAD 83)
50 25 0 50
Kilometers
Formation Codes: 8580, 8585, 8640, 8700, 8712
Gas PDA
Oil PDA
Gas - 0 Contour Value
Oil - 0 Contour Value
Parks
Ministry of Energy, Mines and Petroleum Resources
BRITISH COLUMBIA
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Yukon
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Appendix 1

Formation Codes - Stratigraphic

The following stratigraphic ordered list contains the 369 formation codes used in petroleum reserves and petroleum land administration in British Columbia.

Code	Formation
0040	Cenozoic
0050	Quaternary
0060	Pleistocene
0070	Cape Ball
0075	Pre-Tertiary
0100	Tertiary
0105	Boundary Bay
0108	Mud Bay
0120	Skonun
0130	Masset
0140	Kishenehn
0150	Chuckanut
0175	Mesozoic
0180	Cretaceous
0200	Upper Cretaceous
0500	Nanaimo Group
0600	Gabriola
0610	Spray
0620	Geoffrey
0630	Northumberland
0640	De Courcy
0650	Cedar District
0660	Protection
0670	Newcastle
0673	Douglas Coal
0675	Pender
0680	Extension
0690	East Wellington
0700	Haslam
0710	Comox
0720	Benson
1300	Wapiti
1350	Belly River
1360	Wapiabi
1365	Puskwaskau
1368	Chinook
1380	Bad Heart
1390	Muskiki
1398	Cardium Zone
1400	Cardium Sand
1405	Blackstone
1410	Kaskapau
1411	Second White Speckled Shale
1412	First Petroliferous Shale
1414	Second Petroliferous Shale
1415	Pouce Coupe
1420	Doe Creek
1450	Fort Nelson
1490	Queen Charlotte Group
1492	Honna
1494	Skidegate
1500	Dunvegan
1520	Crowsnest Volcanics
1530	Fort St. John
1600	Haida
1660	Sully
1680	Sikanni
1700	Shaftesbury
1705	Lepine
1710	Goodrich
1713	Base of Fish Scales
1715	Hasler
1720	Buckinghorse
1725	Gates
1730	Scatter
1740	Garbutt
1800	Blairmore
1850	Commotion
1870	Moosebar
2000	Paddy
2200	Cadotte
2220	Harmon
2330	Peace River
2350	Spirit River
2400	Notikewin
2500	Falher
2505	Falher A
2510	Falher B
2515	Falher C
2520	Falher D
2525	Fourth Coal Measure
2530	Falher E
2535	Falher Sand
2550	Wilrich
2600	Bluesky
2625	Basal Bluesky
2630	Bluesky-Gething
2640	Bluesky-Gething-Detrital
2650	Detrital
2690	Bullhead
2692	Lower Blairmore
2700	Gething
2703	Aitken Creek
2705	Lower Bullhead
2710	Lower Gething
2720	Basal Gething
2750	Long Arm
2775	Lower Gething/Upper Dunlevy
2785	Gething/Baldonnel
2800	Cadomin
2805	Chinkeh
2810	Jackass Mountain
2820	Dalhousie

(continued)

Code	Formation	Code	Formation
2830	Basal Cretaceous Sandstone	4575	Inga
2835	Minnes	4578	Coffee Creek
2836	Bickford	4580	North Pine
2837	Monach	4582	Bear Flat
2838	Beattie Peaks	4585	Wilder
2839	Montieth	4590	Pingel
2840	Kootney	4591	Purple Marker
2850	Nikanassin	4592	Second Orange Marker
2852	Mist Mountain	4595	Kern
2890	Buick Creek	4600	Triassic Volcanic Basement
2900	Dunlevy	4605	Second Green Marker
2910	Lower Dunlevy	4608	Trutch Creek
2920	Jurassic	4609	Limestone A Bed
2950	Fernie	4610	A Marker/Base of Lime
2960	First Black Shale	4612	Lower Charlie Lake Sands
2970	Second Black Shale	4615	B Anhydrite Marker
3000	Passage Beds	4700	Artex
3010	Green Beds	4702	Base of Artex
3020	Grey Beds	4705	Dale
3030	Rock Creek	4710	Coldstream
3040	Poker Chip	4750	Liard
3070	Hazelton	4790	Halfway A
3200	Nordegg	4792	Halfway B
3220	Ritchie	4794	Halfway C
3900	Yakoun	4798	Upper Halfway
3990	Maude	4800	Halfway
4000	Triassic	4802	Triassic D
4040	Nordegg-Baldonnel	4805	Lower Halfway
4046	Bocock	4890	Daiber
4050	Pardonet	4900	Doig
4060	Pardonet-Baldonnel	4905	Doig Sand
4090	Schooler Creek	4910	Toad Grayling
4100	Baldonnel	4920	Toad
4150	Baldonnel/Upper Charlie Lake	4930	Grayling
4200T	akla	4950	Spray River
4500	Charlie Lake	4980	Doig Phosphate Beds
4505	First Brown Marker	4990	Bluesky-Gething-Montney
4507	Owl	4995	Lower Charlie Lake/Montney
4510	Siphon	5000	Montney
4511	Siphon Disconformity	5500	Cache Creek
4512	Two Rivers	5999	Paleozoic
4520	Cecil	6000	Permain
4524	Red Creek	6100	Permo Carboniferous
4530	Nancy	6110	Permo Pennsylvanian
4531	First Green Marker	6150	Rocy Mountain
4532	Second Brown Marker	6170	Ishbel
4533	Flatrock	6200	Belloy
4534	Boundary Disconformity	6210	Fantasque
4535	Boundary Lake	6222	Lower Belloy
4536	Basal Boundary	6225	Belcourt
4537	Pink Marker	6250	Belloy-Kiskatinaw
4538	Yellow Marker	6260	Stoddart
4539	First Orange Marker	6295	Upper Taylor Flat
4540	Coplin	6300	Taylor Flat
4541	Coplin Unconformity	6305	Lower Taylor Flat
4542	Septimus	7000	Mississippian
4545	Mica	7100	Mattson
4547	La Glace	7200	Upper Kiskatinaw
4550	Kobes	7220	Etherington
4560	Blueberry	7224	Carnarvon
4570	Farrell	7228	Marston
4571	Groundbirch	7230	Loomis

(continued)

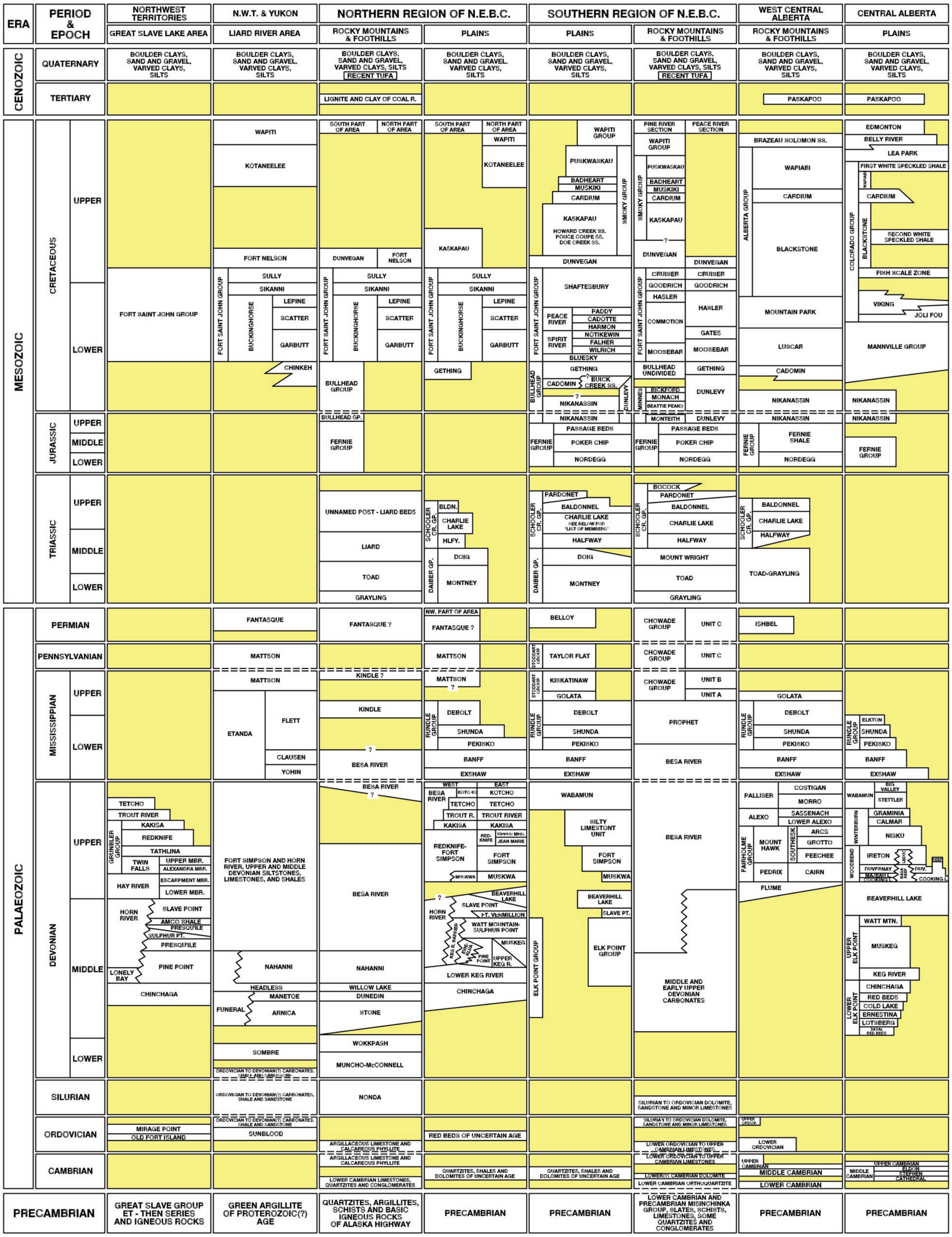
Code	Formation	Code	Formation
7232	Salter	8390	Middle Devonian
7234	Baril	8395	Otter Park
7236	Wileman	8398	Island River
7240	Flett	8400	Slave Point
7250	Kiskatinaw	8410	Fort Vermillion
7270	Tunnel Mountain	8425	Slave Point - Pine Point
7300	Lower Kiskatinaw	8430	Elk Point
7340	Basal Kiskatinaw	8440	Watt Mountain
7350	Golata	8450	Gilwood
7380	Mount Head	8460	Presqu'ile
7386	Prophet	8500	Sulphur Point
7390	Upper Debolt	8510	Klua
7400	Debolt	8528	Upper Keg River
7405	Rundle	8530	Muskeg
7410	Livingstone	8540	Keg River
7420	Lower Debolt	8550	Evie
7450	Elkton	8560	Lower Keg River
7500	Shunda	8580	Nahanni
7510	Desan	8585	Nahanni-Headless
7590	Bear River	8590	Hare
7600	Pekisko	8600	Pine Point
7610	Pekisko Carbonate	8620	Lower Pine Point
7700	Banff	8640	Upper Chinchaga
7710	Exshaw	8658	Headless
7730	Besa River	8660	Chinchaga
8000	Devonian	8678	Dunedin
8070	Upper Devonian	8680	Ebbutt
8090	Kotcho	8700	Lower Chinchaga
8100	Wabamun	8702	Stone
8110	Palliser	8704	Landry
8115	Lower Paleozoic	8708	Funeral
8125	Tetcho	8710	Red Beds
8130	Trout River	8712	Manetoe
8132	Alexo	8715	Granit Wash
8135	Winterburn	8720	Arnica
8145	Calmar	8740	Wokkpash
8150	Kakisa	8750	Muncho-McConnell
8155	Mount Hawk	8752	Pre-Devonian
8180	Fairholme	8755	Pre-Devonian Quartzite
8185	Southesk	8760	Yahatinda
8190	Nisku	8770	Silurian
8195	Arcs	8780	Nonda
8200	Jean Marie	8900	Ordovician
8210	Hay River	8920	Ronning
8220	Redknife	9050	Cambrian
8240	Utahn	9100	Windsor Mountain
8270	Woodbend	9108	Pika
8271	Ireton	9109	Eldon
8272	Duperow	9110	Stephen
8273	Grotto	9111	Cathedral
8275	Leduc	9112	Mount Whyte
8280	Fort Simpson	9120	Elko
8282	Peechee	9130	Gordon
8283	Perdrix	9140	Flathead
8284	Cairn	9900	Precambrian
8285	Horn River	9910	Windermere System
8288	Duvernay	9920	Purcell System
8290	Muskwa	9922	Aldridge
8300	Muskwa-Otter Park-Slave Point	9925	Moyie Intrusions
8310	Cooking Lake	9930	Haighbrook
8330	Flume	9932	Kintla
8340	Beaverhill Lake	9935	Phillips

(continued)

Code	Formation
9940	Gateway
9945	Sheppard
9950	Purcell Lava
9960	Siyeh
9961	Upper Siyeh
9962	Middle Siyeh
9963	Lower Siyeh
9965	Grinell
9970	Appekunny
9971	Upper Appekunny
9972	Middle Appekunny
9973	Lower Appekunny
9974	Altyn
9975	Tombstone Mountain
9976	Waterton
9990	Fault
9991	Repeat
9992	Coquina
9999T.D.	(total depth)

Appendix 2

Stratigraphic Chart



BRITISH COLUMBIA

Ministry of Energy, Mines and Petroleum Resources

STRATIGRAPHIC CORRELATION CHART

NORTHEASTERN BRITISH COLUMBIA AND ADJACENT AREAS

TIME INTERVALS, UNIT THICKNESSES AND EROSIONAL OR DEPOSITIONAL EFFECTS ARE NOT SHOWN TO SCALE

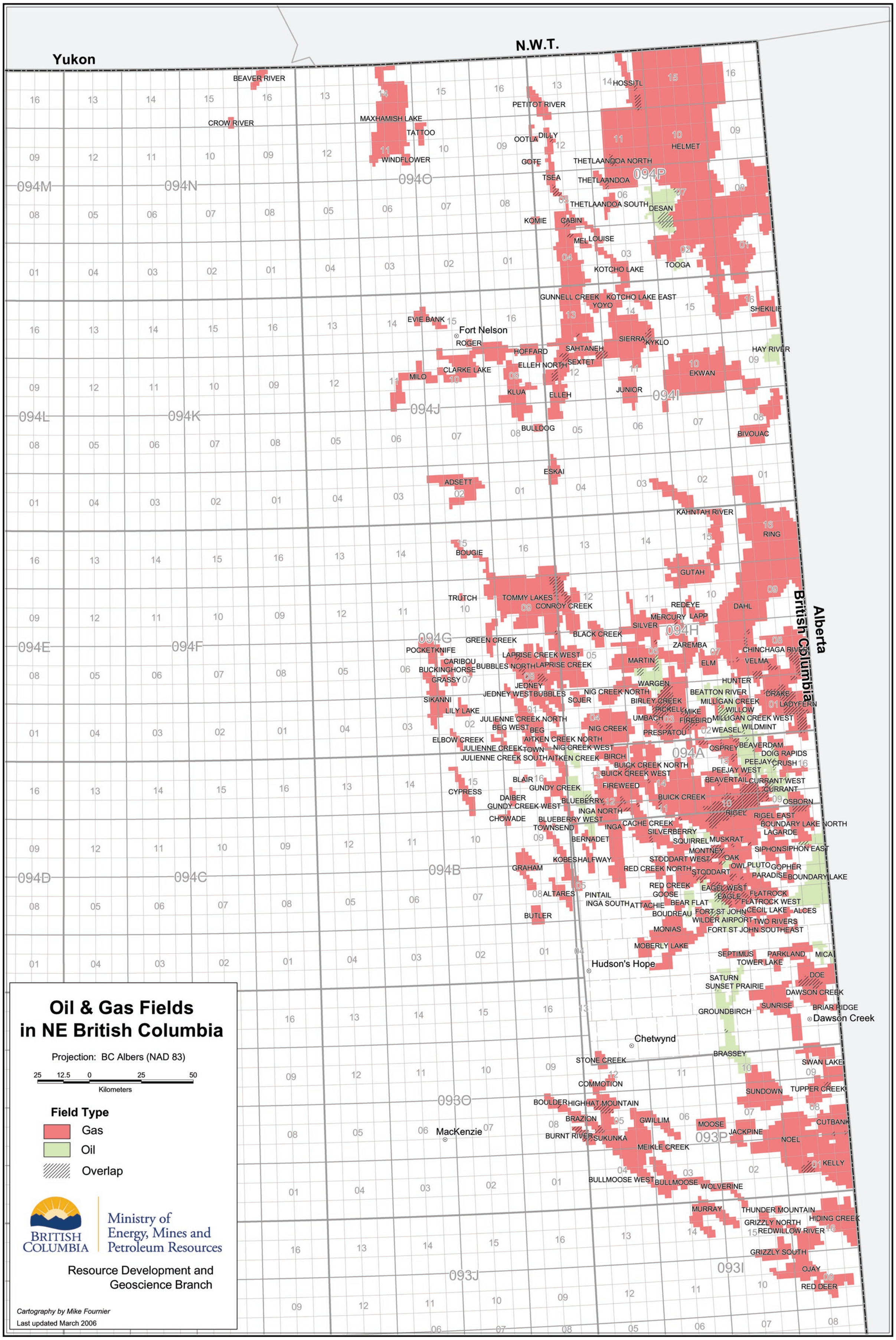
LIST OF CHARLIE LAKE MEMBERS

1. OWL
2. SIPHON
3. CECIL
4. NANCY
5. FLATROCK
6. BOUNDARY BAY
7. BASAL BOUNDARY LAKE
8. COPLIN
9. SEPTIMUS
10. MICA
11. KOBES
12. BLUEBERRY
13. FARRELL
14. GROUNDBIRCH
15. INGA
16. COFFEE CREEK
17. NORTH PINE
18. BEAR FLAT
19. WILDER
20. PINGEL
21. 'A' MARKER
22. ARTEX
23. DALE
24. COLDSTREAM

THE BREAKDOWN ABOVE OF THE CHARLIE LAKE FORMATION APPLIES ONLY TO THE PLAINS AREA OF THE SOUTHERN REGION OF NORTHEASTERN BRITISH COLUMBIA

Appendix 3

Oil and Gas Fields in Northeast British Columbia


Oil & Gas Fields
in NE British Columbia
Projection: BC Albers (NAD 83)
25 12.5 0 25 50
Kilometers
Field Type
Gas
Oil
Overlap
BRITISH COLUMBIA
Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
Cartography by Mike Fournier
Last updated March 2006
Yukon
N.W.T.
Alberta
British Columbia
Fort Nelson
Hudson's Hope
Chetwynd
MacKenzie
Dawson Creek
094M
094N
094O
094P
094L
094K
094J
094I
094E
094F
094G
094H
094D
094C
094B
094A
093O
093P
093J
093I
BEAVER RIVER
CROW RIVER
MAXHAMISH LAKE
TATTOO
WINDFLOWER
PETITOT RIVER
HOSSITL
HELMET
DILLY
OOTLA
GOTE
TSEA
THETLAANDOA NORTH
THETLAANDOA
THETLAANDOA SOUTH
DESAN
KOMIE
CABIN
MEL
LOUISE
KOTCHO LAKE
TOOGA
GUNNELL CREEK
KOTCHO LAKE EAST
YOYO
SHEKILIE
EVIE BANK
ROGER
HOFFARD
SAHTANEH
SIERRA
KYKLO
HAY RIVER
ELLEH NORTH
SEXTET
CLARKE LAKE
MILO
KLUA
ELLEH
JUNIOR
EKWAN
BULLDOG
BIVOUAC
ESKAI
ADSETT
KAHNTAH RIVER
RING
BOUGIE
GUTAH
TRUTCH
TOMMY LAKES
CONROY CREEK
REDEYE
MERCURY
LAPP
DAHL
SILVER
BLACK CREEK
GREEN CREEK
POCKETKNIFE
ZAREMBA
LAPRISE CREEK WEST
LAPRISE CREEK
CARIBOU
BUCKINGHORSE
BUBBLES NORTH
GRASSY
MARTIN
ELM
CHINCHAGA RIVER
VELMA
JEDNEY
JEDNEY WEST
BUBBLES
WARGEN
HUNTER
NIG CREEK NORTH
BEATTON RIVER
DRAKE
SOJER
BIRLEY CREEK
MILLIGAN CREEK
LADYFERN
SIKANNI
LILY LAKE
PICKELL
WILLOW
JULIENNE CREEK NORTH
UMBACH
MIKE
MILLIGAN CREEK WEST
BEG WEST
BEG
NIG CREEK
FIREBIRD
WILDMINT
PRESPATOU
WEASEL
AITKEN CREEK NORTH
ELBOW CREEK
JULIENNE CREEK
TOWN
NIG CREEK WEST
OSPREY
BEAVERDAM
JULIENNE CREEK SOUTH
AITKEN CREEK
BIRCH
DOIG RAPIDS
BUICK CREEK NORTH
PEEJAY
CRUSH
BUICK CREEK WEST
PEEJAY WEST
BLAIR
BEAVERTAIL
CURRANT WEST
CYPRESS
GUNDY CREEK
FIREWEED
CURRANT
DAIBER
BLUEBERRY
BUICK CREEK
OSBORN
GUNDY CREEK WEST
INGA NORTH
CHOWADE
BLUEBERRY WEST
RIGEL
RIGEL EAST
TOWNSEND
INGA
CACHE CREEK
BOUNDARY LAKE NORTH
SILVERBERRY
LAGARDE
BERNADET
SQUIRREL
MUSKRAT
MONTNEY
SIPHON
SIPHON EAST
KOBES
HALFWAY
STODDART WEST
OAK
GRAHAM
RED CREEK NORTH
STODDART
OWL
PLUTO
GOPHER
PARADISE
BOUNDARY LAKE
RED CREEK
EAGLE WEST
GOOSE
EAGLE
FLATROCK
ALTARES
PINTAIL
INGA SOUTH
ATTACHIE
BEAR FLAT
FLATROCK WEST
FORT ST JOHN
CECIL LAKE
ALCES
BUTLER
BOUDREAU
WILDER AIRPORT
TWO RIVERS
MONIAS
FORT ST JOHN SOUTHEAST
MOBERLY LAKE
SEPTIMUS
PARKLAND
MICA
TOWER LAKE
DOE
SATURN
SUNSET PRAIRIE
DAWSON CREEK
SUNRISE
BRIAR RIDGE
GROUNDBIRCH
BRASSEY
STONE CREEK
SWAN LAKE
COMMOTION
SUNDOWN
TUPPER CREEK
BOULDER
HIGHHAT MOUNTAIN
BRAZION
GWILLIM
MOOSE
CUTBANK
BURNT RIVER
SUKUNKA
JACKPINE
NOEL
MEIKLE CREEK
KELLY
BULLMOOSE WEST
BULLMOOSE
WOLVERINE
MURRAY
THUNDER MOUNTAIN
HIDING CREEK
GRIZZLY NORTH
REDWILLOW RIVER
GRIZZLY SOUTH
OJAY
RED DEER

BRITISH COLUMBIA

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