GS-15 Geology and morphology of Cretaceous coal basins, The Pas area, west-central Manitoba (parts of NTS 63F4, 5)

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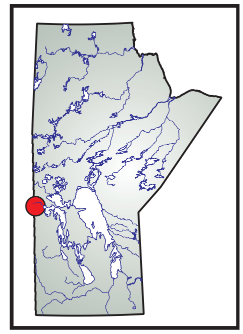

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Summary

In 2011, Westcore Energy Ltd. discovered nine Cretaceous coal basins located southwest of The Pas, Manitoba. Numerous anomalies identified from airborne electromagnetic and airborne gravity surveys were drill tested and proven to contain thick intersections of coal. The bedrock stratigraphy of the area, from top to bottom, comprises the lower beds of the Skull Creek Member, the Lower Cretaceous Ashville Formation underlain by the Swan River Formation and the Jurassic Success Formation, which are in turn underlain by the Devonian Dawson Bay and Winnipegosis formations. The coal is interbedded with carbonaceous sediments and sand within the Swan River Formation. Individual layers of coal range in thickness from less than 1 m up to 63 m; in one instance, the composite thickness of several layers is more than 95 m. The coal is black with brown tinges, has a shiny to dull lustre, a density of 1.3–1.5 g/cm^3 and contains visible carbonized wood fragments. Proximate analysis ranks the coal as lignite A (76%) and sub-bituminous C (13%). The coal deposits appear as circular to oblong-shaped anomalies with areal extents ranging from 200 m by 280 m up to 600 m by 800 m. The basin morphology is interpreted to be bowl-shaped depressions in the Devonian paleosurface. Results are pending from a 500 kg sample of coal sent to the West Virginia University to be analyzed by the Quantex 'coal-to-liquefaction' method, which extracts synthetic crude oil and high-value carbon products from coal via a carbon-dioxide–free, environmentally friendly, cost-effective process.

Introduction

Cretaceous sub-bituminous coal was first discovered in the region north of Hudson Bay, Saskatchewan in 2008 when Goldsource Mines Inc. began exploring for diamonds. After flying an airborne electromagnetic (EM) survey over a large area along the Saskatchewan-Manitoba border, Goldsource tested two geophysical anomalies with one diamond-drill hole each. The holes were 1.5 km apart and both encountered continuous coal intercepts between 25 and 35 m thick, starting approximately 80 m below the surface (Goldsource Mines Inc., 2008).

Westcore Energy Ltd. purchased Quarry Permit 179 (Black Diamond property) in 2008 from a private party and partnered with Goldsource in a joint venture arrangement in 2009. Westcore formed another joint venture alliance in 2010 with 49 North Resources Inc. on the adjacent JV Coal property, with Westcore serving as operator (Westcore Energy Ltd., 2008, 2009a–c, 2010a). The two properties are located approximately 80 km southwest of The Pas, Manitoba, in the vicinity of the Overflowing River (Figure GS-15-1). Westcore and 49 North initially flew airborne EM surveys over the properties and identified a number of anomalies similar in style to the Goldsource coal discoveries. Westcore subsequently conducted a five-hole diamond drilling program in early 2009 on an EM anomaly on the Black Diamond property. A thick intersection of coal (33 m) was encountered in the first hole starting at 29.6 m depth, which was much shallower than the original Goldsource discovery (Westcore Energy Ltd., 2009d).

Westcore conducted another small diamond drilling program (four holes) in early 2010, which explored three additional EM anomalies on the Black Diamond property. All three anomalies proved to be coal deposits, each containing coal intercepts more than 40 m thick (Westcore Energy Ltd., 2009d, 2010b). Results from the 2009 and 2010 drilling programs indicated the original EM data were not detailed enough to adequately predict the edges of the coal basins. Late in 2010, portions of both properties were flown with an airborne gravity survey to ascertain a better definition of the coal deposits. Results of the geophysical survey indicated pronounced gravity anomalies coincident with EM anomalies already known to contain coal; as well, several other gravity anomalies identified were not associated with EM signatures.

A third diamond drilling program was conducted in the early part of 2011 on both the Black Diamond and JV Coal properties, with a threefold objective: 1) conduct step-out drilling on known coal deposits discovered in 2010 with the intention of determining coal volume and basin morphology; 2) drill-test a number of EM and gravity anomalies not previously tested, as well as gravity anomalies occurring without a coincident EM signature and 3) collect a bulk sample for 'coal-to-liquefaction' analysis (Westcore Energy Ltd., 2011a–d).

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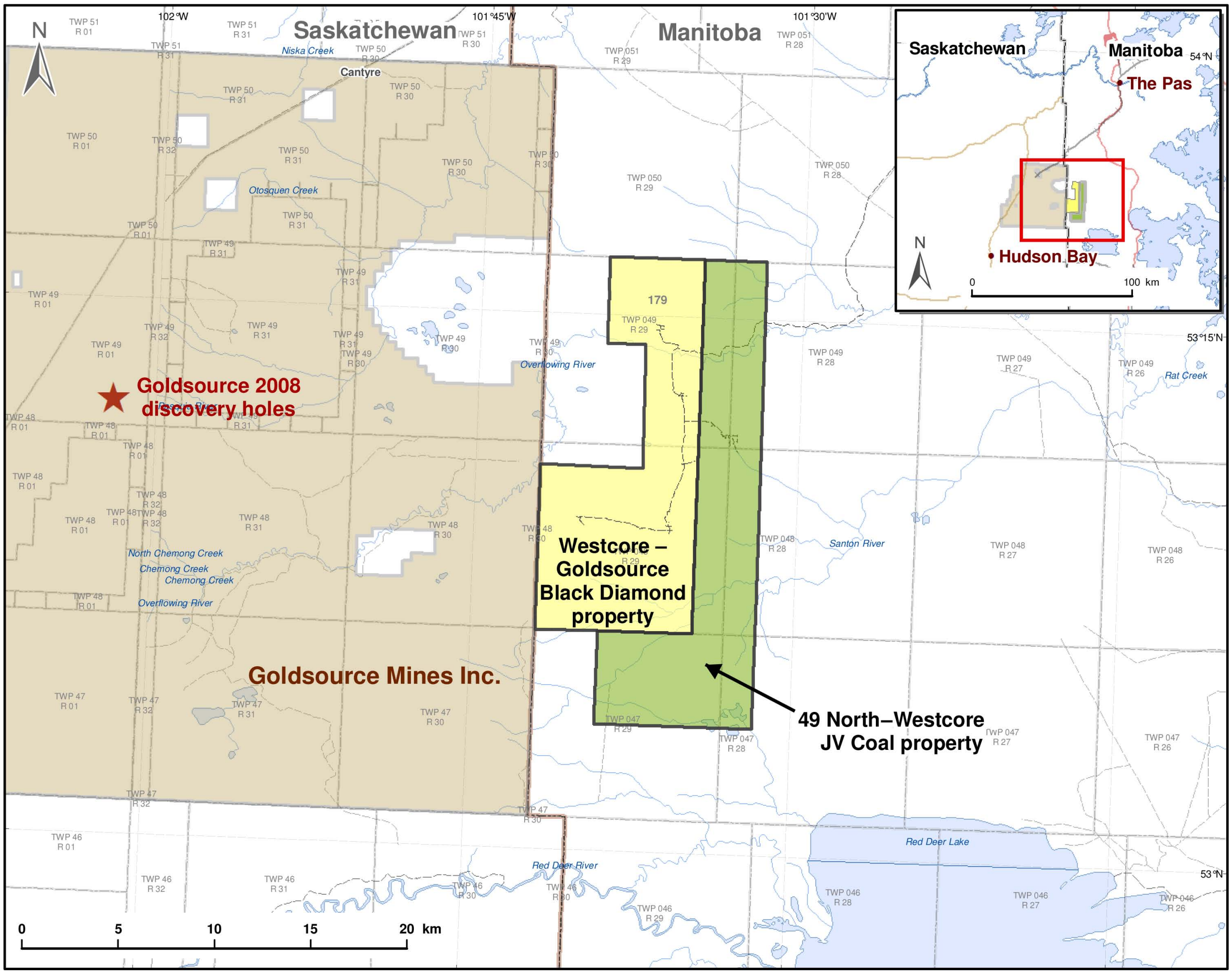

Figure GS-15-1: *Location of the Black Diamond and JV Coal properties.*

Regional setting

The Black Diamond and JV Coal properties occur near the boundary separating Paleozoic carbonate and evaporite rocks from Mesozoic sedimentary rocks of the Phanerozoic Western Canadian Sedimentary Basin (Figure GS-15-2). The Paleozoic strata, which formed in a passive-margin tectonic regime, consist of basal clastic sedimentary rocks followed by a thick sequence of interbedded platform carbonate (limestone, dolomite) and evaporite beds (Saskatchewan Ministry of Energy and Resources, 2011). A major angular unconformity separates the youngest Paleozoic strata, Devonian, from the overlying Mesozoic strata.

The tectonic regime shifted from a passive-margin to a convergent active-margin phase during the Mesozoic era, interpreted by the deposition of basal terrestrial (fluvial and lacustrine) and marine redbeds, followed by thick accumulations of clastic sediments derived from the Rocky Mountains during the Cordilleran orogeny. The Mesozoic strata in Saskatchewan and Manitoba consist almost entirely of shale and sandstone sequences that were deposited in the Western Interior Seaway, a shallow sea bounded by the Rocky Mountains to the west and the North American craton to the east. As a result of numerous transgressions and regressions, the units typically contain repeated sequences of marine mudstone, siltstone and sandstone, as well as local accumulations of fluvial and deltaic channel sandstone deposits, estuarine mudstone beds and coal (Christopher, 1984, 2003; Smith, 1994).

Considerable paleotopographic and structural relief occurs in the subcrops of the region. Below the Mesozoic unconformity, the eroded Devonian surface can exhibit pronounced relief in the form of erosional valleys, scarps, faults and basin development, partly due to karst collapse on the underlying Winnipegosis reefal structures and differential erosion of resistant limestone beds compared to that of soft recessive shaly beds (Norris et al., 1982).

Later Quaternary glaciations left glacial drift covering most of the southern half of Manitoba and Saskatchewan that ranges in thickness from less than one metre up to several hundreds of metres of overburden.

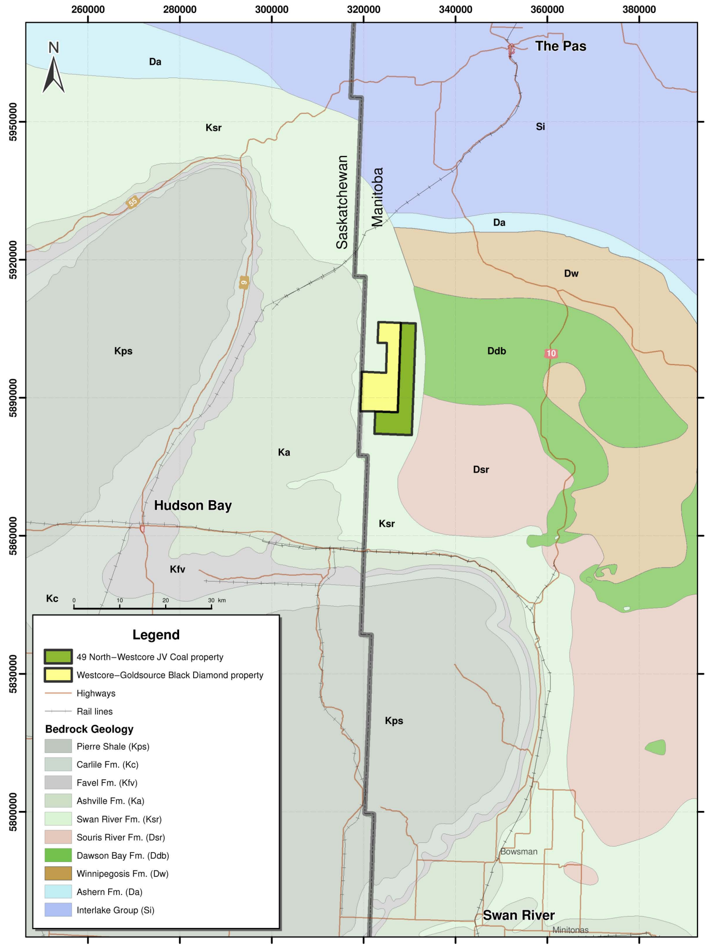

Figure GS-15-2: *Regional geological setting of the Black Diamond and JV Coal properties.*

Current investigations

The 2011 exploration drilling program was the most extensive investigation of the coal basins in west-central Manitoba since the initial discovery by Westcore in 2009. Nine individual gravity anomalies were drilled and all proved to be coal-bearing basins, including those with and those without a coincident EM signature (Figure GS-15-3). Enough drilling was performed in 2011 to determine the stratigraphic units occurring above and below the coal units, and to begin assessing the morphology of the basins and their possible genesis.

Stratigraphy

The stratigraphic sequence and lithological description of the units occurring on both properties is shown in Table GS-15-1. The lower glauconitic beds of the Skull Creek Member are equivalent to the Spinney Hill Member of the Joli Fou Formation in Saskatchewan (Berenyi and Leray, 2009). This is the first documented occurrence of the Spinney Hill Member in Manitoba. The Swan River Formation on the properties is equivalent to the Cantuar Formation of the Mannville Group in Saskatchewan (Nicolas, 2009).

Coal deposits

The coal deposits drill-tested to date occur within discreet bowl-shaped basins formed in the Devonian paleosurface and appear as circular to oblong-shaped gravity anomalies that range areally from 200 m by 260 m up to 600 m by 800 m.

Coal, always intersected in the Lower Cretaceous Swan River Formation, is mostly black with local tinges of brown. Lustre of the coal is generally shiny or dull, and both types are commonly interbedded. The coal is generally well consolidated with local crushed zones (faults?), has a low density (1.3–1.5 g/cm^3) and commonly contains visible carbonized wood fragments and plant debris. Impurities include pyrite lenses and nodules up to 10 cm, as well as quartz sand grains and mud clasts. Individual coal layers vary from less than 1 m up to 63 m in thickness (with little to no partings; Figure GS-15-4). The coal deposits generally consist of one thick coal layer, with or without associated thinner beds, which are locally interbedded with and enveloped by carbonaceous sediments. One drillhole intersected seven coal layers for a total composite thickness of 96 m, with the thickest continuous coal layer in that hole being 63 m. Contacts with surrounding units are either gradational or sharp. The

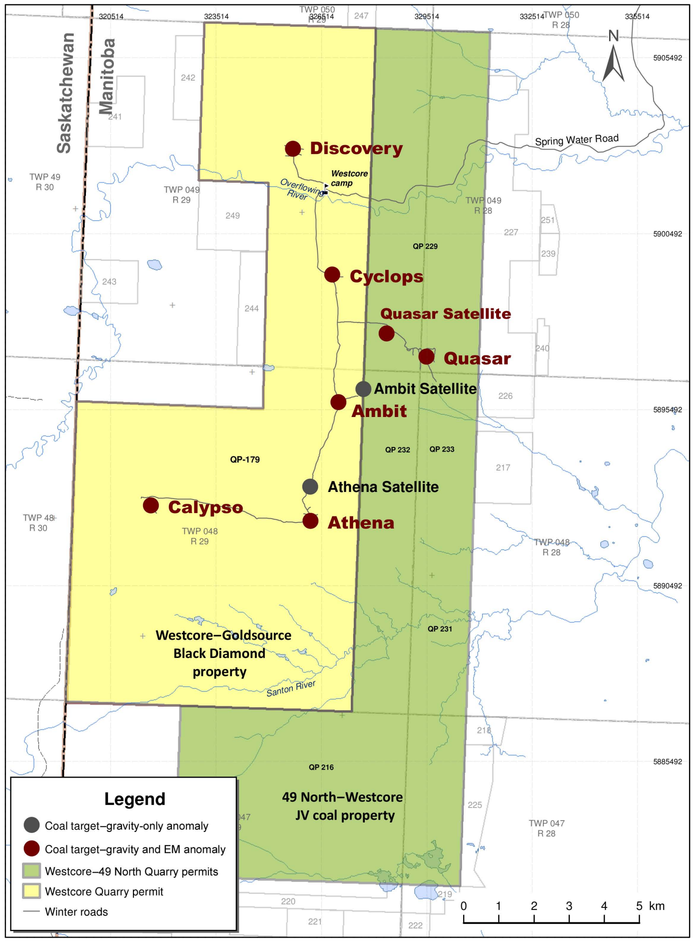

Figure GS-15-3: Location of coal basins on the Black Diamond and JV Coal properties.

Table GS-15-1: Stratigraphy and rock types occurring on the Black Diamond and JV Coal properties.

Age	Stratigraphy	Lithological description
Quaternary	glacial drift	Predominantly till units with local zones of sand and boulders. Depth from surface varies from 9 to 51 m; basal contact is sharp.
Lower Cretaceous	lower glauconitic beds, Skull Creek Member, Ashville Formation	Interbedded glauconitic-rich mudstone, siltstone and sandstone; thickness ranges from 0 to 38 m; basal contact generally sharp.
Lower Cretaceous	Swan River Formation	White to light grey, unconsolidated, clean, quartzose sand interbedded with light beige/tan/grey siltstone (quartzose) and light grey mudstone; can contain coal units and/or black carbonaceous sediments; thickness ranges from 0 to 133 m; basal contacts generally not intact.
Jurassic	S2 Member, Success Formation	Chaotically interbedded siltstone and sand units; polyclastic breccias consisting of Devonian-aged clasts and blocks of limestone, dolomite and redbeds within a muddy/sandy matrix (mass-movement deposits); thickness ranges from 6 to 26 m; basal contacts generally sharp.
Devonian	Dawson Bay Formation	Limestones, dolomites, mudstones and redbeds.
	Winnipegosis Formation	Limestones, dolomites, mudstones.

***Figure GS-15-4:** A 46 m intercept of continuous coal. Each box is 1.5 m long.*

depth below the surface to the top of the coal units varies from 9 to 95 m, with average depths ranging between 25 and 60 m.

Sand, sandstone, siltstone and mudstone containing black carbon fragments, stringers, laminae or fine carbon 'hash', occur both as partings within coal units or as isolated units located above or below coal units. The amount of carbonaceous material present varies from minor to abundant, the latter imparting a dark brown to black colour to the sediments. Individual carbonaceous units range in thickness from centimetres to metres, and contacts with adjacent units are gradational or sharp.

Proximate analysis has been conducted on all coal units retrieved to date. The results indicate that calorific values range from 17 500 to 25 732 kJ/kg (air dried; 7523–11 063 Btu/lb) and average 19 500 to 22 500 kJ/kg (8384–9674 Btu/lb). Ash content ranges from 11 to 36% (air dried) and averages 17 to 26%. Moisture content ranges from 0.6 to 15.5% (air dried) and averages 1.5 to 4.5%. Sulphur content ranges from 0.5 to 7.2% (air dried) and averages 2.0 to 2.6% (air dried). Roughly 76% of the coal ranks as lignite A, 13% as sub-bituminous C and the remainder as lignite B or sub-bituminous B.

Coal basin formation

It is unknown at this time whether the basins were formed as a result of subareal exposure and erosion, dissolution and karst development influenced by deeper structures, or a combination of both. The following drillcore data may give clues as to how the basins formed:

- Spatial stratigraphic relationships between nearby drillholes show thick Skull Creek and Swan River units (including coal) disappearing over short distances.
- Zones of highly broken core suggestive of fault zones occur in otherwise competent rock types.
- Bedding angles that are nearly horizontal in units located near the tops of basins become increasingly steeper near the base of drillholes.
  - Microfaulting of siltstone beds that overlie coal units (i.e., Skull Creek Formation), indicate 'normal' displacement (it should, however, be noted that this could also be a result of compaction of underlying coal beds as opposed to being related to basin formation).
- Figure GS-15-5 offers one possible scenario for basin formation that involves graben-like development that would account for the drillcore features described above.

Coal-to-liquefaction (CTL) technology

A bulk sample of coal weighing approximately 500 kg was trucked to the Chemical Engineering Department at West Virginia University in Morgantown, West Virginia, for coal-to-liquefaction analysis by the Quantex process; results are pending. Quantex Energy Inc. is a Calgary-based company developing a breakthrough coal-to-liquefaction process for extracting synthetic crude oil and high-value carbon products from coal (Quantex Energy Inc., 2011).

The coal-to-liquefaction process used by Quantex was first patented by West Virginia University through their research funded by the U.S. Department of Energy, which was designed to develop cleaner production processes for heavy products such as pitch and coke. West Virginia University was able to produce green coke from coal through a low-temperature, low-pressure dissolution process that resulted in a byproduct of intermediate-grade crude oil. Two-thirds of the treated coal became crude oil, and the remaining coal not converted into oil was further processed to become high-value carbon products such as binder pitch, anode coke and green coke (used in steel blast and electric furnaces, and aluminum smelters). It was also discovered that a higher volume of oil was produced from lower grades of coal (e.g., lignite).

The coal-to-liquefaction process is compatible with conventional oil industry refining techniques so that fuel infrastructures already in place can be used unchanged with coal-derived products. Heavy crude oil from the Quantex process has a lower carbon footprint than heavy petroleum crude (e.g., oil sands) and contains less metal

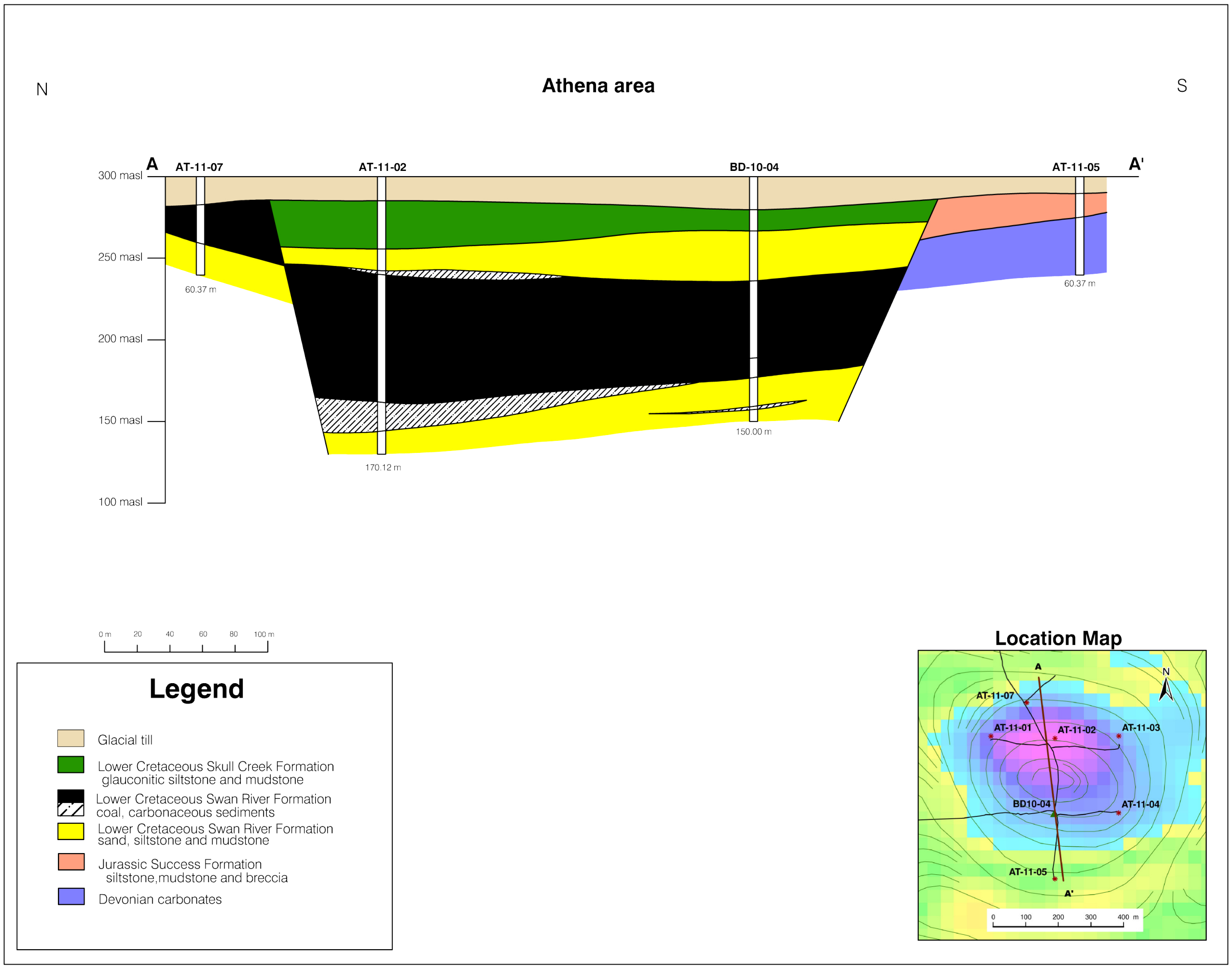

***Figure GS-15-5:** Coal-basin morphology of the Athena deposit.*

contamination. In the Quantex process, the coal is not gasified; instead, it is dissolved in a specially treated, environmentally friendly solvent, with no production of carbon dioxide or waste products. The Quantex process, while producing synthetic crude oil and high-grade coke products from a range of coal types, is cheaper and more environmentally friendly than many of the current technologies.

Economic considerations

In today's environmental and energy climate, the discovery of significant coal deposits in Manitoba is bittersweet. Viable clean energy resources are always being sought after, fuelling much of the energy exploration industry's efforts. Westcore's intention is to develop and deliver locally sourced coal to a future coal-to-liquefaction facility that will use the Quantex CTL process. The CTL technology allows the development of this natural resource in a less expensive and more environmentally conscious manner than many of the current technologies, while extracting a critical energy source.

Acknowledgments

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