Ministry of
Energy, Mines and
Petroleum Resources

Oil and Gas Division
Resource Development and Geoscience Branch

SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2007

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Key Words: *shale gas, exploration and development, industry activity, northeastern British Columbia, petroleum and natural gas rights, resource region, experimental schemes, Horn River Basin, Cordova Embayment, drilling, production, reserves, rig releases.*

INTRODUCTION

Interest by several companies in the shale gas potential of British Columbia continues to mount. Increased attention to shale gas opportunities has sparked a significant boost in the sale of petroleum and natural gas (PNG) rights in northeast British Columbia over the last two years. The Horn River Basin and the Cordova Embayment, both of which are prospective for shale gas, have been generating much of the interest. In 2007, the two areas garnered over 38 per cent of the province's record land sale bonus total of $1.05 billion. Land sales directed toward Upper Montney exploration and development were also significant in 2007. The Upper Montney play region includes areas within the southern Fort St. John region and the northern section of the Deep Basin region. The region has seen a five-fold increase in land sale activity since 2005 and generated $526 million in bonus payments in 2007 alone.

Since 2002, the BC Oil and Gas Commission (OGC) has approved 12 experimental schemes for shale gas potential. The OGC issues approvals for experimental status under section 100 of the Petroleum and Natural Gas Act. Operators receiving such approvals must submit a progress report to the OGC annually. Schemes are considered experimental as they require on going research in drilling, completion and production methodology. To date, most experimental schemes approved for shale gas potential have been in relatively undrilled areas of northeast British Columbia.

BACKGROUND

Shale gas formations in the Western Canada Sedimentary Basin (WCSB) potentially contain large volumes of hydrocarbons *(Table 1)*. Organic rich shales may generate and store methane due to biogenic gas generation during the early diagenesis stage and subsequent catagenic generation at higher levels of maturity. Most shales have low matrix permeabilities and require the presence of extensive natural or induced fracture systems to sustain commercial gas rates. With commercial success of several shale gas plays in the United States, British Columbia's shales are now being recognized as potential reservoirs and are estimated to have the potential capacity to hold 250 to 1,000 trillion cubic feet (Tcf) of gas-in-place. Though recoverable volumes will be considerably less, shale gas remains a significant untapped resource. Only a small portion thus far has been deemed commercially recoverable.

TABLE 1. POTENTIAL SHALE GAS FORMATIONS IN NORTHEAST BRITISH COLUMBIA

Age	Formations
Lower Cretaceous	Wilrich Moosebar, Buckinghorse
Jurassic	Fernie Shale, Nordegg
Upper Triassic	Pardonnet
Middle Triassic	Doig Phosphate
Lower Triassic	Montney
Lower Carboniferous/Upper Devonian	Exshaw, Besa River, Muskwa, Fort Simpson

While shale is abundant throughout northeastern British Columbia, information in terms of its gas potential is limited. A recent study by the Ministry of Energy, Mines and Petroleum Resources that focused on Devonian shale potential (EMPR, CBM Solutions, 2005), estimated an in-place capacity of more than 500 Tcf. The study looked at the shale gas potential within Devonian strata of northeast British Columbia focussing on the Exshaw, Besa River, Fort Simpson and Muskwa formations. Areas of interest included parts of the Liard Plateau and Basin, the Horn River Basin and Prophet Trough as well as western extensions of the Peace River Arch/embayment. In 2006, a Resource Development and Geoscience Branch study evaluated the regional shale gas potential of the Triassic Doig and Montney Formations of northeast British Columbia (Walsh *et al.*, 2006). The study quantified the potential gas-in-place via spatial analysis. Triassic shale gas plays include the Doig Phosphate in the Groundbirch area (Middle Triassic) and the Upper Montney (Lower Triassic) in the Swan Lake, Bissette and Dawson Creek areas. Both studies are available on CD from the Resource Development and Geoscience Branch (RDGB) of the Ministry of Energy, Mines and Petroleum Resources.

In the United States, shale gas is now recognized as a viable and economic resource. Commercial shale gas production in the U.S. occurs primarily in the Devonian shale basins in the eastern portion of the country, the Mississippian shale basin in Texas (Barnett), and the Cretaceous shale basin of Colorado and New Mexico. Drilling data from these regions shows that the use of stimulation techniques are almost always necessary for commercial shale gas production.

DATA SOURCES

Data for this report have been collected from available public sources. No confidential data or information have been utilized in its preparation. There are a number of shale gas projects that are no longer on confidential status.

For ease of analyses and description, activity in northeast British Columbia is often referred to by regions, derived from physiographic and geologic attributes as well as previous competitiveness studies conducted by the Ministry of Energy, Mines and Petroleum Resources *(Figure 1)*.

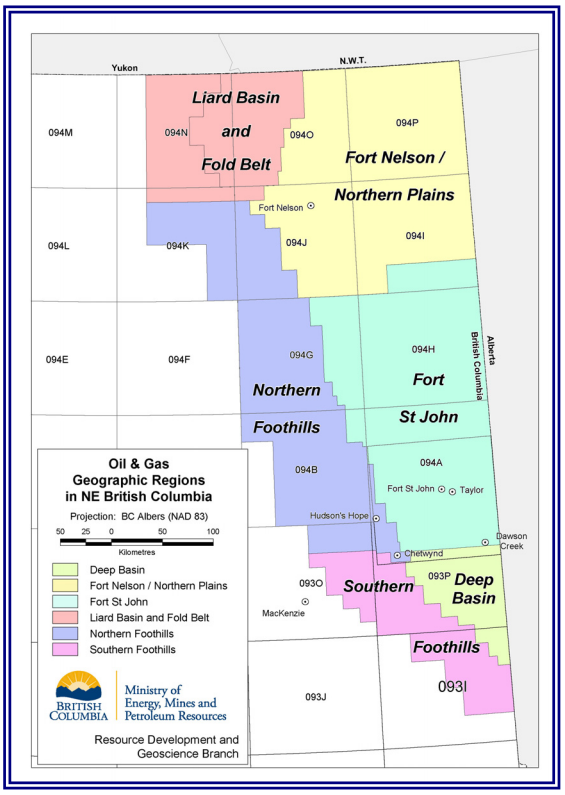

Figure 1. The six oil and gas resource regions of northeastern British Columbia.

SHALE GAS EXPLORATION ACTIVITY

Bonuses collected from the sale of British Columbia's Crown PNG rights in 2006 totalled $630 million. Of that total, $126.4 million or 20% were directly attributed to interest in shale gas plays. In 2007, land sale activity in the province increased significantly with bonuses reaching a record level of $1.05 billion *(Figure 2)*. As much as 89% or $929 million may have been attributed to gas activity. More parcels have been posted for land dispositions in 2008, including 35,919 hectares for the January and February PNG rights sale.

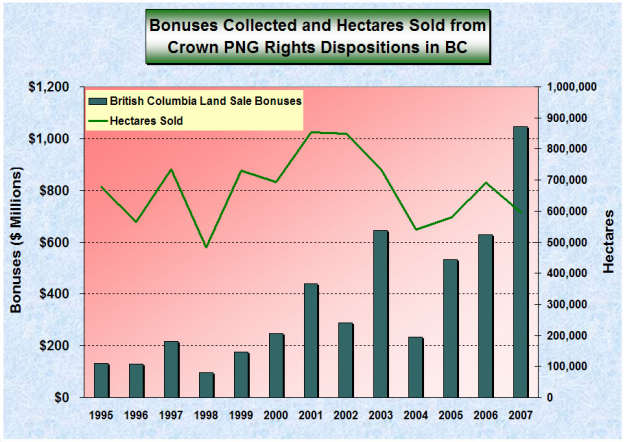

Figure 2. PNG rights sales in British Columbia.

Horn River Basin (Fort Nelson/Northern Plains Region)

The Horn River Basin covers an area of approximately 1.28 million hectares within the Fort Nelson/Northern Plains region. It extends east of the Kledo-Bovie Lake Fault System to the Jean Marie Shelf Edge *(Figure 3)*. Approximately 300 wells have been drilled in the basin since the late 1950s. Exploratory locations reveal carbonate targets extending from the Mississippian Debolt to the Middle Devonian Keg River/Pine Point. The area has now captured the interest of major producers looking to unlock the potential of organic rich shales. Experimental shale gas projects are testing potential reservoirs in the Upper Devonian/Lower Mississippian Exshaw shale source rock and the Muskwa/Otter park members of the Middle Devonian Horn River Basin.

Land Sale Activity

The Horn River Basin has recently seen unprecedented land sale activity, corresponding to growing interest in shale gas plays. The sale of Crown petroleum and natural gas rights in the basin began in earnest in 2000 but has increased significantly over the last two years. Bonus payments garnered from PNG rights in the Horn River Basin from January 2006 to December 2007 totalled $485 million *(Figure 4)*. Most PNG rights parcels were sold to land brokers, although some major producers such as EnCana Corporation and Devon Canada Corporation have purchased parcels under their own name. At the province's December 2007 PNG rights disposition, land broker Meridian Land Services (90) Ltd. paid a bonus of $30.7 million for a 5,572-hectare licence, representing an average price per hectare of $5,502. It was the highest bonus paid for a parcel in the Horn River Basin at any of the 12 provincial land auctions in 2007.

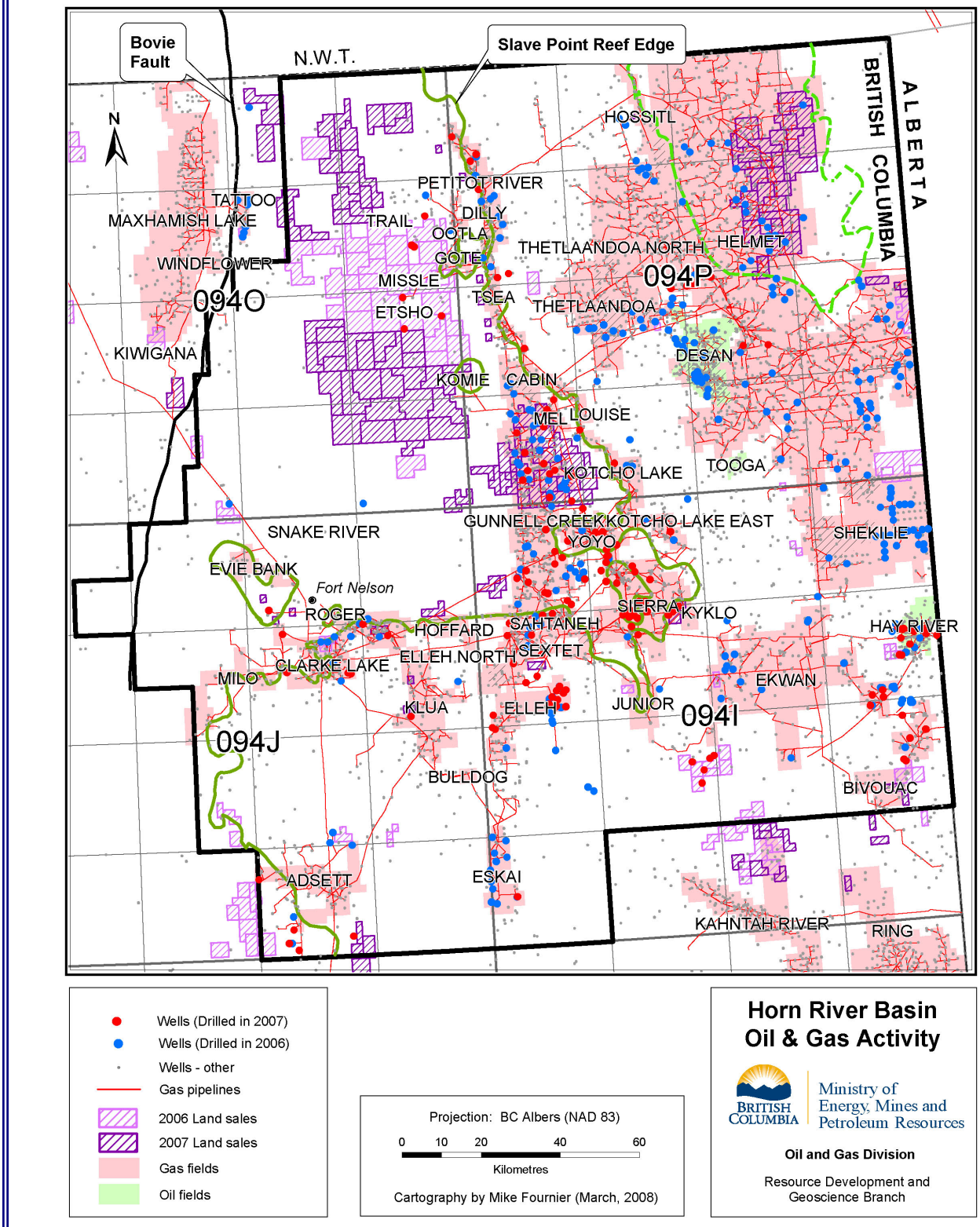

Figure 3. PNG rights sold and wells drilled in the Horn River Basin.

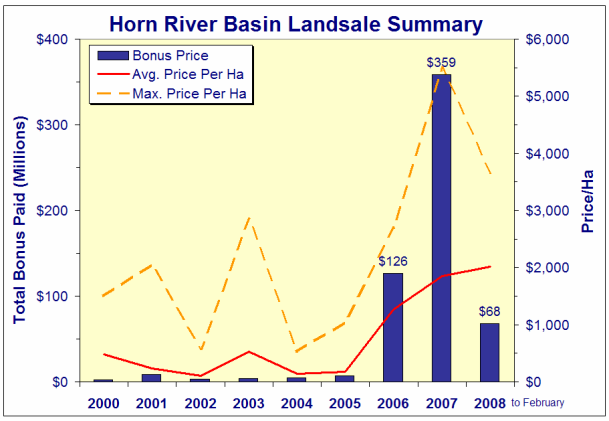

Figure 4. PNG rights sales in the Horn River Basin.

Industry Activity

In 2006 and 2007, a number of shale gas experimental schemes were approved by the OGC for work in the Horn River Basin *(Figure 5)*. Experimental activity in the scheme areas has been high since 2001; sixteen drilled wells and five licensed undrilled locations have been granted experimental status. Three of the experimental wells are non-confidential, while the remaining are confidential until at least 2008 (some until 2010). The confidentiality period for an experimental scheme is three years.

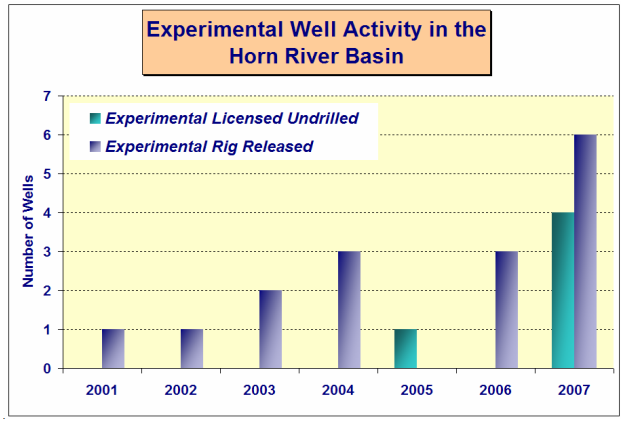

Figure 5. Experimental drilling activity and well licences issued for experimental schemes in the Horn River Basin have increased since 2001.

Experimental scheme areas in the Horn River Basin are currently held by several operators. The following is a list of experimental schemes approved by the OGC in 2006 and 2007:

- September 2006: **EOG Canada Resources Inc.** to evaluate and test the shale gas potential of the Muskwa, Otter Park and Evie formations in the Maxhamish Lake area.
- November 2006: **Apache Canada Ltd.** was given approval for an experimental scheme area totalling 2,098 hectares allowing it to evaluate and test the commercial viability of the Horn River shale gas in the Ootla area.
- February 2007: **EOG Canada Resources Inc.** to evaluate and test the Devonian shale sequence of the Muskwa, Otter Park and Evie formations in the Ootla area. Combined with areas previously approved in June 2005, EOG has experimental scheme areas totalling 8,303 hectares.
- March 2007: **EnCana Corporation** to test the viability of Horn River shale gas in the Ootla area. EnCana was previously given approval for additional scheme areas on March 31, 2006; it also occupies scheme areas that were originally granted on July 29, 2002 to Burlington Resources Canada Inc. EnCana's experimental scheme area totals 13,118 hectares.
- April 2007: **Nexen Inc.** to explore, develop, evaluate and test the shale potential of the Muskwa, Otter Park, and Evie formations. Nexen has experimental scheme areas totalling 6,314 hectares in the Horn River Basin. Nexen is a relative newcomer to the basin with no previous experimental schemes.
- October 2007: **Devon ARL Corporation** to test the commercial viability of Horn River shale gas in the Komie area. This is the first experimental scheme approval for Devon in the Horn River Basin.
- October 2007: **EnCana Corporation** was given approval to amend an existing experimental scheme to test the commercial viability of Horn River shale gas in the Ootla area. In terms of experimental schemes, EnCana is now the most active operator the Horn River Basin.

Some of the aforementioned scheme areas saw drilling activity prior to becoming experimental schemes. Two wells were drilled in the Evie Bank and Snake River areas in the late 1950s. EnCana Corporation drilled a series of wells from 1991 to 2000 in the Kiwigana, Maxhamish and Trail areas, likely targeting the Cretaceous Chinkeh or the Mississippian Mattson and Debolt formations. Recent well activity has been both experimental and non-experimental in nature and many wells have had multiple drilling events associated with them.

The busiest operator in the Horn River Basin since 2001 has been EnCana Corporation *(Figure 6)*. The operator has been responsible for 14 rig releases and another five wells licensed but not drilled. EnCana's latest well was rig released in February 2007 in the Etsho area and is listed as a standing cased well.

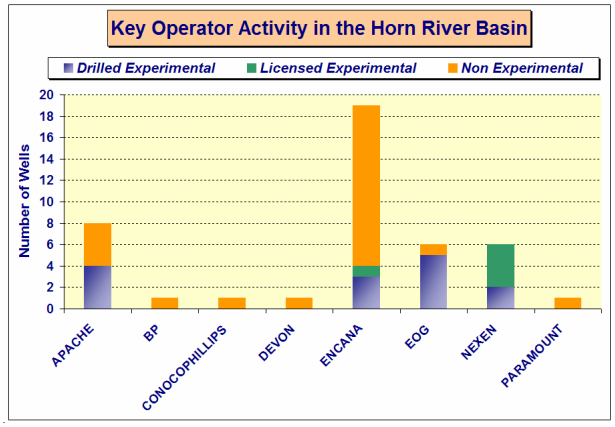

Figure 6. Operators in the Horn River Basin have drilled experimental and non-experimental wells, many with multiple drilling events.

Apache Canada Ltd. has also been active in the basin with six wells drilled and another two that were licensed but not drilled. The company continues to add to its shale gas land base; it now has 81,000 net hectares. All of Apache's wells were located in the Missle and Ootla areas with the most recent well rig released in March 2007.

Nexen Inc. had the highest number of wells licensed in the Horn River Basin in 2007. Well licences were issued for drilling in the Gote, Ootla and Tsea areas in early 2007. Two vertical wells were drilled at Gote with different drilling programs associated with each. Fracture stimulation and test work will be performed on these wells in the next few months. Nexen reports that it has approximately 81,000 net hectares with 100% working interest in the Horn River Basin. The producer is planning to drill three horizontal shale gas wells in the Dilly Creek area this winter (2007/08). Up to $100 million will be spent on shale gas appraisal programs this winter; this will include drilling up to nine wells, construction of an all-weather road and the expansion of pipeline and compression facilities.

Production

To date, there has been no commercial shale gas production in the Horn River Basin. Of note, however, is the recent completion of a 15-kilometre, 168-milimetre diameter natural gas pipeline constructed by EnCana Corporation. The line runs from EnCana's well in the Etsho area at b-90-J/94-O-8 to a connection point at d-54-A/94-O-9 in the Missle area.

Cumulative gas production from conventional sources in the Horn River Basin is approximately 315 Bcf. Almost 80 per cent of this production comes from Middle Devonian targets in the Keg River, Pine Point and Slave Point.

Cordova Embayment (Fort Nelson/Northern Plains Region)

The Cordova Embayment covers an area of approximately 379,000 hectares within the northeast section of the Fort Nelson/Northern Plains region. The area lies to the east of areas that have well-established Devonian Jean Marie gas production as well as deeper exploration targets such as Slave Point and Pine Point (Keg River) carbonates. Over 325 wells have been drilled in the basin since the late 1950s with only a handful targeting shale gas.

Land Sale Activity

The Cordova Embayment has seen a sizable increase in the level of land sale activity compared to previous years. Bonuses payments from the sale of PNG rights so far in 2007 have totalled $43.7 million, more than doubling bonus payments made from 1998 to 2006 *(Figure 7)*. In 2007, all parcels were purchased by land brokers, which may be an indicator to the increasing competitiveness of the region and to the growing interest in shale gas play assessment.

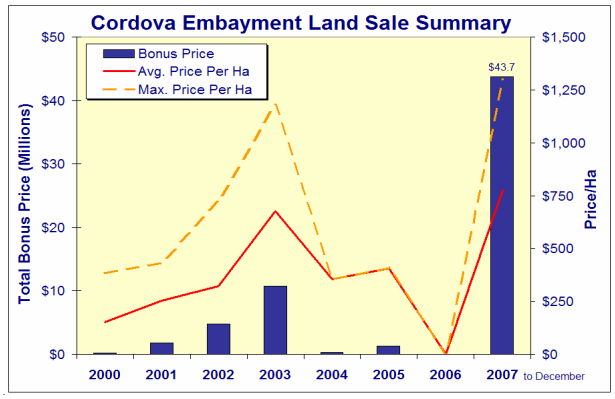

Figure 7. PNG right sales in the Cordova Embayment.

Industry Activity

Because of geological similarity with the Horn River Basin, the Cordova Embayment appears to be a logical place to continue exploration for shale plays. The presence of free gas in natural fractures was evident in a well drilled in 1976 by Chevron Standard Ltd. in the North Helmet area. A core description from a

Devonian shale section noted that the entire core had "bleeding gas from hairline fracture planes." With increasing depth of coverage in the Cordova Embayment, appropriate testing and completion strategies can be determined and the evaluation of the relative success of recompletion vs. new drills can be considered. For example, Nexen Inc. recently announced plans to drill two vertical wells in the Cordova Embayment this winter. The intent is to progressively gather information and knowledge of the basin through a series of drilling, well completion and production testing programs.

Production

To date, there has been no recorded shale gas production in the Cordova Embayment. Approximately 325 conventional gas wells have been drilled in the region since 1960. The region has cumulative gas production of 500 Bcf, primarily from the Upper Devonian Jean Marie and the Middle Devonian Pine Point and Slave Point.

Upper Montney Play (Fort St. John/Deep Basin Regions)

Land Sale Activity

Over the last three years, PNG rights sales have been increasing in the southern Fort St. John region and the northern section of the Deep Basin region. Industry activity in this south Peace region is centered on Triassic-aged stratigraphic plays in the Montney, Doig, Halfway, and Baldonnel as well as clastics in the Lower Cretaceous. The increase in sales and the higher price paid per hectare, particularly in 2006 and 2007, can be correlated with an industry shift to incorporate unconventional gas reservoirs, which include the Doig Phosphate in the Groundbirch area and the Upper Montney Formation in the Dawson Creek and Bissette/Swan Lake areas.

Land sale bonuses within the Upper Montney exploration and development play area have increased by 500 per cent over the last three years. Annual bonus totals rose from almost $85 million in 2005 to $526 million in 2007 *(Figure 8)*. The average price per hectare paid in 2007 was over $3,500 compared to $1,163 in 2006. Many high bonus bids throughout the period were notable but of particular interest were bonus payments made at the September and December PNG rights disposition in 2007. At the September auction, Standard Land Company Inc. paid $10.3 million for a 1,308-hectare licence ($7,859 per hectare) in the Dawson field. ARC Energy Trust is the primary operator in the area. At the province's final land disposition in December, three parcels covering numerous sections in the south Peace region amassed $200.9 million in bonus payments. The three drilling licences, purchased by land brokers, are located south of the Sunrise area and northwest of the Brassey area, near the city of Dawson Creek *(Figure 9)*. One of the drilling licences garnered a $102.6 million bonus payment on 6,665 hectares, translating to an impressive $15,401 per hectare. Drilling records show that ConocoPhillips Canada Ltd. and EnCana Corporation are key operators in the area.

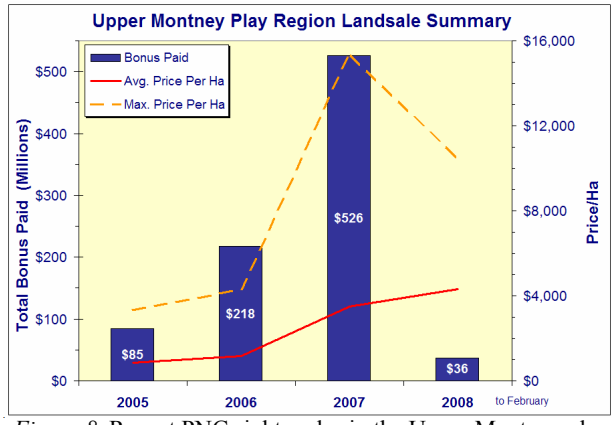

Figure 8. Recent PNG rights sales in the Upper Montney play region.

Industry Activity

ARC Energy Trust is the dominant producer of Upper Montney shale gas in the Dawson Creek area. Production from the Dawson field is currently 31 mmcf per day with 66 wells producing. Production was expected to increase to 40 mmcf per day in the fourth quarter of 2007. In 2006, ARC drilled four horizontal wells and six verticals in the area. Three of the four horizontal wells and all six vertical wells have been tied in. Improved technology has made the economics of the Dawson Upper Montney play more attractive for the long term. To reduce costs and enhance economics, ARC is using horizontal drilling technology along with new and improved completion techniques to exploit the field. Previous vertical drilling through very tight spacing ultimately generated very shallow declines. ARC uses an example of a $5 million horizontal well drilled in the area a few years ago that dramatically reduced the ultimate costs to develop the field and significantly enhanced ultimate recovery. In 2007, ARC planned on drilling eight wells in the area (four horizontal, four vertical) and expected to spend $50 million. Construction of a pipeline to a new third-party gas plant was also expected to be completed later in 2007.

EnCana Corporation continues to develop Triassic shale gas potential from the Montney turbidites in the Swan area. EnCana almost doubled its operations in the area from 2005 to 2006. Production from the Upper Montney play has gone from approximately 26 mmcf per day in 2005 to almost 80 mmcf per day in 2007. EnCana is seeing positive results in 2007 with 20 horizontal wells on production and initial production rates as high as 10 mmcf per day. EnCana's Upper Montney project is within its Cutbank Ridge resource play and has seen encouraging results from the increased use of horizontal drilling technology with multi-stage fracs. Basic completion costs for Montney wells have improved to $2 million per well over the last couple of years and completion days have decreased from 51 to 19. EnCana's experience in the Barnett Shale in Texas is cited as a key component for improved success in the area. With current mapping of the Upper

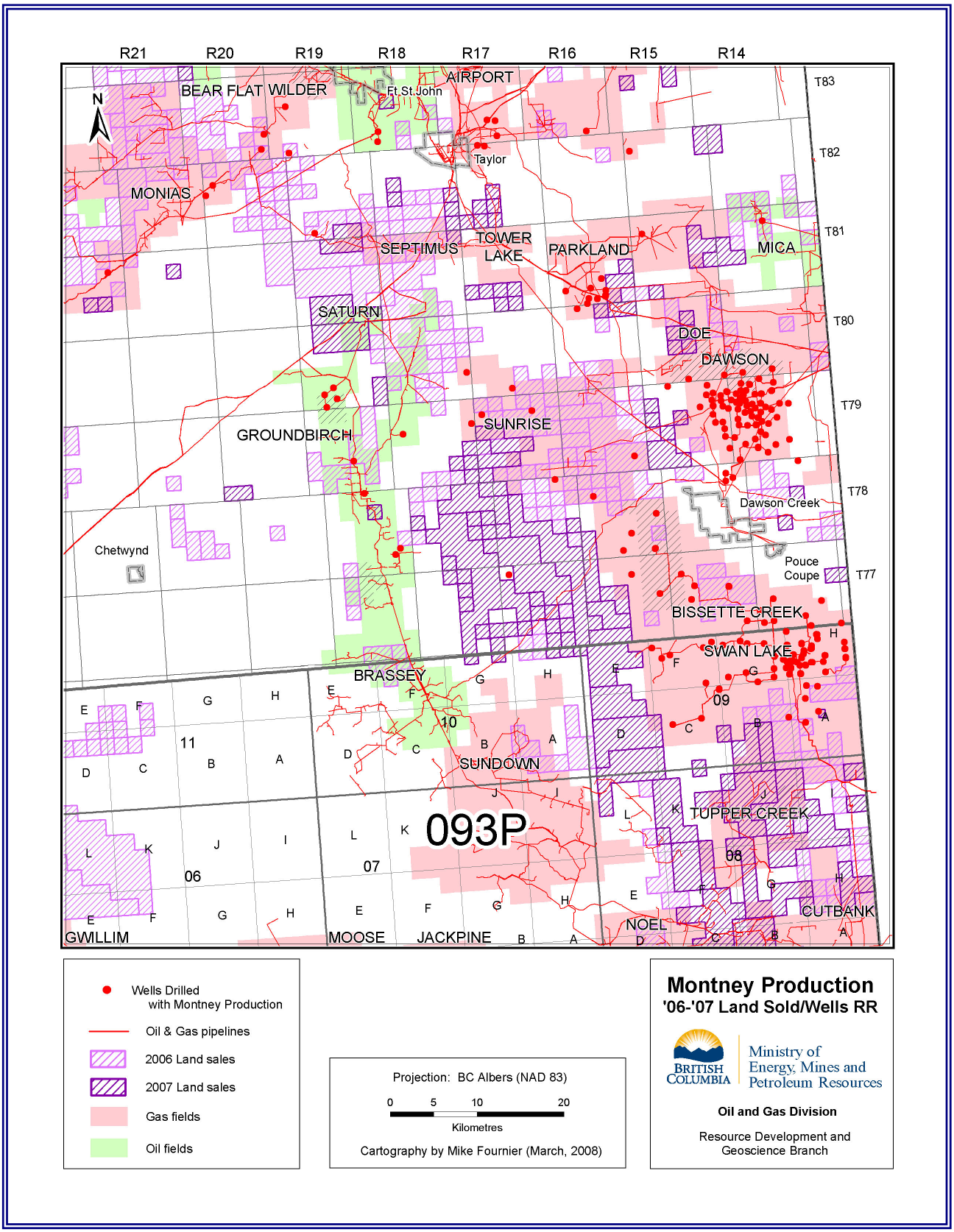

Figure 9. PNG rights sold and wells drilled with Montney production.

Montney, EnCana has identified more than three Tcf of original gas-in-place (OGIP). It plans to drill 50 horizontal wells in the play region in 2008.

Murphy Oil Corporation is well positioned to begin full development of the Upper Montney in the Tupper area. In June 2007, Murphy announced it had spent $155 million to acquire the interests of Bear Ridge Resources Ltd. in the area. In addition, the producer spent $224.6 million on three parcels totalling 16,893 hectares at British Columbia's December 2007 PNG rights sale. Murphy now holds over 32,000 hectares in the Tupper area where it believes it has relatively low-risk but good growth potential. Recently, approval was given by the National Energy Board to construct a 29-kilometre, 12-inch sweet gas pipeline starting at Murphy's proposed Tupper processing plant (a-21-B/93-P-9 and ending at a proposed meter facility near Hythe, Alberta. The first phase of Tupper development is underway with first production scheduled for the last quarter of 2008.

Duvernay Oil Corp. was pursuing shale gas opportunities in 2007. Although Duvernay's activities in northeast British Columbia have been best noted for successful delineation of Triassic Doig tight sands in the Groundbirch area, the company has announced that it successfully completed four wells in the Middle Triassic Doig phosphate zone. Triassic Doig gas pools in the Groundbirch area (Peace River Arch) are interpreted to be in a distal shelf sandstone unit. The basal portion is notable for its phosphate zone, one of the best source rocks in the Western Canada Sedimentary Basin and one that may house significant shale gas resources.

Production

Significant production increases from the Upper Montney have been seen in the Dawson and Swan areas as a result of horizontal drilling and improved completion techniques (*Figure 10)*. Arc Energy Trust, EnCana Corporation and other producers operating in these areas have announced plans to increase capital spending in the play region. This would include the expansion of pipelines and compression facilities to open up more gas production. Newcomers in the region, such as Murphy Oil Corporation, see the Upper Montney as an economically viable resource play that provides a favourable opportunity to expand into a major North American natural gas play.

Cretaceous Shale Gas Activity (Fort St. John and Northern Foothills Regions)

Shale gas activity directed towards Cretaceous horizons is being assessed in several areas of the Fort St. John and Northern Foothills resource regions. Lower Cretaceous sequences are the exploration focus in the Beg/Jedney areas and further south in the Blair Creek and Farrell Creek areas. Each of these areas has unique characteristics in terms of its shale gas potential. Companies currently operating in these areas are evaluating fracture stimulation programs and continue to optimize completion methods that could potentially increase well productivity.

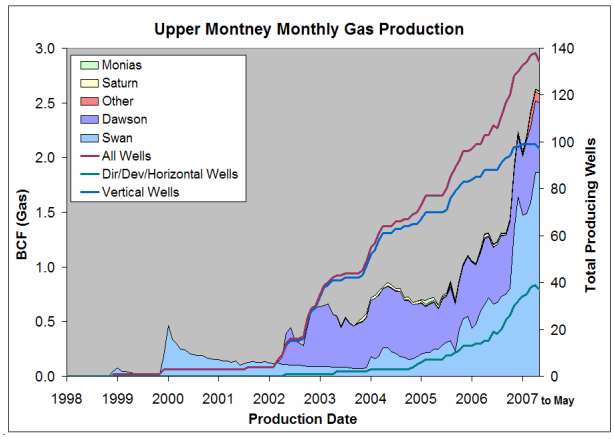

Figure 10. Area gas production and total producing wells from the Upper Montney. Horizontal drilling technology along with new and improved completion techniques are key factors in the increasing production profile from these areas.

Land Sale Activity

The Blair Creek and Farrell Creek areas in the Northern Foothills region are relatively unexplored but there has been a steady increase in the sale of petroleum and natural gas rights over the last three years. In the Blair Creek area, several parcels sold at PNG rights dispositions in 2006, generated an average price per hectare of over $850. Further south in the Farrell Creek area near Hudson's Hope (94-B-1), a 1,447-hectare drilling licence fetched $1.55 million or $1,070 per hectare at the province's PNG rights auction in May of 2006. The drilling licence covers rights from the surface to the base of the Cadomin-Dunlevy-Nikanassin. The purchaser of the licence was Hudson's Hope Gas, Ltd., which is a key operator in the nearby Peace River coalbed gas project.

Industry Activity

In 2002, Petro-Canada was given approval for an experimental scheme in the Jedney area to test the commercial viability of a low permeability, Lower Cretaceous clastic sequence. The experimental scheme consisted of a ten-well exploratory drilling and completion program. Petro-Canada applied for multiple experimental blocks to provide sufficient coverage to allow for a more regional assessment. Some of the objectives of the program were to develop effective completion and stimulation programs to maximize gas production and to obtain further geological and reservoir data to allow for proper assessment of the formation's resource potential. Three key wells were licensed and drilled as experimental wells.

Kereco Energy Ltd. drilled three wells in the Blair Creek area in 2006. A development well drilled in July of that year (c-58-F/94-B-16) produced at an initial rate of 1.2 mmcf per day from the Bluesky but has since stabilized to an average rate of 759 mmcf per day. Priorities for 2006 and 2007 were to evaluate, test and develop the Blair Creek Lower Cretaceous gas play on recently purchased land using newly acquired seismic data. Kereco splits its time between conventional growth prospects and unconventional value-growth

plays. Longer-term plans include a potentially commercial shale gas play (Cadomin) at Blair Creek.

Canadian Spirit Resource Inc. (CSRI) continues to focus on building an unconventional gas play in the Farrell Creek area. The Farrell Creek pilot program includes the staged stimulation and production testing of the Gething Formation coals, interbedded sands and Bluesky tight gas. CSRI is now working towards bringing this "hybrid" gas play to a commercial production level. In 2005 and 2006, the company completed and fracture stimulated four wells in the Gething Formation, which resulted in natural gas flows. A fifth well was recently fracture-stimulated as part of the pilot program. In early 2007, approval was given by the OGC for an experimental scheme covering a six-section block in the Farrell Creek area. Two more experimental schemes were approved in late 2007 covering nine sections of Gething Formation rights. These schemes will facilitate orderly progression of the pilot project and allow CSRI to keep relevant engineering data confidential for a three-year period. CSRI is optimistic about the results of its Farrell Creek pilot program and anticipates that the current evaluation process is valuable towards the development of commercial gas production from the area. A recent evaluation by Sproule Associates Limited of the unconventional natural gas resource on CSRI-interest lands at Farrell Creek reaffirms a total raw gas-in-place of 1.8 Tcf (1.4 Tcf attributed to the Gething, 0.4 Tcf to the Moosebar and Gates formations).

Production

To date, there has been no officially recorded shale gas production from the Cretaceous.

OUTLOOK

British Columbia is still in the early stages of shale gas evaluation, but the potential for this new source of gas supply is becoming increasingly significant. More and more gas discoveries in British Columbia are likely to be made in underdeveloped areas, particularly as producers overcome the technical challenges and complexities of developing unconventional resources such as shale gas. EOG Resources Inc, which recently announced that its Muskwa shale acreage in the Horn River Basin may have uncovered potential reserves of about six Tcf, is an example of how a producer can refine its drilling and completion processes to where tangible results are identified.

Land sale activity in British Columbia's shale gas areas is expected to be high in 2008. At the province's most recent PNG rights sale in February, the highest bonus bids of $20 million and $17.6 million were put up for parcels at map sheets 94-O-10 and 94-O-16 in the Horn River Basin. Further south in the Dawson area, top bids of $10,388 and $9,799 per hectare were paid for drilling licences at 80-18 and 81-20 W6.

With considerable interest from industry in unconventional exploration projects, the province has initiated the net profit royalty program to encourage development of these technically complex, high-risk projects. This targeted royalty program will focus on unconventional reservoir types such as coalbed gas, shale gas, tight gas, enhanced gas recovery, enhanced (tertiary) oil recovery, gas hydrates, and resources remote from existing infrastructure. The net profit royalty program will consist of a small gross royalty levied on production before payout of the capital investment, and thereafter a higher royalty rate applied to the net or gross revenue.

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