COAL CONVERSION PROJECT FOR NORTHEASTERN ONTARIO

by

Aaron Jaan Saber, Ph.D.,
P.Eng.(Ontario),Eng.(Quebec)

330 Westminster Avenue North
Montreal West, Quebec H4X 1Z7
Canada

Tel: (514) 481-2416

6 June 1981.
(Revised: 15 July 1981.)

COAL CONVERSION PROJECT
FOR
NORTHEASTERN ONTARIO

by

Aaron Jaan Saber, Ph.D.,
P.Eng.(Ontario),Eng.(Quebec)

330 Westminster Avenue North
Montreal West, Quebec H4X 1Z7
Canada

Tel: (514) 481-2416

6 June 1981.
(Revised: 15 July 1981.)

A.J. Saber

This report is not, nor is it intended to be construed as an offer to the public to invest or subscribe for shares.

Author's Note:

The author points out that some of the statements made in this report are based on information in cited references. Therefore, statements may constitute only the opinion of the cited authors. Consequently, this author makes no claim attesting to the veracity of statements in the references. Nevertheless, care has been taken to ascertain that such statements are indeed correct.

The Author is a Registered Professional Engineer in Ontario and a Registered Engineer in Quebec and is a Member of the Engineering Institute of Canada.

The Author is a graduate of Princeton University (Aerospace and Mechanical Sciences, Ph.D., 1974, M.A., 1971) and the University of Toronto (Mechanical Engineering, B.A.Sc., Honours, 1969).

The Author holds the position of Assistant Professor of Engineering at Concordia University, Montreal, Quebec.

The dollar values appear in $CDN(1981) unless otherwise noted; and for the purposes of this report, conversion to United States' dollars is $CDN = $US x 1.2.

A.J. Saber

ABSTRACT

A previously undiscovered coal deposit was reported in northeastern Ontario in 1978. This project addresses the conversion of that coal into liquid and gaseous products. First, the need for the program is presented, then, followed by an outline of coal and its conversion in general, are the properties of the coal, lignite.

The 92,745 acre region of northeastern Ontario where the project site is located is shown and the geology of the site is discussed.

The exploration of the site includes a succession of drilling programs beginning with a four hole program centred on a location where a 6 m lignite seam has been located and a parallel examination of cores from 5 additional drillholes which are available from an industrial minerals exploration program underway on the same tract. Further exploratory drilling may be located at 6 additional randomly-spaced locations. A later 24 drillhole program is included to detail potential conversion plant site geology. Following the drilling, in-situ conversion test plants will be established and the results used in the design of a production facility. The deposit estimate is 117.5 million tonnes of 8000 Btu per pound lignite. About 25% of the deposit is presumed recoverable. The energy content equivalent is 69.9 million barrels of oil or 447.4 billion standard cubic feet of natural gas.

The deposit lies approximately 100 Km north of Kapuskasing, through which an east-west gas pipeline, the Trans-Canada highway and the Canadian National Railroad pass.

The notion is to develop the deposit using "in-situ" gasification. With this approach, approximately 25% of the "recoverable" deposit will be converted to pipeline quality gas, or liquid fuels such as methanol, fuel oil, Diesel fuel, gasoline and Jet fuel. The total production is 112 billion standard cubic feet of 1000 Btu per SCF pipeline quality gas or 17.5 million barrels of oil. The conversion supplies 5.6 billion SCF per annum (15.3 million SCF per day) or 900,000 barrels of oil per annum (2500 barrels per day) over a 20 year period.

A.J. Saber

Capital expenditures total $150 million over seven years. In the first year of full-scale production, production costs are about $34.5 million, $53.5 million in the tenth year and $87.2 million in the twentieth year. Production costs total $1141 million over the twenty year period. For the first full production year the transportation costs to the border at Niagara are $5.6 million, in the tenth year $10.6 million, and in the twentieth year $17.2 million. Total transportation costs are $218.4 million.

Revenue is based on the Canadian boundary price. In the first year of full production revenues are $68.5 million, $161.5 million in the tenth year and $418.9 million in the twentieth year. Gross revenue is $3923 million, accumulated over the production period. The benefits of available government assistance, including depletion allowances and tax incentives, and regional and economic expansion grants, for example, are not included. The internal rate of return is 38% per annum over each year of the total 27 year program.

The product is coal-derived pipeline quality gas, which is not subject to export restrictions.

This program adapts well to the environment. Furthermore, this coal gasification program will help to set Ontario on a course to become a net exporter of gas and oil and coal conversion technology.

Initial planning is complete.

Table of (

List of Figures.

1. Introduction - A Coal Conversion Project.

The proposed project is to convert Northeastern Ontario lignite coal feedstocks into liquid fuels or pipeline quality gas. The liquid fuels include transportation fuels such as gasoline, Diesel fuel and methanol and the pipeline quaility gas can serve as a substitute for natural gas and methane. Other hydrocarbon products can also be synthesized from the raw material produced. The project is presented as a commercial venture.

1.1 The Need for Hydrocarbon Materials.

The development of alternate energy sources that do not rely on conventional fuels is becoming valuable. Nevertheless, demand remains high for traditional hydrocarbon-based commodities, which are needed to fuel machines and to provide raw materials for the chemical industry. Indeed, it may be that such demand is a consequence of the vast capital investment in machinery or chemical process equipment. (Examples of this capital investment in the energy field include internal combustion engines, fired heaters and power stations; while chemistry-related examples result since hydrocarbons form the basis of the "plastics" family of engineering materials.)

Petroleum has been the main source of hydrocarbon-based commodities.(1.1) However, petroleum resources are becoming more difficult to locate and develop.(1.2) Coupled with the reality that petroleum suppliers and users are not necessarily party to the same political bases, the cost of this material is escalating.(1.3) Furthermore, since users must transfer real assets to suppliers to pay for their petroleum requirements, the consequence is a shifting economic structure. One solution to this dilemma uses synthetic petroleum substitutes fabricated using coal as a feedstock.(1.4) Such undertakings have been successful economic ventures in the Union of South Africa(1.5) and in Germany.(1.6)

1.2 An Ontario-Based Project.

An area of Canada which shows promise for coal conversion is Ontario, the largest user of hydrocarbons in Canada.(1.7) These hydrocarbons are currently imported from western Canada, in the form of natural gas, or from foreign sources, in the form of oil.(1.8) Yet, Ontario has coal resources which offer a feedstock well-suited for conversion to gas and oil.(1.9)

The project centres on a feedstock coal, in the form of lignite, which lies in the cretaceous basin of northeastern Ontario (Fig. 1.1(1.10)).(1.11) The specific site contains a previously undiscovered coal deposit, in the vicinity of Adam Creek, reported in 1978.(1.12) The site, which lies approximately 100 Km north of Kapuskasing is serviced by an all-weather road, lies approximately 40 Km to the west of the Ontario Northland Railway and is about 100 Km from the Trans-Canada Highway, the Canadian National Railway and the Trans-Canada Pipeline.

The geological base in which this lignite is found is well-suited to underground processing, i.e. "in-situ", without first mining the coal (Fig. 1.2(1.13)). The conversion produces a product which can replace natural gas, as well as liquid hydrocarbon fuels such as methanol. Indeed, the synthesis product can be converted to produce gasoline(1.14) or jet fuel.(1.15)

Using a direct gasification technique, the venture shows the promise of economic profitability.

1.3 Schedule.

The complete program for the coal conversion project involves exploration, design, development and production. These undertakings are to be conducted in a seven phase plan as shown in Table 1.I. The first phase, Planning, constitutes the study of the overall project, securing the land and outlining the program. That phase is complete. The second phase, Exploration I, is an investigation of the site where a lignite coal seam has already been located. The later phase, Exploration II, includes a refined mapping of the coal bed by drilling and performing laboratory analyses on core material brought up from below the surface. Detailed planning of the next four phases of the project are undertaken during the third phase. Also during that third period, technical assessments of coal conversion techniques will be undertaken, in order to match the lignite to the process. The fourth phase includes the construction and operation of a test facility to perform an on-situ evaluation of the underground coal conversion process which is the basis of the first stage of the production plant. During the fifth phase, the full-scale plant is designed and the sixth phase involves the construction of the production facility. Finally comes the projected production term.

The production term is 20 years.

1.4 Summary.

There is no intention here to labour the projected energy demands for the future, such work has already been extensively carried out,(1.16) and bibliographies are available.(1.17) It is the commercial development of northeastern Ontario lignite, by conversion to oil or gas, that is the topic of this report.

1.5 References.

1.1. Munro, L.A., "Chemistry in Engineering," Prentice-Hall, Englewood Cliffs, New Jersey, 1964, Chapters 5 and 6.

1.2. "Financing Energy Self-Reliance," a background paper to "An Energy Strategy for Canada: Policies for Self-Reliance." Energy Policy Sector, Report Number EP 77-8, Energy, Mines and Resources Canada, 1977, 54 pages.

1.3. "Oil and Natural Gas Industries in Canada," Report Number ER 78-2, Energy, Mines and Resources Canada, Catalogue Number M23-14/78-2, 1979.

1.4. Taylor, G.W., "Liquid Fuels from Canadian Coals," CANMET Report Number 79-13, Energy Research Program, Technology Information Division, Energy, Mines and Resources Canada, June 1979, Catalogue Number M38-13/79-13, 43 pages.

1.5. Burns, J.F., "South Africans Converting Coal into Motor Fuel," "The New York Times," 1 June 1977, pp.A1 and D9.

1.6. Schultz, M., "Fuel for the Fuhrer," "Popular Mechanics," November 1979, pp. 102ff.

1.7. "Canadian Oil and Gas Supply/Demand Overview," Energy Strategy Branch, Economic & Policy Analysis, Department of Energy, Mines and Resources Canada, November 1979.

1.8. Shinnar, R., "Gasoline from Coal," "Chemtech," November 1978, pp. 686-693.

1.9. Gronhovd, G.H., Kube, W.R., compilers, "Technology and Uses of Lignite," proceedings, "Bureau of Mines - University of North Dakota Symposium, Grand Forks, North Dakota, 9-10 May 1973.

1.10. Guillet, G.R., "Lignite and Industrial Mineral Resources of the Moose River Basin Property of Lignasco Resources Limited," Project G1-7, prepared on behalf of Lignasco Resorces Limited, April 1981, 28 pages, page 1.

1.11. Guillet, G.R., "Fossil Fuel Programme, Moose River Basin Drilling Project," District of Cochrane, Ontario Geological Survey, OFR 5276, 121 pp., 8 Tables, 4 Figures, 16 photos (XEROX copies), Two figures in back pocket , 1979.

1.12. Stephens, D.R., "An Introduction to Underground Coal Gasification," In-Situ Coal Gasification Project, Lawrence Livermore National Laboratory, Report Number UCID-18801, August 1980, 27 pages, page 4.

1.13. Lamb, G.H., "Underground Coal Gasification," Noyes Data Corporation, Park Ridge, New Jersey, 1977.

1.14. Schora, F.C., Berkowitz, N., Hegarty, W.P., "Fuel Gases from Coal," MSS Information Corporation, New York, New York, 1976, pp. 187ff.

1.15. "Production of Aviation Jet Fuel from Coal," Staff Report prepared for the Use of the Committee on Aeronautical and Space Sciences, United States Senate, 1 June 1976.

1.16. "Oil and Natural Gas Industries in Canada 1978," Report ER 78-2, Energy, Mines and Resources, Canada, Catalogue Number M23-14/78-2, Minister of Supplies and Services, Ottawa.

1.17. "Energy Analysis Methods, Uses, Implications: A Review and Critique of the State-of-the-Art," Research Report Series, Number RR 6, Energy, Mines and Resources, Canada, February 1976.

TABLE 1.I

Program Phases

Phase	Purpose	Year(s)	Duration, year(s)
I	Planning	0	1
II	Exploration I	1	1
III	Exploration II	2-3	2
IV	Test Facility	4	1
V	Plant Design	5	1
VI	Plant Construction	6-7	2
VII	Production	7...	20...

FIG. 1.1 ONTARIO GEOLOGY AND THE
LIGNASCO RESOURCES LIMITED AREA

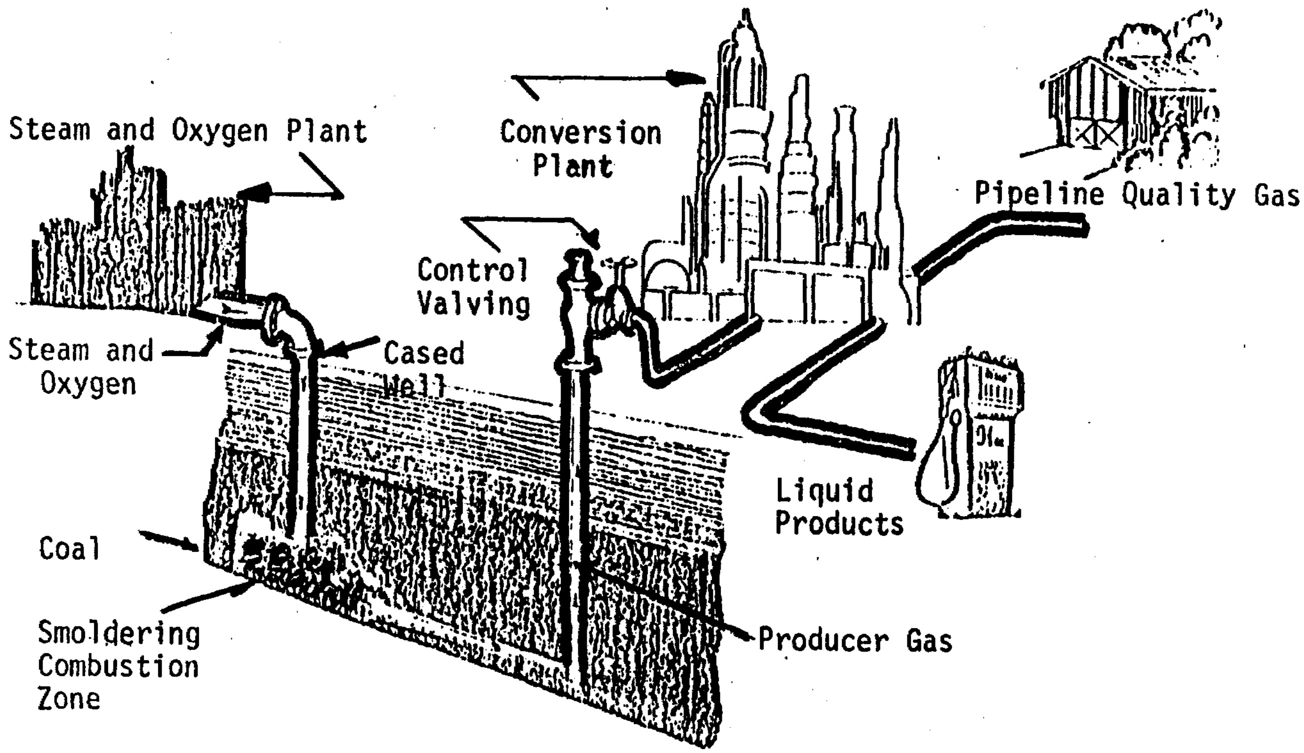


FIG. 1.2 IN-SITU CONVERSION PLANT

2. Coal.

Coal, derived from plant matter, has been defined as "a compact stratified mass of plant debris which has been modified chemically and physically by natural agencies."(2.1)

Found either at or below the surface of the Earth, coal may be developed by mining the solid, and directly consuming it or by converting mined coal to liquid or gas prior to use. Also, coal can be converted to a fluid underground and retrieved as a product for use later.(2.2) The value of each development method, however, depends on economics and the physiochemical suitability of the feedstock.

Coal is used for thermal power generation, metallurgy, space heating and industrial uses in Canada (2.3) and, in foreign countries, coal is also used as a feedstock to produce liquid and gaseous fuels.(2.4)

2.1 Coal Classification.

The coal, depending on the degree of development or departure from the original plant debris, can be classified or ranked according to the proportion of carbon present. The rank, then, can be considered a measure of the maturity of the coal.

These ranks or classifications can be illustrated as shown in Ralston's chart (Fig. 2.1).(2.5) The abscissa of this chart represents the proportion of carbon by per cent, the ordinate is hydrogen and the diagonal lines are constant percentages of oxygen. The curve of the chart signals the mean of the coals considered by Ralston. The coal may be classified as "anthracite" if it contains 1 to 4% hydrogen with a fixed carbon content of 92% or more, "bituminous" with 92 to 80% carbon, "lignite" with 80 to 70% carbon and "peat" with 70 to 60% carbon. Below 60% carbon fall the wood and plant matter from which coal derives.

The energy contents of coal are also related to coal rank. In particular, bituminous to lignite coals can have calorific values ranging from over 14,000 Btu per pound (32.6 MJ/Kg) to 6,000 Btu per pound (14.7 MJ/Kg) and below.(2.6) This compares to about 20,000 Btu per pound (46.6 MJ/Kg) for hydrocarbons.(2.7)

The coal classification by rank according to the American Society for Testing and Materials (ASTM) are shown in Table 2.I.(2.8,2.9)

2.2 Proximate Analysis.

The constitution of coal may be interpreted using the proportions of moisture, volatile matter, mineral matter and ash, and fixed carbon in the coal. This breakdown is called the proximate analysis. According to Ergun, "proximate analysis serves as a simple means for determining the behavior of coals when they are heated."(2.10)

As an example, a lignite-ranked Ontario coal, from the region of Onakawana near James Bay, has a reported proximate analysis of 50% moisture, 21.5% volatile matter, 6.5% ash and the balance (22%) fixed carbon.(2.11) The heating value for this coal has been quoted as 10,120 Btu per pound (23.6 MJ/Kg).(2.12)

However, the proximate analysis measurement of the water, volatile matter, mineral material and ash and fixed carbon contents of coal give only rough thermodynamic and physical property values for this complex material. More detailed information on the elemental composition are provided by "ultimate" analyses, the heating values are evaluated using accepted ASTM procedures, and petrography can be used to examine the coal structure.

2.3 Coal Utilization.

The usage of coal can be illustrated from production and utilization figures from 1978. The demand in Canada for coals of all ranks was 50,418,000 short tons; of which 17,248,000 short tons was imported.(2.13) Of that coal, 5,498,000 tons of lignite were used, mostly for thermal power generation and non-metallurgical industry.

The use of coal depends on the grade of the coal, also. Consider the class of coal called anthracite.(2.14) For anthracite, the proportion of the carbon is so high, 92 to 98%, that the coal can be mined and burned economically.(2.15) However, the high carbon content implies a correspondingly low proportion of hydrogen, so that the potential for gasification or liquifaction of anthracite is low.(2.16) In contrast, the other lower ranks of coal (like lignite or sub-bituminous) do not have the same proportion of carbon content. Consequently, they do not offer the same advantages in direct combustion applications. However, those lower ranks of coal have the correct proportions of carbon to hydrogen to make them attractive candidates for conversion to fluids.

2.4 References.

2.1. Francis, W., "Coal, Its Formation and Composition," Second Edition, Edward Arnold, London, 1980, pg. 1.

2.2. Lamb, G.H., "Underground Coal Gasification," Noyes Data Corporation, Park Ridge, New Jersey, 1977.

2.3. "Statistical Review of Coal in Canada 1978," Energy, Mines and Resources, Canada, Report Number EI 79-6, 1979.

2.4. Taylor, G.W., "Liquid Fuels from Canadian Coals," Canada Centre for Mineral and Energy Technology, Report Number 79-13, Energy, Mines and Resources, Canada, June 1979.

2.5. Potter, P.J., "Power Plant Theory and Design," Ronald Press, New York, New York, 1959, pp. 181-186.

2.6. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy, Mines and Resources Canada, Report Number ER79-09, December 1979.

2.7. Taylor, C.F., Taylor, E.S., "The Internal Combustion Engine," Second Edition, International Textbook Company, Scranton, PA, 1961.

2.8. "1980 Annual Book of ASTM Standards," Part 26, "Gaseous Fuels; Coal and Coke; Atmospheric Analysis," American Society for Testing and Materials, Philadelphia, PA 19103, 1980, pp. 191-468.

2.9. Munro, L.A., "Chemistry in Engineering," Prentice-Hall, Inc., Englewood Cliffs, NJ, 1964, page 41.

2.10. Ergun, S., "Coal Classification and Characterization," in "Coal Conversion Technology," Wen, C.Y., Lee, E.S., eds. Addison-Wesley Publishing Company, Reading, MA, 01867, page 30.

2.11. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy, Mines and Resources Canada, Report Number ER79-09, December 1979.

2.12. Guillet, G.R., "Fossil Fuel Program, Moose River Drilling Project, District of Cochrane; Ontario Geological Survey OFR 5276, 121p., 8 Tables, 4 figures, 16 photos, 1979, page 48.

2.13. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy, Mines and Resources Canada, Report Number ER79-09, December 1979, page 5.

2.14. Francis, W., op. cit., pp. 412-413.

2.15. Aylsworth, J.A., Weyland, H.J., "Coal and Coke," in "Canadian Minerals Yearbook 1977," Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec, Canada K1A 0S9, 20 pages.

2.16. Johnson, J.L., "Relationship between the Gasification Reactivities of Coal Char and the Physical and Chemical Properties of Coal and Coal Char," American Chemical Society Preprints, 170th Anual Meeting, Division of Fuel Chemistry, Vol. 20, Number 4, 24-29 August 1975, pp. 85-101.

TABLE 2.1

ASTM Classification Chart

Rank and Group	Method I % Volatile Matter	Method II (D388-36T) % Fixed Carbon (moisture and mineral free basis)
I. *Anthracite*		
Meta-anthracite	2 or less	98 or more
Anthracite	2–8	98–92
Semi-anthracite	8–14	92–86
II. *Bituminous.*		
Low-volatile group	14–22	86–78
Medium-volatile group	22–31	78–69
High-volatile A group	More than 31	Less than 69
	Heating value: Moist, Btu more than 14,000	
High-volatile B group	13,000–14,000	
High-volatile C group	11,000–13,000 either agglomerating or nonweathering	
III. *Sub-bituminous*		
Sub-bituminous A group	11,000–13,000 weathering and non-agglomerating	
Sub-bituminous B group	9,500–11,000	
Sub-bituminous C group	8,300–9,000	
IV. *Lignite*		
Lignite (consolidated)	Less than 8,300	
Brown coal group (unconsolidated)	Less than 8,300	

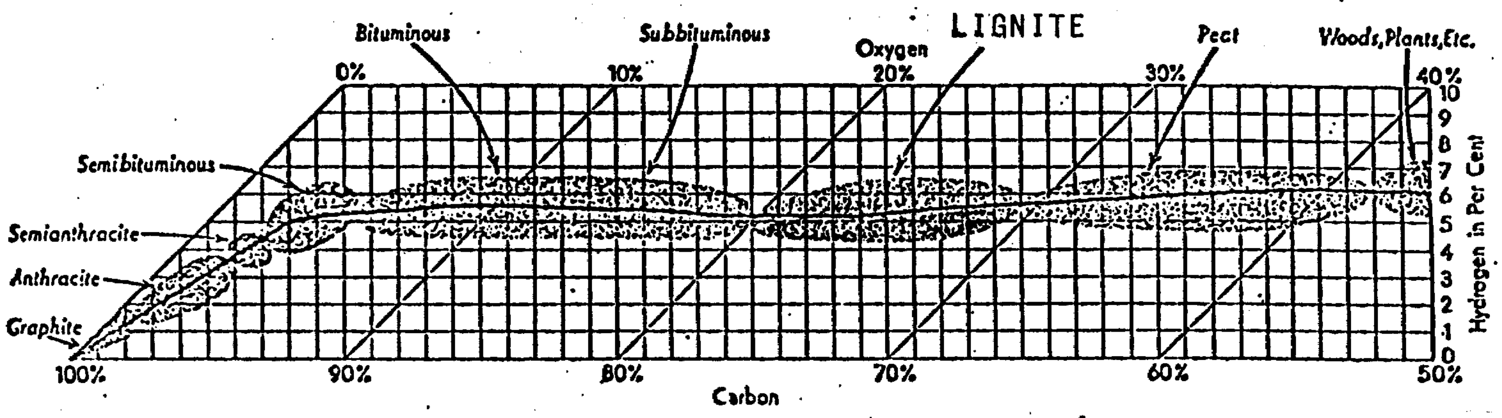


FIG. 2.1 RALSTON'S CHART WITH LIGNITE HIGHLIGHTED

3. Coal Conversion.

Coal converted to gas or oil produces a conveniently transportable and storable energy commodity. Indeed, "producer gases" were the common source of fuel for cooking, domestic hot water, and street lighting in metropolitan centres for 150 years, until producer gas began to be replaced by electricity.(3.1) Other examples of more recent vintage include the use of gasified coal to produce oil in Germany during the Second World War(3.2) and in the Union of South Africa at the present time.(3.3) However, these original processes are inefficient, costly and environmentally dirty.(3.4) In recent years, the drive has been to improve the proportion of the coal that is converted to product gases and liquids, to decrease the cost of the processing, and to clean up the processes; thus making coal conversion economical. The general process for converting coal into high Btu, pipeline quality, gas is shown schematically in Fig. 3.1.(3.5) Coal is prepared for gasification either by transportation or by physical changes in the coal to be converted. Such physical changes may include washing, slurrying, or reduction of the aparcel size. Then, by the addition of air, oxygen or steam, as the process demands, carbon monoxide, carbon dioxide, hydrogen, water and hydrogen sulphide result. This mix is called "producer gas." Next, by "shift conversion," the carbon dioxide and monoxide, and the hydrogen and hydrogen sulphide are increased at the expense of the water. The material is then scrubbed of carbon monoxide and hydrogen sulphide, with the latter used to recover sulphur as a by-product. The remaining carbon monoxide and hydrogen form water and methane in a "methanation" step. Finally the water is removed.

In 1980, there were many distinct coal conversion programs, in either development or use,(3.6,3.7) employing a variety of coals. The producer gases that result have energy contents ranging from 10 to 50% that of methane,(3.8,3.9) the principal component of natural gas(3.10) and a good basis for comparison. These various coal conversion processes differ, however, in both how the coal is converted and in the proportion and utilization of the energy in the process.(3.11)

As indicated above, the low ranks of coal have the relatively high proportions of hydrogen required for effective conversion. The immediate advantage is that the coals least suitable for direct combustion offer the best characteristics for conversion to gas and oil.(3.12,3.13,3.14) These high hydrogen mass fraction coals are found in the lignite and sub-bituminous ranks. The specific rank considered in this project is lignite, since it is both the most suitable for conversion and the most common coal in Ontario.(3.15,3.16,3.17)

3.1 Lignite Conversion.

Considered a lower rank of coal, lignite has been used extensively worldwide. Typically an unclean combustible, and so not an ideal fuel in its natural form, lignite is effective as a producer gas and oil feedstock. It can be processed at twice the rate of the higher-ranked sub-bituminous coal and at a high degree of conversion.(3.18,3.19) Furthermore, since lignite demands less additional hydrogen for the production of gaseous hydrocarbon fuels than higher ranked coals, a substantial portion of the cost of processing is saved.

In Canada, the British Columbia Hydro and Power Authority has already considered a coal gasification process for the production of electricity in a combined cycle project using lignitic Hat Creek coal.(3.20) Their report states "the systematic development of a mature indiginous coal conversion technology appears to be a must for Canada." Furthermore, they state that the coal used, lignite, proved "eminently suitable" for gasification.

3.2 In-Situ Coal Gasification.

To yield its producer gases, coal is generally first mined to bring it to the surface and then gasified. However, the mining step is bypassed in in-situ gasification.(3.21,3.22)

In the in-situ or "underground" coal gasification process, an array of boreholes are drilled into the coal-bed.(3.23) This drilling is shown schematically in Fig. 3.2.(3.24) The drilled holes are then linked underground by directional drilling or by reverse combustion through the coal seam.(3.25) The "link" is the route between the inlet and outlet pipes of the gasifier. As Fig. 3.3 shows, steam, air, or oxygen, for example are pumped into the inlet pipe to reach the coal "in-situ", that is, in place. The producer gas that results is brought to the surface through the "gas outlet", usually some distance away. The producer gas is treated to remove tar and particulates and the result is "shift converted" and purified. Subsequent to the purification the product is methanated or, by the Fischer-Tropsch Synthesis(3.26) for example, converted to liquid.

Like obtaining a yield from an oil field, the in-situ development of a coal deposit involves drilling into the coal-bed or seam as the first stage in production. Then reaction agents, typically air or steam are injected. The coal releases volatile tars and oils and trapped gases, if any exist, and then reacts with the injected reactants to form producer gases. The boreholes provide a route for the injection of reactants, such as steam and oxygen, and a route for the extraction of a low or medium energy gas. The usual first stage of a conversion process is then conducted below ground in a natural rector formed by the bounding clay layers.

The technology of in-situ gasification has been documented since the mid-nineteenth century in the UK, the USSR and the USA.(3.27) A demonstration plant using Bituminous coal 1 m thick at 75 m depth was built at Newman-Spinney in the UK; and a commercial field development near Moskva (USSR), which allows controlled extraction of the entire coal resource, has been in place since 1955. Indeed, Soviet technolgy has been used by Texas Utilities Company in a lignite conversion plant south of Dallas.(3.28) Furthermore, United States Department of Energy considers in-situ gasification advantageous since the process offers pipeline quality gas at costs competitive with or lower than that of other synfuels, can be applied where strip-mining is not economical.(3.29)

3.3 In-Situ Lignite Conversion.

In the lower grades, such as lignite, the reactions cause the coal to shrink as it combines with the reactants, increasing the porosity. Furthermore, the "pre-hydrogenated" coal called lignite permits percolation of the product,(3.30) making the material excellent for in-situ gasification. Also, lignite seams are generally bounded by refractory clays and form a natural reactor consisting of the seam and its bounding strata. As a result, the producer gases percolate through the seam. The products can be piped to the surface, either through the inlet or separate passages.

The Soviet in-situ plant is particularly interesting in terms of this project, since the Moskva deposit lies in the Cretaceous basin at Novo-Basovsk equivalent to the Adam Creek area in northeastern Ontario. Furthermore, the brown coal at Novo-Basovsk has 4900 Btu/lb and 37% ash, and contains 30% moisture and so is similar to the lignite deposit at Adam Creek. The production at Novo-Basovsk in 1955 was 15.6 billion cubic feet per annum of 85 Btu/cubic foot producer gas.(3.31)

Producer gas can be used "as-is" for industrial markets or can be upgraded to pipeline quality gas for transport to local, Canadian or available US markets. Upgrading, by removal of water, carbon dioxide and carbon monoxide, yields pipeline quality gas. Further processing can produce methanol, gasoline, Diesel fuel, heating oil, and jet fuel.

3.4 Remarks.

The success of a specific gasification process depends on both the coal and the engineering skills of the teams responsible. Futhermore, each production scheme has its "optimum" operating condition or range. The consequence of varying any of the operating parameters such as the type or proportions of reactants is a change in the quality and quantity of the synthesized product.

Lignite is well-suited to conversion to gaseous and liquid hydrocarbons because of the proportion of hydrogen to carbon it contains, and lignite shrinks on gasification, and since the lignite in the Adam Creek deposit is bounded by clay layers, it is desirable to use "in-situ" gasification for the first stage of development of the deposit. That is, the energy contained in the feedstock is extracted without mining the coal.

In non-optimized conversion situations, the producer gas energy ranged from about 85 to about 250 Btu per cubic foot, depending on the process.(3.32) This heating value is about 8.5 to 25% the heating value of natural gas. The product is upgradable by shift conversion and methanation to pipeline quality gas, using available production hardware, or can be converted to methanol or other liquid fuels such as gasoline by conventional synthesis methods.(3.33)

Briefly, there are no western hemisphere commercial programs that are currently in operation, however, several major companies are planning for such commercialization. Furthermore, the degree of conversion possible as evidenced by US DoE Lawrence Livermore Laboratory tests at Hanna and Hoe Creek, Wyoming suggest that conversions as high as 60-70% can be achieved for sub-bituminous shrinking coals of about 20% moisture content on a dry basis energy of about 9000 Btu per pound.

The advantages of an in-situ gasification method over a conventional approach to coal conversion are: a reduction in cost; an increase in the overall safety potential of gas production; and a reduction in the impact on the surface environment, since mining is not necessary. The promise, then, is for successful commercialization in the future.

3.5 References.

3.1. Schora, Jr., F., Lee, B.S., Huebler, J., "The HYGAS Process," in "Fuel Gases from Coal," MSS Information Corporation, New York, New York 10021, 1976, pp. 11-29.

3.2. Schultz, M., "Fuel for the Fuhrer," "Popular Mechanics," November 1979, pp. 102ff.

3.3. Burns, J.F., "South Africans Converting Coal into Motor Fuel," "The New York Times," 1 June 1977, pp. A1 and D9.

3.4. Howard-Smith, I., Werner, G.J., "Coal Conversion Technology," Noyes Data Corporation, Park Ridge, New Jersey, 1976.

3.5. Massey, L.G., "Coal Gasification," in "Coal Conversion Technology," Wen, C.Y., Lee, E.S., eds, Addison-Wesley, Reading, MA, 1979, page 396.

3.6. "Evaluation of Coal-Gasification Technology," Part I, "Pipeline-Quality Gas," R & D Report Number 74, Interim Report Number 1, prepared for the Office of Coal Research, Department of the Interior, Washington, DC 20240, 1973.

3.7. Howard-Smith, I., Werner, G.J., "Coal Conversion Technology," Noyes Data Corporation, Park Ridge, New Jersey, 1976.

3.8. Seglin, I., Eddinger, R.T., "Coal" in "Encyclopedia of Chemical Technology," Ed. Kirk-Othmer, Second Edition, Supplementary Volume, 1970, pp. 117-217.

3.9. Taylor, C.F., Taylor, E.S., "The Internal Combustion Engine," Second Edition, International Textbook Company, Scranton, PA, 1961.

3.10. Munro, L.A., "Chemistry in Engineering," Prentice-Hall, 1964, pp 104-8.

3.11. Schora, Jr., F., et al., op. cit. Vancouver, British Columbia, Report Number 4602-00-1-75, October 1975.

3.12. Johnson, J.L., op. cit.

3.13. Grandys, K., "Coal Conversion Technologies," Illinois State Department of Business and Economic Development, Springfield, Illinois, Report Number IODE-75-04 (PB260664), 1 September 1975.

3.14. Schrider, L.A., Whieldon, C.E., "Undersround Coal Gasification - A Status Report," Journal of Petroleum Technolosy, September 1977, pp. 1179-1185.

3.15. "Coal in Ontario," Ministry of Enersy, Government of Ontario, Queen's Park, Toronto, Ontario, 1980, 24 pases.

3.16. Taylor, G.W., "Liquid Fuels from Canadian Coals," Canada Centre for Mineral and Enersy Technolosy, Report Number 79-13, Enersy, Mines and Resources, Canada, June 1979.

3.17. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Enersy, Mines and Resources Canada, Report Number ER79-09, December 1979, pase 5.

3.18. Mills, G.A., "Gas from Coal: Fuel of the Future," in "Technolosy and Use of Lisnite," proceedinss of the Bureau of Mines - University of North Dakota Symposium, Grand Forks, North Dakota 9-10 May 1973, U.S. Bureau of Mines Circular, IC 8650, 1974, pp. 76-82.

3.19. Farkas, G.S., "Coal Gasification Combined Cycle Study," B.C. Power and Hydro Authority, Vancouver, British Columbia, Report Number 4602-00-1-75, October 1975.

3.20. Farkas, G.S., ibid.

3.21. Mills, G.A., op. cit.

3.22. "Podzemnaya pererabotka topliv (Undersround Processins of Fuels)," Izdatel'stvo Akademii Nauk SSSR, "Trudy Instituta Goryuchikh Iskopaemykh," Vol. XIII, Academy of Sciences of the USSR, Department of Technical Sciences, Moskva, 1960.

3.23. Lamb, G.H., "Undersround Coal Gasification," Noyes Data Corporation, Park Ridse, New Jersey, 1977.

3.24. Stephens, D.R., "An Introduction to Undersround Coal Gasification," In-Situ Coal Gasification Project, Lawrence Livermore National Laboratory, Report Number UCID-18801, Lawrence, California, 27 pases, Ausust 1981, pase 2.

3.25. Hill, R.W., "Permeability Enhancement Methods for Preparins a Coal Bed for In-Situ Coal Gasification," Lawrence Livermore National Laboratory, Report Numner UCID-18096, Livermore, California, 10 April 1979, 27 pases.

3.26. Nowacki, P., "Coal Liquifaction Processes," Chemical Technology Review Number 131, Energy Technology Review Number 45, Noyes Data Corporation, Park Ridge, New Jersey 07656, 1979, pp. 233-265.

3.27. Lamb, G.H., "Underground Coal Gasification," Noyes Data Corporation, Park Ridge, New Jersey, 1977.

3.28. Schora, Jr., F., op. cit.

3.29. Stephens, D.R., "Underground Coal Conversion Short Course," University of California, Los Angeles, Course Number 885.76, 2-6 March 1981.

3.30. "A Current Appraisal of Underground Coal Gasification," Arthur D. Little, Inc., 17 April 1972, NTIS Report Number PB209274.

3.31. Lamb, G.H., op. cit.

3.32. Stephens, D.R., Thorsness, C.B., "DOE Sponsored Field Tests," Underground Coal Conversion Short Course, Lecture Notes, 2-6 March 1981.

3.33. Taylor, G.W., "Liquid Fuels from Canadian Coals," Canada Centre for Mineral and Energy Technology, Report Number 79-13, Energy, Mines and Resources, Canada, June 1979.

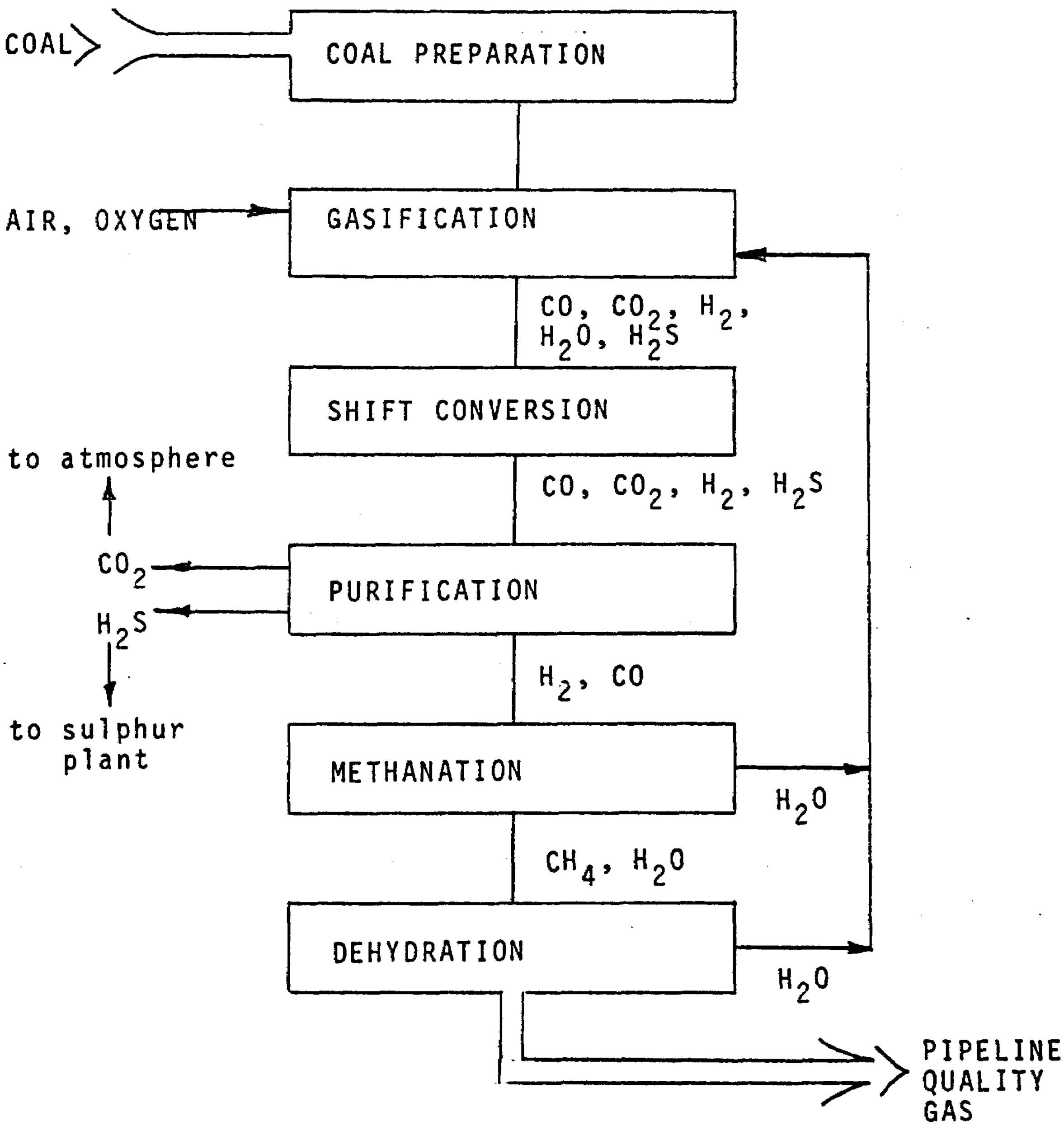


FIG. 3.1 COAL CONVERSION PROCESS FLOWCHART

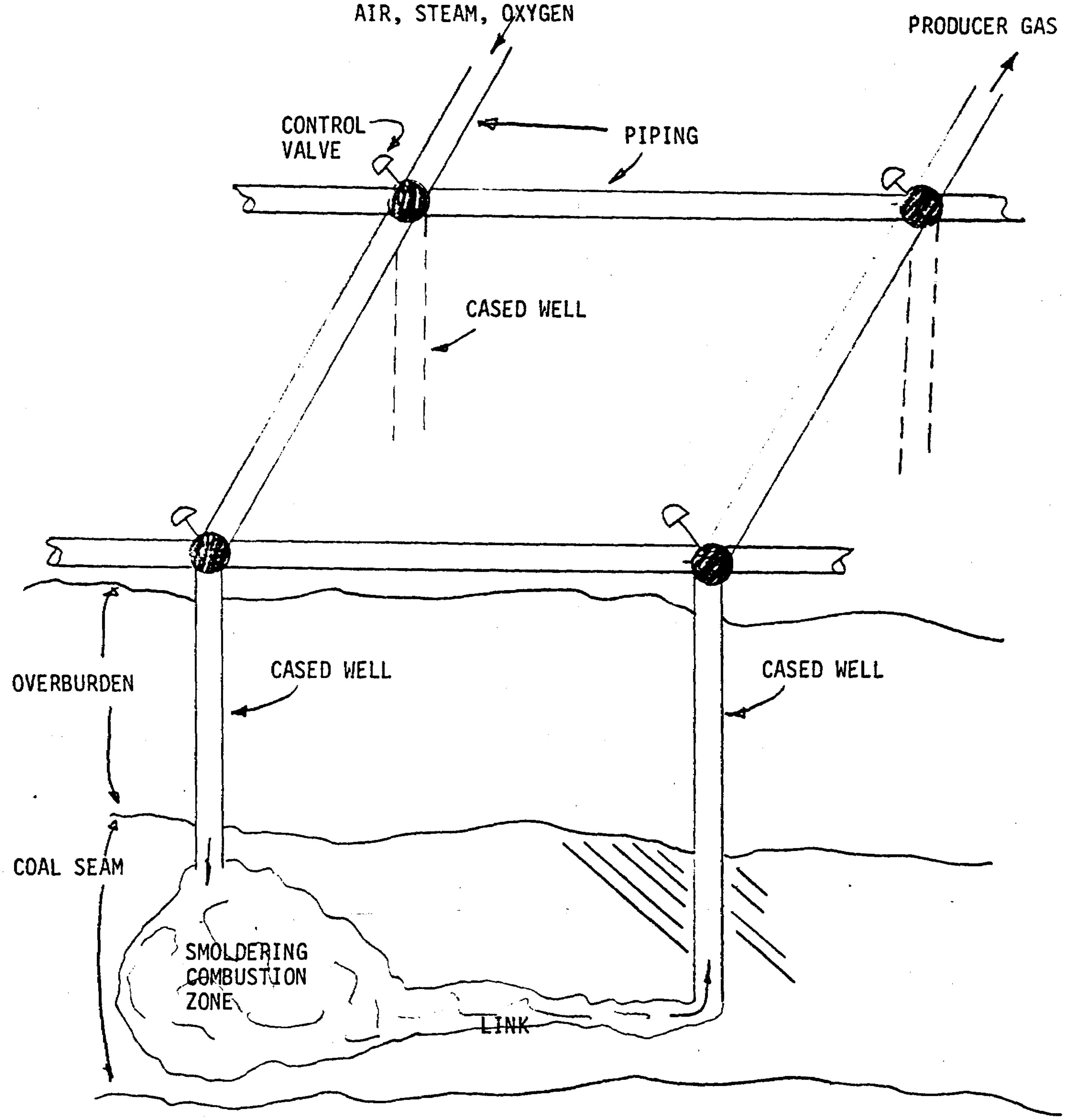


FIG. 3.2 IN-SITU DRILLHOLE AND LINK SCHEMATIC

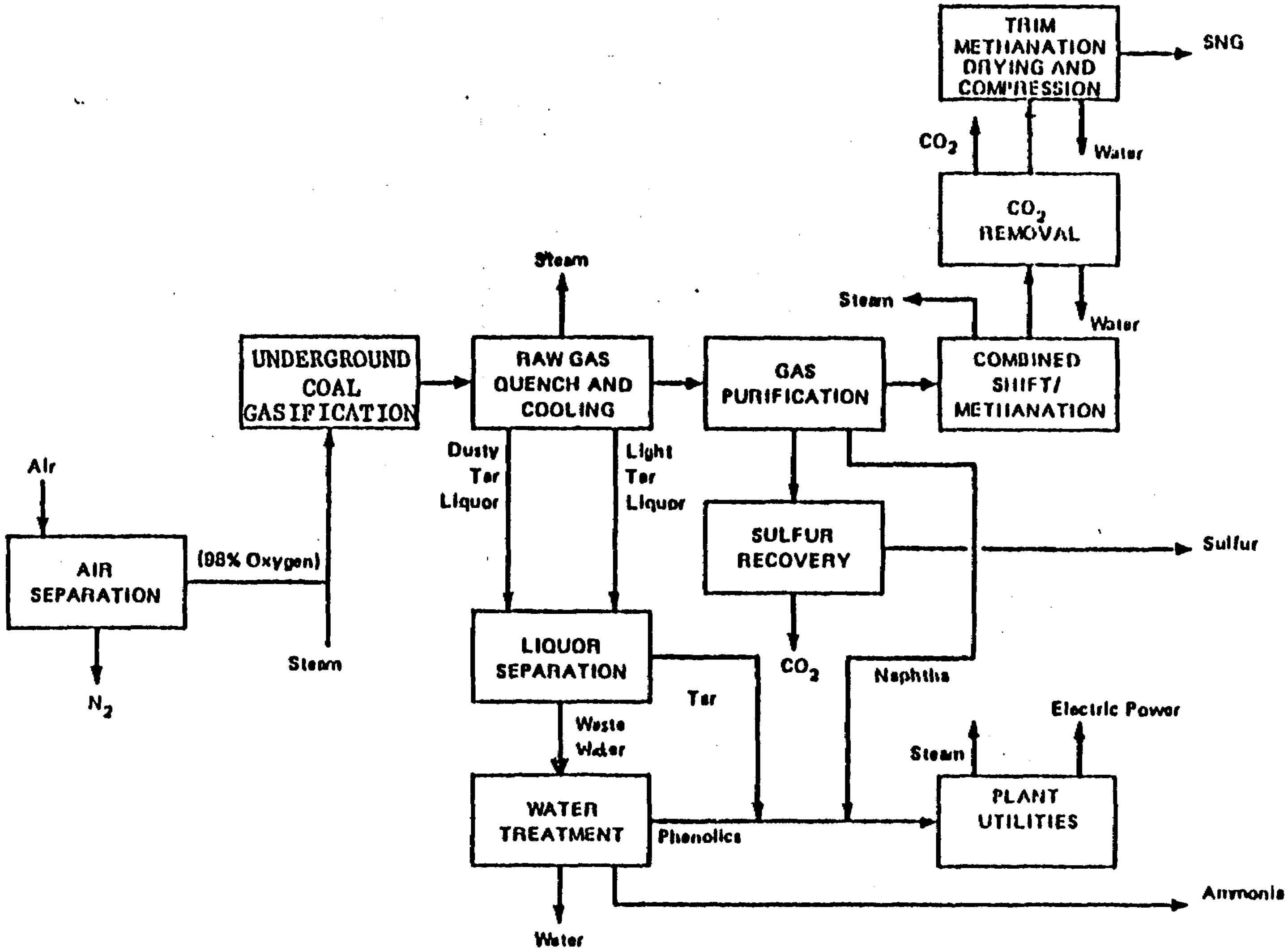


FIG. 3.3 In-Situ Conversion Process Flowchart

4. The Site.

The James Bay Lowlands of Ontario (see Fig. 4.1) show potential as a base for a coal conversion project. Specifically, the location which shows the most promise is the southern part of the Moose River Basin, located in the most southernly part of the lowlands. In that area, a previously undiscovered coal deposit was reported in 1978.(4.1,4.2) The area falls north of the Precambrian Escarpment, and largely within the limits of the District of Cochrane. The area is drained by the Missinaibi, Mattagami and Opasatika rivers, which converge to the northeast to form the Moose River. The area has been studied by Guillet, and is described in detail in his work.(4.2)

The deposit is located within a 92,745 acre (145 square mile, 370 square kilometre) tract, lying approximately 100 Km north of Kapuskasing. The site includes most of Kipling Township, the southern half of Sanborn Township and the western half of Emerson Township,Fig. 4.2) and is described in the Exloratory Licence of Occupation Number 14890 (Appendix A).

The site is serviced by an all-weather road, lies approximately 40 Km west of the Ontario Northland Railway running between Cochrane and Moosonee and is about 100 Km north of the Canadian National Railway, Trans-Canada Pipeline and Trans-Canada highway running through Kapuskasing.

4.1 Site Discussion.

The region is generally flat, featureless terrain and has been described as follows:(4.2)

> Variegated (red, brown, grey) clay and silt marks the top of the Mattagami Type B unit..., in direct contact with Adam till at a depth of 43 metres. Type B sediments comprise a section 22 metres thick that is predominately medium to coarse grained Kaolinite-rich quartz sand with several thick sections of quartz gravel. At a depth of 65 metres a layer of black carbonaceous clay marks the top of the Type A sediments which continue to a depth of 119 metres. At or about this depth is the top of the Devonian Long Rapids formation, a grey clay-shale difficult to distinguish from some of the Mattagami clay beds. A lignite seam 1 metre thick occurs at a depth of 71 metres, and a 6 metre seam occurs at a depth of 96 metres.

4.2 The Exploratory Drilling Program.

The 1978 drilling program involved drilling a total of 8 holes. The drillhole locations are shown in Fig. 4.3. Six of these drillholes lie in line in the east-west direction, at 8 to 14 km (5 to 9 mile) spacing. The two remaining drillholes lie approximately 5 to 10 km (3 to 6 miles) north of the east-west base. In all, the total drilling was 1177 m (3862 ft), with the deepest hole drilled to 189 m (620 ft).

The drillhole logs are shown, along with a preliminary correlation, in Fig. 4.4. One of the drillholes, number 78-06, located previously unrecorded lignite. This newly discovered reserve consists of two main seams. The first is 1 m (3 ft) thick at the 71 m (233 ft) depth and the second 6 m (20 ft) at the 96 m (300 ft) depth.

The coal is bounded from above and below by clay layers. This structure encourages the formation of a natural reactor cavity for the underground coal conversion.

Additional to hole 78-06, holes 78-01 nad 78-08 lie in the area of interest. These drillholes, too, found lignite.

It is noted here that the coal deposits need not be continuous for the project to be economic, although a minimum thickness of 3m and a minimum width of 25m appears favorable for each coal lens.

4.3 Properties of Adam Creek Lignite.

The coal found in the exploration is ranked and known as "Adam Creek lignite."(4.2,4.3) This Adam Creek lignite has ash content estimated at approximately 26.2%. The ash is the residual clay, etc, found after firing tests that determined the energy content of the coal. The sulphur content has been estimated at about 0.5% on a dry basis. The water content of the lignite has not been reported. However, the highest water content of lignite reported by the US Department of Commerce in the "Coal Conversion Systems Technical Data Book," NTIS Report HCP/T2286-01, 1978, is about 50%.(4.4) The water content of the Adam Creek lignite will be determined as part of the drilling program. The density of "as-received" Adam Creek lignite is presumed to be approximately 65.52 pounds per cubic foot. The properties of the lignite are summarized in Table 4.I.

4.4 Comparison.

By way of comparison, the Onakawana lignite deposit, located some 100 kilometres north-east of the site under consideration, consists of two seams 5.4 and 5.5 metres thick. The Onakawana deposit extends over an area of about 8 square miles and contains about 180 million tonnes of lignite. According to Vos,(4.5) Shawinigan Engineering made an assessment of the resources for a power generation plant located at the deposit. They estimated an average heating value of 10,120 Btu/lb on a dry basis for Onakawana lignite, with an ash content of 20.9%. This ratio of the energy of the Onakawana lignite to its ash content is about the same as that for the Adam Creek lignite, under examination here. Therefore, the difference in the energy contents quoted may be a consequence of differences in the firing tests used.

4.5 References.

4.1. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy Mines and Resources Canada, Report Number 79-9, Ministry of Supply and Services Canada Catalog Number M23-14/79-9, December 1979.

4.2. Guillet, G.R., "Fossil Fuel Programme, Moose River Drilling Project, District of Cochrane," Ontario Geological Survey OFR (Open File Report) 5276, 121 p., 8 Tables, 4 Figures, 16 Photos (Xerox copies), Two figures in back pocket, 1979.

4.3. Potter, P.J. "Power Plant Theory and Design," Second Edition, The Ronald Press Company, New York, 1959, pp. 181-186.

4.4. "Coal Conversion Systems Technical Data Book," U.S. Department of Commerce, National Technical Information Service, Report No. HCP/T2286-01, NTIS, Springfield, Va., 1978.

4.5. Telford, P.G., Verma, H.M., "Mesozoic Geology and Mineral Potential of the Moose River Basin," District of Cochrane, Ontario Geological Survey, 311 Pages, 6 Tables, 38 Figures, 1975.

TABLE 4.I

Properties of the Coal in the Deposit

Class/Rank	Lignite
Energy	8000 Btu/lb, dry basis, measured
Moisture	50%, estimated
Ash	26.2%, measured
Sulphur	0.5%, dry basis, measured.
Thickness	6 m (20 ft)
Density	68.64 lb/cu.ft., dry basis, estimated
	65.52 lb/cu.ft., "as received", estimated

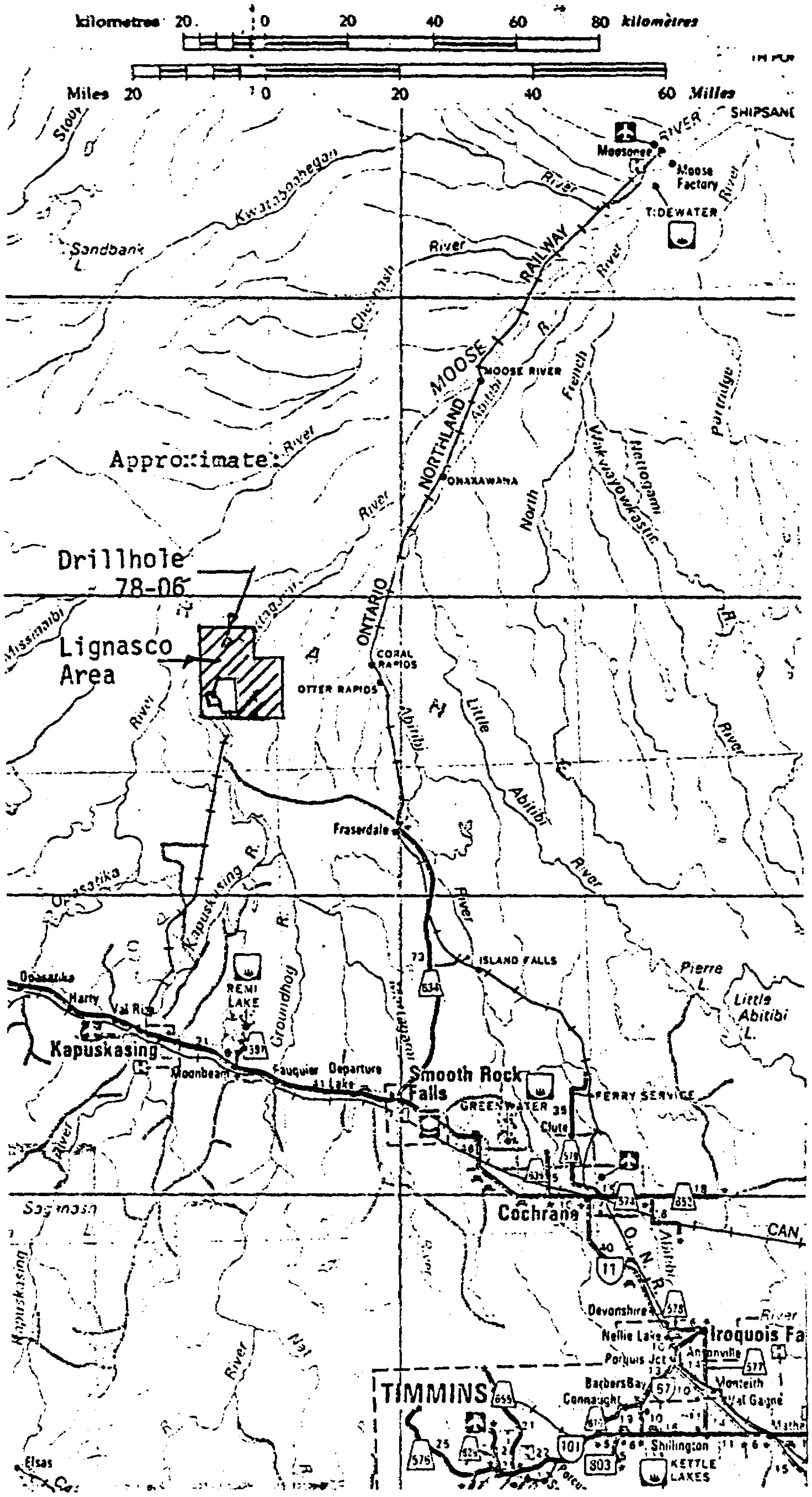


FIG. 4.1 A PORTION OF THE JAMES BAY LOWLANDS AND THE LIGNASCO RESOURCES LIMITED AREA.

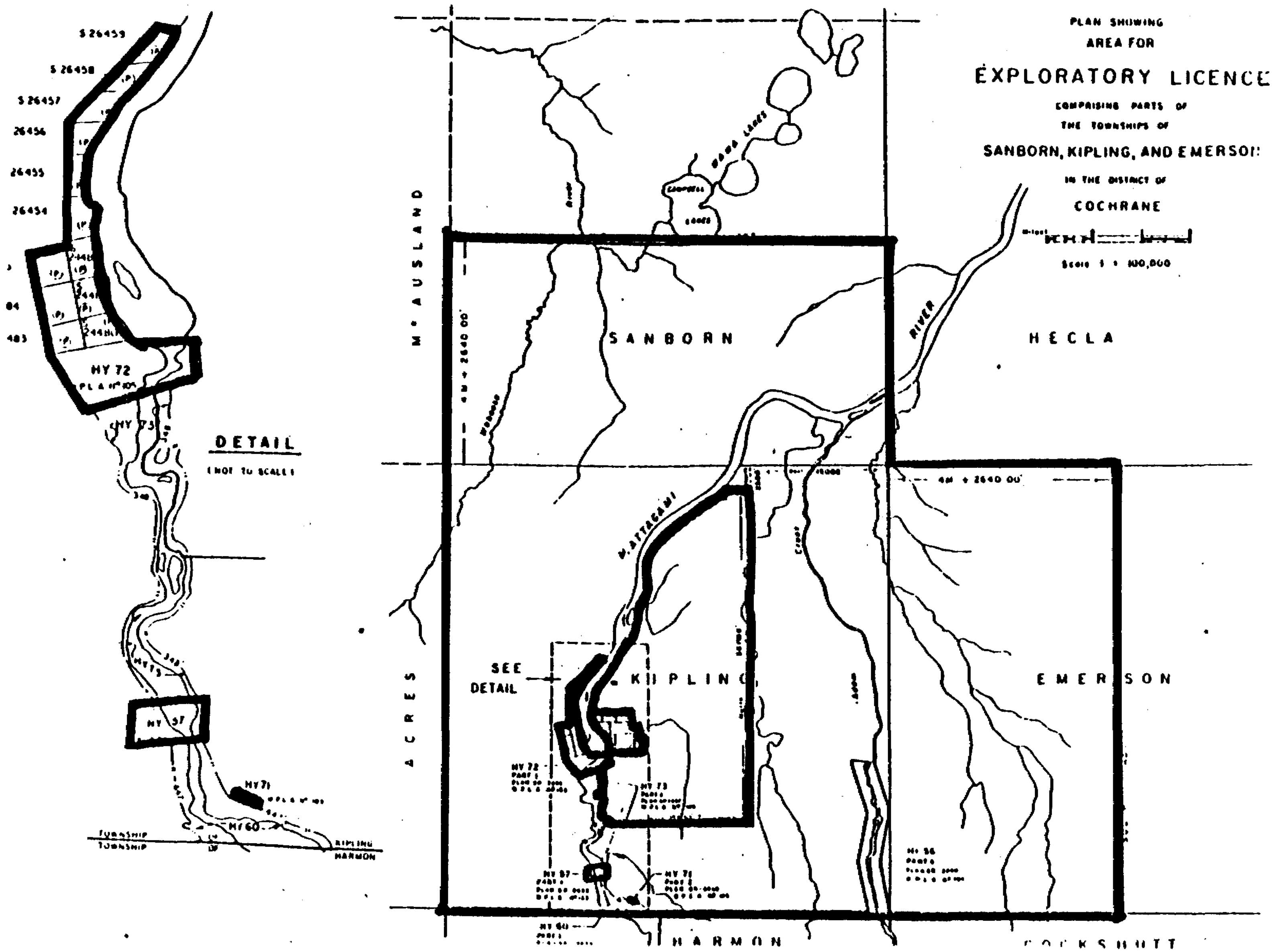


FIG 4.2 THE LIGNASCO RESOURCES LIMITED AREA

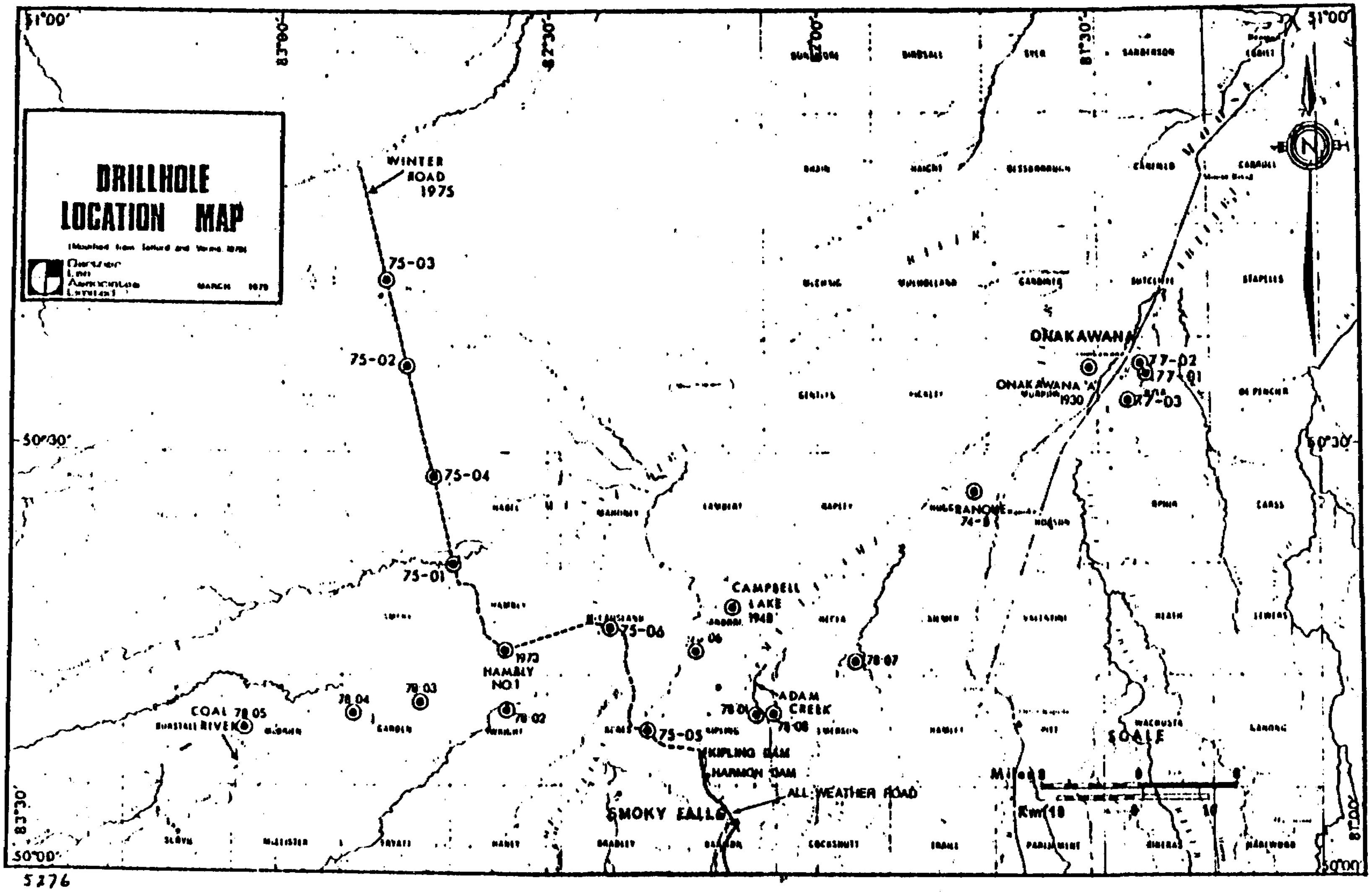


FIG. 4.3 DRILLHOLE LOCATION MAP

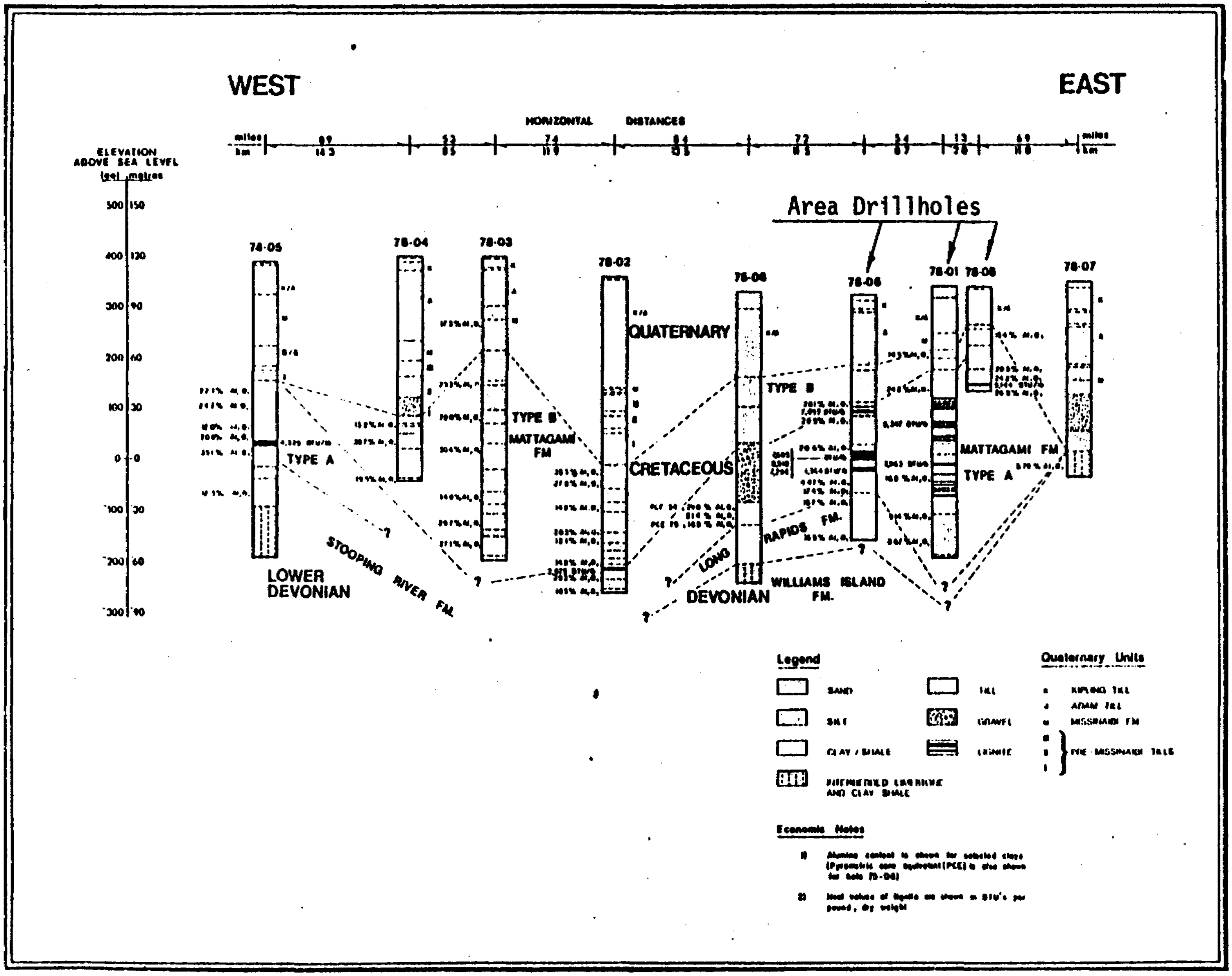


FIG. 4.4 DRILLHOLE LOGS AND PRELIMINARY CORRELATION

5. Exploration Program.

The actual extent of the coal deposit cannot be estimated without further exploration of the region. Using the specific terminology of the "Coal Conversion Systems Technical Data Book,"(5.1) as is adopted in Canada,(5.2) measured reserves are defined as those that fall in the 1/4 mile radius cylinder around the drillhole, indicated reserves fall in the 1/4 to 1/2 mile radius cylinder around the drillhole and inferred reserves lie in the 1/2 to 1-1/2 mile radius cylinder around the drillhole. Thus, since the spacing of the existing 1978 logged drillholes is 8 to 14 Km (5 to 9 miles), a closer spacing is required to detail the deposit.

In any case, the results of the previous drilling in this area has been examined by this author. The examination shows that, except for "downriver" deposits at Onakawana and other surface occurances of lignite, lignite seams have been found in drillholes located where the local elevation is 300 to 400 feet. The region mapped by this contour corresponds to the shore of the Cretaceous age Tyrrell Sea that existed in the region. On that basis, it is conjectured that the six metre thick lignite at drillhole 78-06 signals a deposit lying in the northwest-southeasterly direction. The region of this projected lignite zone occuring in the Lignasco Resources Limited area is shown in Fig. 5.1.

5.1 Discussion of the Drilling.

The previous drilling program reported:(5.3)

> Any drilling in muskeg terrain can be expected to be hampered to some extent by the wetness of the land. The excessive use of drilling water, particularly when operating by reverse circulation, added to the wetness of the site. Once off the drilling platform, it was not uncommon to flounder knee-deep in the boggy terrain. While these conditions caused some discomfort, they impeded very little the progress of the drilling program... The benefit of a summer drilling program serviced by helicopter, versus a winter program using a winter road are partly reflected in the difference in cost between the helicopter and the estimate for road construction and maintenance. The estimate for the winter road was $150,000 to $165,000, whereas the actual cost for the helicopter servicing was half this amount. Additionally, the use of helicopters minimizes the environmental impact, whereas the trace of the winter roads creates a long-lasting imprint on the muskeg

terrain. As to winter drilling, it is generally conceded to be perhaps 20% more costly than summer drilling whatever access is used, simply because of the increased problems of working in freezing conditions.

Due to the close spacing of the drillholes, a winter drilling program is planned. The winter drilling program has the advantage of allowing grade-level moving of equipment. It also allows drilling in the string bogs which are located in part of the area of interest.

The drilling method, sonic, provides a continuous lozenge core of 10-15 cm diameter. This method of drilling provides a relatively large sample for firing tests and petrographic analyses and brings a relatively undisturbed core to the surface. In addition, economic advantages are gained since the sonic drill is being used for other exploratory drilling on the area.

The drilling will be continuous, with continuous core logging. In addition to the core logging, gamma ray and possibly electrical logging will be employed to detail the subsurface geological structure.

5.2 Exploration Outline.

The exploration program is divided into two phases. The first phase involves drilling 4 drillholes to depths of about 140 metres. These drillholes will be spaced approximately 300 metres from the 78-06 drillhole location at the corners of a square. In addition to these four drillholes, and depending on the nature of the find, 6 additional holes may be drilled. These latter holes will include 4 holes spaced approximately 300 metres beyond the initial 4 holes and 2 "randomly spaced" holes elsewhere on the land tract.

In addition to the above drillholes, the cores from an industrial mineral joint venture program, also drilled to a depth of 140 metres, will be available for analysis.

Upon the successful discovery of a lignite reserve, the second phase of drilling will be undertaken. This second exploration program involves twenty-four drillholes spaced at 300 m intervals in the vicinity of the first exploration phase drillholes. Additional planning for that program will depend on the details of the first findings.

5.3 Drilling Costs.

The costs for the exploratory programs are presented and detailed in Tables 5.I to 5.VI. Costs for the initial four hole drilling program are estimated to be about $217,330. The six hole program cost estimate is $308,131, and that for the 24 hole program amounts to about $871,528. The five core sampling program cost is $58,523.

The minimum exploration program, utilizing four drillholes around 78-06 and sampling from another available five cores amounts to $275,853.

5.4 References.

5.1. "Coal Conversion Systems Technical Data Book," U.S. Department of Commerce, National Technical Information Service, Report No. HCP/T2286-01, NTIS, Springfield, Va., 1978.

5.2. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy Mines and Resources Canada, Report Number 79-9, Ministry of Supply and Services Canada Catalog Number M23-14/79-9, December 1979.

5.3. Guillet, G.R., "Fossil Fuel Programme, Moose River Drilling Project, District of Cochrane," Ontario Geological Survey OFR (Open File Report) 5276, 121 p., 8 Tables, 4 Figures, 16 Photos (Xerox copies), Two figures in back pocket, 1979.

TABLE 5.I

Exploration Program and Costs.*
($CDN(1981))

Section	Item	Costs	Cost/Hole	Cost/Metre
a	4 hole program**	217,330	54332.5	388.1
b	6 hole program	308,131	51355.2	366.8
c	24 hole program	871,528	36313.2	259.4
d	5 core program	58,523	11704.6	83.6

* Details are in the following tables.

** Holes drilled to 140 metre.

TABLE 5.II

Schedule of Unit Service Costs.
($CDN(1981))

A. Personnel.		
Project Manager	275	$/day
Assistant to Manager	205	$/day
Geologist	230	$/day
Assistant Geologist	180	$/day
Engineer	230	$/day
Assistant Engineer	180	$/day
Librarian	125	$/day
Secretary	75	$/day
Benefits and Vacation Pay	14	%
B. Technical Services.		
Drilling	145	$/metre
Petrography	30	$/sample
X-Ray	25	$/sample
Firing Tests	25	$/sample
Core Shipping	at laid down cost	
Other Technical Services	at laid down cost	
C. Office Services.		
Telephone	5	$/person/day
Photocopying	5	$/person/day
Office Supplies	10	$/person/day
Computing	1000	$/month
Drafting	at laid down cost	
Photography	at laid down cost	
Blueprinting	at laid down cost	
Travel	at laid down cost	
Technical Information and Data	at laid down cost	
Report Production	at laid down cost	
D. Other Services.		
Accounting	2% of A+B+C	
Auditing	2% of A+B+C	
Legal Fees	4% of A+B+C	
Insurance	4% of A+B+C	
E. Overhead.		
Overhead	10% of A+B+C	

TABLE 5.III

Four Hole Drilling Program Costs.
($CDN(1981))

Project Manager	50 days, 275/day	13,750	
Assistant Manager	50 days, 205/day	10,250	
Geologist	50 days, 230/day	11,500	
Assistant Geologist	50 days, 180/day	9,000	
Secretary	50 days, 75/day	3,750	

	Sub-Total	48,250	
Benefits and Vacation pay	14%	6,755	

		55,005	55,005
Drilling, 560 metres	145 $/metre	81,200	
Petrography, 40 samples	30 $/sample	1,200	
X-Ray, 40 samples	25 $/sample	1,000	
Firing Tests, 40 samples	25 $/sample	1,000	

		84,400	84,400
Telephone, 250 man-days	5 $/man-day	1,250	
Photocopying	5 $/man-day	1,250	
Office Supplies	10 $/man-day	2,500	
Computing	1000 $/month	1,000	
Drafting		2,000	
Photography		2,000	
Blueprinting		2,000	
Travel		20,000	
Technical Information and Data		2,000	
Report Production		3,000	

		37,000	37,000

		Sub-Total	176,405
Accounting, 2% of 176,405		3,528	
Auditing, 2% of 176,405		3,528	
Legal Fees, 4% of 176,405		7,056	
Insurance, 4% of 176,405		7,056	

		21,168	21,168

			197,573
Overhead, 10% of 197,573			19,757

		TOTAL	217,330

TABLE 5.IV

Six Hole Drilling Program Costs.
($CDN(1981))

Project Manager	65 days, 275/day	17,875	
Assistant Manager	65 days, 205/day	13,325	
Geologist	65 days, 230/day	14,950	
Assistant Geologist	65 days, 180/day	11,700	
Secretary	65 days, 75/day	4,875	

	Sub-Total	62,725	
Benefits and Vacation pay	14%	8,782	

		71,507	71,507
Drilling, 840 metres	145 $/metre	121,800	
Petrography, 60 samples	30 $/sample	1,800	
X-Ray, 60 samples	25 $/sample	1,500	
Firing Tests, 60 samples	25 $/sample	1,500	

		126,600	126,600
Telephone, 325 man-days	5 $/man-day	1,625	
Photocopying	5 $/man-day	1,625	
Office Supplies	10 $/man-day	3,250	
Computing	1000 $/month	1,500	
Drafting		3,000	
Photography		3,000	
Blueprinting		3,000	
Travel		30,000	
Technical Information and Data		2,000	
Report Production		3,000	

		52,000	52,000

		Sub-Total	250,107
Accounting, 2% of 250,107		5,002	
Auditing, 2% of 250,107		5,002	
Legal Fees, 4% of 250,107		10,004	
Insurance, 4% of 250,107		10,004	

		30,012	30,012

			280,119
Overhead, 10% of 280,119			28,012

		TOTAL	308,131

TABLE 5.V

Twenty-Four Hole Drilling Program Costs.
($CDN(1981))

Project Manager	100 days, 275/day	27,500	
Assistant Manager	100 days, 205/day	20,500	
Geologist	100 days, 230/day	23,000	
Assistant Geologist	100 days, 180/day	18,000	
Secretary	100 days, 75/day	7,500	

	Sub-Total	96,500	
Benefits and Vacation pay	14%	13,510	

		110,010	110,010
Drilling, 3360 metres	145 $/metre	487,200	
Petrography, 240 samples	30 $/sample	7,200	
X-Ray, 240 samples	25 $/sample	6,000	
Firing Tests, 240 samples	25 $/sample	6,000	

		506,400	506,400
Telephone, 500 man-days	5 $/man-day	2,500	
Photocopying	5 $/man-day	2,500	
Office Supplies	10 $/man-day	5,000	
Computing	1000 $/month	4,000	
Drafting		5,000	
Photography		5,000	
Blueprinting		5,000	
Travel		50,000	
Technical Information and Data		2,000	
Report Production		10,000	

		91,000	91,000

		Sub-Total	707,410
Accounting, 2% of 707,410		14,148	
Auditing, 2% of 707,410		14,148	
Legal Fees, 4% of 707,410		28,296	
Insurance, 4% of 707,410		28,296	

		84,888	84,888

			792,298
Overhead, 10% of 792,298			79,230

		TOTAL	871,528

TABLE 5.VI

Five Hole Sample Analysis Costs.
($CDN(1981))

Project Manager	25 days, 275/day	6,875	
Assistant Manager	25 days, 205/day	5,125	
Geologist	25 days, 230/day	5,750	
Assistant Geologist	25 days, 180/day	4,500	
Secretary	25 days, 75/day	1,875	

	Sub-Total	24,125	
Benefits and Vacation pay	14%	3,378	

		27,503	27,503
Petrography, 50 samples	30 $/sample	1,500	
X-Ray, 50 samples	25 $/sample	1,250	
Firing Tests, 50 samples	25 $/sample	1,250	

		3,000	3,000
Telephone, 125 man-days	5 $/man-day	625	
Photocopying	5 $/man-day	625	
Office Supplies	10 $/man-day	1,250	
Computing	1000 $/month	1,000	
Drafting		2,000	
Photography		500	
Blueprinting		1,000	
Travel		5,000	
Technical Information and Data		2,000	
Report Production		3,000	

		17,000	17,000

		Sub-Total	47,503
Accounting, 2% of 47,503		950	
Auditing, 2% of 47,503		950	
Legal Fees, 4% of 47,503		1,900	
Insurance, 4% of 47,503		1,900	

		5,700	5,700

			53,203
Overhead, 10% of 53,203			5,320

		TOTAL	58,523

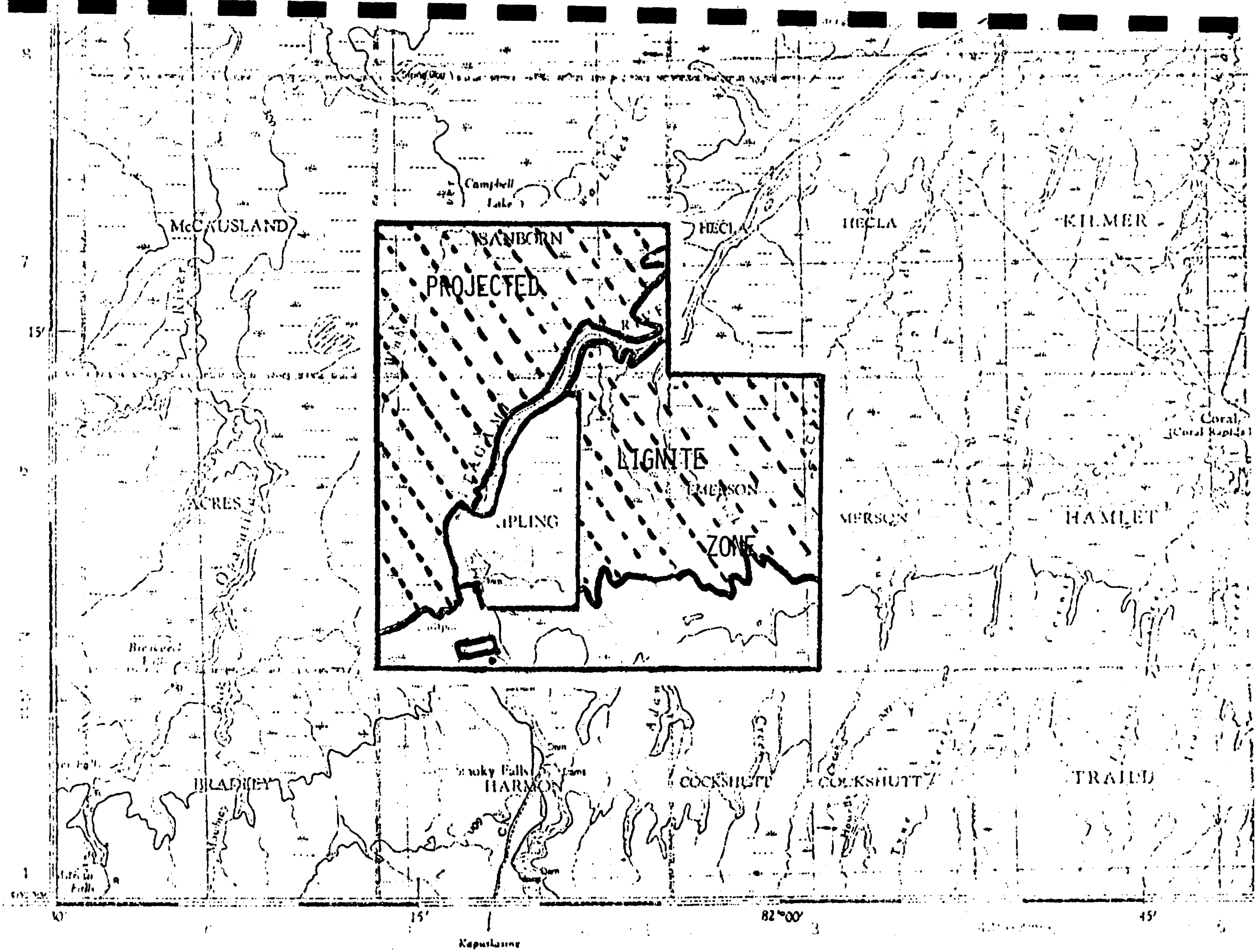


FIG. 5.1 PROJECTED LIGNITE LOCATIONS ON LIGNASCO RESOURCES LIMITED AREA

6. Deposit Valuation.

The Adam Creek lignite found in the 1978 drilling program has an energy content of about 8000 Btu/lb on a dry basis,(6.1) where "dry" implies that moisture has been removed prior to testing. Presuming that the "as received" lignite has a moisture content of 50%, its calorific value is 4000 Btu per pound. Then, to remove the water 540 Btu is required for each pound.(6.2) As a result, each pound of "as received" lignite has 4000-540=3460 Btu. Therefore, for each tonne, (1 tonne = 2200 lb = 1000 kg), the energy content is about 3460(2200) = 7.6 MBtu. In comparison, a barrel of oil contains about 6.4 MBtu and a thousand standard cubic feet of natural gas have 1.0 MBtu. Consequently, each tonne of Adam Creek lignite has the energy equivalent of 1.19 barrels of oil or 7.6 thousand standard cubic feet of natural gas.

However, the energy reserve of the entire deposit depends on the extent of the coal resource.

6.1 Deposit Size.

The extent of the reserve may be catalogued using the specific terminology of the "Coal Conversion Systems Technical Data Book," published by the U.S. Department of Commerce,(6.3) and the Canadian Department of Energy, Mines and Resources.(6.4) These definitions are shown schematically in Fig. 6.1, and the areas are represented on the Lignasco Resource Limited tract in Fig. 6.2.

Measured reserves are defined as those that fall in the 1/4 mile radius cylinder around the drillhole, indicated reserves fall in the 1/4 to 1/2 mile radius cylinder around the drillhole and inferred reserves lie in the 1/2 to 1-1/2 mile radius cylinder around the drillhole.

The reserve is then the area of the appropriate cylinder multiplied by the measured deposit depth times the density of the lignite. That is

Reserve = Area x Depth x Density

The results are summarized in Table 6.I for a horizontal 6 metre thick lignite seam. If the resource extends to 1/4 mile around the 78-06 drillhole, the "measured" deposit is 3.3 million tonnes. Then, extending beyond 1/4 to 1/2 mile, the "indicated" deposit is 9.8

million tonnes. Finally, when the lignite extends from 1/2 to 1-1/2 mile beyond the inner cylinders, the "inferred" deposit is 104.4 million tonnes. Thus, the total is 117.5 million tonnes, over an area of 1-1/2 miles radius (7.07 square miles).

The area marked by the 1-1/2 mile radius circle represents about 5% of the land tract. If the deposit is projected to lie over twice the radius, or four times the area, the reserve would be 470 million tonnes.

6.2 Field Energy.

The economic value estimate of the lignite in the deposit is based on:

a) The reserves.
b) The energy available in the coal.
c) The recovery factor.
d) The demand for the product.

First, the energy content is evaluated from the relationship

Estimate = Deposit x Unit Energy x Recovery Factor

= Deposit (tonnes) x 2200 lb/tonne x 3460 Btu/lb x 0.5

= Deposit (tonnes) x 3,806,000

The results of the calculation are shown in Table 6.II, where the net energy for each pound of lignite has been reduced to account for in-situ dehydration, and the deposit energy is conservatively presumed 50% recoverable.

6.3 Deposit Value.

The value of the deposit can be inferred by comparing the "net inferred deposit" to its equivalent: in oil at the world price; in natural gas at the boundary price; and in Atlantic coal on the Canadian market.

Based on the recoverable energy estimate, if the deposit extends over 1-1/2 miles from the site of the located seam, there are 117.5 million tonnes of coal. The energy commodity is equivalent to 69.9 million barrels of oil or 397.4 Billion standard cubic feet of natural gas as indicated in Table 6.III. Thus, the value of the deposit is estimated at $2097 million based on equivalent barrels of oil at $30 per barrel or $2237 million based on equivalent standard cubic feet of natural gas at $5 per thousand cubic feet. Other values for equivalent oil and gas prices are shown in Tables 6.IV to 6.V.

The selling price for lignite certainly depends on the market conditions or demand for the product. The value of maritime coal FOB the mines has been estimated as high as 46.79 $CDN (1978)/tonne.(6.5) Assuming an inflation of 15%, this becomes 61.88 $CDN (1981)/tonne. Presuming a delivered price of 50% the price above ($35.58 per tonne) and a delivery cost of $15 per tonne,(6.6) the net sale price is $20.58 per tonne F.O.B the site. The 117.5 million tonne deposit is then valued at $2418.15 million.

6.4 Competition.

It is noted that at this time there may be a oil and gas supply capability which exists in Canada. However, that supply is 3000 to 5000 Km distant from the Ontario user for whom the product is intended and some 3000 to 6000 Km distant from available US markets.

6.5 Insurance.

It is pointed out here that insurance policies covering delivery problems deriving from political situations can be underwritten.

6.6 References.

6.1. Guillet, G.R., "Fossil Fuel Programme, Moose River Drilling Project, District of Cochrane," Ontario Geological Survey OFR (Open File Report) 5276, 121 p., 8 Tables, 4 Figures, 16 Photos (Xerox copies), Two figures in back pocket, 1979.

6.2. Bain, R.W., "Steam Tables 1964," Department of Scientific and Industrial Research, National Engineering Laboratory, Her Majesty's Stationary Office, Edinburgh, 1964.

6.3. "Coal Conversion Systems Technical Data Book," U.S. Department of Commerce, National Technical Information Service, Report No. HCP/T2286-01, NTIS, Springfield, Va., 1978.

6.4. Bielenstein, H.U., Chrismas, L.P., Latour, B.A., Tibbetts, T.E., "Coal Resources and Reserves of Canada," Energy Mines and Resources Canada, Report Number 79-9, Ministry of Supply and Services Canada Catalog Number M23-14/79-9, December 1979.

6.5. ibid., page 2.

6.6. Mainville, P., Transit Inspector, Canadian Freight Association, Toronto, Ontario, 1980.

6.7. "The National Energy Programme," Energy Mines and Resources, Canada, Report Number EP 80-4, November 1980.

TABLE 6.I

Lignite Reserves in the Region of Drillhole 78-06.

Reserve	Radius Mile	Area Sq. Mi.	Acre	Deposit Tonnes*	
Measured	0.25	0.196	125	3.3	MM**
M + Ind	0.50	0.785	502	13.3	MM
	0.75	1.767	1131	29.7	MM
	1.00	3.141	2010	53.1	MM
	1.25	4.909	3141	82.9	MM
M+Ind+Inf	1.50	7.069	4524	117.5	MM
	2.25	15.904	10176	264.3	MM
	3.00	28.274	18096	470.0	MM

M = Measured
Ind = Indicated
Inf = Inferred

Measured Reserves.................= 3.3 MTonne

Indicated Reserves.(13.46- 3.36)M = 9.8 MTonne

Inferred Reserves.(121.12-13.46)M = 104.4 MTonne

Total.............117.5 MTonne

* 1 tonne = 1000 kg = 2200 lb.

** MM = 1,000,000

TABLE 6.II

Net Lignite Resource
Centred at the Region of
Drillhole 78-06.

Reserve	Deposit (million tonnes)	Energy (million million Btu)
"measured"	3.3	12.8
"indicated"	9.8	37.2
"inferred"	104.4	397.4
TOTAL	117.5	447.4

TABLE 6.III

Coal, Oil and Gas Equivalents

Reserve	Net Coal (million tonnes)	Oil Equivalent (million bbls)	Gas Equivalent (billion SCF)
Measured	3.3	2.0	12.8
Indicated	9.8	5.8	37.2
Inferred	104.4	62.1	397.4
TOTAL	117.5	69.9	447.4

TABLE 6.IV

Coal Value Based on Oil Price
in $Million

Reserve	Oil Barrel Equivalent Million bbl	Deposit Value $ Million			
(World Oil Price Projections) ($/bbl)		(20)	(30)	(40)	(50)
Measured	2.0	40	60	80	100
Indicated	5.8	116	174	232	290
Inferred	62.1	1242	1863	2484	3105
Total	69.9	1398	2097	2796	3495

TABLE 6.V

Coal Value Based on Natural Gas Price
in $Million

Reserve	Natural Gas Equivalent Billion SCF	Deposit Value $ Million			
(Boundary Gas Price) ($/MSCF)		(2.5)	(5.0)	(7.5)	(10.0)
Measured	12.7	32	64	96	128
Indicated	37.2	93	186	279	372
Inferred	397.4	994	1987	2981	3974
Total	447.3	1118	2237	3356	4474

Note: In the October 1980 Canadian Federal Government Budget, the "Boundary Price" for gas at Toronto City Gate, on 5 November 1980 is $US 4.47 or $CDN 5.14, per thousand standard cubic feet. The price is planned to be increased for each SCF by $US 0.45 per annum ($CDN 0.52) to 1983 and from 1983 by $US 0.75 ($CDN 0.86) per annum.(6.7)

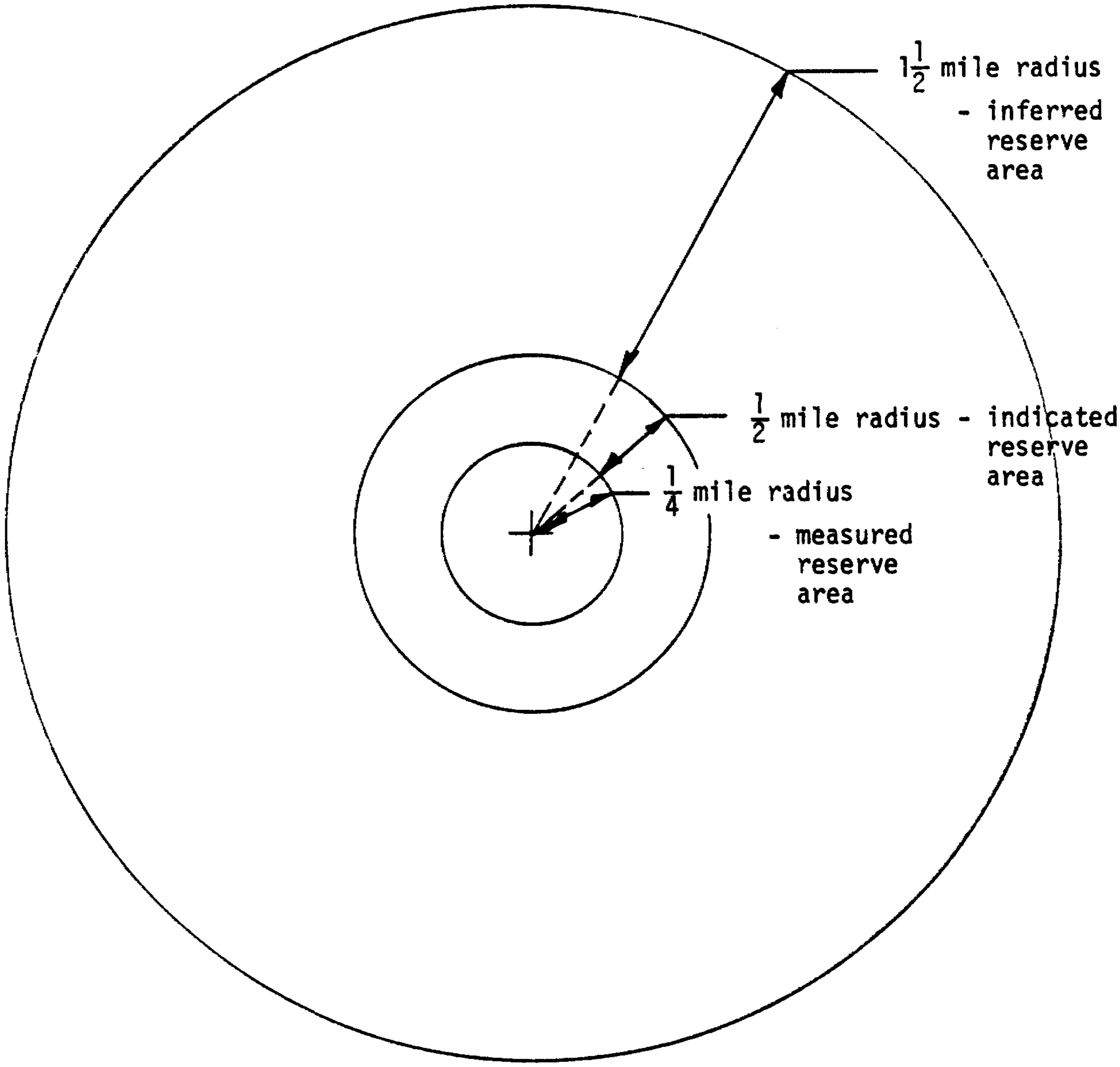


FIG. 6.1 DEFINITION OF THE AREAS OF A COAL DEPOSIT

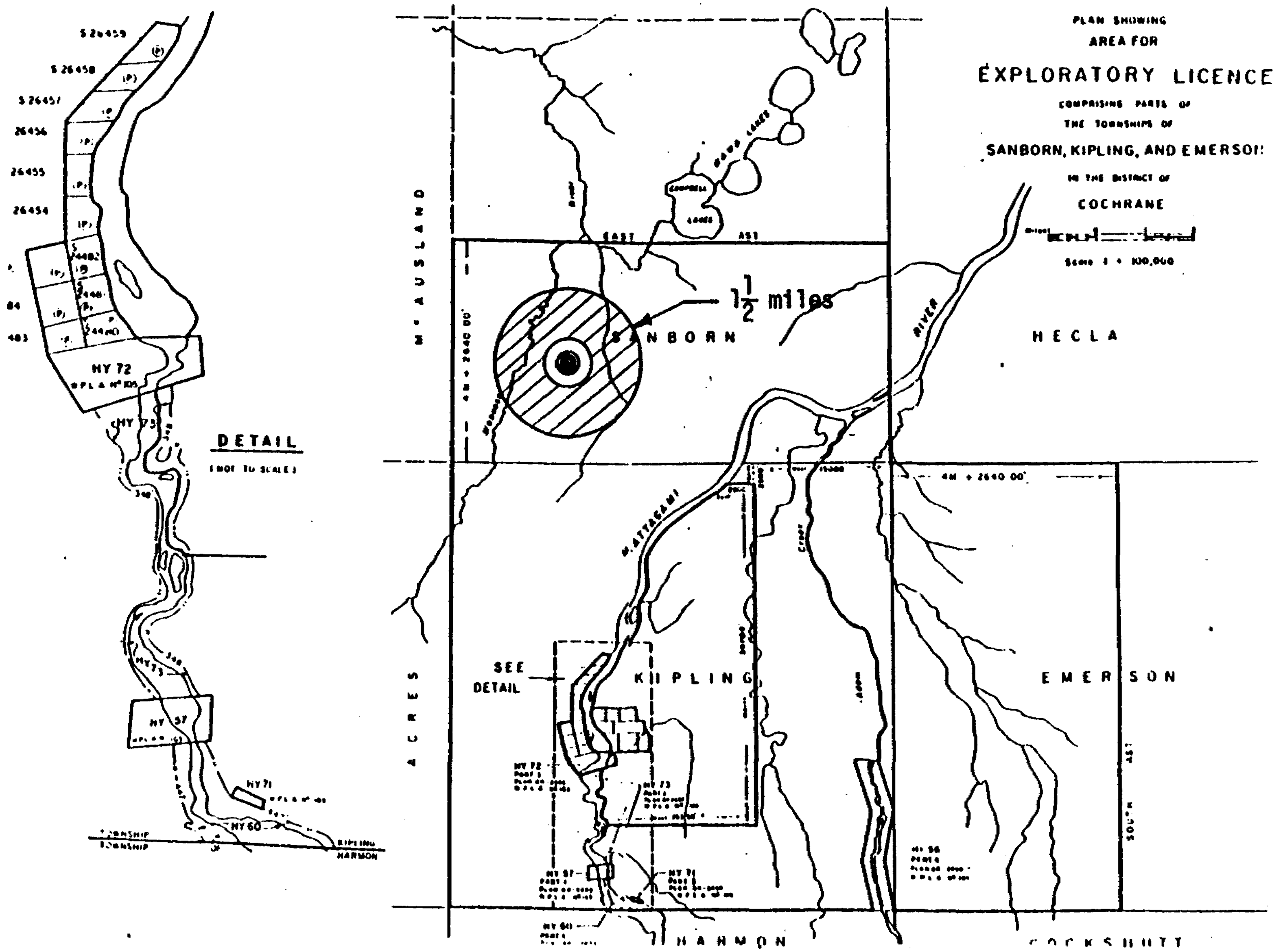


FIG. 6.2 COAL RESOURCES DEFINITION APPLIED TO LIGNASCO RESOURCES LIMITED AREA.

7. Coal Conversion Studies.

For the most advantageous economic realization of the deposit, it is imperative that the conversion scheme be matched to the specific lignite found in the deposit. Consequently, a concurrent coal conversion process selection routine must be addressed.

This program involves technological and economic assessments of successful coal conversion methods as well as visits to plant sites for on-hand evaluation. The costs for this portion of the program are presented in Table 7.I and amount to $364,462.

TABLE 7.IV

Coal Conversion Study Costs
($CDN(1981))

Project Manager	120 days, 275/day	33,000	
Assistant Manager	120 days, 205/day	24,600	
Geologist	25 days, 230/day	5,750	
Engineer	200 days, 230/day	46,000	
Assistant Engineer	175 days, 180/day	31,500	
Librarian	175 days, 125/day	21,875	
Secretary	175 days, 75/day	13,125	
Secretary	120 days, 75/day	9,000	

	Sub-Total	184,850	
Benefits and Vacation pay	14%	25,879	

		210,729	210,729
Telephone, 1110 man-days	5 $/man-day	5,550	
Photocopying	5 $/man-day	5,550	
Office Supplies	10 $/man-day	11,100	
Computing	1000 $/month	6,000	
Drafting		2,000	
Blueprinting		2,000	
Travel		40,000	
Technical Information and Data		10,000	
Report Production		3,000	

		85,100	85,100

		Sub-Total	295,829
Accounting, 2% of 295,829		5,917	
Auditing, 2% of 295,829		5,917	
Legal Fees, 4% of 295,829		11,833	
Insurance, 4% of 295,829		11,833	

		35,500	35,500

			331,329
Overhead, 10% of 331,329			33,133

		TOTAL	364,462

8. Plant Cost Estimation.

The plant capital and operating costs for the conversion of coal to other hydrocarbon commodities has to be estimated. These are discussed in the following sections, where the costs for design, construction and operation of the in-situ coal conversion plant are assessed.

8.1 Plant Size.

For a deposit extent of 1-1/2 miles (2.4 Km) radius, the net energy content is 447.4 thousand billion Btu.

Based on a compendium of coal gasification processes, 25% to 50% of the coal in the deposit can be converted to pipeline quality gas.(8.1,8.2) Therefore, since the net energy in the deposit is 69.9 million barrels of oil or 447.4 billion standard cubic feet of natural gas, the yield of the deposit is 17.5 to 35 million barrels of oil or 112 to 224 billion SCF of pipeline quality gas.

The conversion plant is sized to develop this resource over a period of at least twenty years. As such, for the 25% conversion program, the plant is sized to produce 900,000 barrels of oil per annum (2400 bbl/day) or 5.6 Billion SCF per annum (15.3 million SCF per day).

8.2 Basis of The Estimation.

The plant costs are based on a study conducted by the Lawrence Livermore National Laboratory (LLL) in 1974,(8.3) and updated using the analyses of Synthetic Fuels Associates, Inc. in 1980. In these studies, the plants produce a methane dominated producer gas in-situ and upgrades the product to pipeline quality gas of about 1000 Btu/SCF.

The base plant, whose production is 40 billion SCF of pipeline quality gas is scaled down to 5.6 billion SCF per annum, that is, by a factor of 7.14. This allows production appropriate to the minimum 20 year production term for the deposit.

8.3 Plant Unit Costs.

For the 40 BCSF per annum base plant, the 1980 US dollar costs are shown in Table 8.I. These capital costs total $US (1980) 410. In Table 8.I, the 1980 US dollar costs are increased by 15% to 1981 due to inflation and by a factor of 1.2 to Canadian dollars: The conversion factor is $1US(1980)=$1.38CAN(1981). As a result, the capital cost for the base plant is $CDN(1981) 565.2 million.

Now, the planned facility involves a decrease of the base size, by a factor of 7.14. However, reducing the plant size decreases cost by only 40% each time production is halved. Therefore, the cost for each component of the facility is decreased by a factor of 4.26(8.4) and the results are shown in Table 8.II. The total capital cost is decreased to $CDN(1981) 132.6 million.

8.4 Operating Costs.

The operating costs are itemized in Table 8.III and without escalation amount to $34.8 million per annum. These costs include process heat coal which could have been available for sale.

8.5 Schedule for Construction.

Construction of the plant is undertaken in three stages. One-sixth of the construction is undertaken in the first year, one-third in the second and one-half in the final year (Table 8.IV).

8.6 Concluding Remarks.

It is difficult to project ahead four years in a field with rapidly advancing technology. Indeed, as some components for conversion plants are now available as stock items in the United States and Japan, costs are modified.

Yet, the major capital advantage of the in-situ conversion plant is the bypass of the first stage reactor. This vessel, required to operate at 10 to 70 atmospheres pressure,(8.5) and up to 2000C temperature, is replaced by a "natural" reactor formed underground. The savings are reflected in the plant capital cost of Furthermore, if the deposit extent exceeds 117.5 million tonnes of coal, or if the rate of recovery exceeds 0.5 and the rate of conversion is greater than 25%; the plant life will extend beyond 20 years and further cost advantages result.

8.7 References.

8.1. Howard-Smith, I., Werner, G.J., "Coal Conversion Technology," Noyes Data Corporation, Park Ridge, New Jersey, 1976.

8.2. Stephens, D.R., coordinator, "Underground Coal Conversion," course number 885.76, "University of California, Los Angeles," 2-6 March 1981.

8.3. Stephens, D.R., "Revised Cost Estimate for the LLL In-Situ Coal Conversion Concept," Lawrence Livermore Laboratory Report Number UCEL-51578, 1974.

8.4. Massey, L.G., "Coal Gasification for High and Low Btu Fuels," in "Coal Conversion Technology," Wen, C.Y., Lee, E.S., eds., Addison-Wesley, Reading, MA, 1979, pp. 313-427.

8.5. Cappello, V.F., "Simplifying Scaleup Cost Estimation," in "Calculation Shortcut Deskbook," McGraw-Hill, New York, NY, undated, page 8.

TABLE 8.I
Installed Process Equipment
Gas Processing Plant
40 BSCF per annum Coal Conversion Plant

Unit	1980 Cost $US Million	1981 Cost $US Million	1981 Cost $CDN Million
Oxygen Plant	90.0	103.5	124.2
Gas Distribution and Gathering	22.0	25.3	30.4
Product Gas Compression	22.0	25.3	30.4
Acid Gas Removal and Sulphur Recovery	50.0	57.5	69.0
Tar and Dust Removal	33.0	38.0	45.5
Shift Conversion	35.0	40.3	48.3
Carbon Dioxide Removal	25.0	28.8	34.5
Methanation and Drying	10.0	11.5	13.8
General Facilities	60.0	69.0	82.2
Utilities	63.0	72.5	86.9
TOTAL	410.0	471.7	565.2

Note: $1US(1980) = $1.15US(1981)
$1US(1981) = $1.20CDN(1981)
$1US(1980) = $1.38CDN(1981)

TABLE 8.II
Installed Process Equipment
Gas Processing Plant
5.6 BSCF per annum Coal Conversion Plant

Unit	1981 Cost 40 BSCF Plant $CDN(1981)million	5.6 BSCF Plant $CDN(1981)million
Oxygen Plant	124.2	29.2
Gas Distribution and Gathering	30.4	7.1
Product Gas Compression	30.4	7.1
Acid Gas Removal and Sulphur Recovery	69.0	16.2
Tar and Dust Removal	45.5	10.7
Shift Conversion	48.3	11.3
Carbon Dioxide Removal	34.5	8.1
Methanation and Drying	13.8	3.2
General Facilities	82.2	19.3
Utilities	86.9	20.4
TOTAL	565.2	132.6

TABLE 8.III

Annual Operating Costs for Surface Plant Facilities for 5.6 BSCF per annum Coal Conversion Plant

Item	1981 Costs $CDN(1981) Million
Coal for Process Heat*	1.4
Drilling (5% of Capital Cost)	6.6
Labour (25 men per shift)	3.3
Land	0.5
Maintenance (10% of Capital Cost)	13.2
Chemicals (5% of Capital Cost)	6.6
Sub-Total	31.6
Management (10% of Sub-Total)	3.2
TOTAL	34.8

* The cost for process heat coal is included, since this coal could have been available for sale.

TABLE 8.VI

Construction Cost Schedule
$CDN 132.6 Million (1981)
5 Billion SCF per annum Coal Conversion Plant

Year	$CDN (1981) Million
First	22.1
Second	44.2
Third	66.3

TOTAL COST	132.6

9. Environmental Discussion.

The effect of a coal gasification plant on the environment and the social fabric of the neighbouring and immediate regions must be considered. It is realized, of course, that at this stage of the project the questions that arise cannot fully be answered. However, the notions will be borne in mind throughout the program.

9.1 Worker Safety.

With the large push to coal utilization, traditional coal mining will likely increase. The practice of in-situ coal conversion to obtain the resource is safer than mining the commodity. In-situ conversion will, then, save lives that might otherwise be lost.

9.2 Dirtiness of Coal Combustion.

The major difficulty in the combustion of the coal is the cleanliness of its burning. Mined coal, particularly of the lower grades, produces carbon dioxide and water when burned. However, these products are accompanied by quantities of carbon monoxide, formaldehyde and alcohol. Furthermore, if there are contaminants, such as sulphur, these also will show up in the product mix.

Carbon dioxide cannot be avoided, but is acceptable, since it plays a necessary role in the ecological balance. However, carbon monoxide actively removes oxygen and is a suffocant. Sulphur appears in the form of sulphur dioxide and hydrogen sulphide. These compounds can be scrubbed from the coal. Indeed, they must be removed because of the implications of "acid rain" which are just now being appreciated in the community. Other concerns, such as the cleanliness of crushing operations and transporation effects, are important.

9.3 Carcinogens in Surface Conversion.

Extremely important, although often overlooked, is the question of the production of polynucleide aromatic compounds, PNA.(9.1) Recognized as carcenogenic, these products may appear during coal conversion.

9.4 Groundwater Effects.

Groundwater effects and the behaviour of aquafers to in-situ coal conversion must be considered.(9.2) The effects will be examined as part of the test facility program.

9.5 Subsidence.

The general lowering of the land surface as a result of possible voiding during the in-situ conversion process will be examined in the test facility phase of this coal conversion program.(9.3) Such voiding msy be precluded by the boggy nature of the terrain. However, if subsidence does occur, it may assist drainage of the area. In any case, it is the Author's opinion that strip mining down 100m is probably more traumatic to the area than 6m of subsidence.

9.6 Summary.

In environmental areas, in-situ gasification shows benefits, particularly when coupled to low-sulphur coal deposits. In particular, the Adam Creek low sulphur coal will have a low production of sulphur-bearing compounds, thus requiring little scrubbing. Next, in-situ gasification attacks coal underground so that any PNA which might form is destroyed before the producer gas is brought to the surface. Coupled with the advantages that precluding mining offers, there are distinct advantages to the in-situ approach.

In addition to the personal health advantages, subsidence which may occur will help drain the region aiding other developments such as the mining of industrial minerals and the growth of primary production in northeastern Ontario.

The consequence is that in-situ coal gasification not only offers cost advantages, it is much safer for the workers than conventional forms of coal energy extraction. It promises fewer adverse effects on the environment, since there is no "mining," is best suited to the weakest grades of coal combustibles, and does not carry the premium costs for transportation of solids.

9.1 References.

9.1. Munro, L.A., "Chemistry in Engineering," Prentice-Hall, Englewood Cliffs, New Jersey, 1964, pp. 19-26.

9.2. Wang, F.T., "Effects of Underground Coal Gasification on Ground Water Quality," in "Underground Coal Conversion," course number 885.76, University of California, Los Angeles, California, 2-6 March 1981.

9.3. Ganow, H., "Subsidence Associated with In-Situ Coal Gasification," in "Underground Coal Conversion," course number 885.76, University of California, Los Angeles, California, 2-6 March 1981.

10. Social Impact.

The effect on the residents of any region in which a plant is constructed should be considered. So far, there are two aspects which have been identified. First are the rights and privileges which the inhabitants of the region have; and second are the effects that the plant may have since development will be encouraged by the nature of the product.

10.1 Native Peoples.

Regarding the former, the particular rights of Native Peoples may be effected, since neighbouring lands may have coal deposits on them or, since Indian People may want to be employed. Also, non-native resident rights must be respected.

10.2 Other Considerations.

There should be great confidence that the conversion of coal to transportable gaseous and liquid fuels using an in-situ gasification approach, will not only prove to have powerful benefits for the region, it will reduce the environmental burdens which may be imposed by other energy production methods. These benefits will accrue not only to the north, where the area is essentially virgin, but also will accrue to urban centers where additional environmental burdens would be detrimental.

11. Project Economics.

The costs for the program are summarized in this section. These costs are discussed along with gross revenues and expenditures.

The development has been planned to involve seven phases. These phases are shown in Table 11.I. As discussed in Section 1, the first phase constitutes the study of the overall project, securing the land and establishing the program. The following phases include exploration, test facility design and operation, full scale plant design and construction, and production. The initial costs are outlined in Table 11.II.

11.1 Preliminary Costs.

The preliminary costs include the project planning costs of about $500,000 and fund raising commissions of $150,000; for a total of $650,000.

11.2 Exploration Costs.

Following these preliminary costs are the exploration costs To be expended. The exploration is carried out in two years. The first year involves the four hole ($217,330) and six hole ($308,131) drilling programs described in Section 5. These programs are accompanied by a supplementary analysis program ($58,523) of additional core analyses. The cost of these programs is $583,984.

In the second year, a 24 hole drilling program is to be put is place to map the details of the deposit. The cost for this porion of the program is $871,528.

Therefore, the total drilling expenditure over the two exploration phases is $1,455,512.

11.3 Conversion Study Costs.

The costs for the study of coal conversion, necessary to match the lignite resource to the energy extraction method, is $364,462 (See section 7). This cost is shared equally between years 2 and 3.

11.4 Plant Size and Costs.

It has been assumed, based on the existing coal conversion experience,(11.1) that 25 to 50% of the net deposit can be converted to fluid products using existing technology. For the 25% conversion factor, the energy equivalent of 17.5 million barrels of oil or 112 billion SCF of natural gas can be produced. At 50% conversion, 35 million barrels of oil or 224 billion SCF of natural gas can be produced.

To operate the plant for at least 20 years, the plant is sized to accomodate the production of 5.6 billion SCF of pipeline quality gas per annum. It is pointed out here, that is conversion extends to 50%, the 5.6 billion SCF per annum plant will produce for 40 years. As was illustrated in Section 8, the plant cost is $CDN(1981) 132.6 million.

11.5 Test Facility.

A test facility will be constructed to establish the particular operating conditions appropriate to the conversion of coal from the Adam Creek deposit. This test facility will later take the form of a pilot plant. (The use of pilot plants is standard practice in the chemical processing industry.)

This test facility will be sized to convert coal at 5% of the rate of the full-scale plant. On the same basis as the pricing of the full-scale plant, the cost of the pilot plant will be about $14,579,000.

11.6 Pre-Production Costs.

The pre-production project costs in 1981 dollars are itemized in Table 11.II. These costs, for the first seven years, total $149,648,974 in 1981 Canadian dollars. These costs are shown as a percentage of the total pre-production project cost in Table 11.III.

11.7 Production Costs.

The operating costs total approximately $34.5 million per annum. These costs are presumed to increase at a "real" rate of 10% per annum. Therefore, first year production cost is $34.5 million, the tenth year is $53.5 million and the twentieth year production cost is $87.2 million. The cumulative production cost is $1141 million.

11.8 Product Value.

The product value is shown in Table 11.IV. The values shown in the table are based on the $US 4.47/MSCF ($CDN 5.14/MSCF) border price for natural gas at the Toronto City Gate, as projected on the basis of the Government of Canada, October 1980 Budget.(11.2) The price of the commodity is to escalate by $US 0.45/MSCF ($CDN 0.52/MSCF) per annum to 1983, and then to go up by $US 0.75/MSCF ($CDN 0.86/MSCF) per annum. Although the final price is to be 85% of the "World Price" based on equivalent barrels of oil, it is more conservative to assume here that the price increase is only 10% per annum. The gross product value is $3923 million.

11.9 Transportation Costs.

Transportation costs for each thousand cubic feet of the product for delivery a distance of 1500 Km from the plant are about $CDN 1/MSCF, where the actual shipping cost is based on cited 1978 prices.(11.3) The cost projection includes the installation cost of a 6 inch diameter branch to the site from the existing pipeline, approximately 100 Km distant, and the cost of one pumping station.

Also, since transportation costs are related to the price for energy, the "real" transportation cost is assumed to increase at $CDN 0.1/MSCF from 1987. The cost for transportation of 5.6 billion SCF of pipeline quality gas is $5.6 million in the first year, $10.64 million in the tenth year and $16.24 million in the twentieth year of production.

The gross transportation cost is $218.4 million over the entire program.

11.10 Gross Earnings and Internal Rate of Return.

The gross earnings before interest and taxes is the difference between revenues of $3923 million and the costs of $1489 million and amounts to $2434 million.

The investments are made without return during the first seven years of the program. The project, fully equity funded shows an internal rate of return of about 38% per annum for the entire 27 years of the program.

11.11 References.

11.1. Howard-Smith, I., Werner, G.J., "Coal Conversion Technology," Noyes Data Corporation, Park Ridge, New Jersey, 1976.

11.2. "The National Energy Programme 1980," Department of Energy Mines and Resources, Canada, Report Number EP 80-4, Government of Canada, Ottawa, Ontario, 1980.

11.3. "Oil and Natural Gas Industries in Canada 1978," Energy, Mines and Resources Canada, Report Number ER 78-2, Department of Supply and Services Catalog Number M23-14/78-2, 104 pages, 1978, Ottawa, Canada, pp. 51-58.

TABLE 11.I

Program Phases

Item	Phase	Year(s)	Duration, year(s)
I	Planning	0	1
II	Exploration I	1	1
III	Exploration II	2	1
IV	Test Facility	3	1
V	Plant Design	4	1
VI	Plant Construction	5-6	2
VI	Production	7	20...

TABLE 11.II

Pre-Production Project Costs
(Million $CDN 1981)
Twenty Year Production, 5.6 Billion SCF Coal Conversion Program.

Phase	Year	Item	Costs	
I	1	Project Planning	650,000	650,000
II	2	Exploration I		
		Exploration	583,984	
		Conversion Studies	182,231	766,215
III	3	Exploration II		
		Exploration	871,528	
		Conversion Studies	182,231	1,053,759
IV	4	Test Facility	14,579,000	14,579,000
V	5	Plant Design	22,100,000	22,100,000
VI	6	Plant Construction	44,200,000	44,200,000
	7	Plant Construction	66,300,000	66,300,000
			TOTAL	149,648,974

TABLE 11.III

Pre-Production Project Cost Percentages
($CDN Million, 1981)
Twenty Year Production, 110 BSCF Coal Conversion Program.

Year	1981 Costs $ million	% of Total	Cumulative %
1	0.650	0.434	0.434
2	.766	.511	.945
3	1.034	0.691	1.636
4	14.579	9.744	11.380
5	22.100	14.770	26.150
6	44.200	29.540	55.690
7	66.300	44.310	100.000
Totals	149.648	100.000	100.000

TABLE 11.IV

Annual Product Value durins Production Period.
Twenty Year Production Prosram,
Based on Projected Canadian Boundary Price.

Year	Proj Year	Prod Year	Boundary Price $CDN(1981)	Product Value $CDN(1981) million
1982	0	-	5.66	-
1983	1	-	6.18	-
1984	2	-	6.70	-
1985	3	-	7.56	-
1986	4	-	8.42	-
1987	5	-	9.28	-
1988	6	-	10.14	-
1989	7	-	11.15	-
1990	8	1	12.23	68.5
1991	9	2	13.46	75.3
1992	10	3	14.80	82.9
1993	11	4	16.28	91.2
1994	12	5	17.91	100.3
1995	13	6	19.70	110.3
1996	14	7	21.67	121.4
1997	15	8	23.84	133.5
1998	16	9	26.22	146.8
1999	17	10	28.84	161.5
2000	18	11	31.73	177.7
2001	19	12	34.90	195.4
2002	20	13	38.39	215.0
2003	21	14	42.23	236.5
2004	22	15	46.45	260.1
2005	23	16	51.10	286.1
2006	24	17	56.21	314.8
2007	25	18	61.83	346.2
2008	26	19	68.01	380.8
2009	27	20	74.81	418.9
			Total Returns	3,923.3 million$

12. Funding Scenario.

Various funding scenarios for this coal conversion program. One of these scenarios involves approximately 60% debt funding and 40% equity funding, with the dispersements as shown in Table 12.I. In the table, the funding for the first three years of the program are wholly from equity sources. Then, in later years as the plant is constructed, the major proportion of capital financing is on a debt-funded basis.

The view seen here offers a program with about $57 million in equity and $92 million in debt funding.

12.1 Financing the Debt.

The debt is repaid during the production period. To calculate the carrying charge, the debt is brought forward to the production years at a finance rate of 20% as shown in Table 12.II. The total is, therefore, $130,002,658 and is carried into production at an annual rate of 20% for $26,000,532 per annum.

12.2 Unit Cost of Service.

The unit cost of service can now be established using the production, transportation, and finance costs, and the plant depreciation. These data are tabulated in Table 12.III, and plotted along with the Boundary Price in Fig. 12.1. As the illustration shows, for a program begun in 1982, breakeven occurs in 1990.

12.3 Discussion.

Other scenarios are possible. Nevertheless, the balance of debt and equity financing shown here leads the way to other, more creative and economically profitable approaches.

TABLE 12.I

Funding Scenario 60% Debt/ 40% Equity
($CDN(1981))

Year	Funds	Equity (%)	Debt (%)
1	650,000	650,000 (100)	(0)
2	766,215	766,215 (100)	(0)
3	1,053,759	1,053,759 (100)	(0)
4	14,579,000	8,747,400 (60)	5,831,600 (40)
5	22,100,000	7,735,000 (35)	14,365,000 (65)
6	44,200,000	15,470,000 (35)	28,730,000 (65)
7	66,300,000	23,205,000 (35)	43,095,000 (65)
TOTAL	149,648,974	57,627,374 (39)	92,021,600 (61)

TABLE 12.2

Carrying the Debt to the Production Period

Year	Debt	Years to Carry	Carry Factor	Indebtedness
4	5,831,600	4	2.074	12,094,738
5	14,365,000	3	1.728	24,822,720
6	28,730,000	2	1.440	41,371,200
7	43,095,000	1	1.200	51,714,000
			TOTAL	130,002,658

TABLE 12.III

Estimated Unit Cost of Service

Costs ($/Thousand SCF)

Year	Production	Transportation	Financing	Depreciation	Total
8	6.16	1.00	4.61	1.18	12.95
9	6.47	1.10	4.61	1.18	13.36
10	6.79	1.20	4.61	1.18	13.78
11	7.13	1.30	4.61	1.18	14.22
12	7.49	1.40	4.61	1.18	14.68
13	7.86	1.50	4.61	1.18	15.15
14	8.26	1.60	4.61	1.18	15.65
15	8.67	1.70	4.61	1.18	16.16
16	9.10	1.80	4.61	1.18	16.69
17	9.56	1.90	4.61	1.18	17.25
18	10.04	2.00	4.61	1.18	17.83
19	10.54	2.10	4.61	1.18	18.43
20	11.06	2.20	4.61	1.18	19.05
21	11.62	2.30	4.61	1.18	19.71
22	12.20	2.40	4.61	1.18	20.39
23	12.81	2.50	4.61	1.18	21.10
24	13.45	2.60	4.61	1.18	21.84
25	14.12	2.70	4.61	1.18	22.61
26	14.83	2.80	4.61	1.18	23.42
27	15.57	2.90	4.61	1.18	24.26

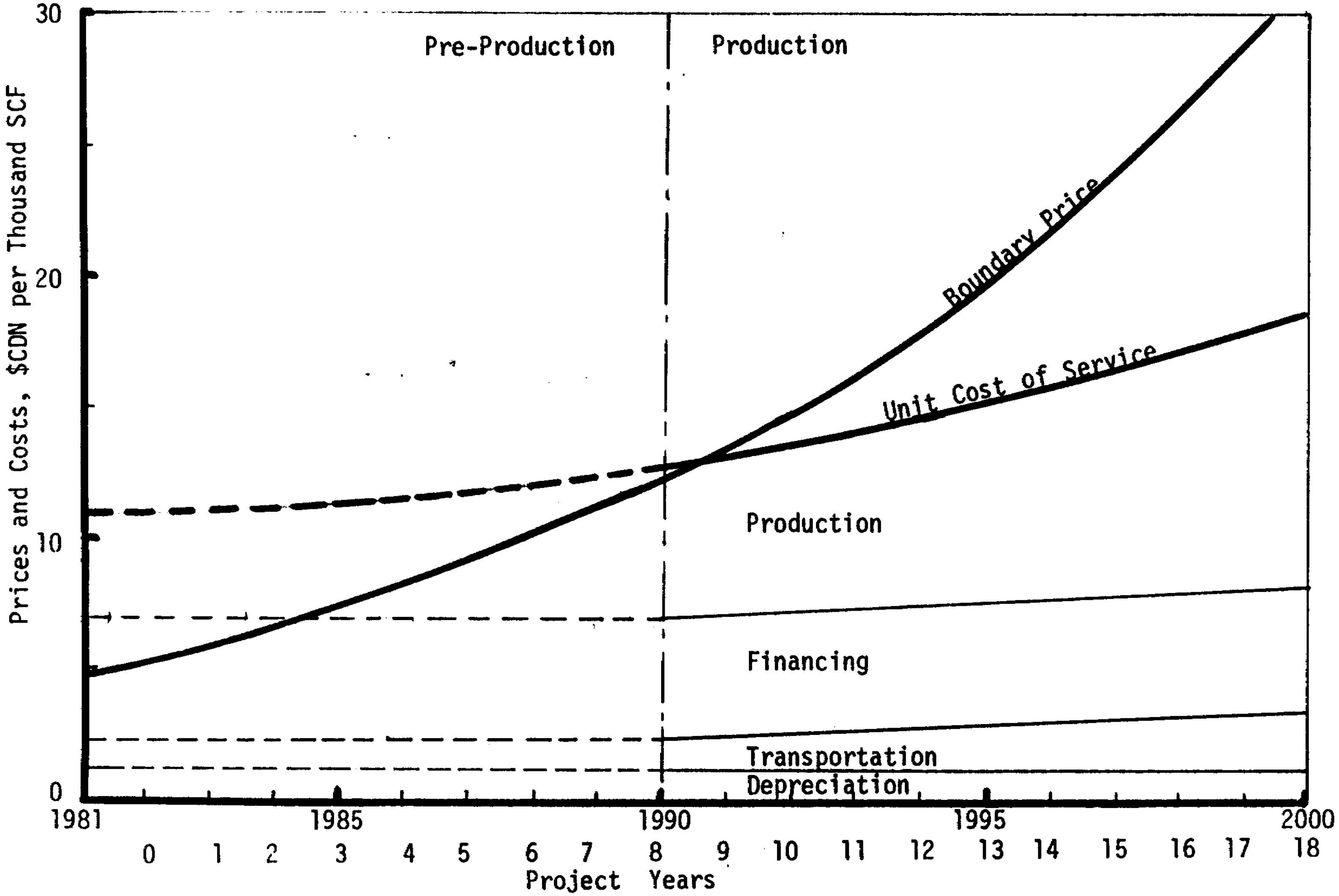


FIG. 12.1 PRICE AND COST RELATIONS FOR PIPELINE QUALITY GAS PRODUCED IN-SITU FROM ADAM CREEK LIGNITE.

13. Concluding Discussion.

The coal conversion program discussed above is based on the use of northern Ontario lignite to produce a hydrocarbon product or chemical feedstock based on in-situ gasification.

The low annual production costs, compared to gross annual revenue and the blended debt/equity financing for capital expenditures over the full project, forms the program financing.

The synthesis gas will be available for use in Ontario or for export. It could play a role, for example, as a domestic fuel source, thus adding to the energy-independance of the province. Its use as a primary chemical feedstock is also important and should not be overlooked. Indeed, this coal deposit can be used to create synthetic natural gas, methanol, jet fuel, gasoline and engineering materials. Furthermore, the development of the area in the neighborhood of the site will encourage new markets for other goods as well as for the plant products.

Next, the development of the program will implement a technology and that technology itself can be exported.

In addition to the above, it should be noted that all estimates are conservative, that no tax advantages have been factored into the economic analysis, that governmental sources of funding have not been addressed (for example, there are depletion allowances, and Federal Department of Regional Economic Expansion funds are available for the region, and there may be direct federal funding), and that the residual coal developed in the gasification process has not been used to aid the economic advantage.

Appendix A - Exploratory Licence of Occupation.

EXPORATORY
LICENCE OF OCCUPATION
NUMBER 14890

TO

LIGNASCO RESOURCES LIMITED

Ministry of Natural Resources
Parliament Buildings,
Toronto, Ont.
M7A 1W3

PROVINCE OF ONTARIO

THE MINING ACT

EXPLORATORY LICENCE OF OCCUPATION

NUMBER 14890

KNOW ALL MEN BY THESE PRESENTS that in consideration of and subject to the terms, provisoes, conditions and restrictions hereinafter contained, I, James A. C. Auld, Minister of Natural Resources for the Province of Ontario, hereinafter referred to as the Minister, do by these Presents give full right and liberty, leave and licence to LIGNASCO RESOURCES LIMITED, incorporated under the laws of Ontario, having its head office at the City of Toronto, its successors and assigns, hereinafter referred to as the "Licensee", to search for, prospect, drill and explore for all minerals excepting natural gas, oil, petroleum, sand and gravel, in, upon and under a certain parcel or tract of land situate in the District of Cochrane, containing an area of 92,745 acres, more or less, and which is more particularly described in Schedule "A" attached hereto.

RESERVING the right to raise, lower or maintain the waters of any lakes, rivers or other bodies of water lying within or near the land described herein.

ALSO RESERVING any lands acquired by Ontario Hydro in connection with the production and distribution of electric power under water power leases HY57, HY71, and HY72

ALSO SAVING AND EXCEPTING thereout and therefrom any lands lying within the limits of the land described herein which have been patented, sold, leased or otherwise alienated or dealt with by the Crown.

TO HAVE AND TO HOLD unto the said LIGNASCO RESOURCES LIMITED for and during the term of three years from the 1st day of May, 1981.

YIELDING AND PAYING therefor to the Treasurer of Ontario in advance the fee of $1000.00 of lawful money of Canada from time to time described hereafter:

1. $1000.00 on or before the execution and delivery hereof,

2. $1000.00 on or before May 1st, 1982

3. $1000.00 on or before May 1st, 1983

PROVIDED that the words set forth hereunder shall, for the purposes of this licence, have the following meanings:

"First Period" means the period of May 1st, 1981 to April 30th, 1982, inclusive.

"Second Period" means the period of May 1st , 1982 to April 30th, 1983, inclusive.

"Third Period" means the period of May 1st 1983 to April 30th, 1984, inclusive.

"Period" means the First Period, Second Period or Third Period as the case may be.

"First Anniversary Date" means May 1st, 1982.

"Second Anniversary Date"means May 1st, 1983.

"Third Anniversary Date"means May 1st, 1984.

"Anniversary Date" means the First Anniversary Date, Second Anniversary Date or Third Anniversary Date, as the case may be.

PROVIDED FURTHER that this licence is subject to the Navigable Waters Protection Act and to any or all rights of Her Majesty the Queen in right of Ontario or Canada and any other person, corporation and commission including Ontario Hydro to control water levels affecting the land described herein and the Licensee shall have no recourse or claim against Her Majesty the Queen in right of Ontario or Canada, Her officers, servants and agents and such other person, corporation and commission including Ontario Hydro by reason of any damages, injury or death caused by or resulting from the exercise of the aforesaid rights.

PROVIDED FURTHER that the Licensee shall within sixty days after each Anniversary Date submit a sworn statement by a responsible officer of the Licensee to the Regional Director, Northern Region, Ministry of Natural Resources, hereinafter referred to as "the Regional Director" providing the following information:

a. Full particulars of the amounts and purposes of all expenditures made by the Licensee in relation to mineral exploration activities carried on during the previous period in respect to the lands subject to this licence.

b. Full particulars of all work, testing, operations and the results thereof performed by the Licensee during the previous period in respect to the lands subject to this licence.

PROVIDED FURTHER that where the Regional Director is not satisfied with the said sworn statement of the Licensee, the Regional Director may send a notice by registered mail to the Licensee, at its last known address recorded in the Ministry of Natural Resources, hereinafter referred to as the "Ministry", requiring the Licensee to submit such further details as may, in the opinion of the Regional Director, be necessary and the Licensee shall provide such further details forthwith.

PROVIDED FURTHER that the Licensee shall:

a. Notify the Regional Director, prior to drilling, of the accurate location and proposed depth of any holes penetrating Phanerozoic rock;

b. Install blow-out protection equipment on any drill holes where a probability exists that gas and/or oil may be encountered;

c. Properly plug all drill holes to prevent transfer of water or Hydrocarbon between formations;

d. Submit to the Regional Director, a detailed core log and plan indicating the location of each drill hole within sixty days after each Anniversary Date;

e. Forward or deliver within thirty days after the end of boring, drilling or deepening operations to the Petroleum Resources Section, Ministry of Natural Resources, at the Licensee's expense.

(i) samples of drill cuttings of Phanerozoic rocks taken throughout the depth of the drill hole from each run or from intervals of not more than 10 feet, and such samples shall be washed, dried and bagged in a bag provided by the Ministry and accurately labelled by the licensee with the depth interval and drill hole number;

(ii) representative core chips of Phanerozoic rocks from intervals of not more than 2 feet and such chips shall be washed, dried and bagged in a bag provided by the Ministry and accurately labelled by the Licensee with the depth interval and drill hole number.

f. Where cores are no longer required by the Licensee for the purpose of analysis, they shall be forwarded or delivered at the Licensee's expense to the Petroleum Resources Section, Ministry of Natural Resources, if requested by the Regional Director;

g. Submit in duplicate, to the Regional Director, full reports and plans of all geochemical, geological and geophysical examinations, detailed core logs and plans indicating the location of each drill hole, full reports and plans of prospecting, testing or other exploratory work for which expenditure credits have been claimed within sixty days after each Anniversary Date;

h. Where cores are taken, pack them in numbered boxes, accurately labelled showing the depth interval and drill hole number and the boxes shall be protected from damage and stored by the Licensee and notify the Regional Director where they are stored.

i. Not destroy any core except for the purpose of analysis nor remove a core from Ontario without the prior written approval of the Regional Director.

PROVIDED FURTHER that the Licensee shall within sixty days after the date of expiration, surrender, cancellation or revocation of this licence, as the case may be, submit in duplicate to the Regional Director full reports and plans of all geochemical, geological and geophysical examinations, drilling, prospecting, testing or other exploratory work carried on in respect to the lands subject to this licence and not otherwise previously submitted.

PROVIDED FURTHER that the Licensee shall have the right to surrender this licence at any time during the term of this licence provided the Licensee shall be liable for and observe in full all of the terms, provisoes, conditions and restrictions as herein provided for the period during which such surrender is made by the Licensee, and those terms, provisoes and conditions and restrictions that would otherwise apply after the expiration of the term of this licence.

PROVIDED FURTHER that servants, employees or agents of the Ministry may at any time or times during the term of this licence, search for, prospect, drill and explore for minerals on the lands subject to this licence and the information derived from such activities may at the discretion of the Minister be disclosed, released or disseminated to any interested person.

PROVIDED FURTHER that the Licensee may within sixty days prior to each Anniversary Date surrender the whole or, excepting as set forth hereinafter, any part or parts of the lands subject to this licence, hereinafter referred to as "Surrender of Lands", and such Surrender of Lands shall be deemed to be effective at the commencement of the period following.

PROVIDED FURTHER that in the event of a Surrender of Lands, the lands retained by the Licensee at any time during the term of this licence if more than one area of land shall be composed of non-contiguous areas of land of not less than four hundred acres each with regular or straight boundaries.

PROVIDED FURTHER that forthwith after any Surrender of Lands as provided herein the Licensee shall provide the Minister with a proper description, satisfactory to the Minister of the lands retained by the Licensee, and should the Minister determine that the aforesaid description is unsatisfactory he may require the licensee to provide a survey satisfactory to the Minister.

PROVIDED FURTHER that it is an express condition of this licence that the Licensee shall make or incur an annual expenditure directly related to the exploration of minerals, hereinafter referred to as "Annual Exploration Expenditure" on the lands subject to this licence, as follows:

a. During the First Period of the term of this licence not less than $329,500

b. During the Second Period of the term of this licence $30 for each acre of land retained and not surrendered hereunder for the purpose of the Second Period or a total amount of $1,000,000 whichever is lesser

c. During the Third Period of the term of this licence $60 for each acre of land retained and not surrendered hereunder for the purpose of the Third Period

PROVIDED FURTHER that where the expenditures made or incurred in respect to mineral exploration exceeds the amount of the Annual Exploration Expenditure the amount of any excess thereof shall qualify as a portion or the whole as the case may be of the Annual Exploration Expenditure for the subsequent period or periods of the term of this licence as the case may be.

PROVIDED FURTHER that the Regional Director may in his discretion disallow any expenditure for the purpose of the Annual Exploration Expenditure which in his opinion is not directly related to the exploration or development of minerals on the lands subject to this licence and in the event of such a disallowance the Licensee shall be liable for the amount of the disallowed expenditure and the Regional Director may direct that the amount of the disallowed expenditure be added to the Annual Exploration Expenditure for the period then in effect.

PROVIDED FURTHER that notwithstanding any other provision of this licence that if default is made by the Licensee in making or incurring the Annual Exploration Expenditure in whole or in part the security as provided hereinafter in the amount equal to the deficiency of the required Annual Exploration Expenditure as contemplated herein may be forfeited to and become the property of the Crown in right of Ontario and this licence may be cancelled or revoked by the Minister.

PROVIDED FURTHER that if any part of the lands subject to this licence is flooded under the authority to control water levels as provided herein and where the Minister is of the opinion that the Licensee is prevented from making or incurring the Annual Exploration Expenditure required herein because of such flooding of the lands, the Minister may reduce the amount of the Annual Exploration Expenditure for the period or periods of the term of this licence during which the said flooded condition of the lands occurs or continues by the percentage that the area of the flooded lands is of the total area of the lands subject to this licence at such time or times of the said flooding.

PROVIDED FURTHER that if the Licensee has not applied for and received a lease as provided herein at the expiration of the term of this licence and in the opinion of the Minister the Licensee has fully complied with and observed all of the terms, provisoes, conditions and restrictions of this licence, the Licensee shall be entitled to make application and receive a licence for the lands subject to this licence at the time of the expiration of its term for a term of three years and such licence shall be subject to such terms and conditions as the Minister may consider advisable provided that the Licensee shall make the aforesaid application to the Minister during the sixty days preceding the expiration of the term of this licence.

PROVIDED FURTHER that if default is made by the Licensee in the observance of any or all of the terms, provisoes, conditions and restrictions as provided herein, and the default is not remedied to the satisfaction of the Regional Director within sixty days or such further period of time as the Regional Director may specify, after notice has been delivered or sent by registered mail to the Licensee at its last known address recorded with the Ministry, setting forth the default and calling upon the Licensee to remedy it, this licence may be cancelled or revoked by the Minister.

PROVIDED FURTHER that the Licensee shall deposit security for the due performance of the Annual Exploration Expenditure and such security shall be in the form of an irrevocable letter of credit acceptable to the Minister in the amount of $329,500 which shall be deposited with the Minister before the issue of this licence and the Licensee shall provide the Minister on or before each Anniversary Date with an irrevocable letter of credit in an amount equal to the amount of the Annual Exploration Expenditure required herein for the period then commencing.

PROVIDED FURTHER that the Licensee shall deposit with the Minister before the issue of this licence, security hereinafter referred to as the "Other Obligations Security" in the amount of $100,000.00 for the due performance by the Licensee of any or all of the terms, provisoes, conditions and restrictions of this licence, other than the due performance of the Annual Exploration Expenditure and such Other Obligations Security shall be in the form of an irrevocable letter of credit acceptable to the Minister.

PROVIDED FURTHER that the Licensee shall maintain the aforesaid irrevocable letters of credit in full force and effect during the term of this licence and for one year after the date of the expiration, surrender, cancellation or revocation of this licence as the case may be or until the District Manager for the District of Kapuskasing hereinafter referred to as the District Manager notifies the Licensee in writing that he is satisfied that the Licensee has fully complied with all the terms, provisoes, conditions and restrictions of this Licence, whichever occurs first, and the amounts of the irrevocable letters of credit for the aforesaid one year period shall be in the amounts equal to the amounts of the irrevocable letters of credit then applicable at the time of the expiration, surrender, cancellation or revocation of this licence.

PROVIDED FURTHER that if default is made by the Licensee in the observance of any or all the terms, provisoes, conditions and restrictions of this Licence the Minister shall have the right to require payment or payments under the aforesaid letters of credit of such amount or amounts in whole or in part from time to time, which in the opinion of the Minister is or are necessary to ensure the due performance by the Licensee of any or all of the terms, provisoes, conditions and restrictions of this licence irrespective and notwithstanding that this licence be in force, expired, surrendered, cancelled or revoked.

PROVIDED FURTHER that on the completion of each drill hole all drill casings are to be removed from each drill hole except;

a. Where written consent to the contrary is given by the District Manager, and provided the drill hole location is identified by a marker on the ground by the Licensee;

b. Where radioactive minerals are encountered, and there is a discharge of water from the drill hole, in which event drill casings shall remain in place and the drill hole immediately capped, plugged or otherwise stopped up to the satisfaction of the District Manager.

PROVIDED FURTHER that all drill holes and open pits shall be left in a safe condition to the satisfaction of the District Manager.

PROVIDED FURTHER that section 114 of The Mining Act, R.S.O. 1970, Chapter 274 as amended shall apply, mutatis mutandis, to the timber and trees standing, being or hereafter found growing upon the land subject to this licence.

PROVIDED FURTHER that the Licensee shall comply with the provisions of the Atomic Energy Control Act, The Mining Act, The Public Lands Act, The Petroleum Resources Act, The Forest Fires Prevention Act, the regulations under these Acts and all other applicable Federal or Provincial Acts and regulations made thereunder.

PROVIDED FURTHER that this licence shall not be asigned or transferred in whole or in part unless with the approval and consent thereto in writing of the Minister or his Deputy.

PROVIDED FURTHER that before the Licensee assigns or transfers part of its right, title and interest under this licence to another person or persons, the Licensee and such person or persons shall provide the Minister with written assurances in a form satisfactory to the Minister that the Licensee and such person or persons will be jointly and severally responsible for the complete and full discharge of the duties and obligations arising from any or all of the terms, provisoes, conditions and restrictions of this licence.

PROVIDED FURTHER that this licence is issued for the sole purpose of granting the Licensee the exclusive right to search, prospect, drill and explore for minerals and shall not be construed as conferring upon the Licensee any right, title and interest in respect to natural gas, oil, petroleum, sand and gravel nor to the surface rights of the lands subject to this licence and the Minister may during the term of this licence dispose of any or all of the natural gas, oil, petroleum, sand and gravel and any or all of the surface rights, provided that the Minister is satisfied that the disposition of the said natural gas, oil, petroleum, sand and gravel or surface rights does not limit or hinder the Licensee in its aforesaid searching, prospecting, drilling and exploring.

PROVIDED FURTHER that the Licensee may remove from the lands subject to this licence such quantities of minerals excepting natural gas, oil, petroleum, sand and gravel as may be necessary for testing purposes, subject to the written approval of the District Manager. Prior to the granting of approval for the removal of bulk samples the District Manager may require the submission of a proposal containing detailed plans showing proposed location, method of extraction, rehabilitation or such other information as may be deemed necessary for the proper evaluation of the proposal. Reasonable advance written notice of the proposal shall be given to the District Manager.

PROVIDED FURTHER that the lands subject to this licence that are prospected, drilled, explored or mined by the Licensee shall be rehabilitated by the Licensee to the satisfaction of the District Manager within ten months of the expiration, surrender, cancellation or revocation of this licence.

PROVIDED FURTHER that if at any time during the term of this licence the Licensee, in the opinion of the Minister, demonstrates that a deposit or deposits of minerals of economic importance excepting natural gas, oil, petroleum, and sand and gravel has been discovered, the Licensee shall be entitled to apply for and, subject to the approval of the Lieutenant Governor in Council, receive a lease for a total area of land consisting of part or parts of the lands subject to this licence at the time of the aforesaid application sufficient to encompass the said deposit or deposits.

PROVIDED FURTHER the aforesaid Lease shall:

(1) Consist of the area or areas of land which have been retained and have not been surrendered by the Licensee as provided herein sufficient to encompass the said deposit or deposits and such surface rights of the said area or areas of land which, in the opinion of the Minister, are necessary for the efficient operation of a mine or mines;

(2) Have a term of ten years at an annual fee of two dollars and fifty cents ($2.50) per acre payable each year in advance. The annual fee shall be subject to review and adjustment in each fifth year from the date of the granting of the lease or renewal thereof and each said adjustment shall take effect in the year next following and the amount of each adjustment shall be determined by the Minister and where the Lessee is dissatisfied with the determination of the Minister the Lessee may within sixty days after notice of the determination of the amount of the adjustment by the Minister give notice to the Minister by registered mail that the Lessee requires the amount of the adjustment to be determined by arbitration and the arbitration shall be governed, conducted and decided under the provisions and authority of The Arbitrations Act, R.S.O. 1970, Chapter 25 and the matter shall be referred to a single arbitrator thereunder who shall be the Mining and Lands Commissioner of Ontario.

(3) Provide that the Lessee shall be entitled to apply for and receive a renewal of the lease for a further term or terms of ten years where in the opinion of the Minister, the Lessee can demonstrate that the Lessee is producing minerals in substantial quantities or has produced minerals in substantial quantities continuously for a period of time of not less than one year during the term of the lease.

(4) Provide that where in the opinion of the Minister the Lessee cannot demonstrate that the Lessee in producing minerals in substantial quantities or has produced minerals in substantial quantities continuously for a period of not less than one year during the term of the lease the Lessee shall be entitled to appy for a renewal and the Minister may in his absolute discretion grant a renewal or renewals of the lease for a further term or terms of ten years.

(5) Contain such other terms and conditions as the Minister may approve.

PROVIDED FURTHER that if this licence is in force at the date of the issue of the aforesaid lease and where the area of lands subject to the lease is less than the area of lands subject to this licence at such date, the area of lands subject to the lease shall cease to be lands subject to this licence and for the purposes of this licence shall be treated in the same manner as Surrendered Lands.

PROVIDED FURTHER that the Licensee, its servants, employees and agents shall conduct all exploration activity in cluding construction of roadways, establishment of encampments and the constrution of drill sites in accordance with the following requirements:

1. No roadways, grid lines, buildings, structures or encampments shall be permitted to be established or constructed without the prior written approval of the District Manager. Prior to the granting of approval of the location of any of the above items, the District Manager may require the submission of a proposal containing detailed plans showing proposed

location, construction methods, rehabilitation plans or such other information as may be deemed necessary for the proper evaluation of the proposal. The licensee shall give reasonable advance written notice of the proposal to the District Manager;

2. The movement overland of any machinery and vehicles by the Licensee may be restricted to such times and places, as in the opinion of the District Manager is necessary to ensure the protection and preservation of the lands;
3. Liquid or solid wastes shall not be permitted to enter into any natural water course;
4. The use of herbicides and the use of pesticides, with the exception of personal size containers of insect repellant, is prohibited on the land described herein.
5. Upon termination of this licence or surrender of lands subject to this licence by the Licensee all structures, buildings and encampments shall be demolished or removed by the Licensee from the land described herein and all drill sites and encampment areas shall be rehabilitated as closely as possible to their former natural state by the Licensee;

6. All oily rags, oil cans, fuel containers, grease containers and other similar discarded material and refuse shall be removed by the Licensee from drill sites, encampments and other work sites and disposed of at waste disposal sites approved by the Ontario Ministry of the Environment.

PROVIDED FURTHER that where in the opinion of the Minister the Licensee is prevented from discharging its obligations under this licence by reason of the Minister prohibiting an activity contemplated hereunder pursuant to any statutory authority of the Minister the term of this licence shall be extended for the period of time such activity was prohibited.

This licence is issued under the authority of subsection 2 of section 646 of The Mining Act, R.S.O. 1970, Chapter 274 pursuant to Order in Council 11/81 dated the 8th day of January, 1981.

IN WITNESS WHEREOF I have hereunto set my hand and seal of office at the City of Toronto in the Municipality of Metropolitan Toronto, this 6th day of May and the Licensee has affixed its corporate seal at the hands of its officers duly authorized in that behalf.

SIGNED SEALED AND DELIVERED in the presence of	
[signature] as to execution by Executive Coordinator, Lands and Waters Group.	[signature] Executive Coordinator Lands and Waters Group, for and on behalf of the Minister of Natural Resources as authorized by Order in Council 2145/78 dated July 19, 1978.
	LIGNASCO RESOURCES LIMITED:
	BY:
	And by: [signature]

SCHEDULE "A"

All that parcel or tract of land in the townships of Emerson, Kipling and Sanborn, in the District of Cochrane, in the Province of Ontario, containing an area of 92,745 acres, be the same more or less, described as follows:

Beginning at the northwesterly corner of the Township of Emerson;

THENCE easterly along the northerly boundary of the Township of Emerson a distance of 4 miles and 2640.0 feet;

THENCE south astronomically to the southerly boundary of the Township of Emerson;

THENCE westerly along the southerly boundary of the townships of Emerson and Kipling to the southwesterly corner of the Township of Kipling;

THENCE northerly along the westerly boundary of the Township of Kipling to the northwesterly corner thereof;

THENCE northerly along the westerly boundary of the Township of Sanborn a distance of 4 miles and 2640.0 feet;

THENCE east astronomically to the easterly boundary of The Township of Sanborn;

THENCE southerly along the easterly boundary of the Township of Sanborn to the plae of beginning.

SAVING AND EXCEPTING therefrom locations HY 57 HY 71 and HY 72,

ALSO SAVING AND EXCEPTING therefrom the following parcel of land;

Begining at a point in the Township of Kipling distant 2300 feet measured south astronomically from a point in the northerly boundary of the Township of Kipling distant 15000 feet measured westerly along the said northerly boundary from the northeasterly corner of the Township of Kipling;

THENCE south astronomically 36,100 feet;

THENCE west astronomically 15,350 feet more or less to the high water mark of the Mattagami River;

THENCE in a general northerly direction along the said high water mark to the southerly limit of location HY 72;

THENCE easterly along the said southerly limit to the southeasterly corner of the said location HY 72;

THENCE northerly along the easterly limit of said location HY 72 to the southerly limit of the Mining Claim T 18492 1/2;

THENCE easterly along the southerly limit of mining claims T 18492 1/2, T 21586 and T 21587 to the southeasterly corner of said Mining Claim T 21587;

THENCE notherly along the easterly limit of Mining Claim T 21587 to the northeasterly corner thereof;

THENCE westerly along the northerly limit of Mining Claim T 21587 to the southeasterly corner of Mining Claim T 21585;

THENCE westerly along the northerly limit of Mining Claim T 21585 to the southeasterly corner of Mining Claim T 21583;

THENCE northerly along the easterly limit of Mining Claim T 21583 to the northeasterly corner thereof;

THENCE westerly along the northerly limit of mining claims T 21583, T 21582 and P 91135 to the high water mark of the Mattagami River;

THENCE in a general northeasterly direction along the said high water mark to a line drawn west astronomically from the place of beginning;

THENCE east astronomically a distance of 2900 feet more or less to the place of beginning;

Also Saving and Excepting therefrom location HY72, and mining claims S24480, S24481, S24482, S24483, S24484, S24485, S26454, S26455, S26456, S26457, S26458 and S26459.

Also Saving and Excepting therefrom mining claims T18492 1/2, T21582, T21583, T21584, T21585, T21586, T21587, T19482, P91135.

SELCO INC.

SMOKY FALLS PROJECT

EXPLORATORY LICENCE OF OCCUPATION NO. 14890

PROGRESS REPORT OF ACTIVITIES

to APRIL 30, 1982

N.T.S. 42J8,J1,I4

W.J. Anderson
Toronto, Ont.

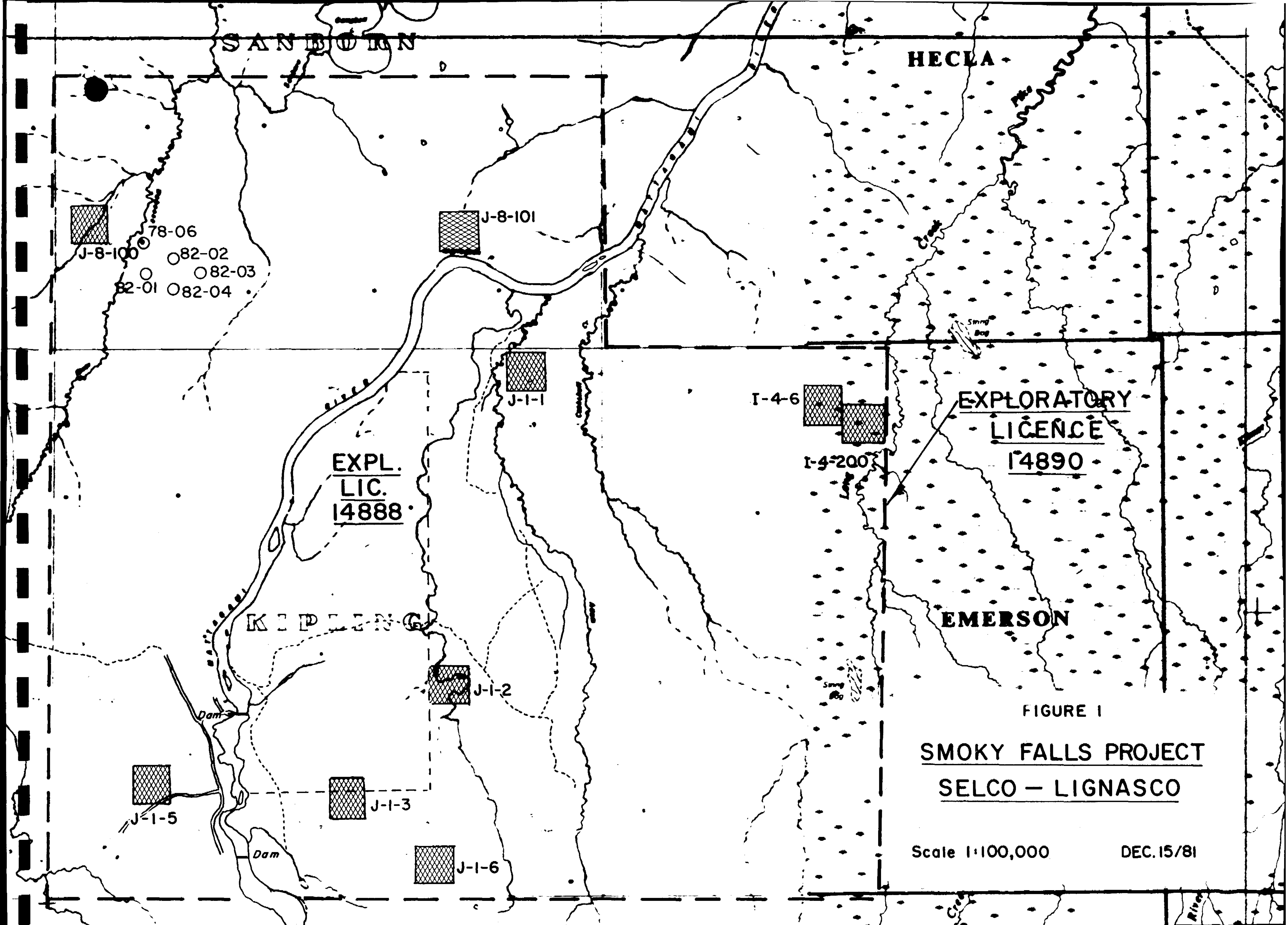


FIGURE 1

SMOKY FALLS PROJECT

SELCO – LIGNASCO

Scale 1:100,000 DEC. 15/81

TABLE OF CONTENT

1.0 INTRODUCTION

1.1 Purpose of Report

This report summarizes the results of exploration activities conducted on Exploratory Licence of Occupation No. 14890, to March 31, 1982.

1.2 Location and Access

The area is located about 200km north northwest of Timmins and includes parts of the Townships of Sanborn, Kipling and Emerson.

Access to the centre of the area is possible via gravel roads from either Kapuskasing or Abitibi Canyon. The roads provide service routes to several dams on the Mattagami River.

Beyond the dam sites heavy mobile equipment can only be moved in winter along packed winter roads. Movement of personnel between work sites is best achieved using helicopter support.

For the program described here, a drill camp was established near Kipling Dam. The helicopter crew and geophysical crew stayed at the town of Smoky Falls, about 5km south of the property. Officials of Ontario Hydro, and especially the staff of Spruce Falls Power at Smoky Falls were very helpful.

2.0 DESCRIPTION OF PROGRAM

The program being conducted by Selco is designed to discover economic diamondiferous kimberlite pipes. In the past winter program, four drill holes were also drilled on behalf of Lignasco Resources Ltd., to search for lignite beds.

Airborne magnetometer surveys provide potential kimberlite targets for detailed ground geophysical definition. Evaluation of the ground geophysics leads to selection of anomalies for drill testing. A single hole is collared on a target, with the objective being to identify the anomaly source, and if of interest, provide sufficient drill core (≈50kg) for mineralogical and chemical investigation. No determination of any diamond - bearing potential of a kimberlite is possible at this stage. If a given anomaly meets both the size and mineralogical criteria, a further bulk test, requiring 10 tonnes or more will be used for processing to establish the presence of diamonds. If diamonds were found in a particular pipe, a quantitative assessment of grade would require the extraction of some thousands of tonnes.

3.0 REGIONAL GEOLOGY

The Licence covers a small portion of the southern flank of the Moose River Basin. Roughly the southern third of the property is underlain by Precambrian rocks.

Outcrops are very few and limited to water courses, but drilling by the Ontario Government, and various companies in the area has established a good stratigraphic framework for the Moose River Basin. Most of the Licence area is underlain by an extensive and thick till cover, which mantles a sequence of unconsolidated Lower Cretaceous beds of the Mattagami Formation. The latter unit is comprised of silica sands, varicolored clays and silts, and occasional lignite seams. (Telford et al 1975). Much of the previous work in the region has been directed toward the industrial minerals and lignite deposits. (Op. cit.)

4.0 DESCRIPTION OF RESULTS

4.1 Geophysical Surveys

In 1981 the property was covered by an airborne magnetometer survey as part of a larger regional program. Coverage on the Licence consisted of flight lines at a nominal spacing of 250m and terrain clearance of 60m. Total volume was about 1500 line-km.

Nine geophysical grids were cut and surveyed in the area. All grids were surveyed using a nuclear precession magnetometer. Line and station separation were a maximum of 100m and 25m respectively. Diurnal variations were removed from the results. One grid (I4-6) was surveyed the previous winter in the follow-up work of another program. The costs of this work are not included in the expenditure statement. Total surveying in 1982 was 157km.

Following is a brief commentary on results.

Grid I4-6

A good small target is centered at 00/050S, and extends off the west end of the grid. Drill testing should await the results of drilling adjacent anomaly I4-200.

Grid I4-200

A good small target is centered at 500W/200N. Diamond drilling is recommended.

Grid J1-1

A large strong positive response with an amplitude of about 700nT is centered at 200E/400S. Diamond drilling is recommended.

Grid J1-2

A very large lobate anomaly is located in the centre of the grid. A drill hole collared at 100S/300W was abandoned at 147m (482'). The anomaly source was not intersected. No further work is warranted at present.

Grid J1-3

Several sharp but low amplitude anomalies are present in the east half of the survey. The grid is underlain by basement rocks and the responses seem typical of this setting. No further work is warranted pending additional studies.

Grid J1-5

All anomalies detected have either a cultural or basement source. No further work is warranted.

Grid J1-6

Two anomalies of possible interest appear at 800W/200S and 400W/300S. The grid is underlain by Precambrian rocks, and while anomaly patterns on the grid confirm this setting, the land should be retained pending further study.

4/...

Grid J8-100

A single good circular anomaly is centered at 700W/450N. The source is likely deep (>150m) and therefore drill-testing is not recommended, pending the results of other regional drilling.

Grid J8-101

A small circular positive anomaly is centered at 200N/300E. The anomaly was drilled (see below).

4.2 Drilling

The winter drilling program was conducted using a Sonic drill operated by Midwest Drilling of Winnipeg. The rig was modified to include a Longyear 150 drill head, so that regular diamond drilling (NQ) could follow Sonic coring. The Sonic drill was chosen for the job so that good core recovery would be achieved in the unconsolidated units.

The drill rig was mounted on a Nodwell carrier accompanied by a trailer. Unfortunately very poor frost conditions in the extensive muskeg cover necessitated long meandering drill moves, and very expensive site preparation. The rig proved to be very successful (but at great cost) in recovering Lower Cretaceous and Quaternary tills.

Four holes totalling 439m were drilled for Lignasco in the vicinity of O.G.S. hole 78 - 06. None of the holes intersected significant lignite. Drill logs are appended.

Two holes were completed on geophysical anomalies.

Hole J8-101 was drilled to a depth 73m. A dark massive ultramafic intrusive was intersected under a till cover of 55m. Laboratory-testing of the core remains to be completed, but early petrographic work indicates the rock consists of olivine phenocrysts set in a groundmass of lath-like pyroxenes. The rock is not likely a true kimberlite, but final classification must await further studies.

5/...

A hole was drilled on J1-2, which was finally abandoned at 147m. Bedrock was never reached. After passing through about 16m of tills, a long interval of largely silica sands (to 59m) was encountered. This was followed by intercalated sands and clays, and some lignite beds. Given the depth of cover on this grid, additional drilling on this anomaly is not warranted.

5.0 SECOND PROGRAM

If the ground conditions had permitted the Sonic drill to be more "mobile" two other holes had been planned for the past winter. Instead, the two holes (on I4-200 and J1-1) will be completed with a helicopter supported diamond drill in the next Commitment Period. The balance of proposed expenditures cover related laboratory studies. A listing of the proposed budget is set out below.

DIAMOND DRILLING		$50,000
Contract Chgs. 250m @ $140,	= 35,000	
Helicopter Chgs. 30 hrs. @ 500	= 15,000	
GEOCHEMICAL STUDIES		10,000
SUPPORT		10,000
SUPERVISION		15,000
	TOTAL	$85,000

CONTINGENCY - $250,000

Depending upon the geochemical studies and the regional program results, one bulk test could be initiated in this area, and this is estimated to cost about $250,000.

W.J. Anderson

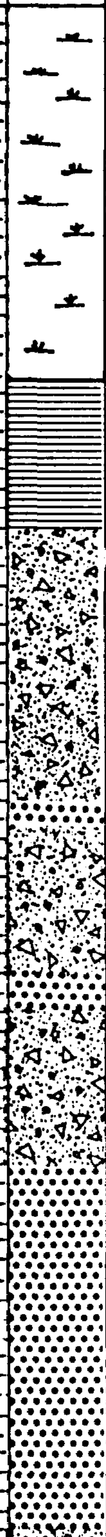
SELCO INC.- LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Program

DRILL LOGS

Prepared by:
Harish M. Verma, Ph. D.,
Consulting Geologist
for
SELCO INC.

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Program
James Bay Lowland
Drilling: Midwest Drilling, Winnipeg
Geology: Harish M. Verma

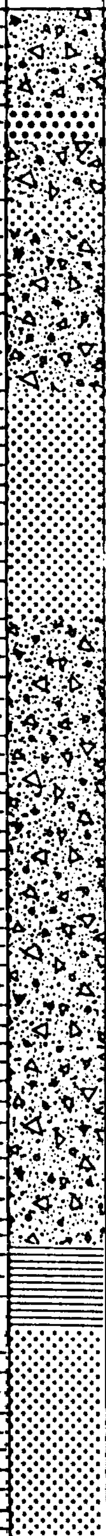
DRILL LOG: DRILLHOLE NO. SL 82-01.
Location: 800 metres south of OGS
Drillhole 78-06 (Long. 82°13'43"W, Lat.50°15'30"N)
Sanborn Township
Started March 16, Finished March 20, 1982
Sheet 1 of 5

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
0		Sonic	0' - 19' Muskeg
10			
20			19' - 27' Greenish grey. highly calcareous plastic clay
			27' - 33' Grey, very dense, coarse, silty and dry till
30			33' - 35' Very dense, sandy calcareous till
			35' - 36' Grey, calcareous clay till
			36' - 41' Grey. ca;careous coarse sand with pebbles (? sandy till)
40			41' - 42' Grey, coarse, calcareous sand
			42' - 50' Grey, coarse, very sandy, highly calcareous till with large cobbles
50			50' - 52' Grey, gravelly sand, highly calcareous
			52' - 56' Grey, sandy, gravel rich till
			56' - 58' Grey, very sandy, coarse till
			58' - 60' Grey, clay till
60			60' - 65' Grey, sandy gravel with large pebbles and cobbles
			65' - 72' Same as above
70			72' - 76' Grey, calcareous gravel, mostly pebble size
			76' - 79' Grey, coarse, sandy gravel with big cobbles
80			79' - 80' Dark grey coarse till with muddy matrix

<u>DRILL LOG</u>

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. S1 82 - 01.
Sheet 2 of 5.



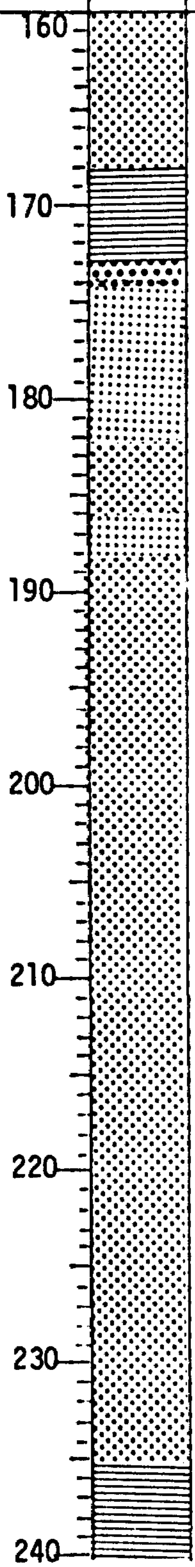
Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
80		Sonic	80' - 85' Grey, calcareous silty till
			85' - 87' Sandy gravel with large cobbles
			87' - 90' Grey, calcareous silty till
90			90' - 92' Grey, medium grained sand
			92' - 95' Dark grey, coarse, very sandy, highly calcareous till
			95' -100' Grey, very sandy till
100			100'-102' Grey, medium to coarse grained sand
			102'-106' Grey, coarse sand with pebbles
			106'-110' Dark grey coarse, very sandy, highly calcareous till
110			110'-112' Grey, coarse sand with pebbles
			112'-114' Grey, sandy till
			114'-116' Grey clay till
			116'-120' Dark grey, coarse sandy till
120			120'-127' Dark grey to brown coarse hard muddy till
			127'-141' Same as above with large clasts
130			
140			141'-144.5'Grey, coarse, calcareous clay till
144.5			-------QUATERNARY-CRETACEOUS CONTACT----------------
			144.5'-147.5' Dark grey, non calcareous clay
			147.5'-148.5' Red fireclay
150			148.5'-160'White to light grey, medium grained silica sand kaolin matrix with some sections showing coarse grained matrix
160			

DRILL LOG

S[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-01.
Sheet 3 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks



Sample: Sonic

160'-166' Greyish white, medium grained silica sand kaolin matrix

166'-168' Same as above but getting coarser
168'-171' Brown fireclay

171'-173' Grey, sandy clay
173'-174' White to light grey coarse silica sand kaolin matrix
174'-178' Fine grained silica sand kaolin matrix
178'-182' Fine grained silica sand kaolin matrix-richer in kaolin
182'-186' Medium grained, white silica sand kaolin matrix
186'-188' Fine grained white silica sand kaolin matrix

188'-195' Medium to coarse grained silica sand kaolin matrix - many coarse quatrz grains

195'-220' Predominantly medium grained slilica sand kaolin matrix - some sections showing coarser quartz grains

220'-233' Medium grained white silica sand kaolin matrix

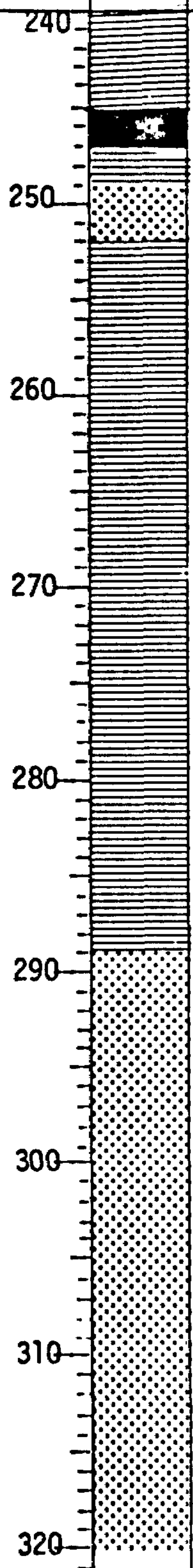
233'-234' Medium grained, greyish silica sand kaolin matrix - lesser amount of kaolin
234'-235' Dark grey clay
235'-236' Light to dark brown fireclay
236'-240' Dark brown carbonaceous clay

DRILL LOG

S[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-01.
Sheet 4 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks



Sample: Sonic

240'-242' Dark brown to black carbonaceous clay
242'-245' Clay as above but becoming sandy
245'-247' LIGNITE
247'-249' Brown fireclay
249'-251' Grey sand
251'-252' Grey, medium grained sand
252'-256' Grey to brown carbonaceous clay with fragments of lignite
256'-264' Dark brown, tan brown, grey stiff, plastic clay
264'-278' Grey, highly silty, micaceous clay
278'-285.5' Brown dense clay
285.5'-289' Dense brown clay-somewhat sandy below 287'
289'-290' Grey, fine grained clayey sand
290'-293' Micaceous sand with high clay content
293'-296' Grey, fine grained clayey sand
296'-299' Grey sand with abundant clay content
299'-301' Fine to medium grained, grey sand
301'-305' Grey, fine grained, clayey sand
305'-309' Mostly grey to greyish white sand
309'-321' Fine to medium grained grey sand

DRILL LOG

SE[illegible] INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-01.
Sheet 5 of 5.

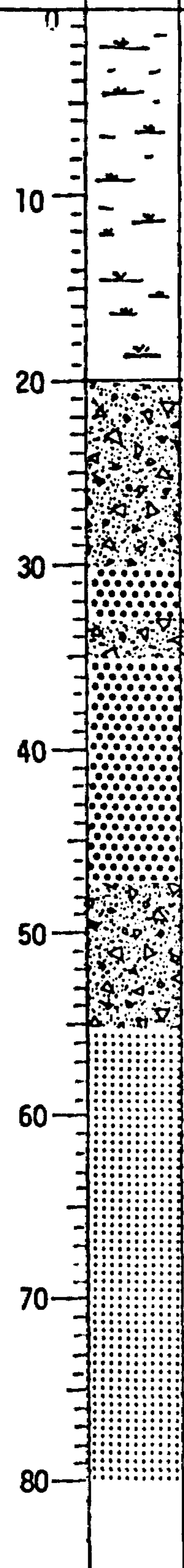
Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
321		Sonic	321'-322' Grey clay
			322'-325' Reddish brown to grey fireclay
			325'-329' Bright red to grey, varicoloured clay
			329'-330' Reddish brown fireclay
330			330'-333' Reddish to grey clay
			333'-335' Grey clay
			335'-353' Grey, plastic, dense, clay
340			
350			
			353'-354' Light grey clay with dolomite cobble
			354'-355' Dark, grey clay
			355'-358' Grey to red brown clay
			358'-361' Grey clay
360			361'-370' Grey to reddish brown fireclay
370			370'-376' Red fireclay with grey streaks
			376'-383' Red fireclay
380			
383			Drilling terminated at 383'. PVC pipe inserted in the hole

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Program
J[illegible]s Bay Lowland

Drilling: Midwest Drilling, Winnipeg
Geology: Harish M. Verma

DRILL LOG: DRILL HOLE NO: SL 82-02
LOCATION: 800 metres southeast of OGS drillhole
No. 78-06 (Long. 82°13'43" W:
Lat. 50°15'30" N)
Sanborn Township
Started: March 29, Finished April 1, 1982

Depth (Ft.) / Lith. Log:



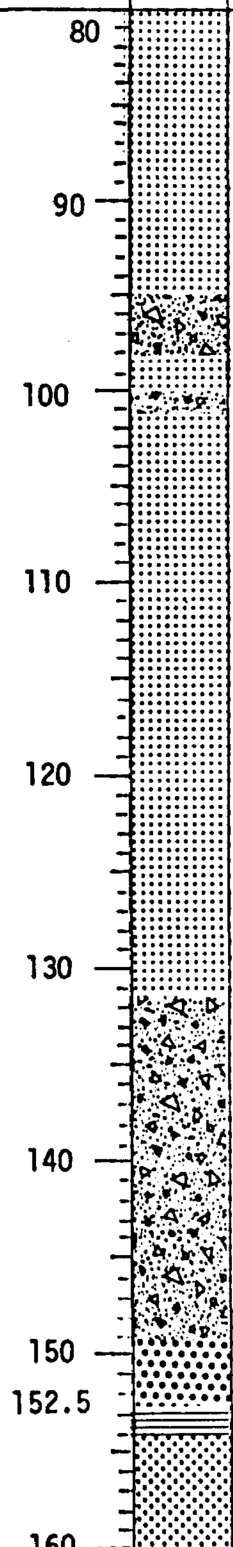
Sample	Field Description and Remarks
Sonic	0' - 20' Muskeg
	20' - 25' Light grey, calcareous clayey till
	25' - 30' Greyish brown sandy silt till
	30' - 33' Coarse to medium gravelly sand
	33' - 35' Light greyish to brown sandy silt till
	35' - 38' Light grey sand
	38' - 43' Coarse, grey, gravelly sand
	43' - 44' Gravel
	44' - 45' Grey, coarse sand and some sandy till
	45' - 47' Grey, coarse sand and sandy till - more clasts
	47' - 50' Light grey, fine sandy till
	51' - 55' Dark grey, sandy, calcareous till
	55' - 60' Grey, fine grained sand with grey clay laminations
	60' - 67' Light grey, fine grained sand
	67' - 79' Dark grey, fine grained sand
	79' - 80' Very fine grained, somewhat clayey sand

DRILL LOG

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-02.
Sheet 2 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks



Sample: Sonic

80' - 89' Very fine, somewhat clayey sand

89' - 90' Same as above, getting coarser
90' - 95' Very fine grained calcareous sand

95' - 98' Olive grey sandy till with clasts

98' - 100' Grey, fine grained calcareous sand
100'-101' Fine grained, sandy till
101'-109' Light grey, fine grained sand

109'-113' Light frey, fine grained sand with darker zone at 110'-110.5'.

113'-122' Light grey fine grained sand

122'-123' Grey, coarse, gravelly sand
123'-131' Grey, fine grained sand
131'-132' Dark grey, calcareous clay till
132'-140' Olive grey, calcareous clay till with large clasts

140'-142' Dark olive grey sandy till
142'-145' Same as above but getting clayey

145'-149' Olive grey calcareous very sandy till

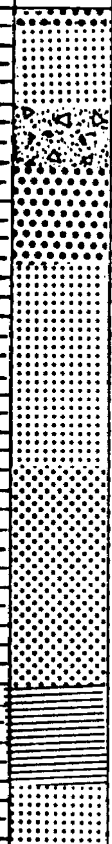
149'-152.5' Coarse, gravelly sand with large pebbles

------QUATERNARY-CRETACEOUS CONTACT--------------- -------
152.5'-154' Tan fireclay
154'-156' Dark grey coarse silica sand kaolin matrix non-calcareous- reduced kaolin
156'-160' Fine to medium grained silica sand kaolin matrix with abundant kaolin

DRILL LOG

SF[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-02 .
Sheet 3 of 5 .

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
160		Sonic	160'-161' Dirty grey sandy gravel with large pebble and cobble
			161'-165' Dark greyish green fine grained calcareous sand
			165'-168' Dark olive grey sandy calcareous till
			168'-173' Coarse dark grey gravel - calcareous
170			Note: From 160' to 173', the sediments appear to be Quaternary deposits. These may have been deposited in an underground channel.
			173'-183.5 Very fine grained greyish white silica sand kaolin matrix with abundant kaolin
180			
			183.5'-185' Medium to coarse grained greyish white silica sand kaolin matrix with kaolin
190			185'-190' Medium to coarse grained greyish white silica sand akolin matrix with increased kaolin
			190'-191' Fine grained light grey sand - little kaolin
			191'-195' Greyish white, coarse to medium grained silica sand kaolin matrix
			195'-200' Dark grey, carbonaceous hard clay
			200'-206' Grey, fine grained sand
			206'-213' Greyish white, fine grained silica sand-
200			213'-231' Medium grained, greyish white silica sand-kaolin matrix
210			
220			
230			231'-234' Coarse grained, grey quartz sand
			234'-236' Tan to grey coarse grained sand
			236'-238' Dark grey sand with detrital lignite
			238'-240' Light grey to tan brown coarse sand
240			

DRILL LOG

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-02.
Sheet 4 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
240		SONIC	240'-242'	Light grey to tan brown coarse sand
			242'-244'	Coarse grained grey sand with detrital lignite
			244'-246'	Tan grey, fine grained sand
			246'-252'	Light grey fine grained sand
250			252'-256'	Grey, fine grained sand
			256'-260'	Fan grey, fine grained sand
260			260'-264'	Dark grey, medium grained sand
			264'-268'	Grey, fine grained sand
270			268'-276'	Coarse grained dark grey sand
			276'-280'	Medium grained grey sand
280			280'-282'	Fine grained grey sand
			282'-288'	Medium grained grey sand
			288'-289'	Dark grey, coarse sand
290			289'-292'	Dark grey, fine sand
			292'-300'	Dark grey, medium grained sand
300			300'-310'	Dark grey plastic clay
310			310'-320'	Dark grey to black, plastic, hard carbonaceous clay with fragments of detrital lignite increasing towards the bottom
320				

DRILL LOG

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

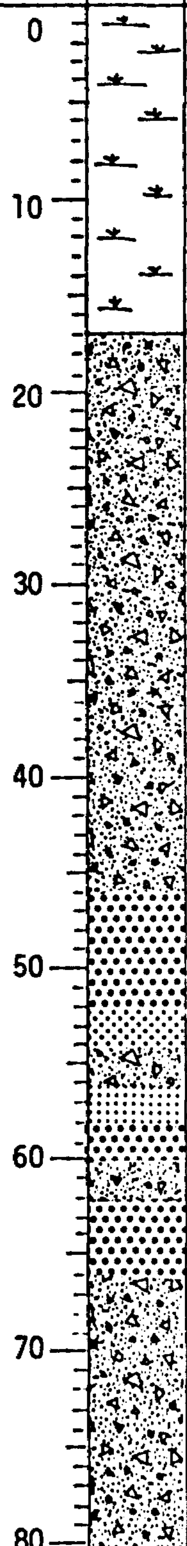
DRILLHOLE NO. SL 82-02.
Sheet 5 of 5.

Depth (Ft.)	Sample	Field Description and Remarks
320	SONIC	320'-332' Dark grey, plastic, very hard slightly sandy clay
330	NQ	332'-336' Dark brown plastic very hard non calcareous clay
		336'-344' Dark grey plastic hard non calcareous clay
340		344'-346' Dark brown plastic, partly laminated clay
		346'-356' Darker clay as above, calcareous
350		------?CRETACEOUS -DEVONIAN CONTACT------------------
		356'-364' Grey calcareous shale and argillaceous limestone
360		
364		Drilling terminated at 364' PVC pipe inserted in the hole

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programe
JAMES BAY LOWLAND

Drilling: Midwest Drilling, Winnipeg
Geology: Harish M. Verma

DRILL LOG: DRILLHOLE NO. SL 82-03
LOCATION: 1600 metres southeast of OGS drillhole 78-06(Long. 82°13'43" W: Lat. 50°15'30" N)
Started March 24, Finished March 29, 1982

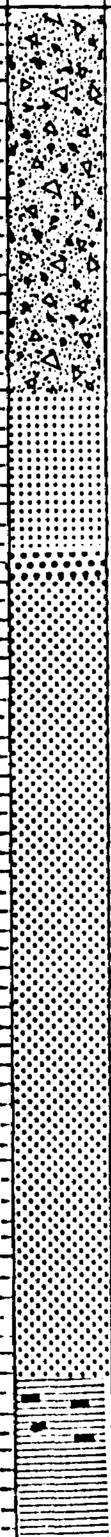


Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
		SONIC	0' - 17' Muskeg
			17' - 25' Greyish brown calcareous coarse till
			25' - 27' Brownish grey, clayey, calcareous coarse till
			27' - 32' Olive grey, coarse calcareous clay till with large clasts
			32' - 36' Grey, calcareous sandy till
			36' - 40' Till as above changing to coarse sand
			40' - 41' Grey, coarse sand
			41' - 46' Grey, coarse, very sandy calcareous till
			46' - 49' Grey, gravelly sand - calcareous
			49' - 52' Dark grey, gravelly sand
			52' - 54' Grey, alluvial sand
			54' - 56' Olive grey, calcareous coarse till
			56' - 58' Fine grained grey sand
			58' - 60' Grey, coarse grained calcareous gravelly sand
			60' - 62' Olive grey, coarse calcareous clay till
			62' - 66' Dark grey coarse calcareous gravelly sand to sandy till
			66' - 70' Olive grey sandy clay till
			70' - 75' Olive grey calcareous clay till
			75' - 78' Same as above with abunadant clasts
			78' - 80' Dark grey to olive grey calcareous clay till with small scattered clasts

DRILL LOG

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-03.
Sheet 2 of 5.



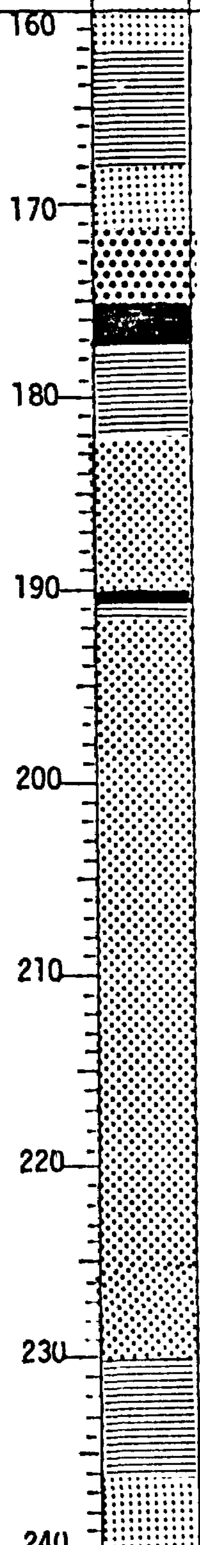
Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
80		SONIC	80' - 96' Dark grey to olive grey calcareous clay till with small scattered clasts
90			
			96' - 100' Darker olive grey to brown hard calcareous till with increasing clasts
100			100'- 108' Fine grained calcareous grey sand
			108' -109 Gravel
109			---------QUATERNARY CRETACEOUS CONTACT----- -------- ------
110			109-110 Coarse, greyish white, non calcareous silica sand-kaolin matrix
			110'-115' Grey quartz sand, little kaolin
			115'-130' Greyish white, medium grained silica sand - kaolin matrix
120			
130			130'-136' Grey, medium grained silica sand-kaolin matrix with lesser amount of kaolin
			136'-141' Same as above with increased amount of kaolin
140			141'-146' Same as above with a darker heavy mineral zone at 145'
			146'-151' Medium to coarse grained silica sand-kaolin matrix - greyish white
150			151'-155' Black carbonaceous clay with lignite fragments and some sandy sections
			155'-157' Dark grey sandy carbonaceous clay
			157'-158' Tan sandy clay
			158'-159' Dark grey sandy carbonaceous clay
160			159'-160 Tan coloured sandy clay

DRILL LOG

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-03.
Sheet 3 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks



Sample: Sonic

160'-162' Grey to tan grey fine grained sand
162'-168' Grey, plastic sandy clay

168'-171' Fine grained grey sand - very little kaolin
171'-173' Coarse grained, greyish white silica sand-kaolin matrix
175'-177.5' LIGNITE
177.5'- 178' Carbonaceous clay
178'-179' Coarse grained sand with detrital lignite
179'-181' Tan brown fireclay
181'-182' Tan to tan-grey sandy clay
182'-183' Dirty brown clayey sand
183'-185' Dirty grey quartz sand without kaolin
185'-190' Tan to grey micaceous clay with fine grained sand
190'-190.5' LIGNITE
190.5'-191' Sandy clay
191'-193' Grey, fine grained sand- little kaolin
193'-195' Medium grained silica sand-kaolin matrix with reduced kaolin
195'-210' Greyish white, coarse to medium grained silica sand-kaolin matrix

210'-225' Greyish white silica sand with reduced amount of kaolin

225'-230' Greyish white silica sand with reduced kaolin
230'-236' Light brown plastic clay

236'-240' Light grey sand

DRILL LOG

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-03.
Sheet 4 of 5.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
240		SONIC	240'-262' Light grey sand Note: The sample from 236'-262' was drilled in one run and was accidentally dropped in the hole while being retreived. It was later picked up but may have been contaminated with sluffing from the hole
250			
260			262'-266.5 Dark grey sand, probable sluff from the hole
			266.5'-270' light brown and grey, very hard, plastic dense clay
270			270'-286' Light brown to dark grey plastic, very dense clay with some red clay intercalations
280			--------CRETACEOUS-DEVONIAN CONTACT ?------------------
			286'-294' Dark brown laminated clay with disseminated pyrite - clay is non-calcareous
290		NQ	294'-303' Dark brown pyritiferous non-calcareous clay
300			303'-304' Lighter brown clay as above - no pyrite
			304'-305' Harder dark brown laminated clay (Shale?) with pyrite
			305'-315' Dark brown laminated clay as above
310			315'-319' Grey calcareous shale
320			319'-320' Grey calcareous shale with argillaceous limestone

DRILL LOG

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-03.
Sheet 5 of 5.

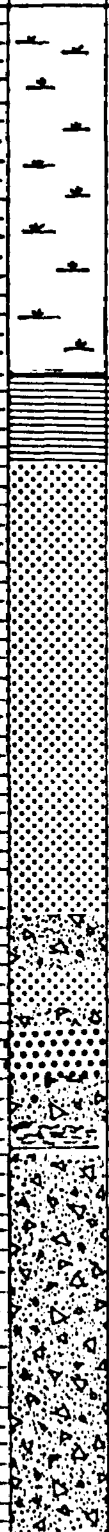
Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
320		NQ	320'-326' Grey calcareous shale with argillaceous limestone
			Drilling terminated at 326' PVC pipe inserted in the hole.
330			

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
James Bay Lowland

Drilling - Midwest Drilling

Geology: Harish M. Verma

DRILL LOG: DRILLHOLE NO. SL 82-04
LOCATION: 1400 metres SSE of OGS Drillhole No. 78-06 (Long: 82°13'43"W; Lat.50°15'30 N") Sanborn Township
Started March 20, Finished March 24, 1982

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
0		SONIC	0' - 19' Muskeg
10			
			19'- 21' Grey clay - sample washed out
20			21' - 24' Fine grained grey calcareous sand with some clay
			24' - 36' Fine to medium grained grey calcareous sand
30			
			36' - 40' Coarse grained, grey, calcareous sand
40			40' - 47' Grey, medium grained calcareous sand
			47' - 50' Grey calcareous clay till with clasts
50			50' - 52' Grey, medium grained calcareous and clayey sand
			52' - 53' Grey clay till
			53' - 56' Grey, coarse grained calcareous sand
			56' - 58' Grey, coarse calcareous clay till with large clasts
			58' - 59.5' PEAT BED (Pleistocene Peat)
60			59.5' - 60' Grey, coarse calcareous till with clasts
			60' - 62' Grey calcareous clay
			62' - 63' Grey, calcareous clay till
			63' - 66' Grey, coarse, clayey and sandy till with numerous clasts
70			66' - 71' Dry, grey, coarse calcareous clay till
			72' - 74' Grey, clay till
			74' - 80' Grey coarse clay till with many clasts
80			

DRILL LOG

S[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

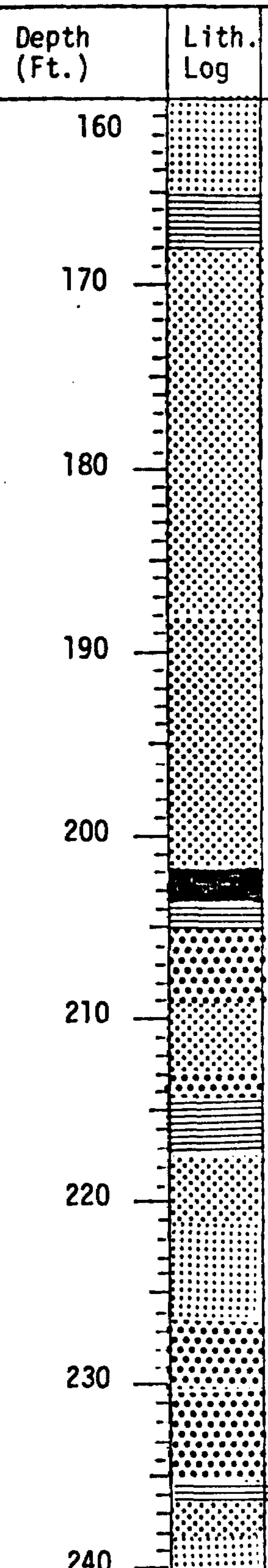
DRILLHOLE NO. SL 82-04.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
80		Sonic	80' - 83' Grey, coarse, sandy clay till with abundant clasts
			83' - 86' More sandy, grey, coarse, calcarecus clay till
			86' - 89' Clay till as above with large cobbles at 88'
90			89' - 90' Grey, calcareous clay till
			90' - 95' Grey, calcareous clay till with numerous clasts
			95' -100' Grey calcareous, sandy till with abundant clay content
100			100'-103' Coarse gravel with many rounded pebbles and cobbles
103			-----------QUATERNARY-CRETACEOUS CONTACT------------------
			103'-106' Fine grained, greyish white silica sand-kaolin matrix-non calcareous
			106'-108' White to tan coloured fireclay
110			108'-111' Interlaminated orange, red and grey fireclay - plastic, non calcareous
			111'-115.5 Light grey, fine grained, micaceous sand with very little kaolin
			115.5'-116 Darker, heavy mineral zone with hematite and magnetite
120			116'-118' Light grey, micaceous, fine grained sand with very little kaolin content
			118'-125' Fine grained silica sand-kaolin matrix with abundant kaolin
			125'-138' Medium grained silica sand- kaolin matrix with abundant kaolin
130			
			138'-142' Red, coarse grained sand
140			142'-146' Greyish white, coarse grained silica sand-kaolin matrix
			146'-159' Medium grained to coarse grained greyish white silica sand-kaolin matrix
150			
160			159'-160' Fine grained, white, silica sand-kaolin matrix

DRILL LOG

SL[redacted] INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-04.
Sheet 3 of 5.



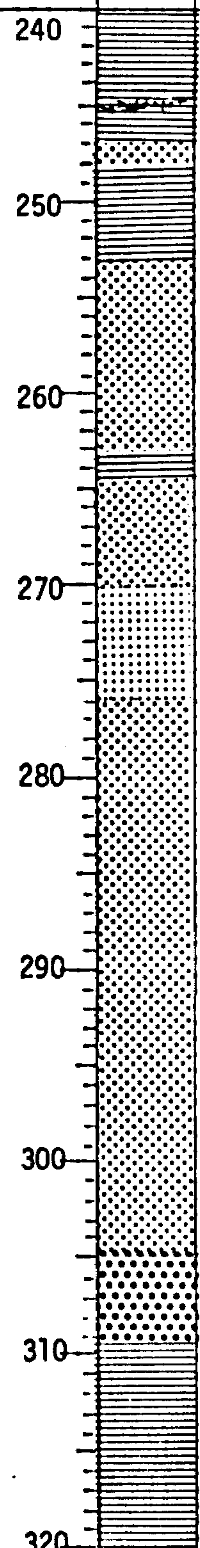
Sample	Field Description and Remarks	
SONIC	160'-165'	Fine grained, white silica sand-kaolin matrix
	165'-168'	Light brown to tan coloured fireclay
	168'-170'	Greyish white silica sand-kaolin matrix
	170'-174'	Medium grained silica sand-little kaolin
	174'-177'	Fine to medium grained greyish white silica sand with some kaolin. Yellowish rim around perimeter of the core
	177'-180'	Greyish white, medium grained silica sand-kaolin matrix
	180'-190'	Greyish white, fine grained silica sand - kaolin matrix
	190'-201.5'	Medium to fine grained silica sand kaolin matrix
	201.5'-203.5'	MIXED WOODY AND EARTHY LIGNITE
	203.5'-205'	Tan to light brown fireclay
	205'-209'	Coarse, grey sand - no kaolin
	209'-212.5'	Dark grey medium grained sand - no kaolin
	212.5'-214	Dark grey, coarse grained muddy sand
	214'-217'	Dark brown fireclay
	217'-221'	Grey, medium grained sand - very little kaolin
	221'-222'	Grey, fine grained sand with darker rim around core
	222'-226'	Dark grey, clayey sand
	226'-230'	Grey, coarse grained sand
	230'-234'	Same as above with some clayey sections
	234'-235'	Dark grey sandy clay
	235'-238'	Grey, medium grained sand
	238'-240'	Fine grained sand with some clay

DRILL LOG

S[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. SL 82-04.
Sheet 4 of 5.

Depth (Ft.) | Lith. Log



Sample	Field Description and Remarks	
SONIC	240'-242'	Grey clay
	242'-244.5'	Tan to light brown fireclay
	244.5'-245	Grey sand, fine grained
	245'-247'	Dark grey clay with some fine sand
	247'-248'	Dark grey Dark grey muddy sand
	248'-251'	Dark grey to brown clay with fine grained sand
	251'-253'	Tan to grey clay with fine grained sand
	253'-256'	Light grey sand - little kaolin
	256'-259'	Light grey to dark grey medium grained sand - no clay
	259'-261'	Light grey sand as above
	261'-263'	Dark grey fine grained sand - no kaolin
	263'-264'	Dark grey sandy clay
	264'-270'	Tan to light grey, medium grained sand
	270'-274'	Light grey, fine grained clayey sand
	274'-276'	Greyish white, fine grained silica sand-kaolin matrix
	276'-278'	Same as above - medium grained
	278'-282-	Dark grey, fine to medium grained sand - core loss
	282'-289'	Dark grey, medium to coarse grained sand
	289'-290'	Fine grained silica sand-kaolin matrix
	290'-300'	Same as above but getting medium grained
	300'-304'	Same as above but with reduced kaolin
	304'-305'	Greyish white, medium grained silica sand-kaolin matrix
	305'-309'	Dark grey, coarse sand
	309'-312'	Dark grey, plastic, carbonaceous clay
	312'-319'	Red and grey fireclay
	319'-320'	Grey plastic fireclay

DRILL LOG

SEL[illegible] INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

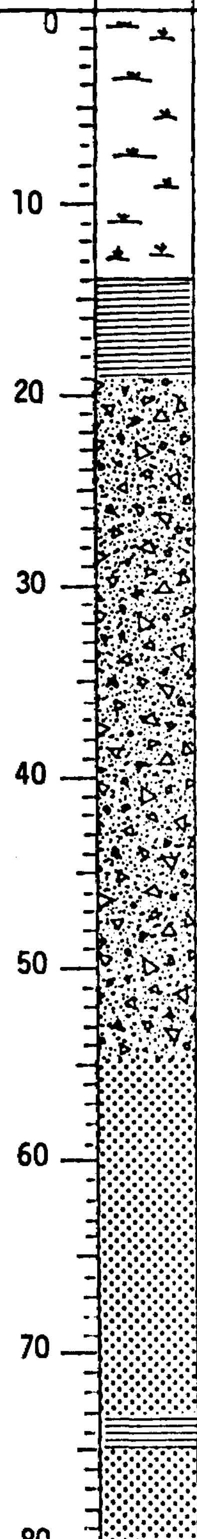
DRILLHOLE NO. SL 82-04 .
Sheet 5 of 5 .

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks
320		SONIC	320'-320.5' Grey plastic fireclay
			320.5'-321' Grey, medium grained sand-no kaolin
			321'-324.5' Light grey, plastic sandy clay
			324.5'-325' Tan coloured sandy clay
			325'-326' Dark brown plastic sandy clay
330			326'-330' Dark brown to dark grey carbonaceous plastic clay
			330'-351' Dark brown to dark grey carbonaceous partly lamainated clay
340			
350		NQ	351'-352' Dark brown laminated clay with grey clay intercalations
			352'-355' Dark brown laminated to dark grey clay
			------------CRETACEOUS DEVONIAN CONTACT ? ----------- ---
			355'-355.5' Bluish light grey calcareous shale & limestone
			355.5'-357' Bluish to light grey calcareous shale with argillaceous limestone
360			357'-360' Dark brown and light grey to bluish shale with argillaceous limestone. Brown portions are non calcaıeous, grey portions are calcareous
367			360'-364' Calcareous greyish blue shale with ? argillaceous limestone
			364'-367' Same shale as above with broken up pieces of limestone included
			Drilling terminated at 367'
			PVC pipe inserted in the hole

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Program
JAMES BAY LOWLAND

Drilling: Midwest Drilling, Winnipeg
Geology: Harish M. Verma

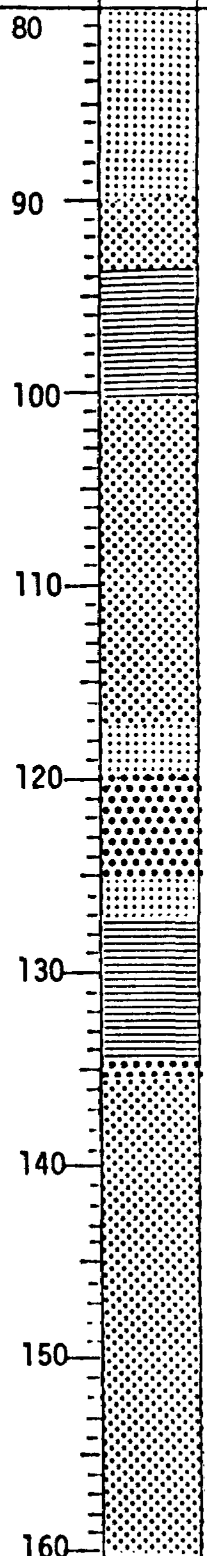
DRILL LOG: DRILLHOLE NO. J-1-2
Location: Selco Grid J-1-2; 100S/300W)
Kipling Township
Started: March 6, Finished March 11,1982
Sheet 1 of 6.

Depth (Ft.) / Lith. Log	Sample	Field Description and Remarks	
	SONIC	0'-14'	Core Loss - bottom part has calcareous grey till. Upper part is Muskeg.
		14'-19'	Calcareous grey clay with very few small clasts
		19'-22.5'	Greyish to greyish brown coarse calcareous till
		22.5'-26'	Very dense, coarse, calcareous grey till with clasts
		26'-30'	Greyish to greyish brown coarse till
		30'-55'	Very coarse and dense calcareous grey till with numerous clasts
		---------QUATERNARY-CRETACEOUS CONTACT-------------------	
		55'-60'	Non calcareous coarse silica sand - kaolin matrix with increasing kaolin towards the bottom
		60'-65'	Medium to coarse grained greyish white silica sand-kaolin matrix
		65'-70'	Medium to coarse grained silica sand-kaolin matrix
		70'-73'	Fine grained silica sand - kaolin matrix
		73'-75'	Brown hard fireclay
		75'-80'	Greyish white fine to medium grained silica sand kaolin matrix

DRILL LOG

SE[illegible]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

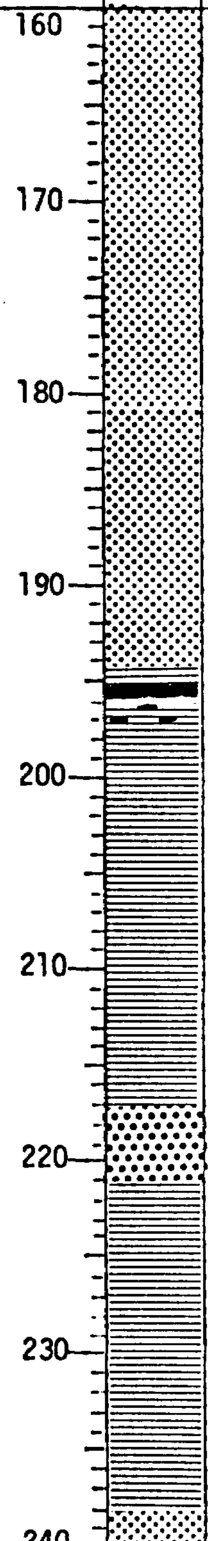
DRILLHOLE NO. J-1-2
Sheet 2 of 6

Depth (Ft.) / Lith. Log	Sample	Field Description and Remarks	
		80'-85'	White, fine grained silica sand-kaolin matrix with abundant kaolin
		85'-90'	Same as above (Box with sample lost during transit from site to camp, but was later recovered - sample may be disturbed)
		90'-93'	Medium to coarse grained, grey to greyish white silica sand - kaolin matrix - lesser amount of kaolin
		93'-93.5'	Greyish white, medium grained silica sand kaolin matrix
		93.5'-96'	Grey to yellowish brown fireclay
		96'-100'	Reddish brown fireclay
		100'-105'	Greyish, medium grained silica sand-kaolin matrix
		105'-110'	Same as above but fine to medium grained
		110'-114'	Same as above but grey in colour and with lesser amount of kaolin
		114'-117'	Same as above but colour changes to greyish white
		117'-120'	Fine grained, white silica sand-kaolin matrix
		120'-125'	Coarse grained silica sand with some heavy minerals - minor amounts of kaolin
		125'-127.5'	Grey, fine grained silica sand-kaolin matrix
		127.5'-130'	Grey fireclay
		130'-134'	Grey, fine sandy clay
		134'-135'	Grey, coarse grained silica sand - kaolin matrix with very little kaolin
		135--140'	Fine to medium grained white silica sand - kaolin matrix with grey rim around the perimeter of the core
		140'-160'	Greyish white, medium to coarse grained silica sand-kaolin matrix

DRILL LOG

SE[illegible]D INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. J-1-2.
Sheet 3 of 6.



Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
160		Sonic	160'-194'	Greyish white, medium to coarse grained silica sand - kaolin matrix
			194'-195'	Black, plastic carbonaceous clay
			195'-195.5'	WOODY LIGNITE
			195.5'-197'	Black to brown carbonaceous clay with some lignite fragments
			197'-203'	Black to brown carbonaceous clay
			203'-206'	Reddish to dark brown carbonaceous clay (?fireclay)
			206'-214'	Black carbonaceous clay
			214'-217'	Silty, sandy, grey to dark brown clay
			217'-221'	Grey, coarse sand - little kaolin
			221'-222'	Light brown clay (?Fireclay)
			222'-227'	Black carbonaceous clay
			227'-230'	Grey to dark brown sandy clay - transition zone between the zone above and the zone below
			230'-235'	Black carbonaceous clay
			235'-238'	Highly carbonaceous black clay approaching earthy lignite
			238'-240'	Medium to coarse grained silica sand - kaolin matrix

DRILL LOG

S[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. J-1-2.
Sheet 4 of 6.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
240		Sonic	240'-243'	Medium to coarse grained silica sand - kaolin matrix
			243'-248'	Fine grained silica sand - kaolin matrix
250			248'-254'	Same as above but getting coarse grained
			254'-258'	Brown fireclay
260			258'-262'	left in the core barrel and could not be retreived, but is most probably the brown fireclay as above and below
			262'-266'	Brown fireclay
			266'-269'	Lost due to washing
270			269'-273'	Dark grey to brown plastic fireclay
			273'-278'	Very dense, grey to brown clay
280			278'-281'	Grey, plastic fireclay
			281'-285'	Grey, plastic fireclay with brown inclusions
			285'-290'	White, fine to medium grained silica sand-kaolin matrix
290			290'-295'	Same as above but mostly medium grained
			295'-299'	Whitish (turning grey towards the bottom) silica sand kaolin matrix - also getting coarser towards the bottom
			299'-300'	Highly carbonaceous clay bordering on earthy lignite
300			300'-303'	Woody lignite - almost no water
			303'-305'	Black carbonaceous clay
			305'-307'	Black carbonaceous clay - some sand at the top
			307'-310'	Dark brown to black carbonaceous clay
310			310'-313'	Mixture of coarse sand, black carbonaceous clay and lignite fragments
			313'-320'	WOODY LIGNITE
320				

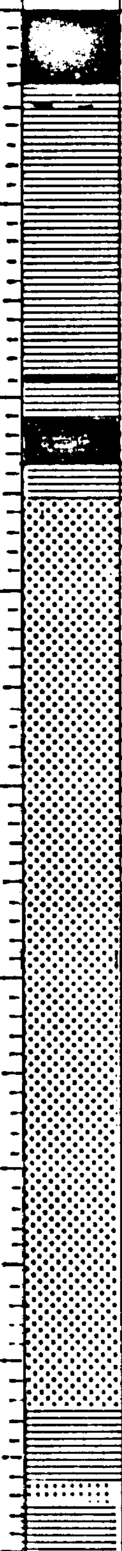
DRILL LOG

S[redacted]O INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. J-1-2.
Sheet 5 of 6.

Depth (Ft.): 320, 330, 340, 350, 360, 370, 380, 390, 400

Lith. Log:



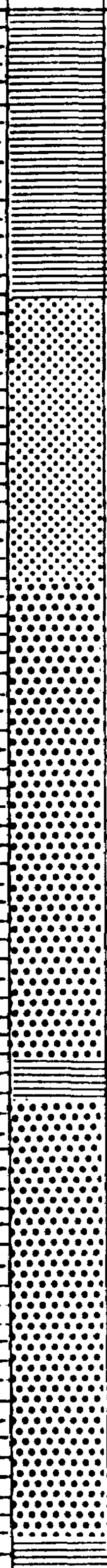
Sample: SONIC

Field Description and Remarks	
320'-324'	WOODY LIGNITE
324'-325'	Highly lignitic black carbonaceous clay
325'-326'	Same as above, probable sluffing
326'-329'	Brown to black carbonaceous clay, somewhat sandy at the bottom and within this run
329'-332'	Black carbonaceous clay
332'-335'	Black to brown carbonaceous clay with some sand
335'-337'	Black to brown carbonaceous clay - plastic in places
337'-340'	Black highly carbonaceous clay with thin (1"-2") lignite seam at 339'
340'-341'	Black carbonaceous clay
341'-343.5'	LIGNITE
343.5-345'	Black, carbonaceous clay
345'-346.5'	Black to greyish black clay with some coarse sand
346.5'-347'	Grey clay with some fine sand
347'-352'	Grey, fine to medium grained sand
352'-357'	Fine to medium grained, grey sand
357'-371'	Grey,fine to medium grained sand with angular quartz grains
371'-377'	Sand as above, but getting medium to coarse grained
377'-382'	Same as above, mixed with clay at the bottom
382'-387'	Medium to coarse grained, grey sand
387'-392'	Same as above but getting coarser
392'-396'	Greyish black, sandy clay
396'-397'	Grey, fine grained sand
397'-397.5'	Coarse sand, mixed with dark grey clay
397.5'-400'	Grey to black, very hard, sandy clay

DRILL LOG

SEL[illegible] INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. J -1-2 .
Sheet 6 of 6 .



Depth (Ft.)	Sample	Field Description and Remarks	
400	SONIC	400'-402'	Grey to black, very hard, sandy clay
		402'-415'	Sample mixed because of difficulties in retreiving it. Mostly dark coarse sand with some clay mixed in it
410			
		415'-430'	Greyish yellow, medium to coarse sand
420			
430	NQ	430'-435'	Grey to dark grey, medium to coarse sand
		435'-455'	Co.re washed out, probably coarse sand
440			
450			
		455'-457'	Black, highly carbonaceous clay with fragments of lignite
		457'-480'	Sample washed out - coarse sand
460	Sonic		
470			
480		480'-482'	Probably hard clay - no sample retreived
482			Drilling terminated at 482' PVC pipe inserted in the hole

SELCO INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Program
James Bay Lowland

Drilling: Midwest Drilling, Winnipeg
Geology: Harish M. Verma

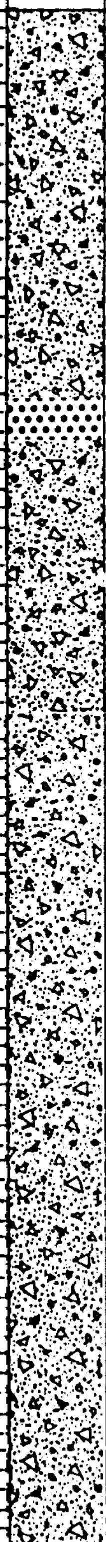
DRILL LOG: DRILLHOLE NO. J-8-101
LOCATION: Selco Grid J-8-101 (200N/300E)
Sanborn Township
Started: Feb 22, Finished Feb 26, 1982

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
0		SONIC	0'-5'	Black organic clay mixed with twigs
			5'-20'	Light brown weathered gritty till with interlayers of grey plastic clay, sandy at places
10				
20			20'-32.5'	Light brown to greyish brown very dense till with small (5-10mm) clasts. Matrix is silt to clay size. Till is highly calcareous
30			32.5'-40'	Same as above but slightly greyer in colour Clasts are bigger and matrix is coarser
40			40'-50'	Grey till with reduced number of clasts Matrix is silty clay increasing sand towards the bottom
50			50'-70'	Mixture of grey clay and silt as above, only a few clasts
60				
70			70'-80'	Same as above with increasing number of clasts- large limestone clast at 70'- Pegmatite boulder at 74'.
80				

DRILL LOG

SE[illegible]O INC. - LIGNASCO RESOURCES LTD.
19[illegible] Joint Venture Drilling Programme
JAMES BAY LOWLAND

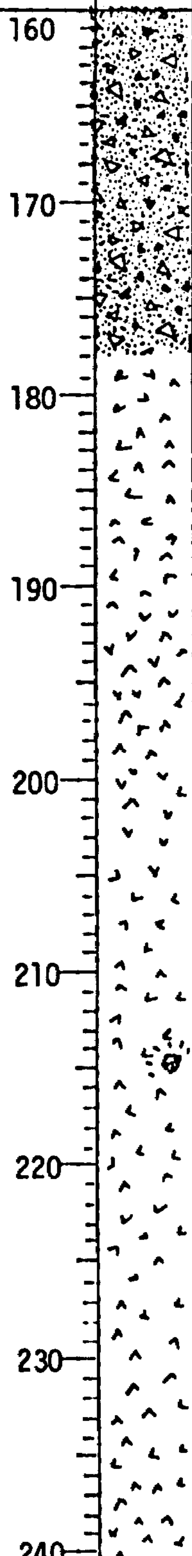
DRILLHOLE NO. J-8-101.
Sheet 2 of 3.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
80		Sonic	80'-90'	Grey, fine grained till with increasing number of clasts
90			90'-100'	Grey, clayey, silt till, fairly friable
100			100'-102'	Coarse gravel
			102'-110'	Dark brown organic silt till - calcareous
110			110'-120'	Blackish brown, highly organic gritty clay till getting harder down section with subangular quartzitic clasts. At the bottom is a much harder till with very large highly calcareous limestone clasts
120			120'-132'	Dark brown clay till with larger clasts than above and also some lignite fragments
130			132'-135'	Grey, finer grained till with lesser number of clasts - highly calcareous
			135'-140'	Very dense dark brown till with numerous large (upto 10 mm) rounded clasts - mostly quartzite- matrix is fine grained
140			140'-160'	Same as above but the colour changes to somewhat greener
150				
160				

DRILL LOG

S[redacted] INC. - LIGNASCO RESOURCES LTD.
1982 Joint Venture Drilling Programme
JAMES BAY LOWLAND

DRILLHOLE NO. J - 8 - 101
Sheet 3 of 3.

Depth (Ft.)	Lith. Log	Sample	Field Description and Remarks	
		SONIC	160'-178'	Very dense dark brown to brownish green till with numerous rounded clasts- matrix is fine grained
			178'-185'	Ground ultra mafic - medium grained blocks and fragments with rock powder magnetic with minor sulphides - first two feet is highly altered
		NQ	185'-240'	Fine to medium grained ultramafic (magnetic) greenish black to greyish black -serpentinized rock - quite soft with seams of green clay and soft altered material - fractured sections alternate with massive sections Minor sulphides (Pyrite and Pyrhotite) disseminated throughout the section). Some relict olivine laths visible as small dark, euhedral to subhedral crystals - fine calcite stringers common
			Drilling terminated at 240' PVC pipe inserted in the hole	

42104NW8082 L014890 EMERSON

900

90

Ontario

Ministry of Natural Resources

60 Wilson Avenue
Timmins, Ontario
P4N 2S7

Our file number

Your file number

Memorandum to:

Assessment Files Research Office
77 Grenville Street
Room 802
Toronto, Ontario

Date: July 21, 1982

Subject: **Geotechnical Report entitled:**
Smoky Falls Project
Progress Report of Activities
to April 30, 1982

The geotechnical report(s) attached hereto have been submitted by Selco Inc. persuant to the terms of Exploratory Licence of Occupation Number 14890 . We have reviewed the report and approved it as a portion of the annual exploration obligation for the first term of this licence.

It is understood by the licencee that this assessment work, when approved, is to form part of the public record, and accordingly, may now be placed on file.

Resident Geologist
Sub-Regional Office, Nothern Region
Timmins, Ontario

c.c. *Mining Recorders Office - Timmins*

Ontario

RECEIVED
MAR 2 4 1982
MINING LANDS SECTION

Ministry of
Natural
Resources

60 Wilson Avenue
Timmins, Ontario
P4N 2S7

Our file number
Your file number

Memorandum to:

Assessment Files Research Office
77 Grenville Street
Room 802
Toronto, Ontario

Date: March 16/82

Subject: Geotechnical Report entitled:
Coal Conversion Project for Northeastern Ontario

The geotechnical report(s) attached hereto have been submitted by Lignasco Resources Ltd. persuant to the terms of Exploratory Licence of Occupation Number 14890 . We have reviewed the report and approved it as a portion of the annual exploration obligation for the term of this licence.

It is understood by the licencee that this assessment work, when approved, is to form part of the public record, and accordingly, may now be placed on file.

Resident Geologist
Sub-Regional Office, Nothern Region
Timmins, Ontario

c.c. Mining Recorders Office - Timmins

Dr. A.J. Saber, professional engineer
800 Eglinton Ave. W. Suite 406
Toronto, Ontario m5n 1e1
Tel. 781-4798

Ministry of Natural Resources
Sub-Regional Office
60 Wilson Avenue
Timmins, Ontario P4N 6S7

March 2, 1982

RECEIVED
MAR 24 1982
MINING LANDS SECTION

Attn: Mr. B. Hanley

Dear Mr. Hanley:

Subject - Coal Conversion Project Report

This authorizes you and the Ministry of Natural Resources to quote or cite, in whole or in part, all and any portions of "Coal Conversion Project for Northeastern Ontario," dated 6 June 1981, revised 15 July 1981.

The Ministry may make the report available for the Ministry's purposes without further authorization from me.

Very truly yours,

A.J. Saber