



CANADA



Going straight to the 'Source'

A spotlight on the emerging Canadian shale oil plays

Welcome to the shale oil revolution

The shale 'oil' revolution has garnered significant attention of late, driven by industry's movement towards anything oil and the onslaught of multi-stage fracture stimulation, which has opened up a number of new and emerging oil (and gas) plays in North America. In Canada, we have witnessed several new plays popping onto investors' radar screens, including the Mississippian Alberta Bakken/Exshaw shales in southern Alberta, Cretaceous Second White Specks in the Deep Basin, Jurassic Nordegg shales in the Peace River area of Alberta, and Devonian Muskwa/Duvernay shales in northwest Alberta/Deep Basin. In this report, we provide a brief background on each of these emerging oil resource plays, along with a framework to evaluate the quality of each play from a technical perspective.

Devil in the technical details

Not all shales are created equal and/or are uniformly prospective for oil or gas. Productive capability is dependent on geochemical, petrophysical, geological, mineralogical, and economic factors. The first step in evaluating a shale prospect is to drill, core, and analyze the rock samples displayed in the cuttings. With an abundance of technical information on the quality of a source rock/shale, the key is distilling the most important factors, which we believe include: 1) Total Organic Carbon (TOC), 2) remaining hydrocarbon potential (S₂), 3) thermal maturity (T_{max} or Ro), 4) Hydrogen Index (HI), 5) permeability, 6) porosity, 7) thickness, 8) lithology, 9) mineralogy, 10) other drilling and completion considerations, and 11) production decline profile.

Get your hands on the red-hot source rock

We expect producers chasing the ever lucrative 'source rock' in Canada to be a major theme over the next five years. In areas where the oil window is more apparent, we see potentially higher drilling and land sale activity over the near term, followed by an increase in production, reserves, and cashflow for producers able to effectively execute on their shale oil strategy over the longer term. At this point, there is no doubt that shale oil is in the first inning of its delineation phase; however, with further technical analysis, drilling, and technology improvements, we are cautiously optimistic and see enormous promise for each of these respective plays in 2010/11.

For those seeking exposure to the theme of emerging oil in the source rock, we would highlight Delphi Energy (DEE CN), Chinook Energy (CKE CN), and Celtic Exploration (CLT CN) for the Duvernay/Muskwa, Crescent Point (CPG CN) for the Exshaw/Bakken, Galleon Energy (GO CN) for the Nordegg, and Angle Energy (NGL CN) and Fairborne Energy (FEL CN) for the Second White Specks.

Company	Price 10/15/10	Target	Rating
Angle (NGL CN)	C\$7.70	C\$10.00	O
Celtic (CLT CN)	C\$12.40	C\$15.50	O
Chinook (CKE CN)	C\$1.97	C\$3.50	O
Crescent Point (CPG CN)	C\$40.01	C\$42.50	N
Delphi (DEE CN)	C\$2.31	C\$3.00	N
Galleon (GO CN)	C\$3.89	C\$4.50	N
Fairborne (FEL CN)	C\$4.04	C\$6.25	O

Source: Bloomberg, Macquarie Research, October 2010

Inside

A spotlight on the emerging Canadian shale oil plays	2
Welcome to the shale oil revolution	4
Understanding the basics	5
Getting down to the core	7
Western Canadian shale source rocks	11
Conclusion	37

Ray Kwan
1 403 539 4355
Ryan Mooney
1 403 539 8514

Ray.Kwan@macquarie.com
Ryan.Mooney@macquarie.com

18 October 2010

A spotlight on the emerging Canadian shale oil plays

In our view, Canadian shale oil is likely to emerge as a significant trend over the next five to ten years, as producers move into the tightest yet largest oil in place rocks available. The focus will be on the 1) Devonian Muskwa/Duvernay shales in northwest Alberta/Deep Basin, 2) Mississippian Alberta Bakken/Exshaw shales in southern Alberta, 3) Jurassic Nordegg shales in the Peace River area of Alberta, and 4) Cretaceous Second White Specks in the Deep Basin (see Fig 1). We note that together these shales are estimated to contain over 40bnbbl of OOIP, which at even a 1% recovery factor would go a long way to extending the productive life of the WCSB.

1) Devonian Muskwa/Duvernay

- We believe the Duvernay or Muskwa oil shales will emerge as one of the most interesting plays heading into the winter of 2010/11. The key catalysts driving development forward will include future well results in 4Q10/1Q11 in the Rainbow area of northwest Alberta, as well as potential drilling results at Sturgeon Lake, just north of Wild-River/Kaybob, in 2011/12.
- Celtic Exploration and CCRL (land broker) were amongst the first producers to test the Duvernay and Muskwa shales at Wild River/Kaybob and Rainbow Lake, respectively. The first Duvernay horizontal by Celtic tested at 2.1mmcf/d plus 75bbl/mmcf liquids, while the first Muskwa horizontal by CCRL produced at a peak rate of 100bbl/d on a calendar day basis. So far, there have been no horizontals drilled in the 'oil window' of the Duvernay.
- Producers evaluating these shales include **Chinook, Pace, EOG, and Delphi**. We also highlight **Celtic, Trilogy, Yoho, Daylight, Talisman and Husky** as potentially having shale oil in the greater Kaybob area.

2) Alberta Exshaw/Bakken

- The Alberta Bakken has generated by far the most buzz of any of the shale oil resources listed in this report. We expect to hear results from up to 20 wells that are expected to be drilled into this play through 1H11, with **Crescent Point** leading this exploration charge.
- Crescent Point and several land brokers have licensed and started drilling/completing wells in the Del Bonita/Reagan area along the US/Alberta border, though no results have been released. In the Horn River Basin, **Quicksilver** has been speaking of potential Exshaw oil shows.
- Other producers targeting these shales include **DeeThree, Bowood, Murphy Oil, Blacksteel and Quicksilver**.

3) Jurassic Nordegg oil

- Jurassic Nordegg oil in the greater Grande Prairie area of Alberta is one of the earliest shale plays to appear in Canada. The only producer we know of chasing the Nordegg is **Anglo Canadian**, which recently drilled and frac'd its first horizontal at Kakut, with results pending.
- The key risk we see with the Nordegg is that the oil here is medium gravity (17-25°API), which may result in a higher chance of plugging or occlusion because of the higher fluid viscosity.
- Given the early stage of this play, we expect producers to take a wait and see approach before licensing or drilling a Nordegg well. Producers with land potentially prospective for the Nordegg include **ARC Energy Trust, Galleon, Delphi, Birchcliff, Daylight and NAL**.

4) Cretaceous Second White Specks

- In the past, the Cretaceous Second White Specks had been the most actively drilled shale within this report. However, because of the plays productive variability, the difficulty in interpreting log data, and the inability to date of the play to demonstrate a repeatable nature capable of generating economic rates of return, we believe there remains a couple of technical challenges to overcome.
- Producers showing a renewed interest in the play include **Delphi, Fairborne, Compton, NAL and Angle**.

Alberta Bakken/Exshaw shales

Similar to the Duvernay/Muskwa oil in shale opportunity, the Alberta Bakken/Exshaw shale prospect in southern Alberta has become a focal point of recent industry activity, highlighted by significant prices paid at recent land sales. The story emerged following a land sale on 21 April when over 55,000 acres were sold for an average of C\$321/acre (with a max of C\$509/acre) right along the Alberta/Montana border. At that point it was uncertain who the buyer was, or what geological target they were planning to explore, but many began to speculate that it could be an extension of the Bakken play northwest into Alberta from North Dakota and Saskatchewan. Subsequent to the aforementioned Crown land sale there have been five other notable Alberta land sales where AB Bakken prospective acres were auctioned off at progressively higher metrics (see Fig 17). In total, producers have cumulatively paid over C\$140m YTD to establish toe-hold positions in the emerging oil play.

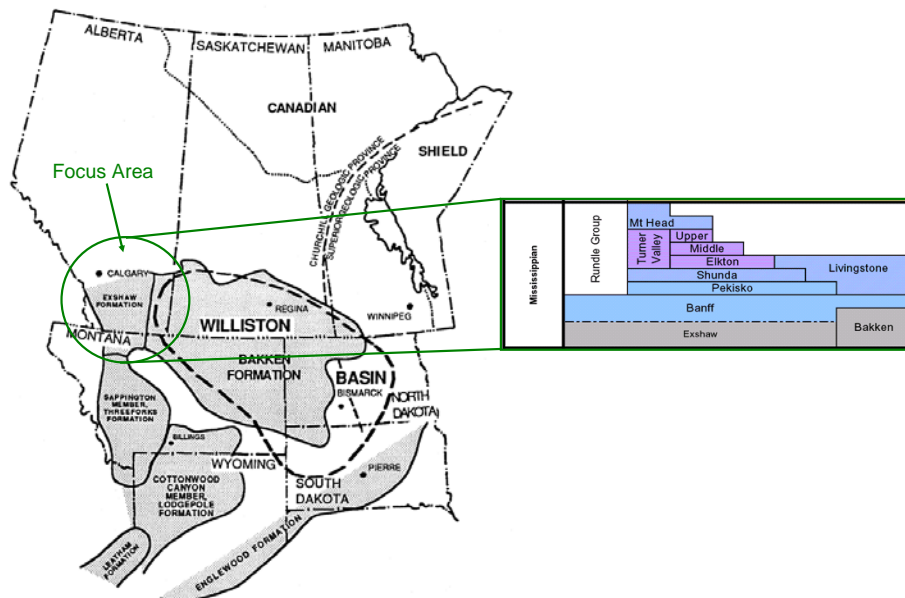
Fig 17 Crown land sales

Date	Parcel(s) Size (acres)	Unit Price (\$/acre)	
		Average	Peak
21-Apr-10	58,036	\$321	\$509
19-May-10	10,911	\$668	\$1,101
16-Jun-10	15,473	\$699	\$1,269
07-Jul-10	22,454	\$1,080	\$1,867
21-Jul-10	70,121	\$710	\$1,448
01-Sep-10	67,830	\$611	\$1,497

Source: geoSCOUT, Macquarie Research, October 2010

The Bakken formation has been clearly defined throughout the bulk of the Williston Basin in Saskatchewan and North Dakota. Conversely, it remains mainly unexplored in southern Alberta, south of the city of Lethbridge, between the town of Magrath and Raymond, and south to Cardston toward the Alberta/Montana border. Lately, the highlighted geographical region shown below has received the most attention by producers for early-stage exploration of the lower Mississippian/upper Devonian Exshaw.

Fig 18 Location of the Bakken/Exshaw



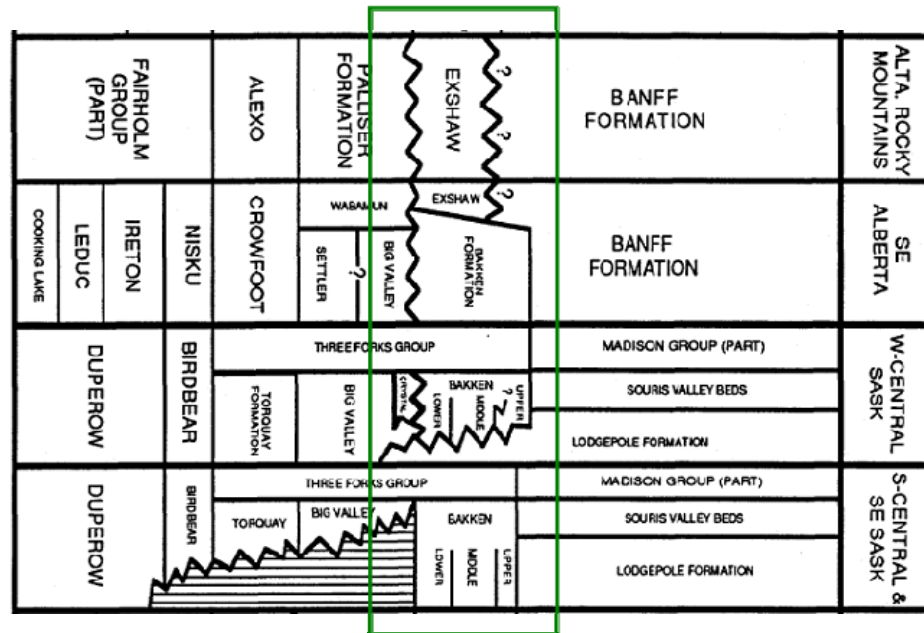
Source: University of Saskatchewan, Macquarie Research, October 2010

Geological properties. Along the northern edge of the Williston basin in central Saskatchewan the Bakken is truncated by the sub-Mesozoic unconformity. To the west in southern Alberta and BC, the lower Bakken members actually correlate with the Exshaw formation, while the upper Bakken member is similar to the basal black shale unit of the Banff formation. An arbitrary line determined by the extension of the Early Mississippian arch axis separates the Exshaw and the Bakken in northern Montana, and northward into southeastern Alberta.

The Exshaw/Bakken is an organic-rich, marine, source rock that occurs in the lower part of the Mississippian-Devonian system. The formation as a whole represents a petroleum system that can be tracked from source to trap. The Exshaw, Bakken (lower and upper members), and Lodgepole formations consist of organic-rich, black, basinal laminites with average TOC's up to 12% in the lower Bakken, 40% in the upper Bakken, 5% in the Lodgepole, and over 20% in the Exshaw. Each formation consists of Type II organic matter (characteristic of most marine oil source rocks), but one of the key differences lies in the average thickness of each interval. Within the Exshaw formation and the upper and lower members of the Bakken the pay is less than 10–15m, which compares to the Lodgepole formation that can extend for well over 10–30m. Unfortunately, the Lodgepole formation is typically less mature than the Exshaw/Bakken shales and as such over time has demonstrated the most oil expulsion of the three layers; in fact, it serves as the source rock for most Mississippian oil pools. Conversely, the Exshaw/Bakken is considered the most conducive (and prospective) for horizontal multi-stage fracturing given that it has experienced limited migration, and most of the oil remains contained within the member.

The Bakken shales were first identified as a potential source rock by Murray (1968) and Dow (1974). Their petrography studies indicated that the upper and lower black shales were composed of primarily indistinct organic material with little clay minerals, silt and dolomite grains. In 1987 Webster reported that the Bakken shales averaged 11.33wt% organic carbon in North Dakota. The stratigraphic column as found in southern Alberta and northern Montana is shown below in Fig 19.

Fig 19 Stratigraphic column



Source: Alberta Geological Survey, Macquarie Research, October 2010

Exshaw/Bakken – Activity. The play is now active from an early, half-cycle standpoint as players jockey to secure a meaningful land position via Crown land sales, strategic farm-ins, asset swaps, and corporate acquisitions. Since 21 April when the first block of land was sold at a Crown land sale, producers have been very quick to act, locking up nearly all the remaining Crown land along the initial footprint of the AB Bakken fairway. In fact, it only took six Crown land sales, a strategic farm-in announced with the Blood Tribe First Nation reserve, and one major company stepping in to purchase a distressed corporate in receivership to secure most of the land in the Alberta Bakken fairway. The only remaining opportunity to enter into the play is through a corporate acquisition of a few select junior companies or a farm-in on a super-major such as Encana, Exxon, or Conoco – all who continue to hold massive inactive vintage land positions in the prospective oil window of the Exshaw shale opportunity.

In terms of activity, we show in Fig 20 the top operators with wells and core data in the Alberta Bakken formation. If this play develops substantially, we believe it will provide a number of producers with an opportunity to farm-down their vintage inactive land position on lucrative terms. Of the ~15,300 total wells on trend, only 417 wells have been drilled and 23 public cores taken from the Exshaw/Bakken. Clearly it is the majors that hold the majority of the relevant core data, and information on the play – they have drilled a combined ~6,100 wells as a group.

Fig 20 Active players

Company	Total Wells	Total Deep Wells	Total Cores
Exxon/Imperial	168	19	5
Husky	2,051	22	4
Chevron	115	7	4
Canadian Natural	2,628	121	2
Nexen	24	5	2
Devon	180	11	1
Suncor	112	9	1
Barons	43	6	1
Starchild	12	2	1
Indra	2	2	1
Universal	3	1	1
ConocoPhillips	838	31	0
Bonavista	544	11	0
Encana	243	8	0
Provident	504	7	0
Chinook	111	6	0
Penn West	332	5	0
Apache	105	4	0
Bowood	91	4	0
Yoho	21	4	0
Wild Stream	156	3	0
Cenovus	42	3	0
Deethree	279	2	0
Crescent Point	171	2	0
Compass	121	2	0
Compton	37	2	0
Pengrowth	489	0	0
Baytex	243	0	0
ARC	223	0	0
EOG	117	0	0
Murphy	83	0	0
Celtic	32	0	0
Connaught	27	0	0
Twin Butte	18	0	0
Primary	1	0	0

Source: geoSCOUT, Macquarie Research, October 2010

No super-majors have announced a serious intention to pursue the AB Bakken in any meaningful capacity...yet. However, with a robust inventory of undeveloped land, this sub-group of producers are in the enviable position to allow the junior/mid-cap players to complete the necessary R&D to effectively delineate the play, while patiently waiting for the relevant geological data. We see the following high yield, mid, and small cap players becoming more active in the play in the near term.

- **Crescent Point.** The company announced on 20 September 2010 an acquisition of more than 1,000,000 net acres of exploratory land in southern Alberta from a combination of Crown land sales, freehold leasing programs and the acquisition of a distressed private company called Darian Resources, which had found itself in receivership. The company paid just C\$96m to acquire the private company. Previously (15 March 2007), Darian had purchased a private company called Bowview Petroleum that had originally negotiated the two freehold farm-in deals with Encana that ultimately provided Crescent Point with its new land position in the Vulcan, Robin, Taber, and Lethbridge areas of Alberta. Crescent Point has confirmed that it has drilled its first horizontal exploration well into the AB Bakken, and in the process of completing the well. Crescent Point will drill up to 19 net development and exploration wells on the play by year-end 2011.
- **DeeThree Exploration.** Historically the company focused on developing Barons, Bow Island, and Sunburst natural gas in the Lethbridge area. Recently, with the plethora of activity unfolding around its position within the heart of the Alberta Bakken fairway its strategy has shifted to focus on the exploitation of 20 identified Bakken drilling locations that are currently in the midst of being licensed to drill. DeeThree holds access to 300 sections of prospective land in the Alberta Bakken fairway. The company plans to drill two vertical stratigraphic tests in 4Q10.
- **Bowood Energy.** The company recently announced that it had entered into an agreement with Kainaiwa Resources (owned by the Blood Tribe First Nation) to acquire through a leasing arrangement an interest in 94.75 contiguous sections (60,640 acres) of land located within the Blood Tribe First Nation in southern Alberta. The deal brought the companies total prospective Alberta Bakken acreage to 162 sections (104,000 net acres) for a total of C\$14.1m with the obligation to drill at least one well to a minimum depth of 1,000m in each of the first two years of the Lease, and two wells per year for three years thereafter. Terms of the agreement allow:
 - 1) for the Blood Tribe First Nation to elect, in advance of drilling a well, to participate for a 20% working interest in any such well on the lands; or
 - 2) if Kainaiwa Resources elects not to participate, the Tribe will be entitled to a 20% working interest in any well drilled on the farm-in lands once 200% of the total capital has been recovered by Bowood Energy.

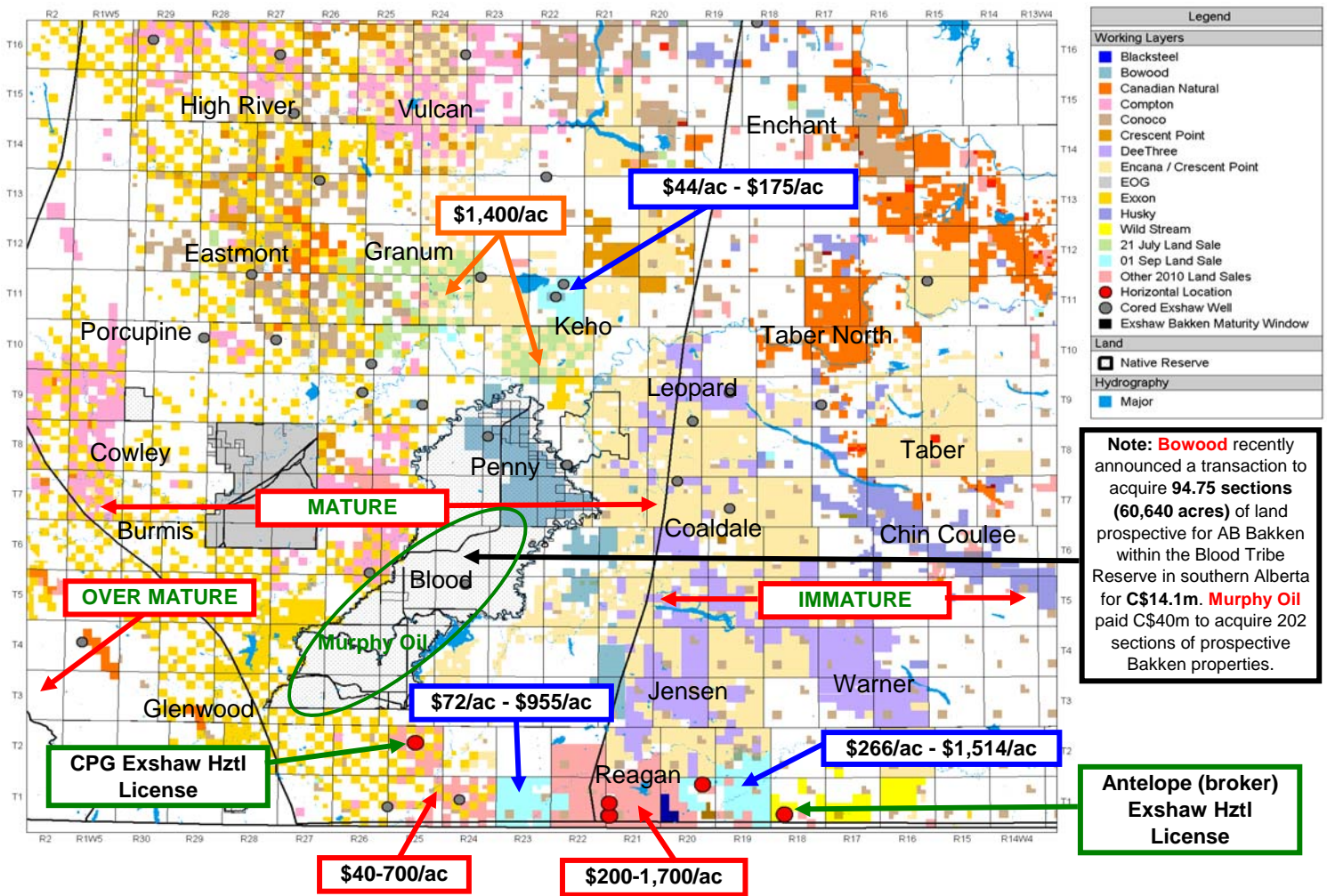
The Blood Tribe First Nation has purchased 5.7m shares of Bowood in support of the company's development of the play. Bowood intends to drill its first horizontal oil well into the play by late 4Q10 or early 1Q11. It has no sizeable expiry issues to deal with across their landbase in the near term.

- **Murphy Oil.** Similar to Bowood Energy, Murphy entered into an agreement with Kainaiwa Resources of the Blood Tribe First Nation to acquire 202 sections (129,280 acres) of prospective Bakken oil properties located in southern Alberta. The agreement is for a term of five years and requires Murphy Oil to drill a minimum of 16 wells during that time, on similar terms to Bowood.
- **Wild Stream.** The company produces 320boe/d from the Red Coulee area of southern Alberta, just east of where the AB Bakken land sold along the border in Crown land sales for ~C\$1,000/ac. Wild Stream has ~31,750 undeveloped acres in the area, and has identified 15 net conventional drilling locations. We are uncertain what rights the company holds across its land base, and therefore what its eligibility to drill for the Exshaw/Bakken shale is.

- **Blacksteel Energy.** The company holds a small, but strategically positioned and relevant 2,530 net acres in the Del Bonita area of Alberta, which is prospective for the Alberta Bakken. The company has mapped out the light oil resource play across its landbase while guiding to expectations of mid-30° API multi-zone oil with 3–9% porosity and 0.1–10mD of permeability. The company believes its land position is prospective for 12.5–15.0mmbbl of OOIP per section.
- **Montana.** South of the Canadian border there are a number of other relevant players that are actively working to explore and develop the Alberta Bakken. They include **Rosetta Resources** (291,000 net acres), **Newfield Exploration** (256,000 net acres), **Stone Energy** (35,000 net acres), **Quicksilver Resources** (130,000 net acres), **Arkanova Energy** (6,400 net acres), **Primary Petroleum** (127,000 net acres), and **Abraxas Petroleum** (3,000 net acres).

Fig 21 below depicts the land position of the most relevant players in the prospective Alberta Bakken fairway, and provides a snapshot of recent activity.

Fig 21 Exshaw Bakken Activity



Note: Geological thermal maturation window depicted as per Alberta Geological Survey estimates.

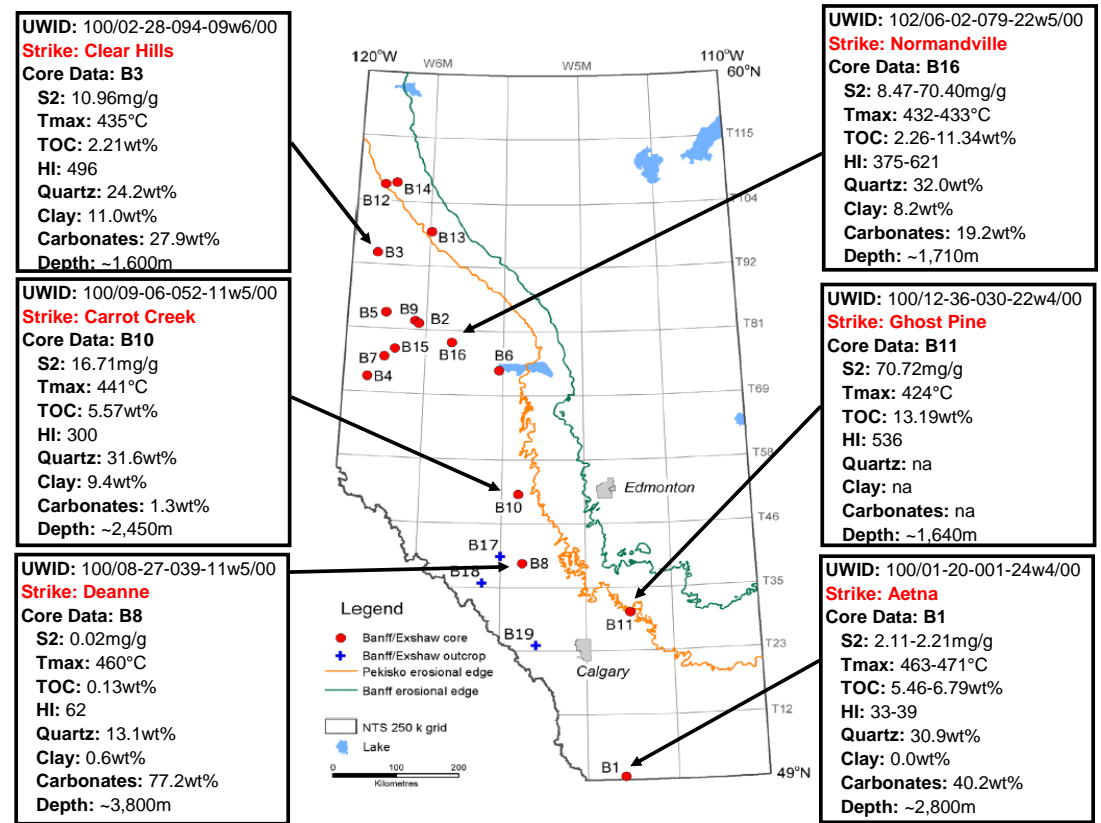
Source: geoSCOUT, Macquarie Research, October 2010

What's next? With land positions already established and producer's having had an opportunity to set capital budgets, we believe there will be a steady flow of news from the Alberta Bakken in early 2011. Highlights over the next 18 months will include:

- 1) **Land affirmation.** The players who bought land under broker at the May-Sep Crown land sales will reveal their name, the size of the established position, and their development intentions for the area.
- 2) **Consolidation.** Junior companies with meaningful, strategically situated lands will be purchased outright by mid/large cap producers who seek to bolt on additional acreage to already established positions. The potential exists that players who were late to the game may try to establish a position in the play via a small corporate acquisition, once some of the associated risks have been mitigated by the early-comers.
- 3) **Farm-ins.** We believe some select junior/midcap companies will execute strategic farm-ins on super-major companies or freehold owners as they look to either expand their land position as an early-comer or establish a position as a player late to the game.
- 4) **Seismic.** Larger players who will proceed forward with sizeable development programs (eg, Crescent Point) will complete 3D seismic programs to help define the resource.
- 5) **Infrastructure development.** Producers will build the necessary infrastructure once the 'sweet-spots' of the play have been determined. Currently there are seven gas plants operated by Bonavista, Altagas, Penn West, and Husky that are lined to handle the solution gas produced from the AB Bakken.
- 6) **Initial results.** We expect to hear results from up to 20 wells licensed or drilled on the play through 1H11. Crescent Point is expected to deliver the most robust development program, and will likely lead the R&D on the play.
 - a. **Crescent Point:** will drill 19 wells to evaluate the play by year-end 2011.
 - b. **Bowood:** will spud its first horizontal in early 1Q11, with follow-ups to be evaluated immediately thereafter.
 - c. **Deethree:** will drill two vertical stratigraphic tests in 4Q10.
 - d. **Murphy:** will drill at least 16 wells over five years.
 - e. **Broker:** results from confidential and proprietary, broker-operated wells will be revealed once the contracting producer has had an opportunity to properly evaluate the productivity of the well.

Core evaluation. We have referred to an analysis piece completed by the ERCB in partnership with the Alberta Geological Survey titled, *Rock Eval, Total Organic Carbon, Adsorption Isotherms and Organic Petrography of the Banff and Exshaw Formations*, to assist in evaluating the Exshaw/Bakken source rock across the rest of Alberta, outside of just southern Alberta. Fig 22 below details some of our findings.

Fig 22 Alberta Bakken/Exshaw core evaluation



Source: Alberta Geological Survey, ERCB, Macquarie Research, October 2010

Using the basic guideline parameters described in the introduction of this report, core B1 (UWI: 100/01-20-001-24w4/00) in the Del Bonita/Aetna area seems to approach an over-mature state. This well, located right in the heart of recent land sale activity exhibits high silica and carbonate content, with little to no clay which suggests that it is amenable to fracture stimulation. However, this is offset negatively by the low S2 content, which indicates low remaining hydrocarbon potential in the rock. The mixed B1 results demonstrate that a greater sample set of cores are needed before a final decision can be made on the prospectivity of the play.

Separately, we have scoured the remaining core data from this study and have found a few notable cores that we deem as potentially prospective for lower Mississippian or Exshaw shale development. The remaining unmentioned cores pictured above were either too immature, or held a TOC content that was too low by our estimates to be considered prospective for oil exploitation with current technology.

- 1) Core B11 (UWI: 100/12-36-030-22W4): Although the core shows to be immature based on its T_{max} of 424°C, we see potential from the area based on the high TOC and HI.
- 2) Core B8 (UWI: 100/08-27-039-11W5): This well would not be considered prospective for development of the source rock given how low the TOC is (<1wt%).
- 3) Core B10 (UWI: 100/09-06-052-11W5): With a T_{max} of 441°C, a high TOC and HI, we believe the Exshaw/Bakken could be prospective for oil in Carrot Creek.
- 4) Core B16 (UWI: 102/06-02-079-22w5): This core in the Normandville area is interesting because the depth of the Exshaw is quite shallow, which would provide better economics (lower drill costs). In addition, the T_{max} , HI, and TOC are all within the windows that we like for oil.
- 5) Core B3 (UWI: 100/02-28-094-09w6): The core shows the right geological parameters for a potential Exshaw oil candidate; however, the TOC content of ~2wt% is on the low-side.