Tenas Mining Concession

Coal/Gas in Place

Telkwa, BC

Technical Discussion

October 26, 2020

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1 EXECUTIVE SUMMARY

The Tenas Coal Development (DFS Presentation March 2019) scope targets 36.5 Mtonnes (million metric tons) of coal in place of which 22.0 Mtonnes of coal and 79.2 Mtonnes of acid and non-acid rock will be extracted. The area from which this coal and overburden will be removed is known as “Area 4” from B. Ryan 1993 study of “Potential Coal and Coalbed Methane Resource of the Telkwa Coalfield, Central British Columbia”. Based on the B. Ryan 1993 study, “Area 4” coal resources are 68.6 Mtonnes. B. Ryan 1993 coalbed methane analysis based on core samples from two wells obtained from Manalta Coal Ltd concluded “Area 4” has about 439.6 MMm3 (million cubic metres) of gas in place.

This implies that if Tenas mine extracts 22.0 Mtonnes of coal then it will likely release some 141 million cubic meters of methane gas into the atmosphere.

If the 141 million cubic meters of gas were to be put to use, it could heat 5600 houses for ten years (a reasonable assumption of 2500 cubic meters per house per year).

Although Tenas mine development currently targets “Area 4”, immediately adjacent to this development is “Area 5”. “Area 5” (B. Ross 1993) is much better understood than “Area 4”, there are more test boreholes and even a test pit dug by Manalta Coal. Based on B. Ryan 1993 report “Area 5” contains some 669 Mtonnes of coal and 2.57 BCM (billion cubic metres) of methane gas in place, that is “Area 5” contains eight times more coal and ten times more gas. It is quite likely that an entrenched operator in “Area 4” will significantly want to expand its operation into “Area 5” resulting in very large releases of methane.

In 2005-2006 NorWest and OutRider Energy of Calgary applied for exploration and production licenses to develop the coalbed methane (CBM) in the Telkwa region. At the time, natural gas prices were averaging 6.5 per MMBTU (million British thermal units). The gas price coupled with a government incentive of $50,000 CDN per well drove the unconventional energy development. Today, gas prices average about 3.0 per MMBTU and are not expected to rise till 2025-2030 hence any CBM development would require significant government incentives and cutting costs to barebones to attain viability.

It is recommended that the government consider the greenhouse gases associated with coal development in its decision-making process. Confirming the gas content of “Area 4” is paramount and requires: additional core from “Area 4”, desorption, and sorption isotherm tests. This will provide the government a means by which to assess environmental liabilities associated with non-renewable (Coal and associated gas) development.

Authors Note: CBM development in the known Telkwa Coal Resources is uneconomic. CBM development is not without its problems, first, each well must be dewatered, these produced waters cannot be considered safe and must be reinjected into deep disposal wells. Secondly, fracking as a means to connect more gas molecules per well, should not be allowed given this basin has seen several stress periods resulting in complex faulting. Given the complex faulting it would be extremely unlikely that any operator could guarantee frac containment. This could result in unpredictable methane leak paths.

OBJECTIVE:

To assess the CBM (coalbed methane) quantities in the Telkwa Area targeted by Tenas Coal Mine. To provide insight into testing methods for CBM in coal.

2 BACKGROUND

Ryan B. D. (2003) summarized the Telkwa Coalfield as a 50-kilometer deposit of coal extending from north of the town of Smithers to South of the village of Telkwa. He described two coal bearing units separated by a marine mudstone unit of the Lower Cretaceous Skeena Group. These two coal units together range in depth from 29 metres to 158 metres. The upper unit contains eight plus coal seams with a combined thickness of about 14 metres. The lower unit is a single coal seam up to seven metres thick (Figure 1). The coal rank ranges from high to volatile bituminous to anthracite. Most of the coal is considered to be high to medium-volatile bituminous coal. Ryan B. D. (2003) quantifies the coal resource at 850 million tonnes.

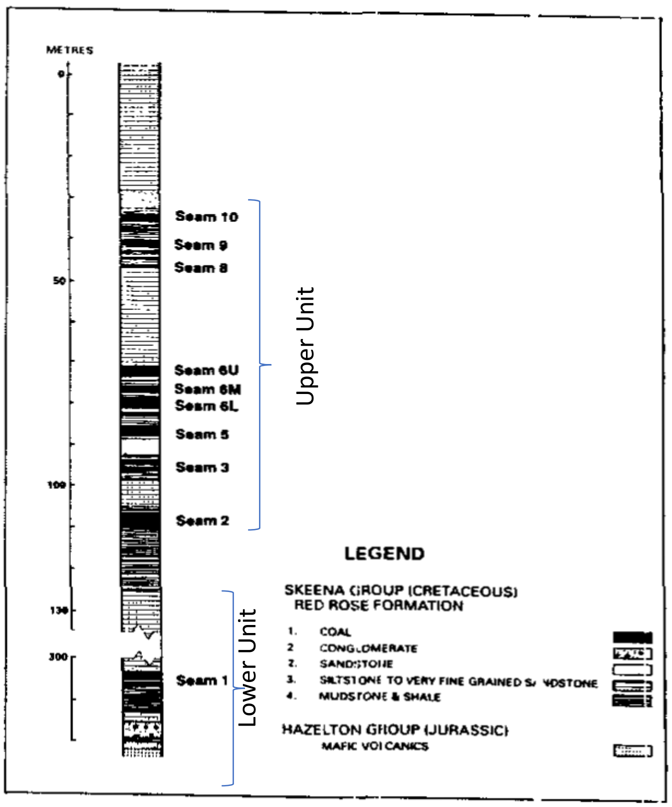

Figure 1 from B. Ryan 1993

3 IN PLACE AND RECOVERABLE VOLUMES OF COAL AND GAS

Ryan 1994 summarized the results from the 1992 Manalta Coal Limited drilling program in the Telkwa field. Based on 5 core samples desorption tests were conducted. In addition, methane adsorption isotherm tests were performed on these samples.

From these tests the gas content was found to range from 3.75 to 4.49 cc/g or 3.7-4.5 m3/tonne. Using the coal field resource of 850 million tonnes (Mtonnes) implies Coal Bed Methane contingent resource volumes are on the order of 3.5 BCM (billion cubic metres) for the entire Telkwa Field.

The most intense coal exploration and past development has occurred south of Telkwa River. Focussing on this area alone, B. Ryan 1993 split the coal resource into ten areas and described each in terms of coal unit thickness and coal rank (based on vitrinite reflectance) see Figure 2.

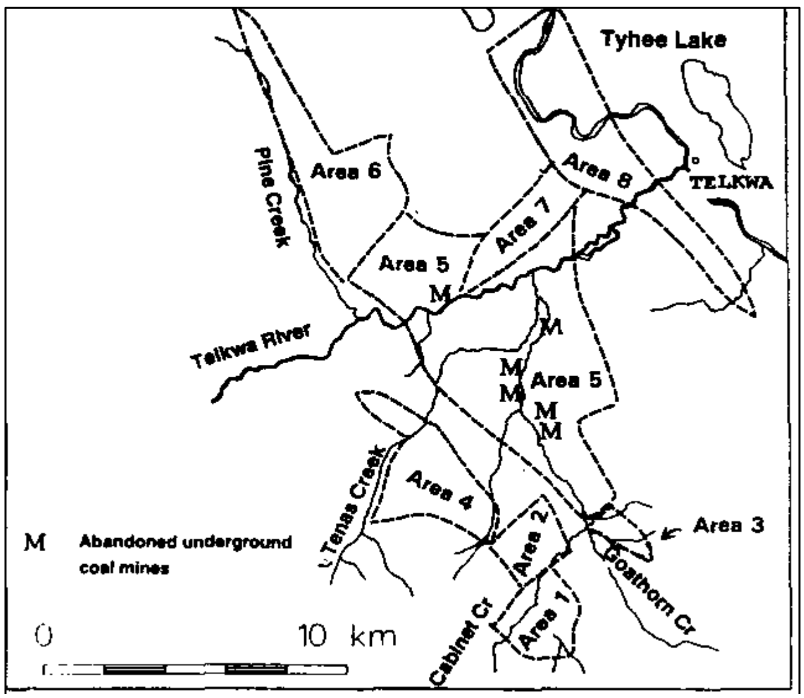

Figure 2 B. Ryan 1993, Showing 8 of 10 areas of Telkwa Coal

Coal and Methane Resource Volumes have been summarized in Tables 1 and 2 respectively (from B. Ryan 1993).

Table 1

Coal Resources in the Telkwa CoalField Million metric tons (Mtonnes)

	Unit 1			Unit 2			
Area	Proven	Probable	Possible	Proven	Probable	Possible	Total
1	0	25	0	0	14.6	0	39.6
2	0	9.7	5.2	0	0	0	14.9
3	0	0	6.6	0	0	0	6.6
4	0	0	49.6	0	0	19	68.6
5	353.7	0	0	316.1	0	0	669.8
6	0	21.6	5.8	0	0.7	0	28.1
7	0		3.1	0	0	2	5.1
8	0		6.5	0	0	13.9	20.4
Total	353.7	56.3	76.8	316.1	15.3	34.9	853.1

Table 2

Coalbed Methane Resources in the Telkwa CoalField Million cubic metres (MMm3)

	Unit 1			Unit 2			
Area	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Total
1	0	229.1	0	0	131	0	360.1
2	0	75.6	40.9	0	0	0	116.5
3	0	0	3.7	0	0	0	3.7
4	0	0	336	0	0	103.6	439.6
5	1836.9	0	0	735.8	0	0	2572.7
6	0	98.8	0	0	2.9	0	101.7
7	0		13.9	0	0	10.3	24.2
8	0		0	0	0	0	0
Total	1836.9	403.5	394.5	735.8	133.9	113.9	3618.5

The Tenas Coal Development corresponds to B. Ryan 1993 “Area 4”. In Figure 3, the Tenas Mine Map (from DFS Presentation March 2019) is superimposed onto the B. Ross 1993 Area Map. Map scales have been made the same.

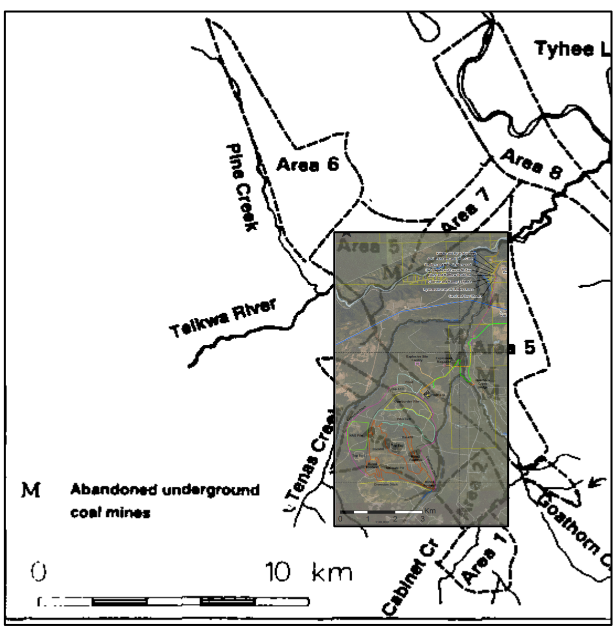

Figure 3, Tenas Mine Development Map imposed on B. Ryan 1993 Map.

Figure 4 below shows an outline of the Tenas Coal Development on the B. Ross 1993 Map for clarity.

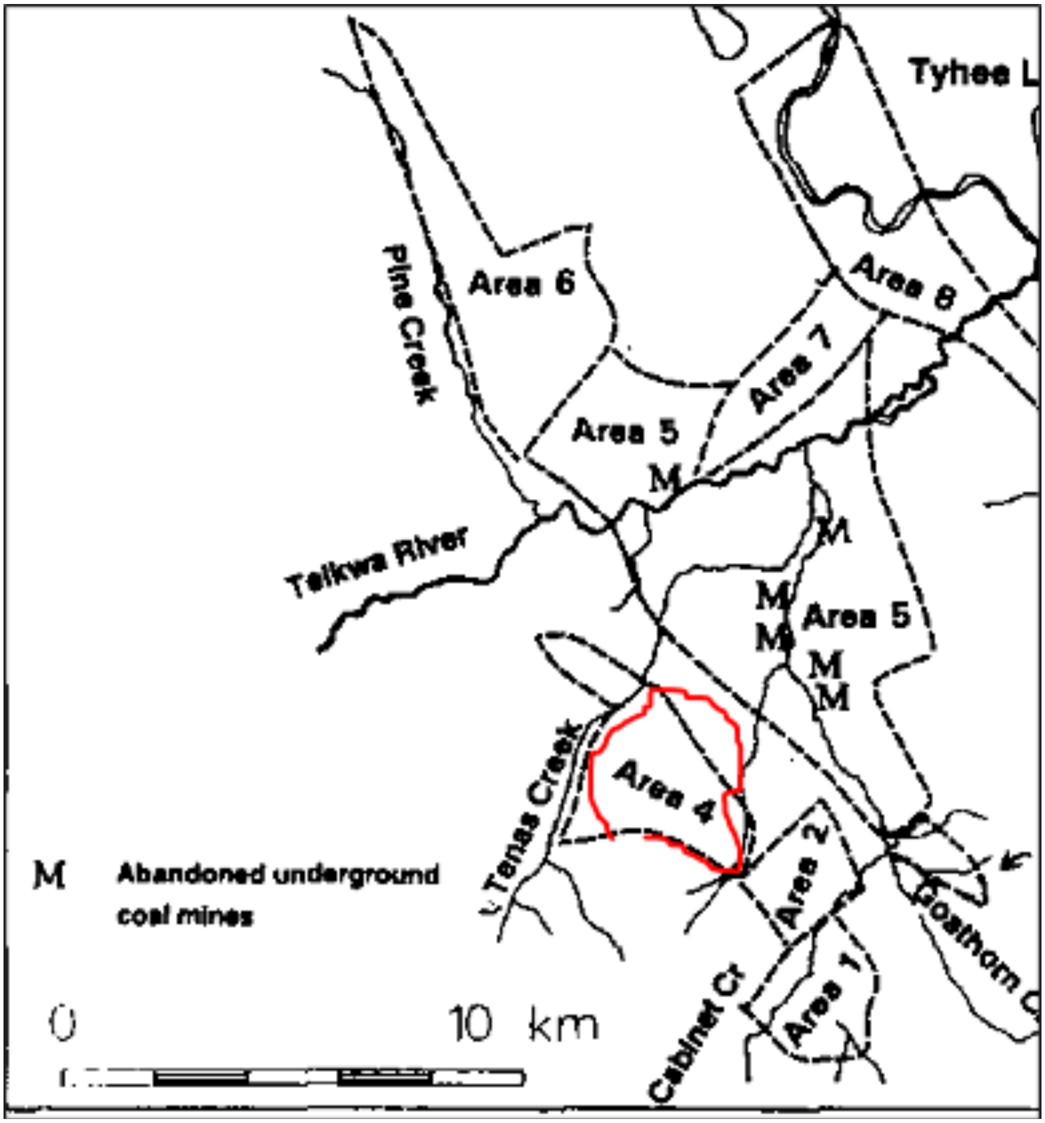

Figure 4, Tenas Coal Development Outline on B. Ross 1993 "Area 4" Coal Resources

Using the area of Tenas Coal Development from the DFS presentation 2019 superimposed on the B. Ross 1993 Coal Resource Map implies the total volume of coal in the mined area is 68.6 Mtonnes (million metric tons) (Table 1), and that CBM gas volume is 439.6 MMm3 (million cubic metres).

However, Tenas Coalmine expects to move only 22 Mtonnes of coal to its processing plant. This corresponds to 141 MMm3 (eq to 5 BCF) of gas is expected to be released to the atmosphere.

If wells were to be drilled to recover the methane, they would target the entire volume in Area 4. Assuming a reasonable recovery factor of 60% of the gas in place means that about 263 MMm3 of natural gas could be recovered. This could provide sufficient energy requirements for 10,000 houses for 10 years (assume each house consumes 2500 m3 gas per year).

4 SHALLOW COAL/GAS ANALOGUES

Traditional CBM projects target deeper coals in the area of 500 to 1000 metres. The Telkwa coal is considered a shallow coal deposit with deposits between 50 and 150 metres.

A review of shallow CBM analogues is presented by Thakur in 2017. It highlights several shallow coal reservoirs where CBM has been applied.

The Powder River Basin is a shallow reservoir made of thick coal seams with an average of 75scf/short t. A wells average production is 0.004 MMm3/d (0.15 MMscf/d) without any inflow performance enhancement.

The Cherokee Basin has a gas content of 6.2 m3/tonne (eq to 200scf/short t) with average well production of 0.007 MMm3/d (0.25 MMscf/d) from hydraulically frac'd wells.

The list goes on and the reader is directed to reference 2.

5 GAS CONTENT ANALYSIS

The following serves to explain the methods used to determine gas in place in a coal field. They can be split into direct and indirect methods.

Direct Method:

<u>Desorption method</u> of measuring methane released from coals samples requires a fresh coal sample to be sealed in a canister. At measured time intervals the gas desorbing into the empty space in the sample canister is released by opening a valve into a manometer and the volume measured at ambient temperature and pressure. The valve on the canister is closed and more gas is allowed **to** desorb. **A** series of measurements that may span months provides data for a gas desorption ***versus*** time plot and an estimate **of** the total desorbed **gas** in the coal. Samples are usually drill core **or** drill chips. Both **types** of samples can be **used** for gas content determination, although the collection techniques are different.

In conventional drilling in the oilfields, bring core to surface takes much longer than wireline retrieved core from coalbeds. This limits the amount of gas desorbed from the core before it enters the sealed canister.

Gas volumes may be underestimated by as much as 25% depending on the workflow.

Corrective techniques to attempt to quantify how much gas escaped before the core was sealed in the canister. The most common uses a plot of Cum gas vs square root of time to back out gas initial gas lost.

There are other corrections in this method that include dead space correction, water vapor correction, and then when the gas content is applied to the coal volume non pay (e.g. ash, interburden,…) must be excluded from the insitu coal tonnage.

If chips are used instead of whole core then the uncertainty in the gas volumes may increase significantly owing to non-representative sampling.

Indirect Method:

Sorption Isotherms method has the advantage of core and cuttings that have been stored. In other words, fresh core or cuttings are not required. The sorption method involves taking powdered samples of coal and maintaining the samples at a constant temperature. At several elevated pressures gas is allowed to adsorb onto the surface of the coal. Typically, the apparatus uses two pressure canisters, one is the reference cell and the other the sample cell. First a non-adsorbing gas is used to determine the volume of coal. Sorption Isotherms method is based on Boyles Law where the reference cell is pressured and then the gas is allowed to bleed into the sample cell. Changes in pressure allow for concise estimate of the coal dust volume.

The system (reference and sample cells) are purged of non-absorbing gas (e.g. Helium) and the reference cell is charged with methane gas. The gas then charges the sample cell and the pressures and volumes are calculated to estimate the volume of gas adsorbed onto the coal dust. This method assumes the coal is always in a saturated state. This may not be valid and may result in over estimation of insitu methane.

Moisture content is very important. At elevated moisture levels the coals adsorption decreases. As such the Sorption Isotherm is usually conducted at several moisture levels or corrected for moisture content. The dry ash free Sorption test may yield gas concentrations as much as 200% of the direct desorption test.

Log Analysis Method:

Gas adsorbed to coal cannot be measured directly. However, density logs, porosity logs, gamma ray and spontaneous potential logs linked to analysis algorithms and empirical relationships to bracket the adsorbed gas saturation. Refer to Ross Crain's Petrophysical Handbook. Be aware most of these analytical technics have been developed through field experiences in various CBM basins around the world. In order for these to apply to a different setting it is important to characterize the coals, depths, pressures, water properties to establish if your setting is an analogue.

6 REFERENCES

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5. Crain Ross, 2020, Crain's Petrophysical Handbook

Author Background:

George P. K. Lebiadowski has degrees in Geology and Petroleum Engineering from University of Alberta. He has thirty years of oil and gas (including CBM) development experience having worked in North America, Europe, Africa, South America and South East Asia for Royal Dutch Shell. He was an engineering technical authority for Royal Dutch Shell since 2011 and has taught courses in reservoir engineering and served as SPE technical editor.