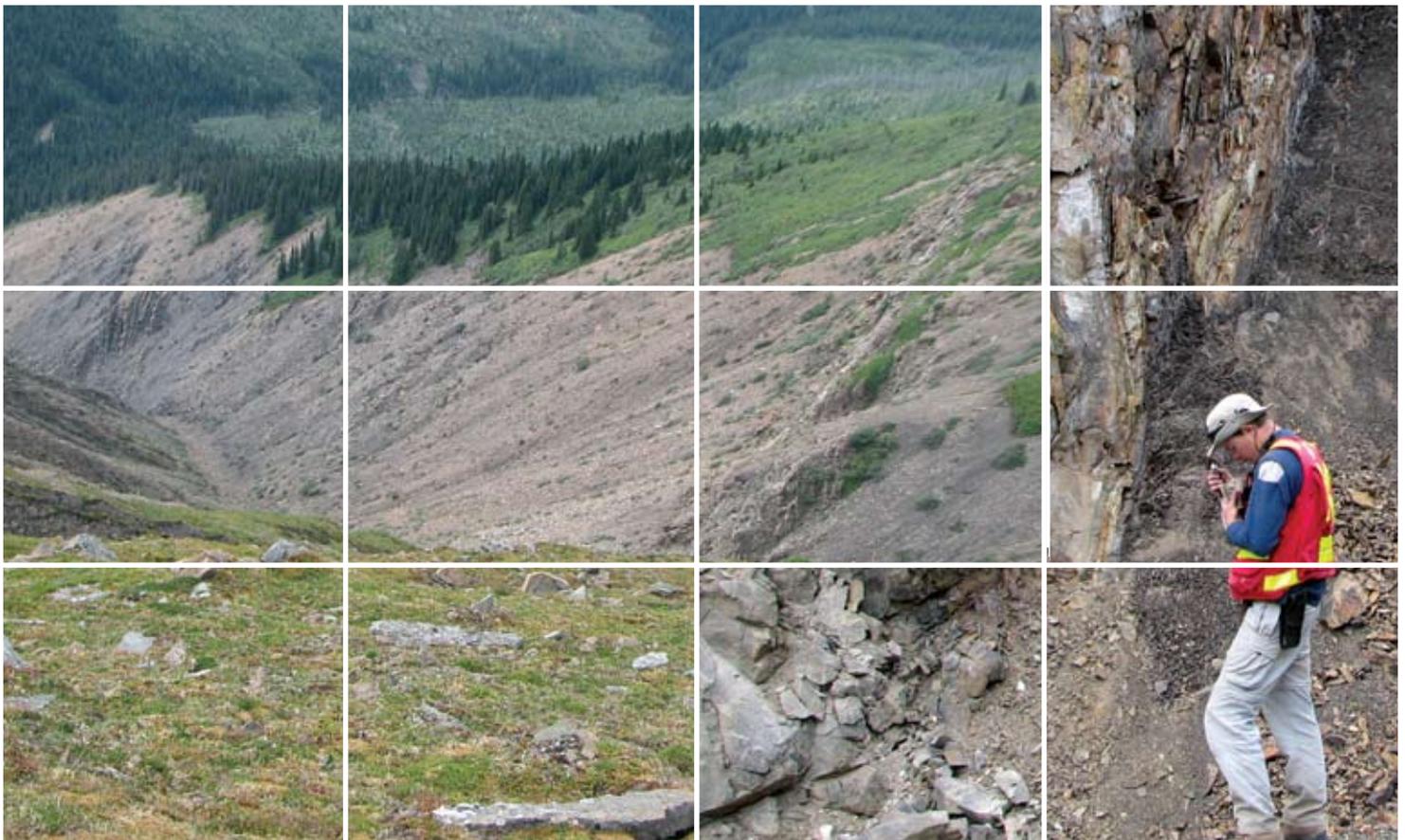


Oil & Gas

Summary of Shale Gas Activity in Northeast British Columbia 2008/09

Petroleum Geology Open File 2009-1



Oil and Gas Division
Resource Development and Geoscience Branch



Ministry of
Energy, Mines and
Petroleum Resources



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SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2008/09

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SUMMARY OF SHALE GAS ACTIVITY IN NORTHEAST BRITISH COLUMBIA 2008

Ministry of Energy, Mines and Petroleum Resources
Resource Development and Geoscience Branch
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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, Montney, drilling, production, reserves, rig releases.

INTRODUCTION

Increased attention to shale gas prospects in British Columbia has sparked a significant boost in the sale of petroleum and natural gas (PNG) rights in the province over the last three years. The Horn River Basin, Cordova Embayment and the Montney play trend, all of which are prospective for shale gas, have been generating much of the interest. In 2008, the Horn River Basin and Cordova Embayment garnered over 41 per cent of the province's record land sale bonus total of \$2.66 billion. Land sales directed toward Montney exploration and development accounted for over 49 per cent of the 2008 bonus total. The Montney play encompasses the southern Fort St. John region and the northern section of the Deep Basin region in northeast British Columbia. Over the four-year period from 2005 to 2008, total PNG rights sales in the Montney play region increase dramatically from \$84.5 million to \$1.32 billion.

Since 2002, the BC Oil and Gas Commission (OGC) has approved 38 experimental scheme projects 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 if they require on-going research in drilling, completion and/or production methodology. To date, most experimental schemes approved for shale gas potential in northeast BC have been in areas of relatively low drilling.

This report highlights shale gas activity in northeast British Columbia by resource region (*Figure 1*). The statistics presented focus on the most recent, complete calendar year of activity (2008). However, where noted, information on land sales and activity up to June 2009 is also included.

BACKGROUND

Formations prospective for shale gas 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 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 capacity to hold 250 to 1,000 trillion cubic feet (Tcf) of original gas-in-place. Assessments are underway to determine the technically recoverable and marketable resource potential. Numerous stratigraphic horizons and play areas in northeastern British Columbia have excellent potential for this huge resource and only a small portion thus far has been deemed commercially recoverable.

TABLE 1. POTENTIAL SHALE GAS FORMATIONS IN NORTHEAST BRITISH COLUMBIA

PROSPECTIVE HORIZONS						
	Formations	Description	Depth	Average Thickness	Total Organic Carbon	Gas in Place
LOWER CRETACEOUS	Wilrich and Buckinghorse shales	Potential Interbedded sand/siltstone	800 to 1,200 metres	100 metres	2.3%	60 Bcf per section
JURASSIC	Nordegg and Fernie shales	Recognized source rocks	1,200 to 2,500 metres	Up to 30 m organic rich section	up to 14%	>20 Bcf per section
TRIASSIC	Doig, Doig Phosphate and Montney	Montney turbidites may increase permeability Phosphate units have high TOC and are excellent source rocks	1,200 to 3,000 metres	300 to 500 metres	0.5 to >10%	10 to 110 Bcf per section
DEVONIAN	Exshaw, Besa River, Fort Simpson and Muskwa	Exshaw and Muskwa are widely distributed organic shales Fort Simpson and Besa River are thick basin-filling shales	1,800 to 3,500 metres	Huge thicknesses are common with some high TOC intervals	0.5 to >10%	10 to 100 Bcf per section
GEOLOGIC ANALOGUE						
MISSISSIPPIAN	Barnett Shale (Fort Worth Basin)	Marine-shelf deposit	2,000 to 2,500 metres	100 metres	4.5%	140 Bcf per section

While shale is abundant throughout northeastern British Columbia, information in terms of the geology and gas potential is limited. A study by the Ministry of Energy, Mines and Petroleum Resources that focused on Devonian shale gas potential (EMPR, CBM Solutions, 2005), estimated an in-place capacity of more than 500 Tcf in northeast BC. The study centered 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 study by the Resource Development and Geoscience Branch 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 original 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, Bisette and Dawson Creek areas. The Upper Montney play area is limited by depth, shallowing to the northeast and deepening to the southwest. Walsh *et al.* (2006) provided original gas-in-place estimates of 30 to 200 Tcf for the Upper Montney, 50 to 500 Tcf for the Lower Montney, 40 to 200 Tcf for the Doig Formation and approximately 70 Tcf for the organic rich Doig Phosphate unit. The study noted that original gas-in-place estimates must be taken in context and cannot be compared directly with estimates for conventional plays as critical reservoir characteristics remain poorly understood. The Montney is considered by many to be a “hybrid” shale-tight gas play so it is included here in this discussion of shale gas activity. Both the Devonian and Triassic studies are available on CD from the Resource Development and Geoscience Branch (RDGB) of the Ministry of Energy, Mines and Petroleum Resources. Also available on CD is the Petroleum Geology Open File entitled *Shale Gas Potential: Core and Cuttings Analysis, Northeast British Columbia* (Walsh *et al.*, 2007) from the RDGB.

In the United States, shale gas is 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 gas production from shale.

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. Detailed information on these projects is available in the Ministry’s Information Resource Centre.

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*).

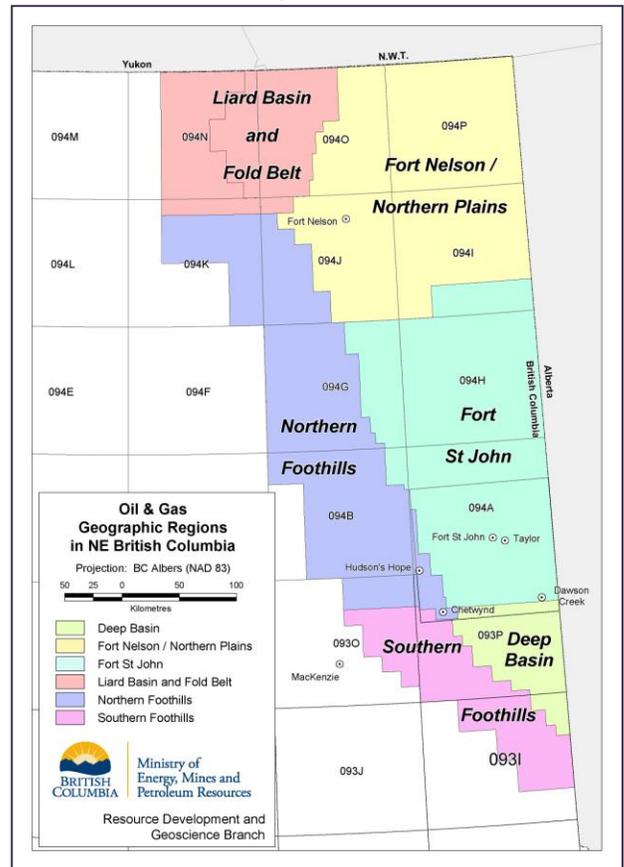


Figure 1. The six oil and gas resource regions of northeastern British Columbia.

SHALE GAS EXPLORATION ACTIVITY

Bonuses collected from the sale of British Columbia’s Crown petroleum and natural rights in 2008 totalled a record \$2.66 billion. Of that, \$2.41 billion or 90% is directly attributed to interest in shale gas plays (*Figures 2 & 3*).

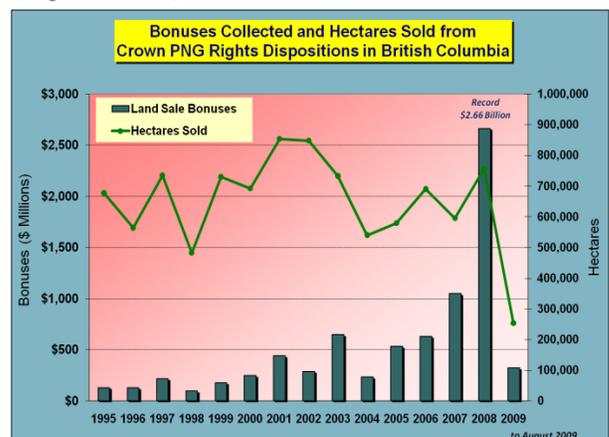


Figure 2. Annual bonuses collected from petroleum and natural gas rights sold in British Columbia.

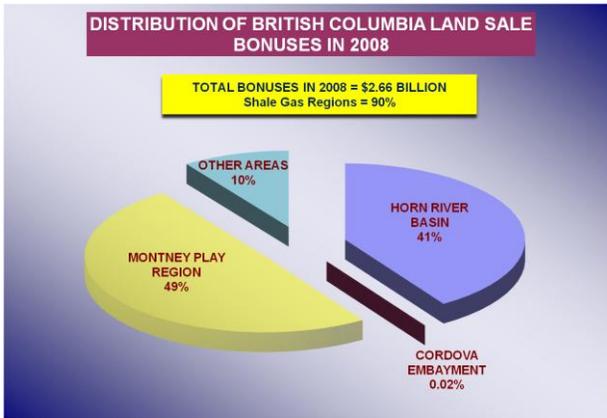


Figure 3. The Horn River Basin and the Montney play region brought in bonus totals of \$1.1 billion and \$1.32 billion in 2008, respectively.

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 lies east of the Kledo-Bovie Lake Fault System and extends east to the Slave Point Reef Edge (Figure 4). Prior to recent shale gas interest, approximately 300 wells had been drilled in the basin mainly targeting carbonate plays of the Mississippian Debolt to Middle Devonian Keg River/Pine Point. The area has firmly 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, a known source rock, and the Muskwa/Otter Park members of the Middle Devonian Horn River Basin.

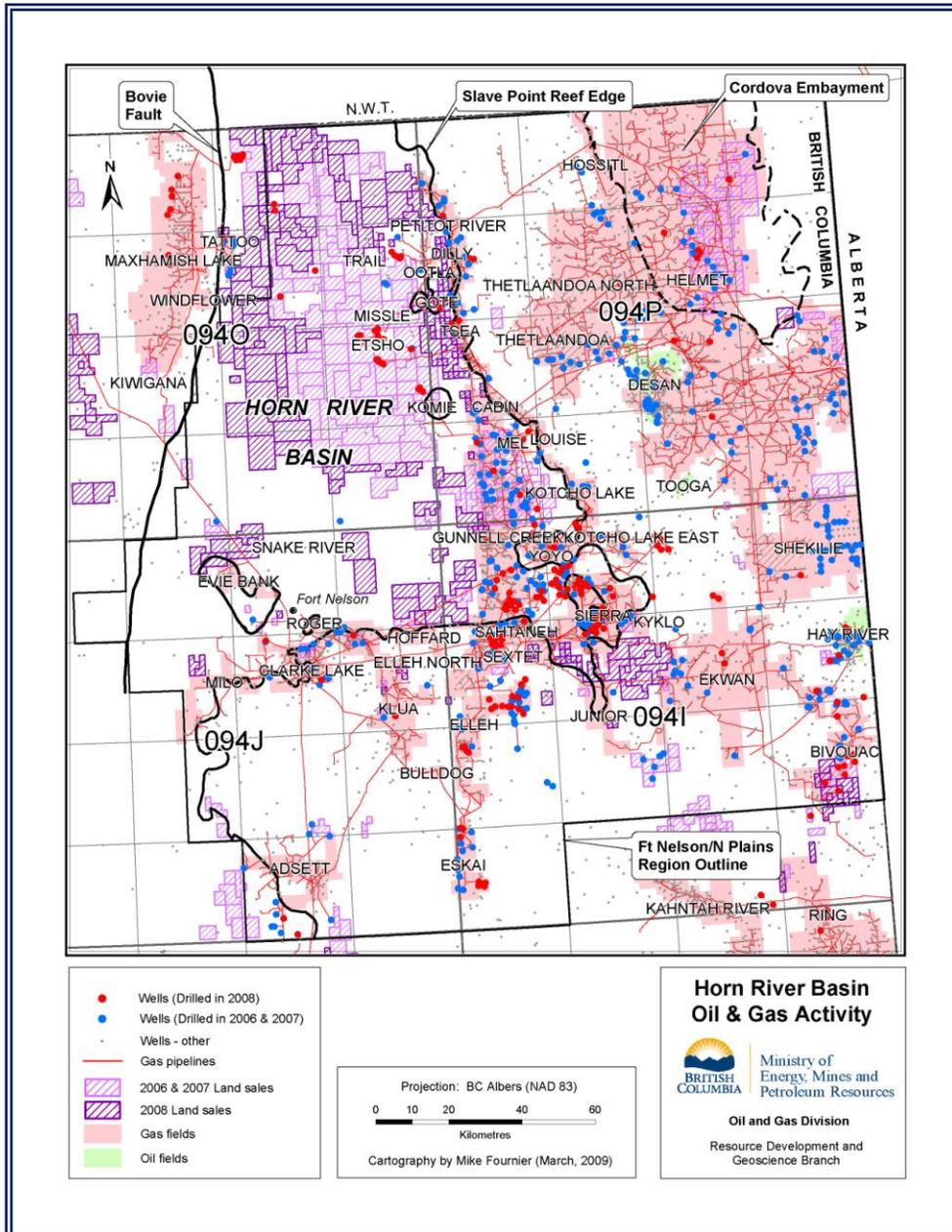


Figure 4. Recent land sale and drilling activity in the Horn River Basin.

Land Sale Activity

The Horn River Basin continued to see unprecedented land sale activity in 2008 corresponding to increased attention to shale gas plays. The sale of Crown petroleum and natural gas (PNG) rights in the basin began in earnest in 2000 but has increased significantly over the last three years. Bonus payments garnered from PNG rights in the Horn River Basin from January 2006 to December 2008 totalled \$1.57 billion (Figure 5). Most PNG rights parcels were sold to land brokers, although some producers such as EnCana Corporation, Storm Exploration Inc. and Quicksilver Resources Inc. purchased parcels under their own name. At the province's August 2008 PNG rights disposition, land broker Canadian Coastal Resources Ltd. paid a bonus of \$75.8 million for a 5,789-hectare lease, representing an average price per hectare of \$13,089. It was the highest bonus paid for a parcel in the Horn River Basin at any of the 12 provincial land auctions in 2008. At the June 2009 British Columbia PNG rights disposition, ExxonMobil Canada Energy and Imperial Oil Resources Limited obtained eight drilling licences in the Komie and Evie Bank areas for \$113.1 million (each with a 50 per cent interest).



Figure 5. Bonuses from PNG rights sales in the Horn River Basin.

Industry Activity

In 2008, the number of shale gas experimental schemes approved by the BC Oil and Gas Commission (OGC) for work in the Horn River Basin continued to climb (Figure 6). Experimental activity in the scheme areas has been on the rise since 2001; thirty-seven drilled wells and 38 licensed but undrilled locations have been granted experimental status to the end of 2008. The confidentiality period for an experimental scheme is three years.

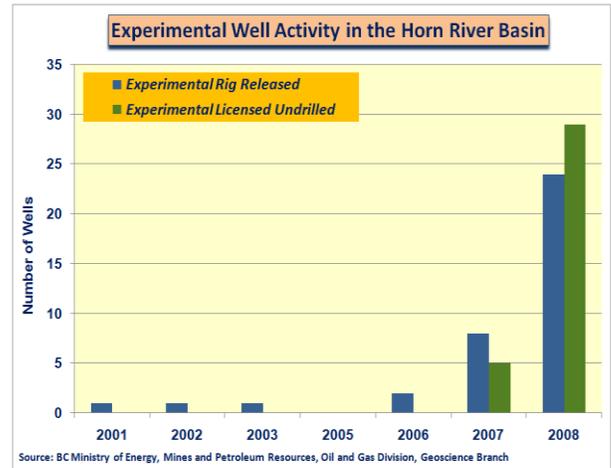


Figure 6. Experimental drilling activity and well licences issued for experimental schemes in the Horn River Basin have significantly increased since 2001.

Experimental scheme areas in the Horn River Basin are currently held by a number of operators. The following is a list of some key experimental schemes approved by the OGC in 2008 and up to May in 2009:

- June 2008: **Stone Mountain Resources Ltd.** was given approval to explore and evaluate the shale gas potential of the Devonian shale sequence, specifically the Muskwa, Otter Park and Evie formations in the **Tattoo** area.
- August 2008: **Kodiak Bear Energy, Inc.** was given approval to explore and evaluate the Muskwa, Otter Park and Evie formations in the **Gunnell Creek** area.
- September 2008: **Imperial Oil** was given approval to explore, develop and evaluate the shale gas potential of the Horn River Basin; specifically the Muskwa, Otter Park and Evie formations in the **Komie** area.
- November 2008: **EOG Resources Canada Inc.** was given approval to explore, evaluate and test the shale gas potential of the Muskwa, Otter Park and Evie formations in the **Tattoo** area.
- May 2009: **Quicksilver Resources Canada Inc.** was given approval to test the commercial viability of the Horn River Formation shale gas in the **Fortune** area.
- May 2009: **Hunt Oil Company of Canada** was given approval to evaluate and test the shale gas potential of the Horn River Formation in the **Evie Bank** area (Hunt Projects #1,#2,#3).
- May 2009: **Storm Gas Resource Corp.** was given approval to explore and evaluate the shale gas potential of the Horn River Formation in the **Ootla** and **Gote** areas (SGR Projects #1,#2,#3).
- May 2009: **EOG Resources Canada Inc.** was given approval to explore and evaluate the shale gas potential of the Horn River Formation in the **Gote** area.

Some of these scheme areas saw drilling activity prior to obtaining experimental status. For example, the experimental scheme approved for **Kodiak Bear Energy, Inc.** in August 2008 was for a licence extension to test the Muskwa shale gas potential on Kodiak's leases in the **Gunnell Creek** area, located on the southeast edge of Horn River Basin (Daily Oil Bulletin website, 2008). After drilling a vertical well in the area in early 2008, Kodiak determined that a seismic anomaly was not a Middle Devonian reef build-up. Consequently, the well was cased due to significant gas shows in the Muskwa Formation (approximately 60 metres in thickness). Kodiak then proposed a Muskwa evaluation program to the Oil and Gas Commission using vertical and horizontal drilling to prove up the lease as an extension of the Horn River Basin.

The most active operator in the Horn River Basin since 2001 has been **EnCana Corporation** (Figure 7). The producer is listed as operator for 90 wells in the Basin with 79 of those categorized as non experimental and another five wells licensed under experimental status but not yet drilled. EnCana is leading the way with deep horizontal wells and multiple fracture stimulations in the Horn River Basin. After completing its 2008 Horn River drilling program, the producer reported average initial production rates of five mmcf per day during the first few months of production. The first wells completed in 2009 have reported flow rates of 9.5 to 11 mmcf per day after 15 days. EnCana said it would direct about \$150 million (net) toward the Horn River play in 2009, however, some well completions will be deferred to 2010. It also anticipated drilling 40 wells in the **Two Island Lake** area with its equity partner, **Apache Canada Ltd.**



Figure 7. Operators in the Horn River Basin have drilled experimental and non-experimental wells. Many of these operators have purchased land in the core area of the basin.

Apache Canada Ltd. reports its Muskwa Formation play in the Horn River Basin is key to its production growth. In 2008, the producer successfully completed seven horizontal wells in the **Ootla** area where it estimates the natural gas resource potential could be in the range of 9 to 16 Tcf (Daily Oil Bulletin website, 2008). On non-operated acreage, two wells were drilled in 2008 which produced at an average flow rate of five mmcf per day. Apache is now moving toward a full-scale development plan for the Ootla area. Apache uses pad-style development drilling in the Horn River Basin and, based on success in 2008, plans to

increase the number of fracture stimulations (fracs) per well (so far, the highest has been 10 per well). Apache has said it will have to make significant investments in infrastructure to produce gas from the Horn River Basin, which could produce significant volumes by 2011 or 2012. Apache is now producing approximately 20 mmcf per day from the Ootla area. Apache and its partner EnCana Corp. are close to completing a shared dehydration compression facility for the area and a 66-kilometre, 24-inch pipeline to a Spectra Energy tie-in point in the **Cabin Lake** area.

Nexen Inc. holds approximately 36,000 hectares (100% working interest) in the **Dilly Creek** area of the Horn River Basin. Nexen has stated its Dilly Creek lands could contain as much as six Tcf of recoverable contingent resources (assuming a 20 per cent recovery factor). However, the producer states that further appraisal activity is required before these estimates can be finalized and commerciality established. In 2008, two vertical wells and three horizontal wells were drilled in the Dilly Creek area with different drilling programs associated with each. Fracture stimulation and test work is now being performed on these wells and it's expected Nexen will have these six wells on production before the end of 2009. The producer now has additional access to its Dilly Creek properties after completing construction on an all-weather road into the area in 2008. Nexen has invested a total of \$340 million in land, infrastructure and wells in the Horn River Basin; approximately \$180 million of that was spent in 2008.

Devon Canada Corp. has completed drilling operations on one vertical and two horizontal wells in the **Komie** area of the Horn River Basin. The producer is also involved in a proposed gas plant and pipeline infrastructure project in the area, which will be funded by several operators (EnCana Corporation taking the lead role). Between \$100 million to \$150 million of Devon's Canadian capital budget has been earmarked for its Horn River program. Devon describes its Horn River program as measured, as it concentrates on decreasing costs and the commercial viability of the basin.

In late 2008, **EOG Resources Inc.** completed three full-length lateral shale gas wells within the Horn River Basin that tested gas at rates of between nine and 16 mmcf per day. These wells were deep experimental tests in the **Maxhamish** area, which were granted experimental scheme status in September of 2006. In early 2009, EOG stated that it will maintain a steady pace of activity in the Horn River Basin and will allow production to grow incrementally as infrastructure construction grows. Currently, it's working on securing long-term transportation and processing agreements for its gas from the area. EOG plans to drill seven horizontal wells this year compared to six in 2008. It was the first company to nominate and purchase large tracts of land in the Horn River Basin at relatively low costs in 2004 and 2005. The producer now holds approximately 63,740 net hectares of land in the basin. EOG has stated that its **Ootla** area holdings could yield as much as six trillion cubic feet of net natural gas reserves.

Storm Energy Inc. is expanding its mineral rights inventory at the edge of the Horn River Basin. In the

winter-only access areas of **Cabin**, **Kotcho** and **Junior**, the producer has not only identified some Bluesky and Debolt formation prospects but is amassing land in the Devonian shale gas play in those areas. Storm Energy has set up a partnership with Storm Gas Resource Corp., which is owned 45 per cent by Storm Gas International Inc.

Crew Energy Inc. has positioned itself for longer term growth in the Horn River Basin. The producer holds 16 net sections of land in the **Missile/Helmet** area, which will target the Upper Devonian Muskwa shale. A third party engineering firm estimates that Crew's land in this area holds 400 Bcf to 2.1 Tcf of gas-in-place.

Result Energy Inc. has increased its focus on the Horn River Basin. The company owns 25 gross sections in the **Dilly Creek** area with its partner **Seven Generations Energy Ltd.** The joint venture lands are believed to contain more than 125 metres of prospective Muskwa/Evie shales. These lands are near a successful well in the **Trail** area, which had reported gas flow rates of up to five mmcf per day following a fracture stimulation of the Muskwa section.

Quicksilver Resources Inc. began work in the **Fortune** area of the Horn River Basin in late 2008. The Texas-based oil and gas oil producer acquired 19 licenses covering approximately 51,397 net contiguous hectares at the November 2007 and March 2008 British Columbia PNG rights dispositions. In early 2009, Quicksilver reached total depth on its first two horizontal wells which tested the Devonian Muskwa and Klua shales. The two wells confirmed more than 150 metres of shale with high silica content and high initial production rates.

ExxonMobil Canada Energy and **Imperial Oil Resources Limited** are 50/50 partners in the Horn River Basin and are encouraged by their exploration of over 100,000 hectares leased in the basin. ExxonMobil stated that initial test results from the first four wells in the **Komie** area produced impressive gas rates that are higher than average rates from wells in Texas's Barnett Shale and certainly comparable to significant wells in Louisiana's Haynesville Shale.

Production

One of the distinctive features of development in the Horn River Basin is formation of the Horn River Producers Group (*Table 2*). This group was started in November 2007 and has the involvement of the British Columbia Ministry of Energy, Mines and Petroleum Resource, the BC Oil and Gas Commission, First Nations and major industry players. Despite being competitors, this producers group is proving to have many benefits, such as having a streamlined approach to dealing with various issues that are inherent in an area that has seen relatively little petroleum industry activity. Their focus is to facilitate communication and co-ordination of activity in the Basin as operators work with key stakeholders and First Nations. Some of the issues being addressed include infrastructure development, optimal type of completion and stimulation techniques to keep costs down and increase productivity, and strategies to compete with other unconventional natural gas plays in North America.

In early 2009, EnCana Corporation announced the planned construction of a natural gas processing facility in the Cabin Lake area, located approximately 60 kilometres northeast of Fort Nelson. The facility, which will be built in six phases, is slated for initial processing capacity of 400 mmcf per day with a projected final capacity of 2.4 Bcf per day, once the area is fully developed. The initial phase is expected to be completed in 2011.

Spectra Energy Corp., which has 2,800 kilometres of pipeline in British Columbia and transportation capacity of 2.2 Bcf per day, is taking steps towards easing the infrastructure requirements in emerging shale gas areas of the Horn River Basin. With pipelines and processing capacity not yet developed, Spectra is planning a multi-phased expansion to boost gathering and processing capacity to accommodate Horn River gas. The expansion involves reactivation of existing processing capacity at the Fort Nelson gas plant, looping and reconfiguration of area gathering and compression, and the addition of new processing capacity at the Cabin Lake compressor station. Spectra has firm gathering and processing commitments from 10 customers for 791 mmcf per day with staged in-service dates between 2009 and 2012 and onwards.

TABLE 2. HORN RIVER PRODUCERS GROUP

ENCANA CORPORATION
APACHE CANADA
DEVON CANADA CORPORATION
EOG RESOURCES INC.
NEXEN INC.
QUICKSILVER RESOURCES INC.
STONE MOUNTAIN RESOURCES LTD.
IMPERIAL OIL LIMITED-EXXONMOBIL CANADA LIMITED (PARTNERSHIP)
CONOCOPHILLIPS
PETRO-CANADA
PENGROWTH ENERGY TRUST
RESULT ENERGY INC.

Beaver River Area (Liard Basin and Fold Belt Region)

The Beaver River area lies west of the Kledo-Bovie Lake Fault and is located near the border of the Yukon Territory and British Columbia (Figure 4). The relatively unexplored area, 160 kilometres northwest of Fort Nelson, has captured the interest of producers looking to evaluate and test the potential of Mississippian-aged shales of the Mattson/Besa River. Some promising results have come out of testing completed to date.

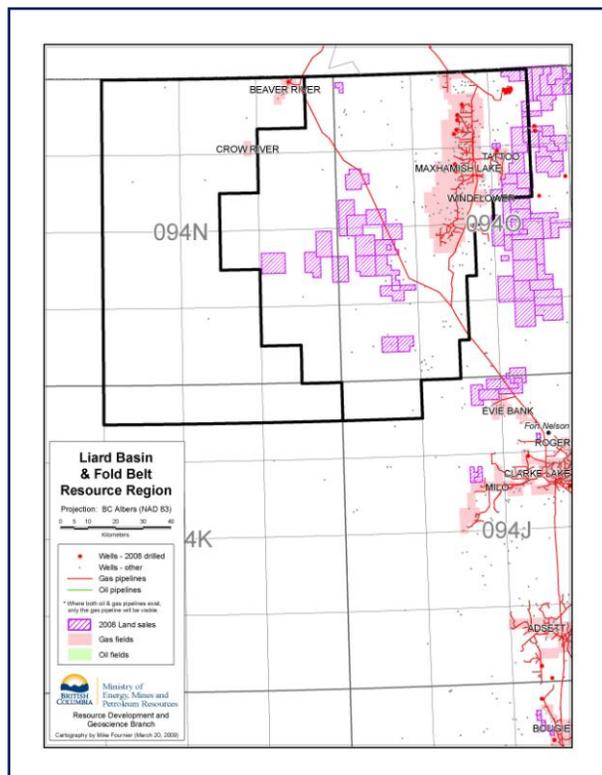


Figure 8. The only parcel sold near the Beaver River area in 2008 was at the April 25 Crown petroleum and natural gas rights sale.

Land Sale Activity

The Liard Basin's Beaver River area has seen very little land sale activity compared to other shale gas regions in northeast British Columbia. Only one parcel was purchased in 2008; it was located east of the Beaver River area in map sheet 94-O-13, Block L. A successful bid of \$237,127 was submitted by Western Land Services for a 778-hectare drilling license covering petroleum and natural gas rights from surface to basement. So far in 2009, one parcel has been purchased just west of the Beaver River area in map sheet 94-O-13, where Mineral Consulting Services Ltd. purchased a 2,120-hectare drilling licence for \$1.02 million.

Further south in the Liard Basin, interest is developing in and around the Patry area (94-N-8, 94-O-5, 94-O-12), a potentially high-impact shale gas play that may have prospects comparable to the adjacent Horn River Basin. In 2008, land brokers paid \$16.8 million for the purchase of 68,464 hectares (\$245 per hectare) in and around the Patry area. In 2009, the April

and July BC land sales saw another \$38.5 million to purchase 52,624 hectares (an average of \$751 per hectare). Recent activity shows that Apache Canada Ltd. has a Patry area new field wildcat well listed as standing at d-28-B94-O-12, with the Middle Devonian Besa River Formation as the projected zone.

Industry Activity

Gas shows in the Mississippian Mattson in the **Beaver River** area are likely due to the presence of a significant shale gas reservoir. **Questerre Energy Corporation** and **Transeuro Energy Corp.** have been conducting joint operations in the area to evaluate Mississippian-age shales of the Mattson/Besa River as a potential resource play. Re-entry and perforating operations were conducted in three old wells named A-2, A-6 and B-2. Wells A-2 and A-6 were re-completed in the Mattson and hydraulically fractured to stimulate production. Well A-2 has been on production since March 2006 with gas rates increasing gradually from 1.6 to 4.2 mmcf per day. Well A-6 produced successfully at around 0.5 mmcf per day prior to fracturing, but has water production problems. Operations on well B-2 were suspended due to poor cement isolation between casing, and the wellbore was retained for a future deep sidetrack into the Middle Devonian Nahanni Formation (Daily Oil Bulletin website, 2008).

Questerre and Transeuro continued with their development program in 2008. In the summer of 2008, compression was added to the A-2 well with good initial results (production increased to more than four mmcf per day). In November 2008, another well called A-5 well was tied into a local gathering system. The tested interval in A-5 was a brittle layer, rich in dolomite at the top of a thick sequence of organic rich shale. The appraisal strategy for this well targets the more brittle rock intervals that have higher carbonate and silica content, expected to respond favourably to stimulation. The brittle rocks contain free gas and may serve as a pathway for the shale gas to enter the well. The A-5 well has been flowing at a facilities-constrained rate of around five mmcf per day with occasional interruptions due to operating issues. As the well produces, Questerre and Transeuro hope see clear evidence of the surrounding shales contributing gas into the carbonate sequence and for the well rates and pressures to stabilize.

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 east of the well-established Devonian Jean Marie gas production as well as deeper exploration targets such as Slave Point and Pine Point (Keg River) carbonates. Over 335 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 since 2001 with bonuses reaching a high of almost \$44 million in 2007. Bonus payments from the sale of PNG rights in 2008 totalled only \$598,401 (*Figure 9*).

To date, most parcels purchased in the Cordova Embayment have been by land brokers, clearly an indicator of the increasing competitiveness of the region and the growing interest in shale gas play assessment in northeast British Columbia.

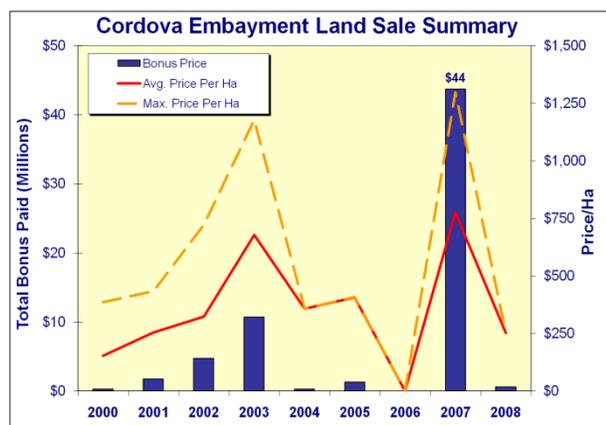


Figure 9. Bonuses from PNG rights sales in the Cordova Embayment.

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 gas 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 determined.

Experimental scheme areas in the Cordova Embayment are currently held by three operators. The following is a list of experimental schemes approved by the OGC in 2008 and to July 2009:

- May 2008: **Nexen Inc.** was given approval to explore, evaluate and test the shale gas potential of the Muskwa, Otter Park and Evie formations in the **Helmet** area of the Cordova Embayment.
- October 2008: **Penn West Energy Trust** was given approval to explore and evaluate the Devonian shale sequence, specifically the Muskwa and Evie formations, in the **Helmet** area of the Cordova Embayment.
- July 2009: **Nexen Inc.** was given approval to explore and evaluate the shale gas potential of the Devonian shale sequence, specifically the Muskwa, Otter Park and Evie formations within the **Helmet** area.
- August 2009: **Canadian Natural Resources Ltd.** was given approval to explore and evaluate the shale gas potential of the Devonian shale sequence, specifically the Muskwa and Evie formations within the **Helmet** area.

Over the winter months of 2008 and 2009, **Nexen Inc.** drilled one vertical and one horizontal well in the **Helmet** area of the Cordova Embayment. The intent of Nexen's program in the area is to progressively gather information and knowledge through a series of drilling, well completion and production testing programs. Nexen has approximately 1,540 hectares in the Cordova Embayment with a 100 per cent working interest.

Penn West Petroleum Ltd. drilled two horizontal wells in the Cordova Embayment in late 2008 (Helmet area). One is on-stream and the other is approaching completion. Penn West will continue testing this area of the Cordova Embayment and says the resource play will deserve more capital and development at the appropriate time.

Production

To date, there has been no recorded shale gas production in the Cordova Embayment. The region has cumulative gas production of over 600 Bcf, primarily from the Upper Devonian Jean Marie and the Middle Devonian Slave Point and Keg River.

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

Land Sale Activity

Over the last four years, PNG rights sales have been increasing extensively 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 PNG rights for sale and the higher price paid per hectare can be correlated with an industry shift to incorporate unconventional gas reservoirs, including the Doig Phosphate in the Groundbirch area and the Upper Montney Formation in the Dawson Creek and Bissette/Swan Lake areas.

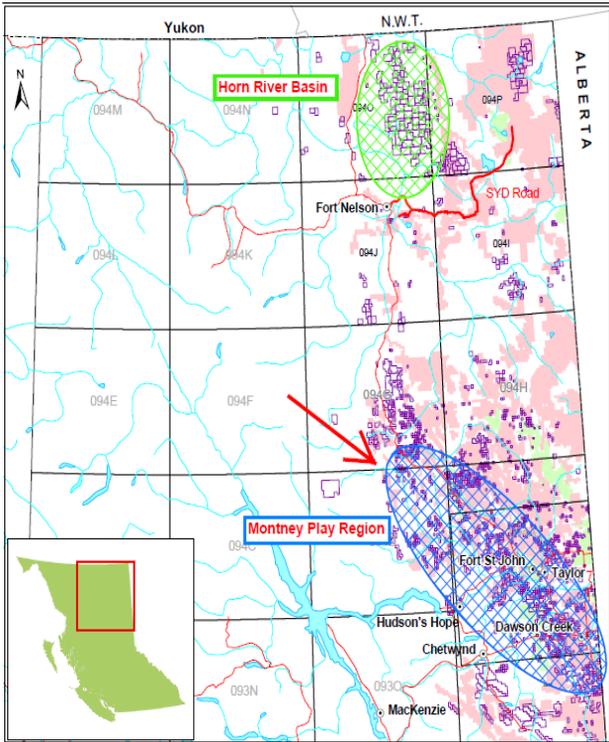


Figure 10. The main play area of the Montney trend covers approximately one million hectares (2.5 million acres) in the Fort St. John/Dawson Creek region.

Annual bonuses from PNG rights within the greater Montney exploration and development fairway went from \$85 million in 2005 to over \$1.3 billion in 2008 (Figure 11). The average price per hectare paid in 2008 was \$10,890 compared to \$3,507 in 2007. Many high bonus bids throughout 2008 were notable but of particular interest were bonuses paid at the May and July PNG rights disposition. At the May auction, Petroland Services (1986) Ltd. paid \$140.8 million for a 5,518-hectare licence in the Groundbirch area (southwest of Dawson Creek). At the July auction, Standard Land Company Inc. paid the highest bonus ever at a British Columbia PNG rights disposition with a \$156.8 million payment for a 4,661-hectare licence (\$33,649 per hectare) in the Groundbirch area. This purchase covered all PNG rights from surface to basement. Drilling records show ARC Energy Trust

and Shell Canada Limited as the primary operators in this area.



Figure 11. Bonuses from PNG right sales in the Upper Montney play trend.

Industry Activity

The Triassic Upper Montney has seen exceptional growth in production in recent years. The Upper Montney consists of light brown, blocky siltstones with interlaminated fine grained sands. Producing fields within the Montney play trend include the **Monias, Dawson Creek, Swan Lake** and **Tupper Creek** areas (Figure 12). The Upper Montney play area is limited by depth; it's shallow in the northeast and deepens to the southwest. Technological advances and the application of new horizontal well techniques are a major component to unlocking the potential of the Montney resource.

ARC Energy Trust is the dominant producer of Upper Montney tight/shale gas in the **Dawson Creek** field. The Trust entered the play in 2003 with the purchase of Star Oil & Gas Ltd. and has since developed significant operational expertise in developing tight, low permeability formations. To reduce costs and enhance economics, ARC uses horizontal drilling technology along with improved completion techniques to exploit the field. In 2008, ARC successfully drilled seven horizontal and nine vertical wells targeting the Montney. The completed construction of a sales gas pipeline in mid-November of 2008, which transports production from the Dawson field to a third-party gas plant in Alberta, allowed production to reach a record 48 mmcf per day. At the end of 2008, ARC had 12 vertical and three horizontal wells awaiting tie-in. The Dawson field remains a key focus for ARC's 2009 capital program. The completion date for a new 60 mmcf per day gas plant for the Dawson area is scheduled for the first quarter of 2010.

EnCana Corporation has significantly ramped up its operations in the **Swan Lake** area over the last two years. Its drilling program to develop gas from the sandstone, siltstone and shale sequences of the Triassic Montney has exceeded expectations. EnCana now holds over 295,000 net hectares of Montney rights in its **Cutbank Ridge** resource play. EnCana is producing about 226 mmcf per day from 85 horizontal wells at Swan Lake. The producer can now complete as many as eight staged fracture stimulations along the horizontal leg of a well in just four days. Only a couple of years

ago, the average time for a staged frac was one every four days using the labourious procedure of coiled tubing conveyed bridge plugs and perforating guns. Continued optimization of these horizontal completion

techniques will continue to unlock the economic potential of the area. With current mapping of the Upper Montney, EnCana has identified 3.7 Tcf of original gas-in-place (OGIP) or 25 to 40 Bcf per section.

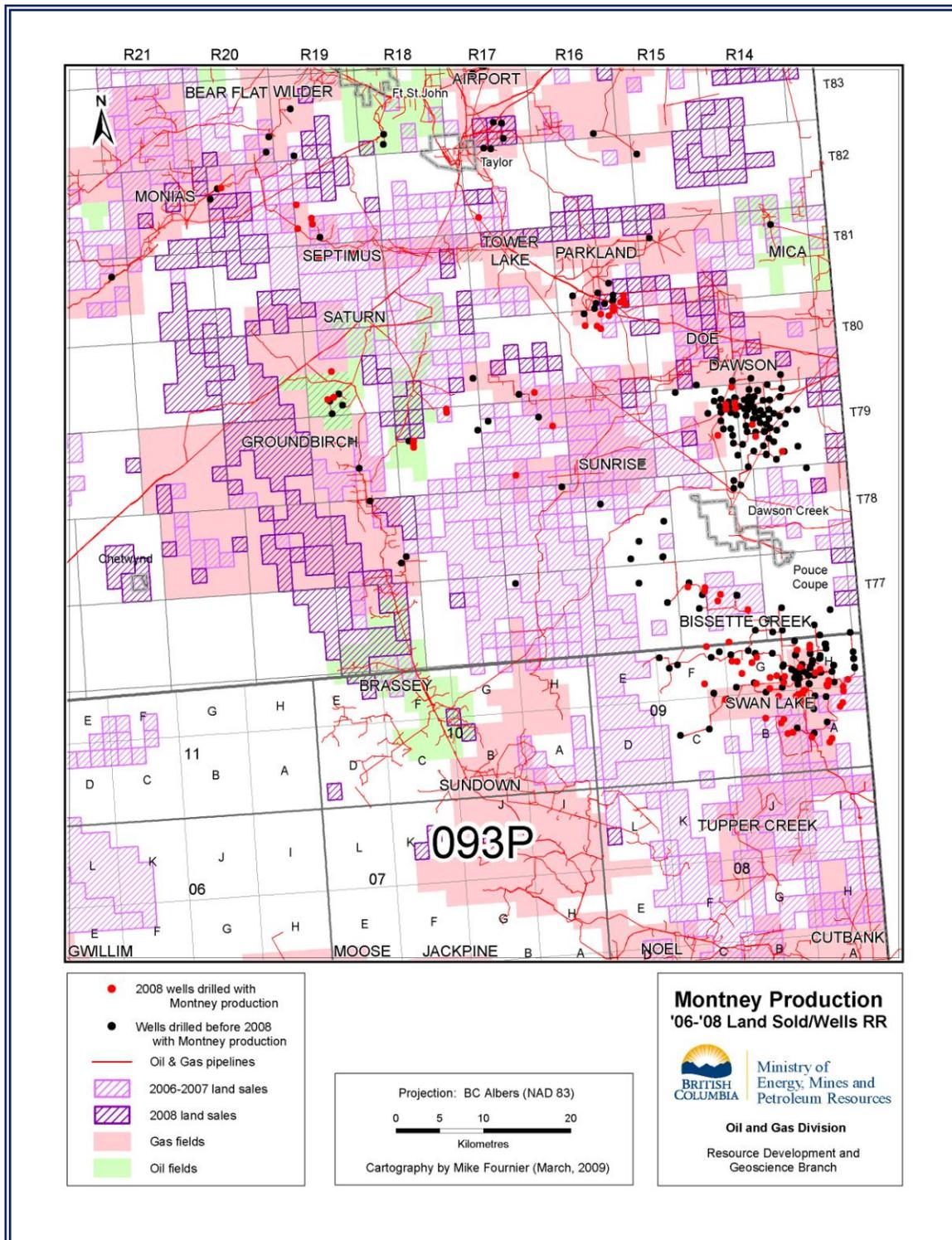


Figure 12. PNG rights sold and wells drilled with Montney production.

Murphy Oil Corporation continues to develop triassic shale gas potential from the montney turbidites in the **Swan Lake** and **Tupper** areas. In June 2007, Murphy spent \$155 million to acquire the interests of **Bear Ridge Resources Ltd.** in these areas. In addition, Murphy spent \$224.6 million on three parcels totalling 16,893 hectares at British Columbia's December 2007 PNG rights sale. The producer now holds over 132 sections of land in the Tupper area where it believes there is relatively low-risk but good growth potential. Murphy has so far drilled nine vertical wells to delineate the play and says the west Tupper area is substantially thicker in terms of the Montney. Some of these wells have also encountered pay in the Triassic Doig. Natural gas production from the Tupper area began in earnest in late December and is currently flowing at approximately 57 mmcf per day (as of May 2009).

Storm Exploration Ltd. focuses a significant portion of its activity on delineation and development of the Montney in the **Parkland** area. Development of Storm's Montney discovery at Parkland entails using four horizontal wells per section with six to eight fracs per wellbore. At the beginning of 2008, the company was producing 14 mmcf per day of raw gas from six horizontal Montney gas wells and another three mmcf per day of raw gas from nine Montney vertical wells. Approximately 85 per cent of Storm's production is now sourced from vertical and horizontal wells producing from its Montney discovery. Storm's estimate of discovered petroleum initially in-place from the Montney at Parkland is 410 Bcf with an estimated ultimate recovery of 50 per cent. In 2009, activity at Storm's Parkland property will include drilling four horizontal Montney development wells and five to six vertical wells targeting the Montney as well as potential in the uphole Halfway and Doig formations. As a result of increased gas production from the area, Storm will add a third compressor at its Parkland facility and will also twin part of its gas gathering system to allow for a further increase in production volumes.

Duvernay Oil Corp. (recently acquired by Shell Canada Limited) continues to expand its Montney program in the **Sunset Prairie-Groundbirch** areas. In the second quarter of 2008, Duvernay had five rigs active in the complex. An additional five horizontal wells were drilled after spring break-up 2008. One of those five horizontals tested at initial rates of 6.4 mmcf per day. Duvernay expected an additional 35 horizontal wells to be drilled by spring break-up of 2009. The producer has 120 net sections of Montney rights in the prime Montney gas fairway. Depending on ultimate well spacing, this could represent up to 500 future horizontal drilling locations. After achieving major success from its Triassic Doig discovery in 2002, Duvernay has built extensive gas infrastructure in the Sunset Prairie-Groundbirch area. Four natural gas processing plants now serve the area as well as two direct tie-in points to Spectra Energy's main sales gas system.

Progress Energy Resources Corp. (created from a corporate merger between ProEx Energy Ltd. and Progress Energy Trust) will continue to focus on proving up play concepts in the Montney play trend. Using tight gas expertise and a geographically concentrated asset base in northeast BC, the energy company has built a significant Montney rights land base totalling 320,000 of net undeveloped hectares in northeast British Columbia and northwest Alberta. Progress has penetrated the Montney in eight vertical wells in northeast BC since mid 2008.

The **Dawson** and **Tupper** fields within the Montney play trend have become key focus areas for **Crocatta Energy Inc.** The company has an average working interest of 73 per cent on 37 sections of land in the two areas. The highlight so far has been a Dawson area horizontal well targeting the Montney, which initially flowed at over five mmcf per day with a final test rate of 2.5 mmcf per day on an extended flow test. The well was completed in the first quarter of 2009.

Talisman Energy Inc. is building a considerable land position in the Montney fairway in northeast BC where it holds 35,200 net hectares. Active in several regions within the Montney, Talisman continued to pilot various areas within the trend throughout 2008. The producer drilled 13 pilot wells to test drilling and completion techniques and to assess the quality of the reservoir. Talisman plans to drill up to 35 development wells in 2009 with horizontal wells drilled primarily from pad locations.

Crew Energy Inc. controls 184 net sections in the Montney play region and has spent over \$79 million on undeveloped lands in northeast BC that are prospective for Montney gas. Crew has drilled or re-completed 12 wells targeting the Montney. The company continues to concentrate drilling efforts in the **Septimus** area where it has experienced exceptional results with wells testing at rates as high as 15 mmcf per day. Crew is currently producing at a restricted rate of seven mmcf per day from the Montney at Septimus. Approvals from provincial regulatory authorities have been acquired for construction of a 25 mmcf per day natural gas processing facility in the Septimus area. Commissioning of this facility is planned for the third quarter of 2009. The plant has been designed for expansion to 50 mmcf per day, which will be evaluated in late 2009.

Production

Significant production increases from areas within the Montney play region resulted from horizontal drilling and improved completion techniques. The application of horizontal well techniques has been an important key to unlocking the economic potential of the region.

The graph in Figure 13 incorporates all non-confidential wells along the Montney play trend. Most production to date is from the Montney “A” pool, which originally produced in “sweet spots” found in the Upper Montney using vertical well technology. Now, the Upper Montney is being developed by drilling horizontal wells with multi-stage fracture stimulations. The first horizontal well on the trend was drilled by Arc Energy Trust, which saw significant improvement in productivity. Subsequent application of horizontal well technology along with continuous refinement in completion technologies has improved production. An example would be the use of longer-reach horizontal

wells and the experimentation with different frac treatments and fluids used in these processes. In the pre-horizontal era, one would see an average rate of about 500 thousand cubic feet per day; the average rate has climbed continuously and is now about 1.3 million cubic feet per day. To the end of January 2009, cumulative gas production from the Montney in the Regional Heritage field (a newly designated field for categorizing this large regional gas accumulation) was approximately 190 Bcf, of which 150 Bcf was produced in the last 3 years (*Figure 13*).

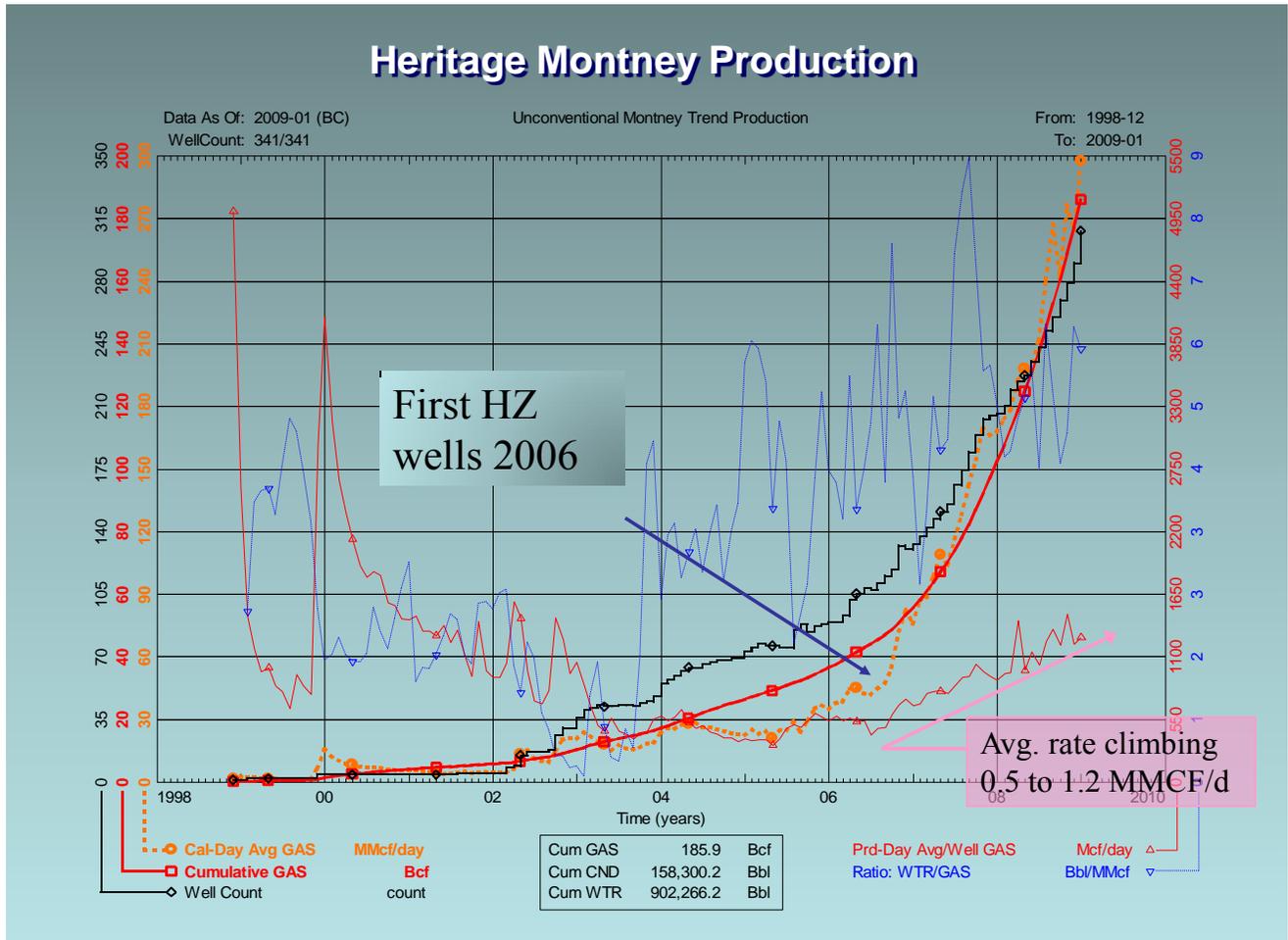


Figure 13. Chart displaying area gas production and total number of producing wells from the Heritage Montney. Horizontal drilling technology along with new and improved completion techniques are key factors in the increasing production profile from these areas. Data from Hayes (2009).

optimize completion methods that could potentially increase well productivity.

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

Shale gas activity directed towards Cretaceous horizons in northeast British Columbia continues to be 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 shale gas potential. Companies currently operating in these areas are evaluating fracture stimulation programs and continue to

Land Sale Activity

The Farrell Creek and Blair Creek areas, both in the Northern Foothills region, are relatively unexplored but have seen a steady increase in the sale of petroleum and natural gas rights over the last three years. In 2008, bonuses garnered from PNG rights dispositions in the Farrell Creek area (near the town of Hudson’s Hope) fetched a total of \$156.7 million or \$3,342 per hectare for 14 parcels. Ten of the 14 parcels were purchased by land brokers while the remaining were purchased

directly by producers (Canadian Spirit Resources Inc. and Bancroft Oil and Gas Ltd.). Most of the PNG rights in these parcels cover rights from the surface to the base of the Cadomin-Dunlevy-Nikanassin or from surface to basement. The Town area also saw high activity in terms of land sales in 2008. Although most drilling in this area focuses on conventional gas in the Lower Cretaceous Gething and Bluesky formations, there exists potential for shale gas in the Buckingham Formation (Fort. St. John Group). In northeast British Columbia, the Buckingham Formation is about 1,000 metres thick and extends in a north-westerly direction in a broad, low lying belt along the eastern edge of the Foothills between the Halfway and Muskwa rivers (Glass, 1997).

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 objectives of the program are to develop effective completion and stimulation programs to maximize gas production and to obtain further geological and reservoir data to allow proper assessment of the formation's resource potential.

Since 2003, three key wells have been licensed and drilled by Petro-Canada as experimental and outpost wells in the **Bubbles North, Beg** and **Jedney** areas. In 2003, an experimental well (c-A94-F/94-G-8) was directionally drilled to 1,333 metres in the Bubbles North area. Seven cores were cut in the Lower Cretaceous Buckingham shales from 893.0 to 934.2 metres. Completion work was performed to evaluate the Lower Cretaceous tight gas interval but, subsequently, the zone and wellbore were prepared for abandonment. At the Beg experimental well (a-A54-F/94-G-), nine cores were cut in Lower Cretaceous from 737 to 793 metres, however, no completion, stimulation or test work was done to evaluate these Lower Cretaceous zones. In the Jedney area, an exploratory outpost well drilled in 2005 was removed from confidential status on March 8, 2008. The well was drilled underbalanced to a depth of 1,005 metres to the Lower Cretaceous tight gas reservoir and cased with 178 mm casing. The well was completed as an openhole Buckingham shale gas well and was perforated from 1,005 to 1,350 metres. A 10-hour single point test was conducted on March 17, 2005 which saw the well flow at a final production rate of 100 mcf. The well is currently listed as standing.

Painted Pony Petroleum Ltd. participated in the experimental re-completion and tie-in of two vertical wells in the **Blair Creek** area in late 2008. Both wells were completed in the Lower Cretaceous Buckingham Formation and were placed on production at modest rates. Encouraged by the initial results of this new resource-type project, Painted Pony plans to experiment with drilling and completion techniques throughout 2009. Painted Pony believes the Buckingham shale may have potential further north in the **Julienne Creek** area and to the south in the **Cameron** area.

In May 2009, **Unconventional Gas Resources** was granted approval by the BC Oil and Gas Commission for

two experimental schemes in the **Town** area. The purpose for the schemes is to test the commercial viability of shale gas potential in the Fort St. John Group. Unconventional Gas Resources was formed in early 2007 by the founders of **MGV Energy**.

Canadian Spirit Resources Inc. (CSRI) has been active in its primary resource property of **Farrell Creek**, north of Hudson's Hope. In 2008, CSRI announced it had entered into a shallow rights joint venture with Shell Canada Energy on a combined 39,000 hectares at Farrell Creek. The land position was secured to advance the development of the Lower Cretaceous Gething play, an organically rich rock package. Shell expanded CSRI's Gething Pilot Project through the acquisition of approximately 95 sections of shallow PNG rights. To the end of 2007, CSRI had drilled eight test wells. In 2008, Shell, as the new operator, drilled four vertical wells on the property targeting the Gething and other shallow rights. In June 2009, CSRI announced that the first sale of natural gas had commenced at the Farrell Creek Pilot Project. CSRI will proceed with long-term production testing from previously drilled and future Gething wells. The company is expected to report production volumes from its Gething Pilot Project in the third quarter of 2009; seven wells are expected to be on production by the end of the year.

CSRI is optimistic about the results of its Farrell Creek pilot program and anticipates continued development of commercial production from the area. Evaluation of the unconventional natural gas resource on CSRI-interest lands at Farrell Creek (Sproule Associates Limited) reaffirms a total raw gas-in-place of 1.8 Tcf (1.4 Tcf attributed to Gething, 0.4 Tcf to Moosebar and Gates formations).

Production

To date, only Canadian Spirit Resources Inc. has officially recorded shale gas production from Cretaceous-aged reservoirs.

OUTLOOK

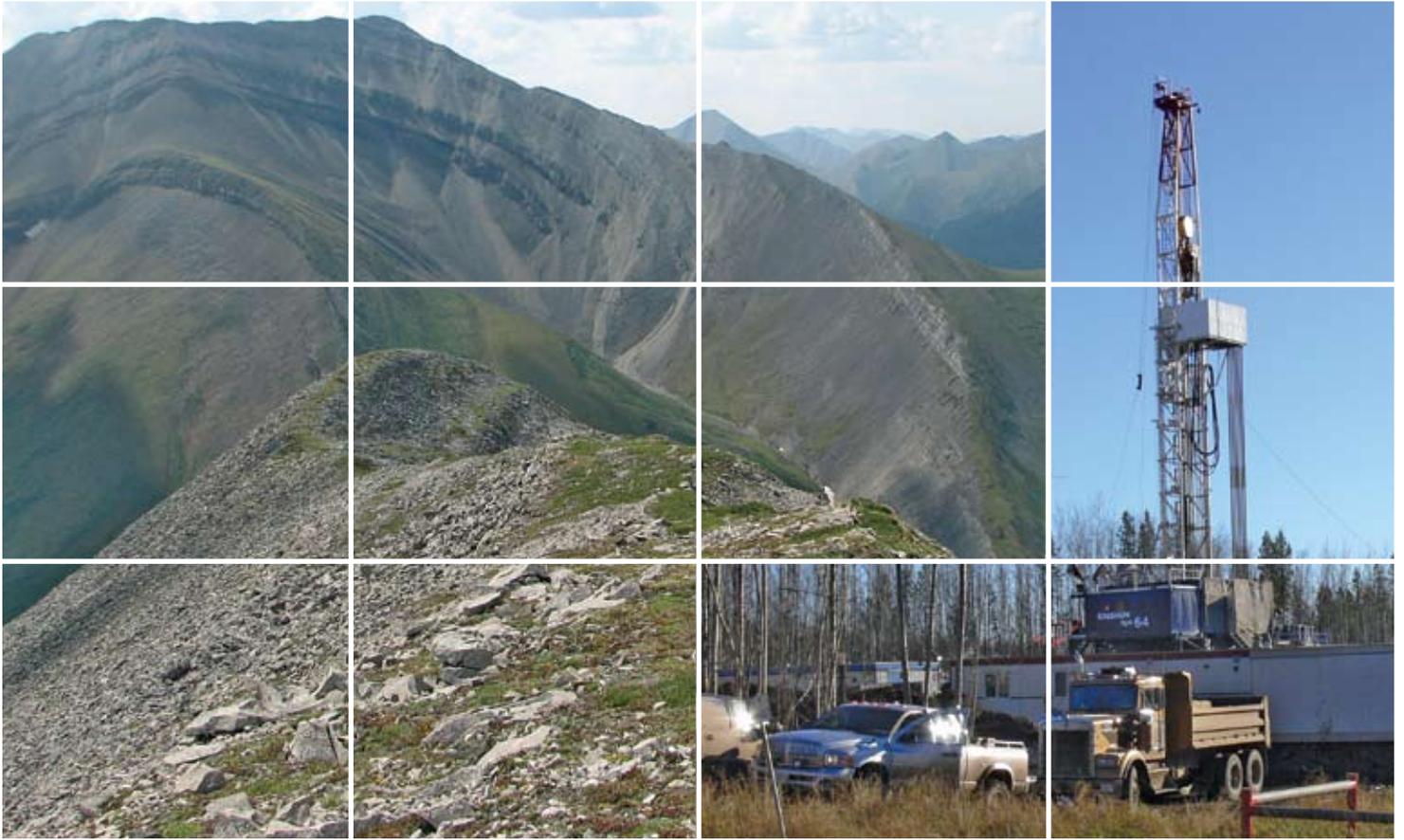
Natural gas producers looking to unlock the vast potential of unconventional gas resources in British Columbia are clearly meeting the formidable technical challenges inherent with this type of play development. The favourable oil and gas royalty regime in place in British Columbia continues to have a positive impact on industry activity, particularly in the province's emerging shale gas regions. Although land sale activity in these regions in 2009 has dropped off compared to the previous two years, producers have countered with measurable gains in overcoming the difficulties of these technically complex, high-risk projects. Recent corporate announcements of higher resource and recovery estimates from BC's shale gas regions has relayed the message to industry players and watchers that tangible results are being achieved and that much is being done to convert shale gas resources into reserves and actual production.

The oil and gas industry in British Columbia has seen unparalleled growth and investment over the last eight years. The trend towards unconventional resource play development, promising discoveries, and a fiscally-responsible energy regime continues to give the province a competitive advantage as an oil and gas jurisdiction. Despite current falling natural gas prices, industry activity in British Columbia remains reasonably strong in 2009.

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