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GEOLOGICAL STUDIES AND EVALUATION OF MacDOUGALL CORE HOLE 1A, WESTERN PRINCE EDWARD ISLAND

R.D. HOWIE

Energy, Mines and Resources Canada
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Foreword

A decision was made by the Government of Canada, through its Department of Energy, Mines and Resources, to co-operate with the Government of Prince Edward Island and its Department of Industry and Commerce in the coring of a hole to determine the possible occurrence of coal, and of uranium and vanadium mineralization, in a specified area in the western part of that province. The Geological Survey of Canada was requested to outline a program of studies and I was appointed co-ordinator of the project. The Department of Industry and Commerce assigned Mr. K. Murricane to be responsible for the technical input of the province. With the advice and support of their respective organizations, the project was set-up on a shared cost basis:

i) The Department of Industry and Resources would be responsible for selecting the site, legal matters pertaining to drilling on the site, arranging a drilling contract, and supervising the drilling program.

ii) The Geological Survey of Canada would be responsible for (a) transport of the core to its Atlantic Geoscience Centre in Dartmouth, (b) geological logging of the core, (c) geophysical logging of the drillhole, (d) such other studies as deemed pertinent toward evaluation of the coal and mineral potential of the area, and (e) compilation of a scientific report on the project.

Items (a) and (b) were taken care of by R.D. Howie of the Geological Survey's Atlantic Geoscience Centre, and his studies constitute the body of the accompanying scientific report. The geophysical logging of the hole was handled under contract with Roke Oil Enterprises Ltd., Calgary, and these operations were supervised in the field by Dr. P.G. Killeen and A.V. Dyck of the Geological Survey. Two of the geophysical logs are shown in Figure 3 (column two) together with the rock types as logged by R.D. Howie. Dr. R.V. Kirkham of the Geological Survey examined the core for sulphides. His report, as well as that by Killeen and Dyck, which supplies pertinent information on the geophysical program, are given in the appendices. The numerous studies under item (d) re coal and mineral content of the core had to be modified, and certain water and gas analyses and gravity measurements had to be deleted from the plans because of difficulties encountered during and following the drilling operations. Also the character of the core itself precluded certain mineralogical and chemical studies though it was examined specifically for sulphides (see Appendix 4). The accompanying report and its appendices fulfil the requirements of the scientific report (Item e) of the joint federal-provincial project.

During the drilling program two attempts were made to reach the planned depth of 3000 feet: MacDougall Core Hole 1 was abandoned at 1798 feet and 1A at 2338 feet, in both cases due to caving of the holes and the attendant drilling difficulties. Aside from some coaly or carbonaceous partings and traces of coaly debris at depth in the holes, only one 4-inch layer of predominantly 'coaly material' was encountered, and this at a depth of 1887 feet in core hole 1A. The provincial government had a summary geological log made for MacDougall Core Hole 1, and it is on file in the relevant government offices; the core also remains in their care for future reference.

Geophysical logging operations were conducted immediately on completion of MacDougall Core Hole 1A to better evaluate the stratigraphic sequence and to check for possible sulphide mineralization and radioactivity. Rapid caving of the walls of this hole prevented the successful completion of some of the planned tests.

V.K. Prest
December 30, 1976

GEOLOGICAL STUDIES AND EVALUATION OF MacDOUGALL CORE HOLE 1A, WESTERN PRINCE EDWARD ISLAND

Abstract

As the source and implications of chips of coal from a rotary hole drilled by Imperial Oil Limited in 1958 were not precisely known, a 6-inch core hole was drilled nearby in 1975 to better evaluate the occurrence. The results of this drilling are given, together with a summary account of the historical geology and of former exploration work pertinent to the island's coal and hydrocarbon potential. A columnar section shows the stratigraphic relationships between the Imperial rotary hole and the recent core hole, and also the corresponding geophysical logs. Appendices to the report, by several authors, include a geological log of MacDougall Core Hole 1A and the results of palynological studies, geochemical analyses, geophysical logging, and sulphide mineral studies.

Résumé

La source et les incidences des fragments de charbon prélevés dans un puits de forage rotary effectué par l'Impérial Oil Limited en 1958 n'étant pas parfaitement connues, un trou de carottage de six pouces de diamètre a été foré tout près en 1975 afin de permettre une meilleure évaluation de la venue. Sont maintenant connus les résultats de ce forage ainsi qu'un rapport récapitulatif de géologie et des travaux antérieur d'exploration sur le potentiel en hydrocarbures et de charbon de l'île. Un profil stratigraphique démontre les rapports stratigraphiques qui existent entre le puits de forage rotary de l'Impérial et le récent trou de carottage ainsi que les diagraphies géophysiques. Les annexes au rapport, qui ont été rédigés par plusieurs auteurs, comprennent une diagraphie géologique du trou de carottage 1A (MacDougall) et les résultats des études palynologiques, des analyses géochimiques, d'une diagraphie géophysique et des études sur les minéraux sulphurés.

INTRODUCTION

Coal has been mined in the Maritime Provinces for about 200 years. The presence of coal measures on Prince Edward Island was first mentioned by Dawson (1842), but the first significant geological account was by Gesner (1846). During 1844 and 1845, he traversed most of Prince Edward Island, studying the topographic features, examining the bedrock, and collecting rock, mineral, fossil and soil samples. Although the surface exposures only represented a very limited stratigraphic section, he stated that the strata at "Gallas Point" were an extension of the Nova Scotia coalfields but did not contain any valuable coal beds.

Ells (1902) published a geological report on the rock structures of the island in which he recommended that a number of anticlinal structures be drilled for coal. This report resulted in the Federal Government contracting 10 000 feet of exploratory drilling to check the coal potential. As the economic limit for coal at that time was considered to be around 2000 feet, the footage allotment was sufficient for five wells. From 1908 to 1909, five cable-tool holes were drilled. They are: Borehole no. 1, Gallows (Gallas) Point (1910 feet); Borehole no. 2, Earnscliffe (1685 feet); Borehole no. 3 Glencoe (2044 feet); Borehole no. 4, Little Sands (2082 feet); and Borehole no. 5, Miminegash (1670 feet). Wells 1 to 4 were drilled east of Charlottetown and well no. 5 on the west coast of Prince Edward Island (Fig. 1).

Boreholes no. 2, 3 and 4 were collared and completed in red beds. Boreholes no. 1 and 5 were collared in red beds but were completed in interbedded grey and red beds. Only Borehole no. 5 contained traces of carbonaceous material, and this below 1000 feet (Brock, 1910); this occurrence is somewhat suspect as it was only "a scum on top of the pumpings". In each of the wells, softness of the strata and the numerous water-bearing horizons caused almost constant caving, which made drilling very difficult. The drilling program did not test the Carboniferous as well as had been expected, but it did indicate that mineable coal was not present within 2000 feet of the surface in the areas drilled.

Brock's report curtailed the exploration for coal on Prince Edward Island for over 65 years. During this period, however, a number of wells were drilled by industry for oil and gas, and by the Federal Government for stratigraphic and palynological purposes (Fig. 1). Nine of these wells, completed below the upper red bed sequence, encountered some carbonaceous material variously described as carbonaceous partings, plant remains, carbonized wood, coaly partings, coaly fragments, coal layers or thin coal beds. Although the description of the carbonaceous material varied from well to well, much of this material was coal. Hacquebard (1956) reported two thin coaly layers at approximately 4080 and 5350 feet below the surface in the Hillsborough No. 1 well. Determinations as to the grade or rank of the coal have been made on coal fragments at 5030 and 5440 feet in the Doherty No. 2 well; at 1910, 2650 and 3060 feet in the Imperial Port Hill No. 1 well; and from 1775 feet in the Imperial MacDougall No. 1 well (Hacquebard and Donaldson, 1970).

The wells listed in Table 1 indicate coal or coaly material in varying amounts, from a few fragments up to 20 or 30 per cent of the rotary sample. Although the estimate as to quantity of coal in each sample may have been correct, the actual thickness of an individual coal seam may actually be much less than the assumed thickness based on the cuttings. This is due to the soft nature of both the coal and the bedrock. When a coal horizon is being drilled by a cable tool or rotary rig, it may cave to many times the area actually cut by the drill, thus inflating the presence of coal in the cuttings to four or five times the true value. If the coal seam continues to cave after it has been penetrated by the drill, the fragments may contaminate the drilling mud, as the hole is deepened, for hundreds or even thousands of feet, giving the impression that the drill has penetrated a whole series of coal seams. In the HB Fina, East Point well, Hacquebard (1973) collected coal fragments for rank determinations from 12 horizons. Under normal circumstances, coal rank increases with depth. In this well a rank of 1.08% Ro (reflectance) was calculated from coal at 7480 feet, 1.14% at 7630 feet, 1.02% at 7700 feet, 1.14% at 9760 feet, 1.12% at 8060 feet, 1.08% at 8150 feet, etc. Hacquebard attributed these anomalous readings in the vitrinite reflectance to mixing of coals due to caving. As the general stratigraphy of Prince Edward Island sediments varies little from area to area, mixing of well-cuttings due to caving is probably true to some extent in each of the other wells.

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Acknowledgments

The writer is indebted to K. Murricane, formerly with the Department of Industry and Commerce, Prince Edward Island, for making all the arrangements regarding the site location and the drilling contract, for supervising the drilling program and arranging temporary core storage in the field. He is appreciative also of the time and effort given by M.S. Barss, A.V. Dyck, P.G. Killeen and R.V. Kirkham who prepared the appendices to this report, and to Dr. V.K. Prest for his advice during compilation of the report and its critical review. Dr. P.A. Hacquebard also reviewed the first draft of the report and advised on matters pertaining to rank of coal.

GENERAL GEOLOGY

Depositional History

During the deposition of Permo-Pennsylvanian rocks in southeastern Canada, Prince Edward Island appears to have been a subsiding basin in which thick accumulations of sediments were deposited (Fig. 2). The repetition of the lithologic sequences, interpreted from drillhole data and surface section, indicate cyclical deposition. The impression is one of fairly uniform and regular subaerial deltaic deposition under relatively uniform climatic conditions (Langston, 1963). As the alluviation continued to build up a surface, the predominant deltaic-lacustrine environment changed to a floodplain-alluvial fan environment. Better drainage caused the destruction of plant and animal remains as an oxidizing environment replaced a partly reducing environment (Frankel, 1966). The occurrence of freshwater fish, terrestrial vertebrates and plants, and intraformational breccias can be attributed also to an aggrading surface with large, shallow, temporary lakes fed by numerous streams. Isostatic adjustments appear to have been maintained near equilibrium during the deposition of these sediments in late Stephanian and early Permian time.

A small outcrop of basaltic rock on George Island in Malpeque Bay is the only igneous rock exposed at the surface in Prince Edward Island (Prest, 1972). Paleomagnetic determinations on this rock suggests a late Upper Permian intrusive (Larochelle, 1967), but K/Ar dates of 200 to 225 m.y. indicate a Triassic age (Prest, 1973).

Age Relationships

The red beds of Prince Edward Island have been assigned by various authors to the Carboniferous, Permo-Carboniferous, Permian and Triassic periods. The occurrence of only scattered amphibian bones in some breccia lenses, and of poorly preserved plant stems and imprints of fern-like leaves in sandstone and siltstones in widely scattered localities, have made dating very difficult. Early correlations were based mainly on lithological similarities which were later supplemented by paleobotanical studies. A summary of the various age assignments and correlations are recorded in Frankel (1966).

In recent years the age of the red beds has been more clearly established through the study of vertebrate fossils (Langston, 1963), and of spore and pollen grains (Barss et al., 1963), from various parts of the island. These reports indicate that the sediments are late Pennsylvanian to early Permian in age and belong to the Pictou Group (Fig. 2). Much of the data confirms the age speculations of earlier workers, except for those advocating the presence of Triassic sediments.

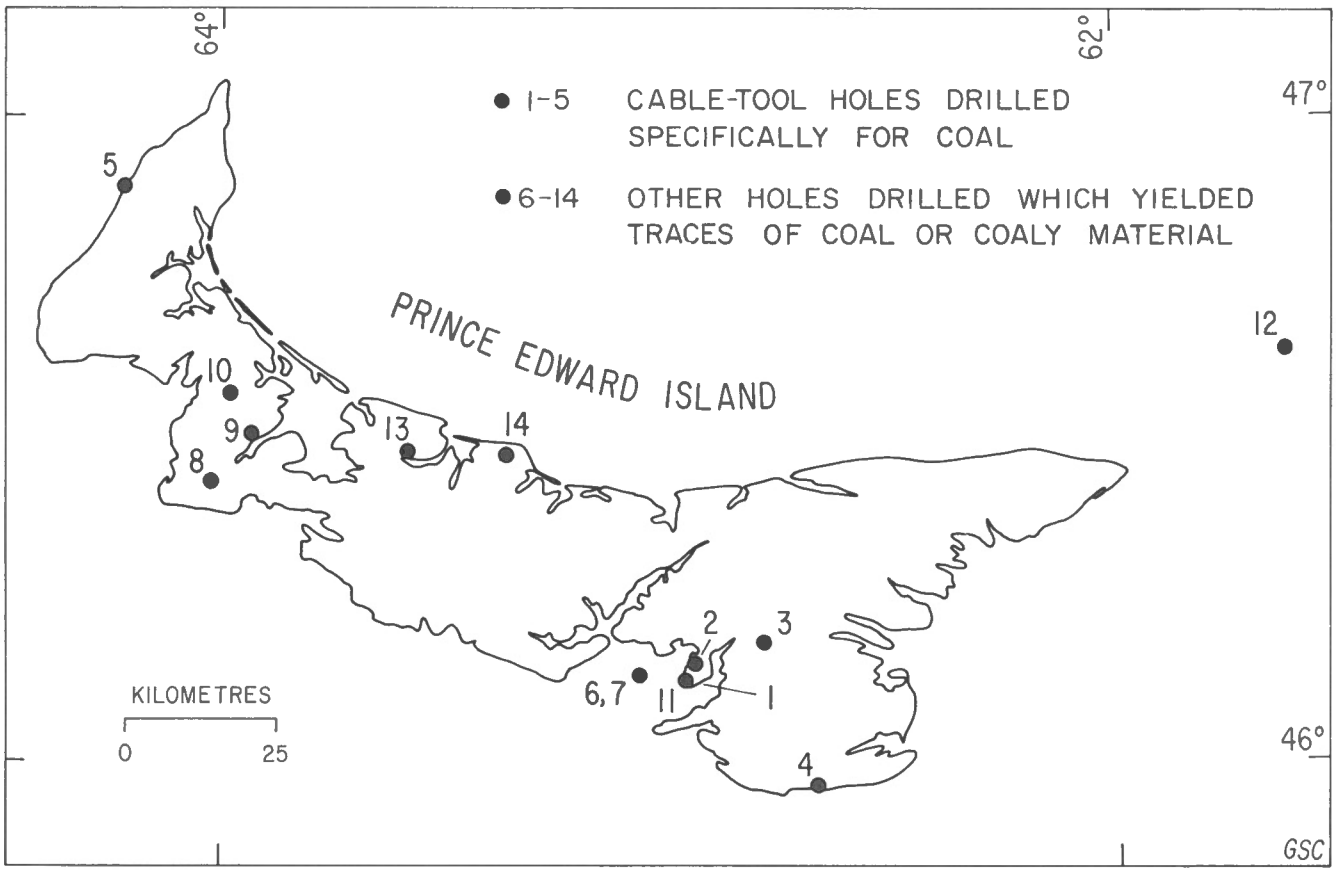

Figure 1. Index map, borehole locations.

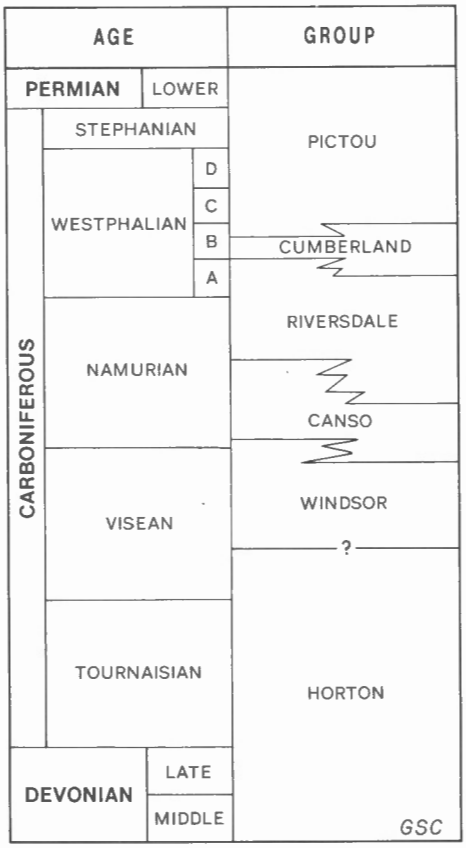

Figure 2. Stratigraphic subdivisions and ages of Upper Paleozoic rocks of Eastern Canada.

Stratigraphy and Terminology

The Permo-Carboniferous sediments on Prince Edward Island consist of weakly cemented mudstone, claystone, siltstone and sandstone, with variably cemented calcarous mudstone breccia and minor conglomerate. These rocks are of terrestrial origin. Although the finer, soft, sediments are mainly noncalcareous, and are bonded only by ferruginous cement and clay, some horizons contain enough calcium carbonate as a cementing medium that they are rather hard and competent. Surface exposures and drill cores indicate rapid facies changes, and cross-bedding is common. The rocks are flat lying to gently undulating with dips of less than 8 degrees. In many horizons the true attitude of the beds is masked by foreset beds and cross-beds with dips ranging up to 25 degrees. The virtual absence of fossils, and the lack of continuity of the beds and of good marker horizons makes stratigraphic and structural interpretation very difficult.

Colour is the most variable characteristic of these rocks. Most of the surface exposures are red of diverse hue and chroma but mainly weak red (Munsell Soil Colour chart), with grey, purple, green and brown as well as red at depth. The various shades of red in the sediment are due to variable amounts of hematite and manganese oxide. Grey or greenish grey mottling in the beds is due to the reduction of ferric iron to ferrous iron in a swamp or other reducing environment containing plant material. The green to grey colour along joints or bedding planes is due to reduction of iron oxide by percolating groundwater.

In general, central Prince Edward Island is underlain by a series of cyclothems composed of 70 to 75 per cent sandstone, 15 to 20 per cent mudstone and up to 10 per cent pebbly sandstone, conglomerate and mudstone breccia (Frankel and Crowl, 1970). The highly cross-bedded character of the sandstones and the lenticularity of all the deposits, the abrupt facies changes and the red colour of the rocks, are all good indicators of a deltaic or low alluvial plain type of depositional environment (Crowl, 1969).

Although the regional geology and rock types of the MacDougall region are dealt within a report on the Malpeque-Summerside area (Prest, 1972), a résumé of the major rock types encountered in MacDougall Core Hole 1A, has been included in this report. They are as follows:

Claystone – A rock composed of indurated clay-size particles; the rock lacks the fissility required by most investigators to be termed a shale.

Siltstone – Indurated sediment with mostly silt-size particles.

Mudstone – Indurated sediment composed of both clay and silt-size particles.

Sandstone – Indurated sediment with fine to coarse grained sand-size particles. The grains are predominantly angular to subrounded with poor to moderate sorting. Quartz and 10 to 30 per cent feldspar are the dominant minerals. Mica, gypsum, apatite, amphibole, chlorite, magnetite and garnet are the main accessory minerals. The individual grains are cemented by a mixture of hematite and clay to form soft arkosic or feldspathic sandstones. Small amounts of carbonate are commonly present also in these rocks. In places the sandstones are highly calcareous and have a white-flecked appearance. Individual sandstone units commonly wedge-out in less than 300 feet or are terminated by scour-fill structures. The thickness of these units may vary, but usually they do not exceed 10 feet (Frankel, 1966).

Calcareous mudstone breccia – An intraformational breccia (locally conglomeratic) composed of angular to roughly-rounded fragments of mudstone, along with grains of quartz and feldspar and fragments of mica, cemented by calcium carbonate and small amounts of iron oxide (Frankel and Crowl, 1970). The platy and angular lithic fragments usually vary in length from less than an inch up to three inches. The colour of the breccia depends on the hue and chroma of the fragments and the ratio of these fragments to the calcium carbonate cement. Greenish grey mottling and greenish grey lenses are due to the presence of plant fragments. Rarely the breccia contains angular to subrounded pebbles of acidic lava, porphyry and quartzite up to a half inch in cross section. These lenticular breccias, in eastern and central parts of the island, are up to 100 feet long and range in thickness from about 3 inches to about 4 feet (Frankel and Crowl, 1970). Field observations indicate they were derived mainly from the underlying strata that were torn up and redeposited during periods of increased runoff. Most vertebrate fossils found in the island red beds have been obtained from the breccias which occur repeatedly through the section (Langston, 1963).

Mudstone breccia – The term mudstone breccia is used where the breccia matrix is noncalcareous.

MacDOUGALL CORE HOLES 1 and 1A

In 1958, when Imperial Oil Limited drilled the MacDougall No. 1 exploratory well for oil and gas, a 30 per cent coal content was reported in well-cuttings form 1890 and 1900 feet below the surface. Geophysical logs over this same interval could be interpreted as representing shale, coal, or a combination of both coal and shale. Geological reports on the Upper Paleozoic rocks of the area by Milligan (1949), Barss et al., (1963), Prest (1962, 1964, 1972), Frankel (1966), Crowl (1969), Frankel and Crowl (1970), Hacquebard (1972) gave the impression that the depositional history of the Prince Edward Island area was not suitable for the accumulation of mineable coal reserves. Nevertheless, the occurrence of questionable amounts of coal and coaly

material in the Imperial MacDougall No. 1 rotary well was instrumental in the funding of a 3000-foot Federal-Provincial exploratory core hole at MacDougall. MacDougall Core Hole 1 was spudded on February 15, 1975 and drilled to 1798 feet, where it was abandoned due to caving and a broken drill rod. The drill rig was skidded 16 feet east and MacDougall Core Hole 1A was spudded on March 16, 1975. This second well was abandoned on April 14, 1975 at 2338 feet due to caving.

As the Imperial MacDougall No. 1 rotary-drill hole and the MacDougall 1A cored hole are only a few hundred feet apart (Fig. 3), the sandstone-siltstone-claystone ratios in both wells are very similar, but the MacDougall 1A core shows details of lithology not available from the chip samples from the rotary well. A general correlation between the two holes, in the columnar sections of Figure 3, is indicated by the dashed lines. A detailed lithologic log of MacDougall Core Hole 1A is given in Appendix 1.

As MacDougall Core Hole 1A was drilled for coal, a résumé of the carbonaceous content is shown in Table 2. The core from 1140.4 to 1505.5 feet contained some carbonaceous horizons and partings. The core from 1887.1 to 1887.4 feet contained about 4 inches of coaly material which corresponds to the 1890-1900 foot level in the Imperial MacDougall well that reported a 30 per cent coal content in the cuttings. The discrepancy in coal content is attributed to caving of the coal horizon in the Imperial MacDougall well. Geochemical analyses were made of 18 core samples to establish the gaseous hydrocarbon content (Table 3). All readings were extremely low — at or close to background.

Spore assemblages from MacDougall Core Hole 1A are considered to be of Stephanian age (Barss, in this report, Appendix 2).

Information on the geophysical work performed in MacDougall Core Hole 1A is given in Appendix 3, and notes on sulphide mineralization is given in Appendix 4. Uranium and vanadium minerals had been reported on Prince Edward Island (Prest et al., 1969) and copper was reported by Gesner (1846) hence specific efforts were made to check for such occurrences.

Table 2

Carbonaceous material from MacDougall Core Hole 1A

Interval in feet below rig floor	Remarks
1140.4 - 1140.8, 1141 - 1141.5	carbonaceous horizons
1441 - 1480.2	carbonaceous partings
1489 - 1498	carbonaceous fragments, 1/2 - to 1-inch thick
1498 - 1505.5	carbonaceous fragments, up to 1/2 inch thick
1887.1 - 1887.4	coaly material
2012.6 - 2012.8, 2013.3 - 2013.4, 2013.5 - 2013.7 2014.5 - 2016.4	scattered coaly fragments
2094.6 - 2102.1, 2110.8 - 2117	carbonaceous partings

Table 3

Geochemical analyses of samples from MacDougall Core Hole 1A*

Depth (feet)	Gaseous hydrocarbons ppm by volume	% organic carbon
1639	180	.14
1668	30	.12
1698	160	.09
1728	100	.14
1758	60	.19
1890	90	.17
1988	80	.26
2024	40	.31
2065	10	.15
2068	10	.15
2123	10	.11
2127	10	.09
2158	10	.13
2188	50	.17
2208	10	.18
2238	30	.18
2278	30	.34
2315	10	.34

*Marine geochemistry laboratory, Atlantic Geoscience Centre, Geological Survey of Canada, Dartmouth

CONCLUSIONS

1. The deltaic, flood plain and alluvial fan type of depositional environment that existed on Prince Edward Island during the deposition of much of the Upper Paleozoic sediments was not conducive to the accumulation of coal deposits.
2. Coal exploration from 1908-1909, occurrences of coal in wells drilled from 1926 to 1972, and the cored hole at MacDougall, all suggest that only minor coal occurrences are present on Prince Edward Island.
3. In order to mine coal from 1800-2000 feet below the surface on Prince Edward Island, it would be necessary to have a number of coal seams that are at least 3 to 5 feet thick and have a considerable areal extent. As the coal occurrences to date are limited to scattered bands, a few inches thick, the possibility of locating an economic deposit on Prince Edward Island is not encouraging.
4. The gamma-ray log of MacDougall Core Hole 1A indicated that there were no favourable horizons of uranium mineralization.
5. Examination of the core from the MacDougall hole for sulphides revealed only limited amounts of pyrite.

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APPENDIX 1

Geological Log of MacDougall Core Hole 1A, Prince Edward Island

R.D. Howie

Drilling Co:	Canadian Longyear Ltd., North Bay, Ontario		
Location:	About 345 feet southeast of Imperial MacDougall no. 1 and about 24 feet north-northwest of an abandoned school at MacDougall, Prince Co., P.E.I.		
	Latitude: 46°30'34"		
	Longitude: 63°56'25"		
Elevation:	30' (Topo Map)	Rig Type:	D.C. Core
Proposed T.D.:	3000'	Completed T.D.:	2338'
Spudded:	March 16, 1975	Completed:	April 14, 1975
Rig Released:	April 28, 1975		
Purpose of Well:	A joint Federal-Provincial project to test for coal and mineralization in the MacDougall area, P.E.I.		

Core examined and colour coded: November, December, 1975

The colour-coding of the core (i.e. 2.5 YR 5/4) refers to the Munsell Soil Color Charts[1]. The first number and letter(s) refers to a constant hue (mixture of red, yellow, green, blue and purple); the second number gives the value of the colour from dark to light (1 to 8); the third number gives the strength or chroma, increasing (1 to 8) from a neutral of the same 'lightness'. In a broad or general way the rocks are mainly "weak red" to a depth of 1270 feet, whereas below this they are generally 'greyish' with some "weak red" to "dark brown" interbeds that diminish in importance downward. Note that shades 5YR4-6/1 are termed dark gray to gray (grey) under the Munsell system.

Section drilled (in feet)	Thickness (in feet)	Lithology
0-38	38	overburden
38-39.3	1.3	calcareous mudstone breccia; angular to well rounded fragments: 10R4/3; in a greenish grey sand matrix
39.3-47.3	8.0	sandstone: 10R5/3; fine grained
47.3-48	0.7	calcareous mudstone breccia
48-48.8	0.8	sandstone: 10R5/3; fine to medium grained
48.8-49.5	0.7	calcareous mudstone breccia
49.5-50.8	1.3	mudstone: 10R4/3
50.8-51.2	0.4	sandstone: 5Y6/1; fine to medium grained
51.2-54.9	3.7	calcareous mudstone breccia
54.9-56.1	1.2	sandstone: 10R5/2; fine to medium grained
56.1-57	0.9	sandstone: 10R5/2; fine to medium grained, with some claystone fragments 10R5/2
57-57.8	0.8	sandstone: 10R5/2; fine to medium grained
57.8-63.9	6.1	calcareous mudstone breccia
63.9-66.3	2.4	sandstone: 10R5/2; fine to medium grained
66.3-67.1	0.8	calcareous mudstone breccia
67.1-77.5	10.4	sandstone: 10R4/2; fine to medium grained; bedding a few degrees from horizontal with foreset beds dipping up to 25°
77.5-78.1	0.6	mudstone fragments 10R4/2 in a sandstone matrix 10R4/2 and some 5Y6/1; fine to medium grained

[1] Munsell Soil Color Charts, 1954 Edition, Munsell Color Company, Inc., Baltimore 18, Maryland, U.S.A.

Section drilled (in feet)	Thickness (in feet)	Lithology
78.1-90.6	12.5	sandstone: 10R4/2-10R5/2; fine to medium grained; dip within a few degrees from horizontal with cross-beds at 12°
90.6-93.7	3.1	claystone: 10R5/2
93.7-96.9	3.2	calcareous mudstone breccia
96.9-97.6	0.7	sandstone: between 10R4/2 and 10R5/2; medium to fine grained; slightly calcareous; some claystone fragments 10R4/2
97.6-99.4	1.8	calcareous mudstone breccia
99.4-114	14.6	sandstone: 10R5/2-10R4/2; fine to medium grained; dip within a few degrees of horizontal
114-114.9	0.9	calcareous mudstone breccia
114.9-116.7	1.8	claystone: near 2.5YR4/2
116.7-117	0.3	calcareous mudstone breccia
117-123.9	6.9	claystone: 2YR4/2; reduced zone near 5Y6/1 at 123.2 to 123.3 feet; bedding within a few degrees of horizontal
123.9-124.1	0.2	claystone and siltstone: banded to mottled 2.5YR4/2 and near 5Y6/1
124.1-124.5	0.4	siltstone: 10R5/2
124.5-140	15.5	sandstone: between 10R5/2 nd 10R4/2; fine to medium grained; dips horizontal to 20°
140-143.2	3.2	calcareous mudstone breccia
143.2-144.7	1.5	claystone: 2.5YR4/4
144.7-149.3	4.6	siltstone to very fine grained sandstone: 2.5YR4/4; dips horizontal to 15°
149.3-150.5	1.2	siltstone 2.5YR4/4, calcareous with some fine to medium size quartz grains
150.5-156	5.5	siltstone to very fine grained sandstone: 2.5YR4/4; green mottling 5Y6/1 at 150.5 to 151 feet; numerous claystone partings 45° to vertical; 151-152 feet with bedding horizontal to near horizontal
156-157.7	1.7	calcareous mudstone breccia
157.7-165	7.3	siltstone to very fine grained sandstone: red 2.5YR4/2 with green mottling near 5Y6/1; some near horizontal bands up to 1/2 inch wide
165-167.7	2.7	calcareous mudstone breccia
167.7-179	11.3	claystone: 10R5/2 to 2.5YR4/2; partings horizontal to 15°; slightly calcareous claystone to siltstone horizons 175.9-176.4 feet and 177.1-177.4 feet; horizontal to near horizontal bedding
179-181.9	2.9	claystone to siltstone: 2.5YR4/2
181.9-186.6	4.7	claystone: 2.5YR4/2; horizontal to near horizontal partings
186.6-193.6	7	claystone to siltstone: 10R4/2; bedding near horizontal; some greenish grey streaks and blotches 5Y6/1, 186.6-187.1 feet and 188.7-188.9 feet
193.6-199.3	5.7	sandstone: 10R5/2 fine to medium grained; bedding horizontal to 8°; slightly calcareous with scattered mudstone fragments at 198-199.3 feet

Section drilled (in feet)	Thickness (in feet)	Lithology
199.3-199.6	0.3	calcareous mudstone breccia
199.6-207.7	8.1	claystone: 2.5YR4/2
207.7-210	2.3	calcareous mudstone breccia
210-212.1	2.1	claystone: 10R4/3
212.1-212.3	0.2	sandstone: near 2.5YR5/2; very fine to fine grained; calcareous
212.3-212.6	0.3	claystone: 10R4/3
212.6-212.9	0.3	sandstone: near 2.5YR5/2; very fine to fine grained; calcareous
212.9-214	1.1	calcareous mudstone breccia
214-215.5	1.5	claystone: 10R4/3
215.5-216.8	1.3	calcareous mudstone breccia
216.8-217.2	0.4	siltstone to fine grained sandstone: 2.5YR5/2; dip 12°; calcareous
217.2-233	15.8	claystone: 2.5YR4/2; massive; bedding near horizontal with some jointing at 45°; scattered calcareous clay nodules; some red blotches at 219 and 234.8 feet
233-234	1.0	siltstone to very fine grained sandstone: 2.5YR/2; near horizontal "greenish grey" horizons approximately 1/2 inch wide at 233.3 and 233.9 feet
234-237.6	3.6	claystone: 2.5YR4/2; partings near horizontal
237.6-239.4	1.8	siltstone: between 2.5YR5/2 and 2.5YR4/2 with green banding near 5Y6/1 from 237.6 to 238 feet and a blotch at 239.3 feet
239.4-247.6	8.2	claystone: 2.5YR4/2; partings near horizontal
247.6-250.8	3.2	claystone to siltstone: 2.5YR4/2; 1/2 inch horizontal band near 5Y6/1 at 249.1 feet
250.8-255.3	4.5	sandstone: between 10R5/2 and 2.5YR5/2; fine to very fine grained
255.3-264.8	9.5	siltstone to very fine grained sandstone: 10R5/2; dip varies from horizontal to 9°; 1 inch horizontal band 5Y6/1 at 255.4 feet
264.8-265.8	1.0	siltstone: 5Y6/1; horizontal bedding
265.8-268.4	2.6	claystone: 2.5YR4/2; partings near horizontal
268.4-270.4	2.0	siltstone to very fine grained sandstone; 10R5/2; a 1-1/2 inch band 5Y6/1 at 268.9 feet
270.4-273.5	3.1	sandstone: 10R5/2; very fine to fine grained, to silty
273.5-275	1.5	calcareous mudstone breccia
275-298.8	23.8	claystone: 2.5YR4/2; mottled 2.5YR4/2 and 2.5Y6/2 from 285.6 to 286 feet; scattered calcareous nodules; partings mainly horizontal; some slickensides with 25° dip from 286 to 288 feet
298.8-305	6.2	claystone to siltstone: 2.5YR4/2; some mottling near 5Y6/1
305-311	6	claystone: 10R4/3; some mottling near 5Y6/1 from 305 to 306.4 feet; horizontal partings
311-320.5	9.5	claystone to siltstone: 2.5YR4/2; some banding near 5Y6/1 from 318 to 318.7 feet

Section drilled (in feet)	Thickness (in feet)	Lithology
320.5-324	3.5	siltstone to very fine grained sandstone: 10R5/2; horizontal partings
324-334.1	10.1	sandstone: 10R5/2; fine to medium grained; partings near horizontal; calcareous from 333.5 to 334.1 feet
334.1-407	72.9	claystone: near 2.5YR3/4; some slickensides with dips from 15 to 60°; occasional calcareous nodules; mottling from 379.3 to 380.7 and 395 to 396.5 feet; some claystone to siltstone zones from 381.5 to 381.9, 386.5 to 387.1 and391.7 to 392.2 feet
407-408	1.0	sandstone: near 10YR6/2; very fine to fine grained with disseminated coaly plant fragments
408-429.1	21.1	sandstone: 10R5/2 to 2.5YR5/2; fine to medium grained; bedding horizontal to 12°
429.1-430.1	1.0	sandstone: 2.5YR5/2; fine to medium grained, calcareous; some claystone fragments near 10R5/2
430.1-437	6.9	sandstone: 2.5YR5/2 to 10YR5/2; fine and medium grained
437-444.3	7.3	sandstone: 2.5YR5/2; fine grained to silty with mudstone breccia from 438.6 to 438.8, 439.8 to 439.9, 440.5 to 440.8 and 442 to 442.4 feet; dips range from horizontal to 25°
444.3-448	3.7	calcareous mudstone breccia
448-449.4	1.4	claystone: 2.5YR5/2 with interbeds of sandstone 5Y6/1 and 2.5YR5/2; fine to very fine grained
449.4-450.8	1.4	claystone to siltstone: 2.5YR4/2
450.8-458	7.2	claystone: 10R4/3; horizontal partings; a few calcareous nodules
458-459.6	1.6	siltstone: 10R5/2-10R4/3; a few calcareous nodules
459.6-465.9	6.3	claystone: 2.5YR4/2; a few calcareous nodules and a few blotches 5Y6/1 related to plant fragments; near horizontal partings and slickensides
465.9-470.5	4.6	siltstone to very fine grained sandstone: 10R5/2; some vertical to near vertical partings containing slickensided claystone
470.5-483	12.5	siltstone to claystone: 2.5YR4/2; partings near horizontal; a few calcareous nodules and a few 5Y6/1 blotches
483-492	9.0	calcareous clay breccia: 10R4/3 with some 5Y6/1 mottling
492-502	10	claystone: 10R5/3 with numerous calcareous nodules
502-507	5.0	claystone to siltstone; 10R4/3; a few small calcareous nodules
507-509.7	2.7	claystone: 10R4/3
509.7-513.7	4.0	claystone to siltstone: 2.5YR4/4; horizontal partings
513.7-519.1	5.4	claystone: 2.5YR4/2; horizontal partings
519.1-520.4	1.3	claystone to siltstone: 2.5YR5/2; horizontal partings
520.4-522.9	2.5	claystone: 10R4/3
522.9-524.6	1.7	siltstone: 2.5YR5/2; some streaks and lenses near 10YR6/1

Section drilled (in feet)	Thickness (infeet)	Lithology
524.6-525.1	0.5	siltstone to very fine grained, silty sandstone: 2.5YR5/2
525.1-528.2	3.1	siltstone to claystone: 2.5YR4/2; a few calcareous nodules
528.2-532	3.8	claystone: 2.5YR4/2
532-534.7	2.7	siltstone: 10R4/4; numerous calcareous nodules
534.7-540.7	6.0	silty sandstone: 10R5/1; a few bands near 5Y6/1; fine to medium grained
540.7-552	11.3	siltstone: 10R5/2; near horizontal partings; a few calcareous horizons and nodules
552-554.5	2.2	claystone: 2.5YR4/2; horizontal partings; a few calcareous nodules
554.5-558	3.5	siltstone: 2.5YR4/2; numerous calcareous nodules; occasional blotches 5Y6/1
558-563.6	5.6	claystone: 2.5YR4/2; horizontal partings; a few calcareous nodules
563.6-568	4.4	siltstone to claystone: 10R4/3 to 10R4/4; some calcareous nodules; some blotches 5Y6/1 from 566 to 568 feet
568-577.3	9.3	claystone: 10R5/3; slickensides 573 to 574 feet; numerous calcareous nodules 570 to 571.5 feet
577.3-579	1.7	siltstone to very fine grained sandstone: 10R4/3 to 2.5YR5/2; some mottling 5Y7/2 to 5Y6/1 from 578 to 579 feet
579-580	1.0	claystone: 2.5YR4/2; horizontal partings
580-580.1	0.1	siltstone: greenish grey 5Y6/1
580.1-584	3.9	siltstone to very fine grained sandstone: 2.5YR4/2
584-595	11	sandstone: 2.5YR5/2; fine to medium grained; bedding 0 to 15
595-606.3	11.3	sandstone: 2.5YR5/2; medium grained
606.3-613.8	7.5	sandstone: 2.5YR5/2; medium to coarse grained
613.8-620	6.2	sandstone: 2.5YR5/2; fine grained; near horizontal bedding
620-621.2	1.2	sandstone: 2.5YR5/2; medium to fine grained
621.2-622.9	1.7	sandstone: 2.5YR5/2; very fine to fine grained
622.9-626	3.1	sandstone: 2.5YR5/2; coarse grained, dip 16°
626-627.4	1.4	sandstone: 2.5YR5/2; fine to medium grained
627.4-628.3	0.9	sandstone: 2.5YR5/2; coarse grained
628.3-629.6	1.3	sandstone: 2.5YR5/2; fine to medium grained
629.6-633.2	3.6	sandstone: 2.5YR5/2; coarse to very coarse grained; near horizontal bedding
633.2-635	1.8	sandstone: 2.5YR5/2; medium to fine grained; near horizontal bedding
635-635.8	0.8	sandstone: 2.5YR5/2; coarse grained; near horizontal bedding
635.8-636.7	0.9	sandstone: 2.5YR5/2; medium to fine grained; near horizontal bedding
636.7-643	6.3	sandstone: 2.5YR5/2; coarse to very coarse grained; dip 10°
643-643.6	0.6	calcareous mudstone breccia
643.6-644.7	1.1	sandstone: 2.5YR5/2; very fine to coarse grained fragments; calcareous cement

Section drilled (in feet)	Thickness (in feet)	Lithology
644.7-646	1.3	sandstone: 2.5YR5/2; fine to very coarse grained
646-647.2	1.2	sandstone: 2.5YR5/2; coarse to conglomeratic
647.2-648.6	1.4	sandstone: 2.5YR5/2; fine grained, near horizontal bedding
648.6-650.5	1.9	sandstone: 2.5YR5/2; medium to coarse grained; near horizontal bedding
650.5-651.8	1.3	calcareous mudstone breccia
651.8-652.5	0.7	sandstone: near 5Y6/1; fine grained; calcareous; horizontal bedding
652.5-659.6	7.1	claystone: near 10R5/2; a few calcareous nodules with sandstone 5Y6/1 from 658.4 to 658.7 and 659.3 to 659.6 feet; fine grained; slightly calcareous
659.6-662.1	2.5	sandstone: 5YR5/2; with lower 1 1/2 inch 5Y6/1; fine to medium grained; horizontal bedding
662.1-663.2	1.1	claystone: 2.5YR4/2; horizontal partings
663.2-673.6	10.4	siltstone and fine grained sandstone: near 10R4/2
673.6-682.5	8.9	sandstone: 10R4/2; medium to coarse grained
682.5-698	15.5	sandstone: 10R4/2; medium to fine grained; partings near horizontal to 17°
698-700.2	2.2	sandstone: 5Y6/1; fine grained with some medium grained fragments
700.2-701.5	1.3	claystone: 2.5YR4/2
701.5-707.2	5.7	sandstone: 10R4/2; fine to medium grained
707.2-712.4	5.2	sandstone: 10R5/2; medium grained with a few coarse grained fragments at 708.6 to 711.4 feet; calcareous sand with claystone fragments to calcareous mudstone breccia
712.4-712.8	0.4	claystone: 2.5YR4/2; partings at 12°
712.8-713.3	0.5	sandstone: near 5Y6/1; medium grained
713.3-714	0.7	claystone: 2.5YR4/2
714-714.6	0.6	calcareous mudstone breccia
714.6-726	11.4	sandstone: 10R5/2-2.5YR5/2; fine to medium grained; some coarse grained calcareous horizons 719.2 to 719.7, 722.3 to 722.5 and 724.2 to 724.6 feet
726-733.2	7.2	sandstone: 10R5/2-10R4/2; fine to medium grained
733.2-748.6	15.4	sandstone: 10R5/2; very fine to fine grained; near horizontal partings
748.6-749.9	1.3	sandstone: 10R5/2; fine to medium grained
749.9-750.3	0.4	mudstone breccia
750.3-752	1.7	sandstone: 10R5/2; medium grained
752-753.9	1.9	mudstone breccia: a few rounded foreign pebbles (altered volcanics and metasediments)
753.9-758.8	4.9	sandstone: 2.5YR5/2; fine to medium grained with a few coarse grained fragments and a few pebbles as above
758.8-759.4	0.6	sandstone: 10R5/2; fine to medium grained with a few foreign pebbles and claystone fragments; calcareous

Section drilled (in feet)	Thickness (in feet)	Lithology
759.4-763.8	4.4	sandstone: 10R4/2; fine to medium grained
763.8-766.9	3.1	sandstone: 10R4/2; medium to coarse grained slightly calcareous
766.9-769	2.1	sandstone: 10R4/2; fine to medium grained
769-770.2	1.2	sandstone: 10R4/2; medium grained
770.2-776	5.8	sandstone: 10R4/3; fine to medium grained
776-778.5	2.5	sandstone: 10R4/2; medium to very coarse grained with some fine grained fragments
778.5-782	3.5	sandstone: 10R4/3; fine grained
782-803	21	sandstone: 10R4/3; fine to medium grained with numerous micaceous partings 798 to 803 feet
803-804.1	1.1	calcareous mudstone breccia
804.1-810	5.9	sandstone: 10R4/2 and some 2.5YR5/2; fine to medium grained; a 1 inch mudstone horizon at 806.2 feet
810-844	34	sandstone: 10R4/2 to 10R4/3 and some 10R4/1; fine to medium grained, with some coarse granules
844-845	1	calcareous mudstone breccia
845-857.2	12.2	sandstone: 10R4/2; fine to medium grained with some micaceous horizontal partings
857.2-858.5	1.3	sandstone: 10R4/2; medium to coarse grained
858.5-862.3	3.8	sandstone: 2.5YR5/2; medium to coarse grained with some fine grained sand fragments; calcareous with scattered claystone fragments
862.3-866	3.7	calcareous mudstone breccia
866-869	3	claystone: to siltstone 10R4/3
869-870.2	1.2	claystone: with a high concentration of calcareous nodules 10R5/3
870.2-871.7	1.5	claystone: 10R5/3 with some calcareous nodules
871.7-873.6	1.9	claystone to siltstone: 2.5YR4/2
873.6-873.9	0.3	calcareous nodules in a claystone matrix: 10R4/3
873.9-881.1	7.2	claystone: 10R4/3; some calcareous nodules; horizontal bedding
881.1-888.5	7.4	claystone to siltstone: 10R4/3 to 2.5YR4/2; some near horizontal greenish grey bands and blotches; numerous calcareous nodules
888.5-890	1.5	siltstone to very fine grained sandstone: 2.5YR5/2; upper inch of this section reduced to greenish grey
890-890.3	0.3	nodular limestone with a sand matrix to a very calcareous sandstone: 2.5YR5/2
890.3-893	2.7	siltstone to very fine grained sandstone: near 2.5YR5/2
893-900.3	7.3	sandstone: 10R6/1 to 10R5/1; fine to medium grained with a number of 3 to 6-inch very calcareous horizons
900.3-901.3	1	sandstone: 10R5/1; medium to coarse grained
901.3-901.8	0.5	calcareous mudstone breccia
901.8-902.6	0.8	sandstone: 10R5/1, fine to medium grained
902.6-912.1	9.5	claystone: 10R4/3; a few calcareous nodules; horizontal partings

Section drilled (in feet)	Thickness (in feet)	Lithology
912.1-915.8	3.7	claystone to siltstone: 2.5YR4/2
915.8-926	10.2	siltstone to fine grained sandstone: 2.5YR5/2; with a few medium grained sand fragments; the upper 1/2 inch of section is reduced to a greenish grey; dip horizontal to 17°; calcareous horizon 919.2 to 919.4 feet
926-926.7	0.7	calcareous mudstone breccia
926.7-938.2	11.5	sandstone: 10R5/2 to 10R4/2; fine to medium grained
938.2-946	7.8	sandstone: near 10R4/3; fine to medium with some coarse grained fragments; calcareous horizons 938.2 to 938.3, 939.4 to 939.5. 940.7 to 941.5 feet
946-948	2	sandstone: 10R4/2; fine to medium grained
948-948.3	0.3	calcareous mudstone breccia
948.3-950	1.7	sandstone: greenish grey pale 5Y6/1; fine to medium grained; the lower half of section slightly calcareous
950-965	15	claystone to siltstone: 10R5/2 to 10R4/3; rubbly with numerous small calcareous nodules 958 to 962 feet
965-968	3	sandstone: 2.5YR5/2; very fine to fine grained
968-974.2	6.2	sandstone: 2.5YR5/2; fine to medium grained
974.2-983	8.8	sandstone: 10R4/2; medium to coarse grained with some fine grained fragments
983-983.4	0.4	siltstone: 10R4/3; and some silty sandstone 5Y6/1; medium grained
983.4-1020.7	37.3	sandstone: near 5R4/3 to 5R5/3; fine to medium grained; massive; but locally bedding is horizontal to 18°; some calcareous horizons
1020.7-1022.8	2.1	siltstone to very fine grained sandstone: 10R4/2; some streaks and lenses 5Y6/1 up to 1 inch thick
1022.8-1043	20.2	sandstone: 10R4/2; fine to medium grained; massive; with numerous calcareous horizons; 1 to 3 inch thick from 1031 to 1036 feet and a 2 inch band at 1039.6 feet
1043-1058.6	15.6	claystone to siltstone: 10R4/2; some calcareous nodules and calcareous horizons; a few greenish grey blotches and a thin band at 1056.1 to 1056.3 feet
1058.6-1058.9	0.3	siltstone to very fine grained sandstone: 5Y6/1
1058.9-1059.2	0.3	claystone to siltstone: 10R4/3 to 5Y6/1
1059.2-1060.7	1.5	siltstone to very fine sandstone: 2.5YR5/2
1060.7-1063	2.3	claystone to siltstone: 2.5YR4/2; horizontal partings
1063-1063.2	0.2	siltstone to fine grained sandstone: 5Y6/1; greenish grey
1063.2-1069	5.8	sandstone: 10R4/2; fine to medium grained, with a few coarse granules
1069-1075.3	6.3	sandstone: 10R5/2 to 10R4/2; medium to coarse grained
1075.3-1078.3	3	sandstone: 10R4/3; medium to fine grained
1078.3-1080.6	2.3	calcareous mudstone breccia
1080.6-1085.3	4.7	sandstone: 10R4/3; medium grained
1085.3-1086.2	0.9	calcareous mudstone breccia

Section drilled (in feet)	Thickness (in feet)	Lithology
1086.2-1089	2.8	claystone to siltstone: 10R5/2
1089-1089.5	0.5	siltstone to fine grained sandstone: some medium grained fragments 2.5YR4/2
1089.5-1098.5	9	sandstone: fine to medium grained 2.5YR4/2; 5Y6/1 from 1089.5 to 1090.2, 1098.3 to 1098.5 feet; calcareous horizons 1093.4 to 1093.7, 1095 to 1096.5 and 1097.2 to 1098.5 feet
1098.5-1100.7	2.2	siltstone to fine grained sandstone: 2.5YR4/2; 5Y6/1 from 1100 to 1100.2 feet
1100.7-1138.8	38.1	sandstone: 2.5YR5/2; fine to medium grained; massive with calcareous horizons 1105.6 to 1106.2 feet
1138.8-1141.5	2.7	sandstone: 10R4/2; medium to coarse grained some fine grained granules; carbonaceous horizons 1140.4 to 1140.8 and 1141 to 1141.5 feet
1141.5-1158	16.5	sandstone: 10R4/2; medium to fine grained, with some coarse grained fragments
1158-1159.9	1.9	calcareous mudstone breccia
1159.9-1162	2.1	sandstone: 10R4/2; medium to fine grained, some coarse grained fragments
1162-1165.5	3.5	sandstone: 10R4/2; medium to coarse grained, with some fine grained granules
1165.5-1166.1	0.6	calcareous mudstone breccia
1166.1-1166.8	0.7	sandstone: 10R4/2; medium grained
1166.8-1167.4	0.6	calcareous mudstone breccia
1167.4-1167.8	0.4	sandstone: 10R4/2; medium grained
1167.8-1170.3	2.5	claystone to siltstone to very fine grained sandstone: 2.5YR4/2; 1/2 inch greenish grey horizontal band at 1169.7 feet
1170.3-1187.2	16.9	sandstone: 2.5YR5/2; medium grained
1187.2-1187.8	0.6	calcareous mudstone breccia
1187.8-1213.7	25.9	sandstone: 2.5YR5/2; fine to medium grained; dip horizontal to 15°
1213.7-1214.6	0.9	calcareous mudstone breccia
1214.6-1216.5	1.9	sandstone: 10R5/2; fine to medium grained
1216.5-1217.7	1.2	calcareous mudstone breccia
1217.7-1227.2	9.5	sandstone: 10R4/3; fine to medium grained
1227.2-1228	0.8	sandstone: 10R4/3; a few silty lenses
1228-1237.3	9.3	sandstone: 10R4/3; very fine to fine grained; some medium grained sand granules; bedding horizontal to 28°
1237.3-1251.2	13.9	sandstone: 10R4/3; fine to medium grained
1251.2-1252.3	1.1	calcareous mudstone breccia, with a high content of sand
1252.3-1253.6	1.3	sandstone: 10R4/3; medium grained
1253.6-1254.2	0.6	calcareous mudstone breccia
1254.2-1259.3	5.1	siltstone to very fine grained sandstone: 10R4/3; about 2/3 of section is calcareous with a couple of greenish grey streaks
1259.3-1269.9	10.6	sandstone: 10R4/3 to 10R5/1; fine to medium grained
1269.9-1270.4	0.5	sandstone: near 5Y6/1; fine to medium grained calcareous with some irregular clay partings

Section drilled (in feet)	Thickness (in feet)	Lithology
1270.4-1271.2	0.8	sandstone: near 5Y6/1; fine grained
1271.2-1272.6	1.4	calcareous mudstone breccia
1272.6-1273.7	1.1	sandstone: near 5Y6/1; fine to medium grained; numerous irregular clay partings
1273.7-1276.1	2.4	sandstone: near 5Y6/1; fine to medium grained; horizontal bedding
1276.1-1277.9	1.8	claystone: mottled red and green 10R3/2 and 5Y6/1
1277.9-1283	5.1	claystone: near 10R4/3
1283-1285.5	2.5	calcareous claystone breccia: near 10R4/3
1285.5-1288	2.5	claystone: 10R4/3
1288-1288.5	0.5	claystone breccia: 10R4/3
1288.5-1290.9	2.4	claystone: 10R4/3; numerous calcareous nodules
1290.9-1297.8	6.9	claystone: 10R4/3; horizontal partings
1297.8-1306	8.2	sandstone: 2.5YR5/2; fine and medium grained; upper 7 inches of section is near 5Y6/1
1306-1306.9	0.9	sandstone: 2.5YR5/2 to near 10R4/2; fine grained to siltstone
1306.9-1334.3	27.4	sandstone: 2.5YR5/2; fine to medium grained; a few red and greenish grey shale partings
1334.3-1335.2	0.9	sandstone: 10R5/1; medium grained, calcareous
1335.2-1343.2	8	sandstone: 10R5/1; fine to medium grained; calcareous from 1342.7 to 1343.2 feet
1343.2-1343.8	0.6	calcareous mudstone breccia
1343.8-1345.8	2.0	sandstone: 10R5/1; fine to medium grained
1345.8-1346.7	0.9	calcareous mudstone breccia
1346.7-1357.2	10.5	sandstone: 10R5/1; fine to medium grained; 5Y6/1 from 1356 to 1357.2 feet Note: manganese in fractures – from 1346.3 to 1347.5 feet
1357.2-1358	0.8	claystone: near 10R4/2
1358-1361.4	3.4	claystone to siltstone: greenish grey to grey
1361.4-1362.2	0.8	claystone: 5R3/2; with yellow and green mottling
1362.2-1372.7	10.5	claystone: 5YR4/1; some slickensides
1372.7-1382.5	9.8	claystone: grey; some slickensides
1382.5-1383	0.5	claystone: mottled 10R3/1 and greenish grey
1383-1391.6	8.6	claystone: 10R3/1; numerous calcareous nodules to very calcareous claystone 1383.9 to 1384.7 feet and a 2 inch greenish grey horizon at 1387.2 feet
1391.6-1393	1.4	sandstone: near 5Y6/1; fine grained
1393-1394.1	1.1	claystone: near 5YR4/1; near horizontal partings
1394.1-1395.9	1.8	sandstone: greenish grey from 1394.1 to 1394.5 feet and 5YR5/1 from 1394.5 to 1395.9 feet very fine to fine grained
1395.9-1413.2	17.3	sandstone: 5YR5/1; and from 1411.9 to 1413.2 feet greenish grey; fine to medium grained
1413.2-1415.1	1.9	calcareous mudstone breccia
1415.1-1425	9.9	claystone: 5YR5/1 to 5YR4/1
1425-1426.4	1.4	claystone to siltstone: 5YR5/1
1426.4-1427.2	0.8	sandstone: near 10R5/1; medium grained

Section drilled (in feet)	Thickness (in feet)	Lithology
1427.2-1431.9	4.7	claystone to siltstone: 5YR5/1 to 5YR4/1
1431.9-1437.5	5.6	siltstone to fine grained sandstone: 5YR5/1; the lower 6 inches of section is greenish grey
1437.5-1441	3.5	claystone to siltstone: 5YR5/1-5YR4/1
1441-1456.7	15.7	sandstone: 5Y6/1; very fine to fine grained with carbonaceous and micaceous partings; dip horizontal to 12°
1456.7-1480.2	23.5	sandstone: greenish grey 5Y6/1, very fine to fine grained with some fine to medium grained horizons; carbonaceous and micaceous partings horizontal to 10°
1480.2-1480.5	0.3	mudstone breccia: grey, very pyritic with coaly plant fragments
1480.5-1498	17.5	sandstone: 5Y6/1; very fine to medium grained; numerous carbonaceous or micaceous partings; horizontal to 15°; pyritic sandstone with carbonaceous fragments 1/2- to 1-inch thick in two to three horizons between 1489-1498 feet
1498-1505.5	7.5	sandstone: 5Y6/1; very fine to medium grained; 5 inches pyritized containing carbonaceous plant fragments up to 1/2 inch thick
1505.5-1522.6	17.5	sandstone: 5Y6/1; very fine to medium grained; carbonaceous fragments with associated pyrite at 1517.6 feet
1522.6-1524.4	1.8	calcareous mudstone breccia
1524.4-1525.2	0.8	siltstone: 5Y6/1 and 5YR4/1
1525.2-1532.5	7.3	claystone: 5YR4/1; partings horizontal to 10°
1532.5-1533.8	1.3	claystone: 5Y4/1; slickensides
1533.8-1534.5	0.7	claystone: mottled; 5YR4/1 to 5Y4/1
1534.5-1541.3	6.8	claystone to siltstone: 5YR4/1
1541.3-1542.4	1.1	claystone to siltstone: mottled; 5YR4/1 and 5Y4/1
1542.4-1549.6	7.2	claystone: 5YR4/1
1549.6-1560.1	10.5	siltstone to very fine grained sandstone: 5YR5/1-5YR4/1; partings horizontal to 15°
1560.1-1579.5	19.4	sandstone: 5YR6/1 to 5YR4/1; fine to medium grained
1579.5-1600	20.5	sandstone: 2.5Y7/1 to 2.5Y6/1; fine to medium grained
1600-1602.6	2.6	siltstone: 5YR4/1
1602.6-1616.7	14.1	claystone: 5YR4/1; slickensides and greenish grey mottling 1610.5 to 1612 feet
1616.7-1617	0.3	siltstone: 5YR4/1; greenish grey
1617-1622.3	5.3	siltstone: 5YR4/1; flaser bedding
1622.3-1629.1	6.8	claystone: 5YR4/2; 1622.3 to 1624.2 feet mottled greenish grey and 5YR4/2
1629.1-1639.6	10.5	claystone to siltstone: 5YR5/1 to 5YR4/1
1639.6-1643.8	4.2	claystone: mottled 5YR4/1 and 5Y5/2
1643.8-1651.8	8	claystone: 5YR4/1
1651.8-1652.1	0.3	calcareous mudstone breccia: mottled greenish grey 5Y5/2 and some 5YR4/1
1652.1-1658	5.9	claystone: 2.5YR5/2; scattered calcareous nodules; calcite in small fractures; a few greenish grey blotches 5Y5/2

Section drilled (in feet)	Thickness (in feet)	Lithology
1658-1712.2	54.2	claystone to siltstone: 10R4/2 to 2.5YR5/2; scattered calcareous nodules; highly mottled greenish grey, calcareous from 1684.6 to 1685.5, 1701.6 to 1702.9, 1709.7 to 1710.5 feet; partings near horizontal
1712.2-1725.6	13.4	claystone: 5YR4/1; a few pale greenish grey streaks or blotches; generally a little calcareous
1725.6-1726.5	0.9	siltstone: 5YR4/1 to near 5Y6/1; mottled
1726.5-1732	5.5	claystone: 5YR4/1; high concentration of pale greenish grey, calcareous nodules from 1729.6 to 1730 feet and some greenish grey streaks
1732-1739	7	claystone to siltstone: 5YR4/1 and 5YR5/1; horizontal bedding with occasional thin greenish grey streaks
1739-1745.6	6.6	claystone: 5YR4/1; horizontal partings
1745.6-1747.5	1.9	claystone: 5YR4/1; some greenish grey streaks grading to grey
1747.5-1751.5	4	claystone: grey to black
1751.5-1755.5	4	claystone to siltstone: grey
1755.5-1758.3	2.8	claystone: grey to grey with a purplish cast 5YR5/2; horizontal partings
1758.3-1791.9	33.6	sandstone: grey, mainly fine grained with some fine to medium grained horizons; massive; locally bedding near horizontal
1791.9-1794	2.1	calcareous mudstone breccia: grey
1794-1806.3	12.3	sandstone: grey; fine to medium grained; scattered mudstone fragments
1806.3-1813.2	6.9	claystone to siltstone: fairly dark grey to grey; bedding near horizontal
1813.2-1838.4	25.2	sandstone: grey; medium grained; massive; with a few mudstone fragments from 1835.5 to 1837 feet
1838.4-1839.9	1.5	calcareous mudstone breccia
1839.9-1841.9	2	claystone: 5YR5/1
1841.9-1850.2	8.3	siltstone to very fine sandstone: 5YR5/1 to grey; with thin interbeds, mottled purplish brown and green
1850.2-1863.6	13.4	claystone: 5YR4/1 to 5YR3/2; some greenish grey laminae; bedding near horizontal
1863.6-1877.4	13.8	claystone and siltstone: 5YR4/1 to 5YR3/2; green interbeds, laminae and blotches with colour gradations from purple to greenish grey and grey
1877.4-1879.5	2.1	claystone to siltstone: dark to light grey; interbedded to gradational
1879.5-1883.5	4	siltstone to very fine grained sandstone: light grey with small scattered plant fragments
1883.5-1883.9	0.4	calcareous mudstone breccia
1883.9-1887.1	3.2	claystone: grey; partings near horizontal
1887.1-1887.4	0.3	coaly material
1887.4-1888.4	1	claystone: dark grey to black, with horizontal laminae; slickensides
1888.4-1893.7	5.3	claystone: light to fairly dark grey; a little pyrite from 1891 to 1892 feet
1893.7-1897.8	4.1	claystone: 5YR4/1; grades to grey; mottled

Section drilled (in feet)	Thickness (in feet)	Lithology
1897.8-1899.6	1.8	claystone: grey to greenish grey
1899.6-1902.5	2.9	claystone: 5YR4/1; some slickensides, horizontal to 35°
1902.5-1904.8	2.3	claystone to siltstone: 5YR4/1 with grey; blotchy interbeds
1904.8-1905.9	1.1	calcareous mudstone breccia
1905.9-1915.8	9.9	siltstone to very fine grained sandstone: 5YR4/2; grades to grey; interbedded; gradational to blotchy
1915.8-1922.8	7	sandstone: 5YR5/1 grading to pale grey; medium grained
1922.8-1948	25.2	sandstone: grey; fine to medium grained; massive; mudstone breccia from 1932 to 1932.9 feet
1948-1950.4	2.4	calcareous mudstone breccia: some laminae of grey sandstone and purple siltstone 5YR5/1
1950.4-1961.7	11.3	sandstone: 5YR5/1; thin bedded; fine grained, with calcareous nodules from 1958.1 to 1958.4 feet
1961.7-1963	1.3	calcareous mudstone breccia
1963-1978.1	15.1	claystone: 5YR4/1; a few greenish grey blotches and pale grey calcareous nodules
1978.1-1984.5	6.4	siltstone to fine grained sandstone: 5YR5/1; flaser bedding
1984.5-1985.6	1.1	sandstone: grey; medium grained
1985.6-2005.8	20.2	sandstone: grey; some 5YR6/1 to 5YR4/1; fine to medium grained; bedding horizontal to 15°
2005.8-2012.6	7.2	sandstone: lighter grey; medium to coarse grained
2012.6-2016.5	3.9	sandstone: light grey; pyritic coaly debris from 2012.6 to 2012.8, 2013.3 to 2013.4, 2013.5 to 2013.7 feet; a 1/4 inch pyritic zone at 2015 feet coal partings and small fragments 2014.5 to 2016.4 feet
2016.5-2017.5	1	calcareous mudstone breccia
2017.5-2026.4	8.9	claystone: grey
2026.4-2027.1	0.5	sandstone: grey; very fine grained
2027.1-2027.5	0.4	claystone to siltstone: grey
2027.5-2056.5	29	sandstone: grey; medium grained; a few coaly partings
2056.5-2057.3	0.8	calcareous mudstone breccia
2057.3-2060	2.7	claystone: grey
2060-2063.5	3.5	claystone: mottled 5YR5/1 to 5YR4/1 and 5Y5/2
2063.5-2072.3	8.8	claystone 5YR4/1: horizontal partings
2072.3-2082.4	10.1	claystone to siltstone: 5YR4/1
2082.4-2094.6	10.2	siltstone to very fine grained sandstone: 5YR5/1; horizontal bedding
2094.6-2102.1	7.5	sandstone: pale grey; fine to medium grained; a few carbonaceous partings
2102.1-2104	1.9	calcareous mudstone breccia: light grey
2104-2105.8	1.8	sandstone: grey; very fine grained
2105.8-2106.2	0.4	calcareous mudstone breccia
2106.2-2117	10.8	sandstone: light grey; medium grained; some carbonaceous partings; from 2110.8 to 2117 feet calcareous mudstone breccia and shale partings
2117-2123.9	6.9	sandstone: grey to light grey; very fine grained
2123.9-2135.8	11.9	claystone to siltstone: 5YR4/1 and dark grey to grey

Section drilled (in feet)	Thickness (in feet)	Lithology
2135.8-2155.6	19.8	claystone to siltstone: 5YR5/1 and 5Y5/3; mottled
2155.6-2160.3	4.7	claystone to siltstone: dark to light grey; some slickensides in upper part of section
2160.3-2164.1	3.8	claystone: mottled 5YR5/1 and 5Y5/3
2164.1-2167.6	3.5	claystone: 5YR5/1; a few calcareous nodules
2167.6-2179.4	11.8	siltstone to fine grained sandstone: 5YR5/1 to light grey
2179.4-2185.1	5.7	claystone to siltstone: fairly dark grey to grey; thin bedded
2185.1-2190.6	5.5	sandstone: light grey; very fine grained; light grey beds contain wisps of dark grey, carbonaceous and micaceous sandstone to claystone; flaser bedding
2190.6-2219.7	29.1	sandstone: light grey; fine to medium grained; massive with a few carbonaceous partings; bedding near horizontal; coal fragments from 2210 to 2210.2 and from 2210.7 to 2210.9 feet
2219.7-2220.4	0.7	claystone to siltstone: grey; two sand lenses
2220.4-2235.6	15.2	sandstone: light grey; medium grained; numerous horizontal carbonaceous partings from 2231 to 2233 feet; carbonaceous partings, calcareous mudstone breccia and calcareous medium to coarse sandstone from 2233 to 2235.6; a few dark grey mudstone fragments from 2224.8 to 2225.5 feet
2235.6-2236.6	1	claystone to siltstone: light grey
2236.6-2242.7	6.1	claystone: banded to mottled 5YR5/1 and 5Y5/3 from 2236.6 to 2242.7; highly slickensided from 2240.7 to 2242.7 feet
2242.7-2247.9	5.2	claystone: 5YR4/1 to 5YR3/1
2247.9-2253.2	5.3	claystone: 5YR4/1 and 5Y5/3; banded and mottled; slickensides
2253.2-2255.7	2.5	claystone to siltstone: 5YR4/1 and 5Y5/3; mottled
2255.7-2275.9	20.2	siltstone to fine grained sandstone: 5YR5/1 to light grey; bedding near horizontal
2275.9-2281	5.1	sandstone: 5YR5/1 to dominantly grey; fine to medium grained; calcareous
2281-2297.7	16.7	sandstone: grey with some bands of 5YR5/1; medium grained
2297.7-2303	5.3	claystone: 5YR4/1 to 5YR6/1; a few calcareous nodules
2303-2308.7	5.7	claystone to siltstone: 5YR4/1 to 5YR6/1; near horizontal; some flaser bedding
2308.7-2310.4	1.7	claystone to siltstone: grey
2310.4-2317.7	7.3	claystone: grey to fairly dark grey; black coaly and some pyritic fragments from 2322.4 to 2322.6 and 2322.5 to 2322.7 feet
2317.7-2325	7.3	claystone to siltstone: grey
2325-2333.1	8.1	claystone: 5YR5/1 to 5YR3/1; a few calcareous nodules
2333.1-2335.2	2.1	claystone to siltstone: 5YR5/1 to 5YR4/1; numerous calcareous nodules; horizontal partings
2335.2-2337.6	2.4	claystone: 5YR5/1, to 5YR4/1, numerous calcareous nodules
2337.6-2338	0.4	siltstone to very fine grained sandstone: grey horizontal banding with flaser bedding

END OF HOLE

APPENDIX 2

Report on Palynological Analysis of MacDougall Core Hole 1A, Prince Edward Island

M.S. Barss

GSC Locality No.: D-147

Location: 46°30'34"N; 63°56'25"W

Depth: 2338 feet

Samples were processed from 1808.5, 1808.9, 1809.3, 1886.5, 1888.1 and 2317.7 feet. Only a few specimens were recovered from 1886.5, 1888.1 and 2317.7 feet. All spores recorded are present in the 1808.5 to 1809.3 foot interval.

The spores identified are as follows:

Apiculatisporis sp.
Calamospora breviradiata Kosanke
C. liquida Kosanke
C. minuta Knox
C. pallida (Loose) Schopf, Wilson & Bentall
C. sp.
Cirratriradites ornatus Neves
C. saturni (Ibrahim) Schopf, Wilson & Bentall
Columnisporites ovalis Peppers
Converrucosisporites sp.
Convolutispora sp. 1 Peppers
Convolutispora sp.
Cyclobaculisporites indicus Bharadwaj & Salujha
C. minutus Bharadwaj & Salujha
Cyclogranisporites aureus (Loose) Potonié & Kremp
C. microgranus Bharadwaj
C. vagus (Kosanke) Potonié & Kremp
C. sp.
Dictyotriletes sp.
Endosporites zonalis (Loose) Knox
Florinites antiquus Schopf
F. circularis Bharadwaj
F. dissacoides Alpern
F. eremus Balme & Hennelly
F. mediapudens (Loose) Potonié & Kremp
F. millotti Butterworth & Williams
F. ovatus Dybova & Jachowicz
F. pumicosus (Ibrahim) Schopf, Wilson & Bentall
F. triletus Kosanke
F. visendus (Ibrahim) Schopf, Wilson & Bentall
F. spp.
cf. **Grumosisporites varioreticulatus** (Neves) Smith & Butterworth
cf. **Hymenospora paucirugosa** Peppers
cf. **Knoxisporites triradiatus** Hoffmeister, Staplin & Malloy
Laevigatosporites crassus Peppers
L. vulgaris Ibrahim
Leiotriletes sphaerotriangulus (Loose) Potonié & Kremp
L. sp.
Limitisporites monstruosus (Luber & Waltz) Hart
L. sp.
Lophotriletes commissuralis (Kosanke) Potonié & Kremp
L. sp.
Lycospora pseudoannulata Kosanke
Piceapollenites sp.
Potonieisporites cf. **P. elegans** (Wilson & Kosanke) Wilson & Venkatachala
P. novicus Bharadwaj
P. simplex Wilson
P. sp.
Protohaploxypinus globus (Hart) Hart
P. samoilovichii (Jansonius) Hart
P. sp.
Punctatisporites edgarensis Peppers
P. sinuatus (Artuz) Neves
P. sp.
Punctatosporites minutus Ibrahim
Raistrickia crocea Kosanke
R. saetosa (Loose) Schopf, Wilson & Bentall
R. subcrinita Peppers

Reticulatisporites sp.
Schopfipollenites ellipsoides (Ibrahim) Potonié & Kremp
Secarisporites crenatus Peppers
Spinosporites sp.
Striomonosaccites sp.
Striatopodocarpites sp.
Triquitrites bransonii Wilson & Hoffmeister
T. crassus Kosanke
T. sculptilis Balme
T. verrucosus Wilson & Coe
T. sp.
Verrucosisporites microtuberosus (Loose) Smith & Butterworth
Vestispora fenestrata (Kosanke & Brokaw) Wilson & Venkatachala
V. laevigata Wilson & Venkatachala
Vestigisporites sp.
Vittatina sp.
Wilsonites kosankei Bharadwaj

The assemblage contains numerous specimens of **Potonieisporites novicus, P. simplex** and specimens of other striate saccate forms such as **Protohaploxypinus globus, P. samoilovichii, Striatopodocarpites, Striomonosaccites,** and **Piceapollenites.** These forms, occurring with **Vestispora fenestrata** and **V. laevigata**, typify an assemblage belonging to the **Potonieisporites** zone of Barss and Hacquebard (1967) which is considered Stephanian age.

APPENDIX 3

Geophysical Logging of MacDougall Core Hole 1A, Prince Edward Island

P.G. Killeen and A.V. Dyck

As part of the MacDougall core hole investigations, a suite of geophysical logs was run in Core Hole 1A. These included caliper, gamma-gamma density, natural-gamma, neutron-porosity, resistance, resistivity (16" and 32" normal) and self potential.

Due to the problems of caving which were encountered, not all logs were run over the entire length of the hole, and the greatest depth at which measurements were obtained was 1900 feet. Logging was carried out under contract by Roke Oil Enterprises Ltd., Calgary. The Resource Geophysics and Geochemistry Division of the Geological Survey of Canada monitored the geophysical logging at the drill site.

A summary diagram (Fig. A1) indicates the portions of the hole which were logged by each of the geophysical techniques. As no significant coal occurrences were observed, other applications of the geophysical logs were investigated. Geophysical logs are on file with the Geological Survey of Canada.

Logging to Determine Uranium Potential

Although the primary purpose of the hole was to provide coal information, the natural gamma log which was run for coal can also indicate the presence of anomalous concentrations of uranium, thorium, or potassium (the three naturally occurring radioelements). For this reason a special effort was made to obtain gamma-ray measurements which had good counting statistics and which could provide unambiguous indications of radioactive zones.

Figure A1 shows that several repeat runs down the hole were made with natural-gamma logging tools. These repeats consisted of the following measurements:

Borehole Probe	Footage	Casing
1. Small (1" diameter)	0 to 1882	BQ inside NQ inside HQ
2. Large (1 11/16" diameter)	0 to 1794	NQ inside HQ
3. Large (1 11/16" diameter)	0 to 350 950 to 1616	Open Hole Open Hole
4. Large (1 11/16" diameter)	0 to 350 (Repeat Run)	Open Hole

The large probe provided better counting statistics than the small probe, and provided a double check on any anomalous readings measured from inside the casing by the small probe. Apparently no significant anomalies were recorded. Small anomalies occur at depths of approximately 200, 400, 1270, 1350 and 1740 feet. These vary between two and two and one half times the background measured in the vicinity of each small anomaly. This is consistent with the variation in surface radioactivity measured by airborne gamma-ray spectrometer surveys of Prince Edward Island (Geol. Surv. Can., Open File 269, 1975).

Logging to Determine Lithology

The geophysical logs from MacDougall Core Hole 1A were examined to determine the degree of correlation with the intersected lithology. The electrical logs and natural-gamma logs appeared to be best for this purpose. The density log was dismissed because insignificant density variations were obscured by variations believed due to caved portions of the hole but these areas could not be identified with confidence since the density log was run in the cased hole.

The 16" and 32" normal resistivity logs and the resistance log all exhibited very similar characteristics; the electrical logs are, therefore, represented by the 16" normal resistivity log plotted on Figure 3. Several of the resistivity lows on this log correspond, as expected, to the locations of claystone material, especially in the upper portion (0-350 feet) and from 950-1450 feet. Below 1270 feet a very low-resistivity background is observed; increased salinity of groundwater would be a possible reason if the effect could also be observed on the resistivity log in the neighbouring hole (Imperial No. 1). It is not, however, possible to correlate the resistivity log with the known occurrences of pyrite (Appendix 4), due to the generally low background resistivity.

The gamma-ray log was chosen to show the higher level of radiation also associated with the claystone material; several gamma-ray highs correlate with resistivity lows.

The geophysical logs from Imperial MacDougall No. 1 are also displayed in Figure 3. While some degree of correlation between geophysical logs and geology was observed in MacDougall Core Hole 1A, it was, in general, not adequate to generate confidence in utilizing the geophysical logs for geological correlation between the two holes.

SUMMARY OF BOREHOLE LOGGING April 22-24, 1975

ORIGINAL DEPTH 2338'

MACDOUGALL CORE HOLE IA

(If "open hole" not indicated then casing was in place)

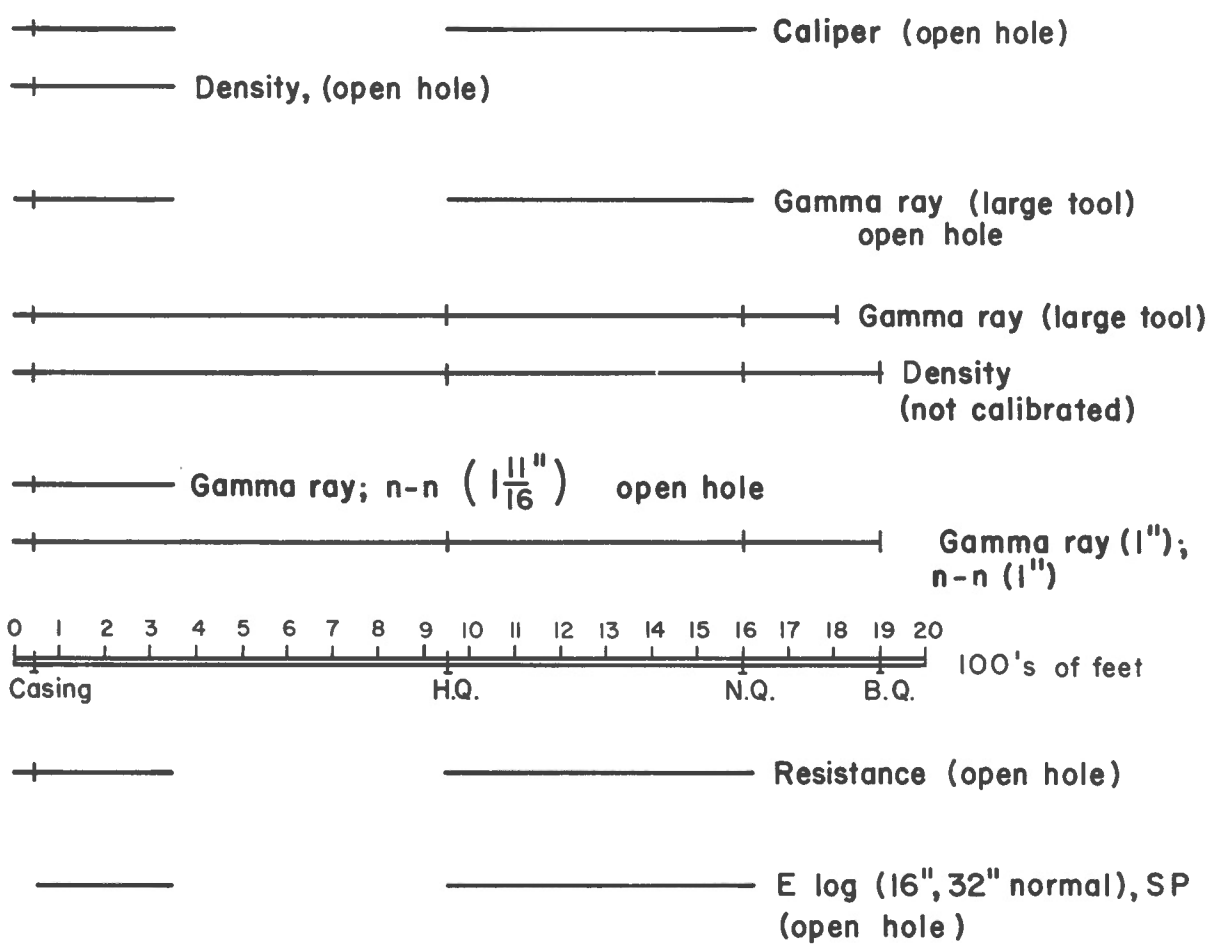

Figure A1

APPENDIX 4

Sulphide Studies of MacDougall Core Hole 1A

R.V. Kirkham

Introduction

Carboniferous clastic sequences in some localities in the Atlantic Provinces are known to contain copper, lead, and/or zinc sulphides. As part of continuing studies by the Geological Survey of Canada, of the distribution of base metals in Carboniferous rocks of the Atlantic Provinces, the MacDougall 1A drill core from 950 to 2338 feet was systematically logged for sulphides; only spot checks were made from the top of the hole to 950 feet.

Although no base metal sulphides were found during this megascopic examination, pyrite was identified in a number of units, especially towards the base of the hole. Because pyrite and wood trash are common precursors of base metal sulphides and uranium oxides in a number of the Carboniferous occurrences, their distribution in this drill core could be of value in understanding the origin and distribution of base metals and uranium.

Observations

The part of the core studied by the writer is characterized by a series of cyclothems consisting of grey and red arkosic sandstone, siltstone, claystone, and intraformational mud-pebble breccias and conglomerates (see Fig. A2, and the accompanying report and log by R.D. Howie). Coalified wood fragments, pyrite, and calcite concretions are typical minor constituents. In the interval 950 to 2298 feet, there are a minimum of 13 fining-upward cycles, ranging from 40 to greater than 200 feet thick. These cycles have sharp, scoured basal contacts with intraformational breccia (claystone pebbles or rubble) along them. The lower parts of the cycles are characterized by fining-upward grey or red arkose grading up into interlayered red, grey, or green claystone and siltstone which typically contain numerous calcite concretions (Fig. A2).

Pyrite tends to occur as disseminations and as masses or nodules around or near coalified wood fragments predominantly in the lower parts of the grey, fining-upward, arkosic units. It is also abundant in some of the more reduced or carbonaceous, grey and green claystone and siltstone in the upper parts of the cycles. Although it could not be documented from the drill core studies, based on field observations in other areas the distribution along strike is probably somewhat erratic and is to some degree dependent on the distirbution of wood trash. About 1357 feet, even though similar fluvial cycles are present, the units are distinctly reddish and the amount of pyrite and wood trash is very much less than deeper in the hole.

In the lower part of the drill core (1357 to 2338 feet) there seems to be much more pyrite and wood trash than is found in most outcrops on Prince Edward Island, except around Hillsborough Bay where similar beds are exposed in the centre and on the flanks of a structural dome (V.K. Prest, 1964, p. 4). Elsewhere on Prince Edward Island the strata are flat lying or have very gentle dips, and hence the lower strata intersected in the drillhole are not extensively exposed on Prince Edward Island.

In the upper part of the core (above 1300 feet) minor reduction spheres, analogous to those described by Prest et al. (1969) and Poll and Sutherland (1976), occur locally. Although some of them have dark centres that may contain heavy metals their very fine grained nature precludes megascopic mineral identification. About ten were checked by H.E. Dunsmore but showed no signs of anomalous radioactivity.

Interpretation

These fining-upward clastic cycles are characteristic of a meandering river environment with a relatively low gradient. The sharp, scoured lower contacts of the cycles are probably erosional bottoms of stream channels that were subsequently lined with channel lag material, consisting mainly of claystone fragments and some wood trash that slumped from the stream bank as it was being eroded. This accumulation of wood trash in shallow, mildly anoxic, near surface environments was probably responsible for the localization of early diagenetic pyrite.

The fining-upward arkosic sands most likely were deposited on point bars in the stream channels. The claystone and siltstone above the arkose are presumably flood plain and overbank deposits. Carbonaceous plant matter and pyrite in some of these beds probably were deposited in swampy, anoxic environments, whereas the red sections with abundant calcite concretions probably were deposited in more exposed, dessicated areas where soil and caliche could develop. Hydrogen sulphide evolving from decaying vegetable matter may have caused the precipitation of early diagenetic iron monosulphide that was later transformed to pyrite. Although the finer grained upper parts of the cycles were partly eroded during the development of successive channels, there is little evidence of extensive development of back swamp deposits conductive to coal formation.

The reddening of beds in the core about a depth of 1357 feet is probably a diagenetic feature. At aobut 1350 feet there are some hematized wood fragments indicating that at least some of these sediments once contained organic matter which was subsequently oxidized. The extensive oxidation high in the sequence could reflect an increasingly arid climate with resultant greater fluctuations of the water table. If sulphides were once present in this part of the section they probably were destroyed by this oxidation.

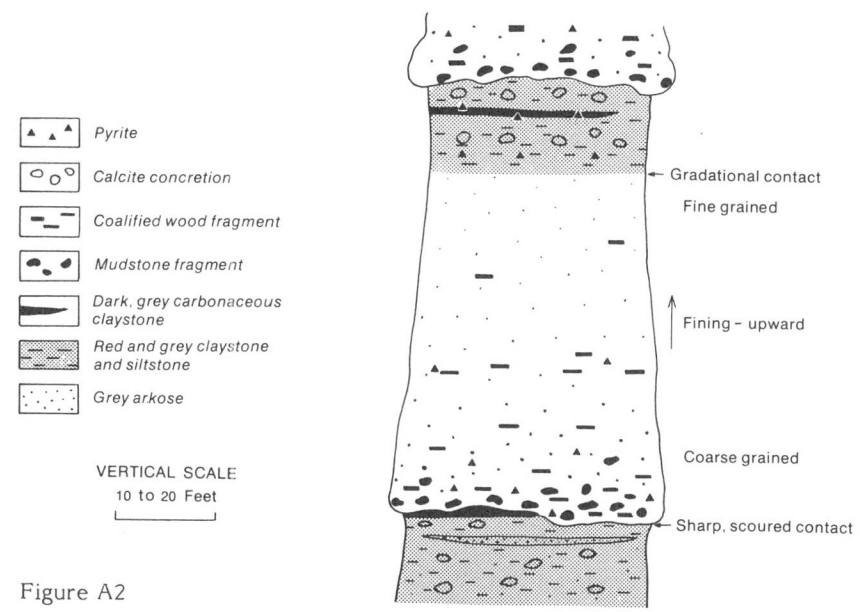

Figure A2

Conclusions

No important concentrations of base metal sulphides exist in the MacDougall drill core and checks by H.E. Dunsmore of more than 40 samples showed no particularly anomalous concentrations of uranium. Nevertheless, there is sufficient pyrite and carbonaceous wood trash in many of the beds to have caused extensive precipitation of base metals or uranium if such metalliferous solutions had ever passed through them.

In many red bed sequences the oldest significant anoxic unit is the most important site for base metal deposition. Hence, even though no traces of base metals were identified in this drill core, the possibility still exists that a mineralized bed may occur lower in the sequence.

References

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