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**I.E.** Intelligent Exploration
59 Nicholas Road, RR. 4
Campbellford, ON, Canada K0L 1L0

# Memo



To: Mr. Michael Kozub,
2560344 Ontario Ltd.,
800-65 Queen St. W.
Toronto, Ontario M5H 2M5

From: C. J. Hale Ph. D., P. Geo

Re: Division Mountain Coal Project, Yukon Territory

Date: July 21, 2017

## Introduction

Intelligent Exploration was engaged by 2560344 Ontario Ltd., to conduct an appraisal of the potential of geophysical techniques to outline coal deposits on a property that the company holds in the Carmacks area, north of Whitehorse, Yukon Territory. This memo is intended to provide the results of that assessment along with recommendations for geophysical studies that might be used to delineate the coal deposits economically. The scope of this work involved three phases:

1. A review of past geophysical studies related to Division Mountain and Carmacks area coal deposits that may be found in the Yukon Geological Survey assessment files. These were accessed online and copied where appropriate. Documents from former producers at Division Mountain and Tantalus Butte were also consulted because they provide a useful characterization of the widths and attitudes of historically economic coal deposits in the area.

2. A site visit to various coal showings in the Carmacks area to gauge whether the terrain conditions and coal seam geometry are amenable to geophysical surveys and to collect a small suite of samples for measurements of physical properties. Differences between the properties of the coal and the clastic sedimentary rocks that host it are the essential foundation for geophysical detection of the coal seams.

3. The physical properties of the samples were measured and compared with historical results compiled by Ager and Beretta, 1976. These data underpin our opinion that geophysical studies will be problematic in this project and unlikely to provide a direct and economical way to delineate the coal deposits.

## Historical Results

The search for coal in the Carmacks area has been complicated by a shortage of outcrop and thick till cover, the tendency of the north trending coal seams to be cut off and displaced by a number of east-west faults, and the moderate to steeply dipping fold structures in the Tantalus Fm. that make it hard to image the coal using seismic surveys.

Some prospecting work was done on Carmacks area properties early in the twentieth century and Cairnes (1910) described the coal from showings along the Klondike Highway. Subsequent work led to the development of Tantalus Mine and Tantalus Butte Mine that remained in intermittent production from1923 to1978 when an underground fire closed the mine. Production shifted to a series of surface open cuts lasting until 1981. Total production from surface and underground workings was about 335,800 tonnes of thermal coal that was used locally for heating at the silver mines at Keno Hill from 1948 to 1967and later for heat and concentrate drying at the Faro lead-zinc mine (Carne, 2006).

The Division mountain coal deposits were also discovered by Cairnes in 1907 but no work was done on them until 1970 when bulldozer trenches were opened on them by Arjay-Kirker Resources Ltd (Carne and Gish, 1996). These were acquired by Cash Resources Ltd in 1992 who confirmed earlier reserve estimates and defined additional reserves with a drilling program. According to Brewer (2017), a total near-surface historical "Measured" resource of 52.5 Mt high volatile Bituminous "B" coal was defined by Norwest (2005, 2006, and 2008). The pre-feasibility level study by Norwest in 2008 also defined an estimate of 26.4 Mt of high volatile Bituminous "B" in-place coal reserves in the Proven assurance category. An excellent summary of exploration activity on the Division Mountain leases is provided in Appendix "B" of Allen (2000).

There has been very little historical geophysical work on the Carmacks area coal deposits beyond some measurements of physical properties presented by Ager and Berretta (1976) and a field test of VLF and IP/Res techniques performed over a few Tantalus Butte trenches by Berretta (1976). These results appear in Appendix 4 of this memo.

Ager and Berretta concluded that the only significant difference between the coal and the host sedimentary rocks was in density and possibly electrical resistivity but a large difference between the electrical conductivity of wet (versus dry) samples of coal suggested that the differences were more due to fracturing than any real difference in the coal conductivity. The VLF results were equally unconvincing, showing an anomaly that did not coincide with the known location of coal in the trenches and probably reflected either facies transition within the sedimentary host or possible enhanced conductivity due to the increased fracture density in a minor fault zone.

The YGS library also holds records of correspondence between Cyprus Anvil (operator of the Tantalus Butte mine until 1981) and various seismic consultants and contractors investigating whether seismic might be useful in delineating the coal. Eventually, a decision was made not to proceed with seismic surveys largely because it was anticipated that 1) the shallow depth of the coal seams required that arrivals be registered in a time range that is usually obscured by surface waves ("ground roll") and 2) that imaging the steeply dipping reflectors associated with anticline and synclinal structures in the Tantalus and Tanglefoot formations would be difficult. Field tests were not conducted by any of the contractors. Improvements in seismic acquisition since 1976, particularly with portable, digital engineering type seismographs and the use of optimum offset reflection techniques pioneered by the GSC in the 1980's for shallow reflection surveys may now overcome many of the problems that precluded the use of seismic surveys in 1976.

## Field Examination of Carmacks Area Coal Exposures

Coal showings in the Carmacks area were visited to obtain representative samples of the coal and to determine whether the typical widths and attitudes of the coal seams would be reasonable geophysical targets. All of the sites that are visited are listed in the Yukon Geological Survey Minfiles and two were historical coal producers.

The Sites included:

| | |
|---|---|
| Andesite | Coal outcropping on the east side of the Klondike highway |

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| | |
|---|---|
| Losch | Coal outcropping on the east side of the Klondike highway |
| Tantalus Mine | Remains of the historical producer on the river at Carmacks |
| Tantalus Butte | Historical producer just N of Carmacks, underground and open pit |
| Tantalus South | Series of Bulldozer trenches SE of Carmacks |

An attempt to visit the Division Mountain property was not successful because flooding closed the access trail at several locations. The 30km quad trip to the property from the road access point could not be made safely so the attempt was abandoned at km 11 where the trail was under flowing water.

**Andesite** 61°52'57" N - -136°6'48" W

The Andesite site is directly accessible on the side of the Klondike Highway. A 0.5 m wide coal seam is hosted in graded pebble conglomerate and sandstone with

occasional intrusives. The seam strikes approximately 140 degrees and dips to the south at 65 degrees. Samples were obtained of the coal, sedimentary host and intrusives for measurement of physical properties.

**Losch** 61°56'13" N - -136°9'44" W

Losch also occurs on the east side of the Klondike Highway. The quality of coal viewed at Losch was poor, narrow seams of carbonaceous mudstone dipping 65 degrees toward the east-southeast. The carbonaceous sediment is variably light grey-buff to dark gray, fissile and laminated.

**Tantalus Mine** 62°5'36" N - -136°15'50" W

The historical Tantalus mine property is found along the river about 1km upstream from the Carmacks Bridge. It is accessed by a good trail but is heavily overgrown. Steeply dipping coal seams are visible in the river bank but the determination of the width of the seam and the attitude of contacts will require some hand trenching. Coal was produced early in the twentieth century and used as fuel for river boats. Conveyor equipment and pumps remain abandoned on the riverbank along the access trail.

**Tantalus Butte Mine** 62°7'25" N - -136°15'49" W

Tanntalus Butte Mine lies on the north side of the Yukon River on the south facing side of Tantalus Butte. The remains of a loading chute and core storage remain along the trail from which a footpath leads to the closed adit of the underground workings. The coal seams are also revealed in a series of filled pits along a north-south trend that projects southward toward the Tantalus Mine and South Tantalus showings across the river. Most of the coal at Tantalus Butte was extracted and the pits have been reclaimed.

Samples were obtained from the southeastern end of a filled open pit where stripping has revealed a 2 m wide, steeply dipping seam of fissile coal. The remainder of this showing is mined out and reclaimed with spoils and till. The overlying sedimentary rock is largely a tight pebble conglomerate.

**Tantalus South** 62°4'49" N - -136°15'10" W

The Tantalus South showing was discovered by projecting the mine trend southward from Tantalus Butte and exploring where the coal seams subcrop in a series of east-west bulldozer trenches. These are clearly visible on the "Google" satellite view of the Carmacks area. Samples were obtained from a trench where 15-20m of steeply dipping, fissile coal subcrops below till cover. The contacts are covered at present but a number of narrow (< 1 m) coal seams are indicated along the length of the trench by coal fragments in the trench floor. The trenches were mapped and those records can be obtained from the YGS files so no additional excavation was attempted.

## Physical Property Measurements

### Instrumentation and Procedures

The measuring instruments used for this work were a GDD Sample Core IP system and a GDD Multi-parameter Probe. The details of these instruments can be obtained from the Instrumentation GDD website.

Weights were obtained with an Ohauss 602 Scout-pro electronic laboratory pan balance and the volume of each specimen was calculated from the weight difference between sample measurements in air and with the core suspended in water. Fissile coal granules were weighed in air and then enclosed in a neutrally buoyant weighing paper for submersion weighing.

Sample length and approximate cross-sectional areas were measured with the calibrated sample holder of the SCIP instrument. Electrical resistivity measurements were made on dry samples after exposure to the air for several hours. Fissile coal granules were contained in a cardboard tube closed at each end with salt water/paper electrodes.

Photographs were taken against a 2 mm gridded background were taken with a 12 mp digital SLR using a 55mm f/2.8 Micro-Nikkor in natural day light.

These measurements were carried out:

1) Specimen dry and wet weight, length and diameter (for Specific Gravity)

2) Magnetic Susceptibility

3) High Frequency EM Conductivity

4) DC Resistivity

5) Induced Polarization Chargeability (with 20 Cole-spaced time windows)

6) High resolution photography

All of the data are tabulated in an Excel spreadsheet attached to this memo. Results are discussed and summarized in the next section.

**Physical Property Results**

The only important contrast in physical properties between the coal and the hosting sedimentary rocks is found in the specific gravity. The coal samples typically have specific gravity between 1.4 and 1.5 but the remaining rock samples have specific gravity values that are close to their average value of 2.55.

1) This distinct difference could provide the basis for delineation of the coal seams by gravity surveying.

2) Because seismic velocity depends inversely on the density of earth materials low density coals will probably provide distinct seismic reflections at their contacts.

None of the samples tested indicated any magnetic susceptibility, DC Conductivity, EM or High Frequency EM Conductivity. Electric, magnetic or electromagnetic surveys will thus not be useful in delineating the coal seams.

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## Conclusions and Recommendations

Geophysics will be of limited use in exploration for coal at Division Mountain. The low density of the coal samples suggests that a gravity survey might be able to detect a mass deficiency over coal seams but this will be difficult with their narrow widths.

Gravity surveys are difficult to conduct in mountainous terrain where the variations due to elevation changes are much larger than the subtle anomalies that reflect the target. We do not believe that the cost and difficulty of gravity surveying would be justified in the hope that it would detect additional coal resources at Division Mountain.

A small "optimum offset" seismic reflection survey might be useful in tracing the coal seams but this would need to be demonstrated in a field test over a known coal exposure before it could be recommended as a technique for coal exploration. The use

of seismic reflection is made difficult by the steep dips of many of the coal seams and the variability of the sedimentary host and intrusives that probably provides a better seismic contrast than the coal.

In the final analysis the best approach to delineating coal seams at Division Mountain and increasing the resource is by traditional direct exploration by trenching.

A portable drill should be used to test the coal seams at depth where they are found in the trenches.

Respectfully submitted,

C J Hale

C. J. Hale Ph. D., P. Geo

Partner, Intelligent Exploration

## References

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Carne R.C., 2006. Assessment report describing 2006 diamond drilling on the Tantalus Butte coal prospect. Yukon Mining Assessment Report 094736

Carne, R.C. and Gish, R.F., 1996. Geology of the Division Mountain Coal Deposit of Cash Resources Ltd. In: Yukon Exploration and Geology 1995, Yukon Geological Exploration, Indian & Northern Affairs Canada/Department of Indian & Northern Development: Exploration & Geological Services Division, 37-42.

Cyprus Anvil Mining Corp., 1977. Electromagnetic survey map - Contours of Fraser filtered in phase readings - Carmacks coal project. Energy, Mines and Resources Property File Collection, ARMC007842Cyprus Anvil Mining Corp., 1977.

Cyprus Anvil Mining Corp., 1977. Electromagnetic survey map - profiles of in phase and quadrature readings - Carmacks coal project. Energy, Mines and Resources Property File Collection, ARMC007843.

Cyprus Anvil Mining Corp., 1979. V.L.F. electromagnetic survey map - Contours of Fraser filtered in phase - Carmacks coal project. Energy, Mines and Resources Property File Collection, ARMC008254.

Instrumentation GDD Website, www.gddinstrumentation.com

Yukon Geological Survey Minfiles: Andesite, Losch (115H001), Tantalus Mine ((115I002), Tantalus Butte (115I003), Tantalus South (115I001)

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## Appendix 1. Physical Properties of Collected Coal and Host Samples

| Sample | Lithology | Spec. Grav | DC Res o-m | Charge mV/V | EM Conduct. | HF Cunduct. | Mag. Susc. |
|---|---|---|---|---|---|---|---|
| L1 | aminated Grit/Sandston | 2.57 | 376.7405 | 26.5 | 0 | 0 | 0 |
| L2 | Laminated Mudstone | 2.61 | 3357.168 | 3 | 0 | 0 | 0 |
| L3 | : Grained Muddy Sandst | 2.75 | 3357.168 | 4.6 | 0 | 0 | 0 |
| A1 | Quartz Diorite | 2.64 | 246.3795 | 5.3 | 0 | 0 | 0 |
| A2 | Sandstone | 2.6 | 3285.829 | 5.5 | 0 | 0 | 0 |
| A3 | Diorite | 2.55 | 2492.694 | 3.8 | 0 | 0 | 0 |
| A4 | Conglomerate/Wacke | 2.48 | 3986.604 | 5 | 0 | 0 | 0 |
| A5 | artz Pebble Conglomera | 2.51 | 744.4025 | 6.4 | 0 | 0 | 0 |
| TB1 | Medium Grained Wacke | 2.44 | 503.9767 | 2.7 | 0 | 0 | 0 |
| TB2 | Laminated Wacke | 2.41 | 2686.391 | 3.5 | 0 | 0 | 0 |
| TB3 | Sandstone | 2.49 | 936.6597 | 2.6 | 0 | 0 | 0 |
| A6Coal | Anthracite (?) Coal | 1.41 | 28171.76 | 22.1 | 0 | 0 | 0 |
| South Tantalus | Fissile Coal Granules | 1.51 | 29869.7 | 4.4 | 0 | 0 | 0 |
| SE Pit | Massive Coal | 1.42 | 347199.9 | 247.8 | 0 | 0 | 0 |

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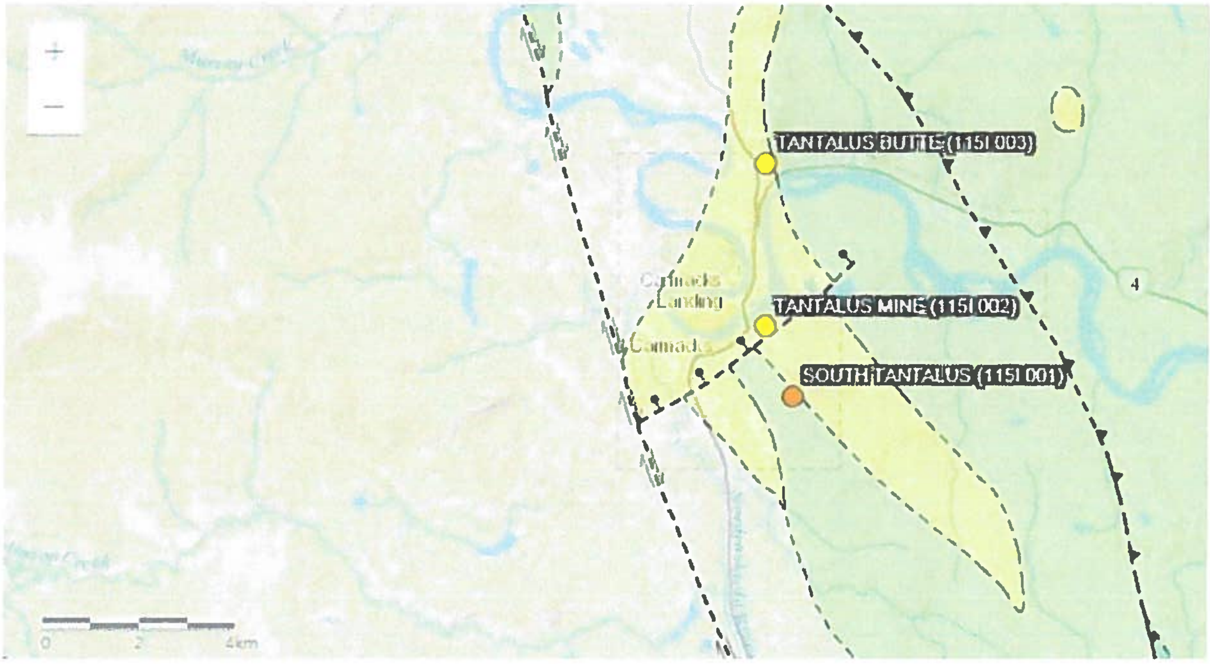
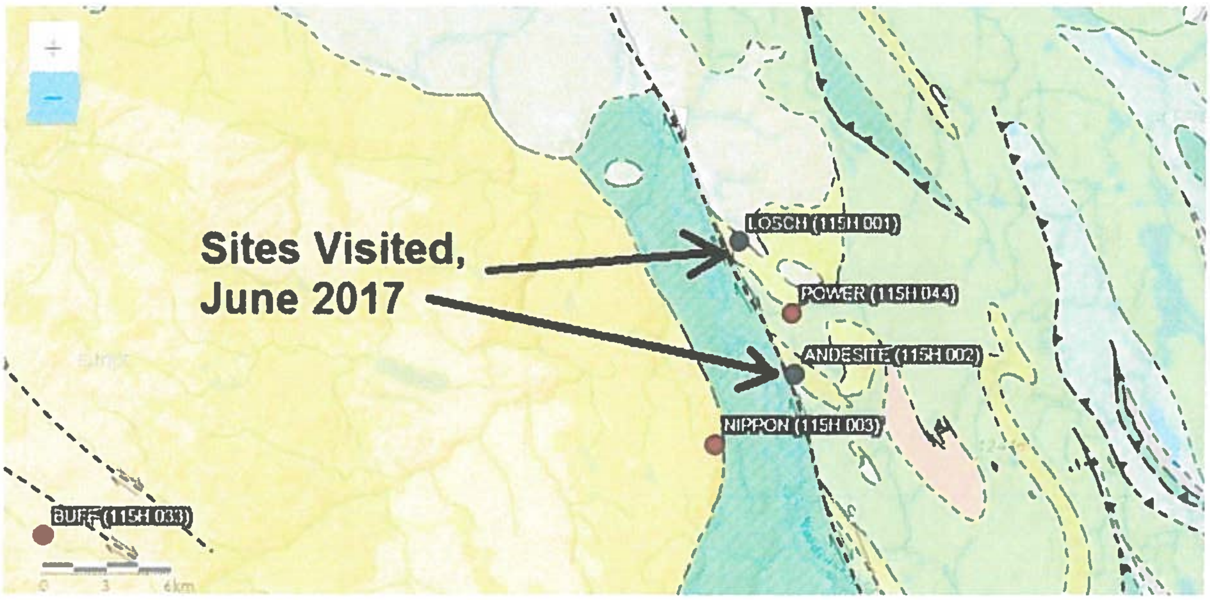
Appendix 2: YGS Minfilemaps showing the locations of the sites visited.

Carmacks Area Sites




Klondike Highway Sites



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Appendix 3: Google Satellite views of Tantalus Butte and Tantalus South Trenches


The Tantalus Butte pits and trenches are clearly shown in this Google satellite image, just east of the Klondike Highway, north of the Robert Campbell Highway intersection. The Yukon River appears in the lower left corner of the image.

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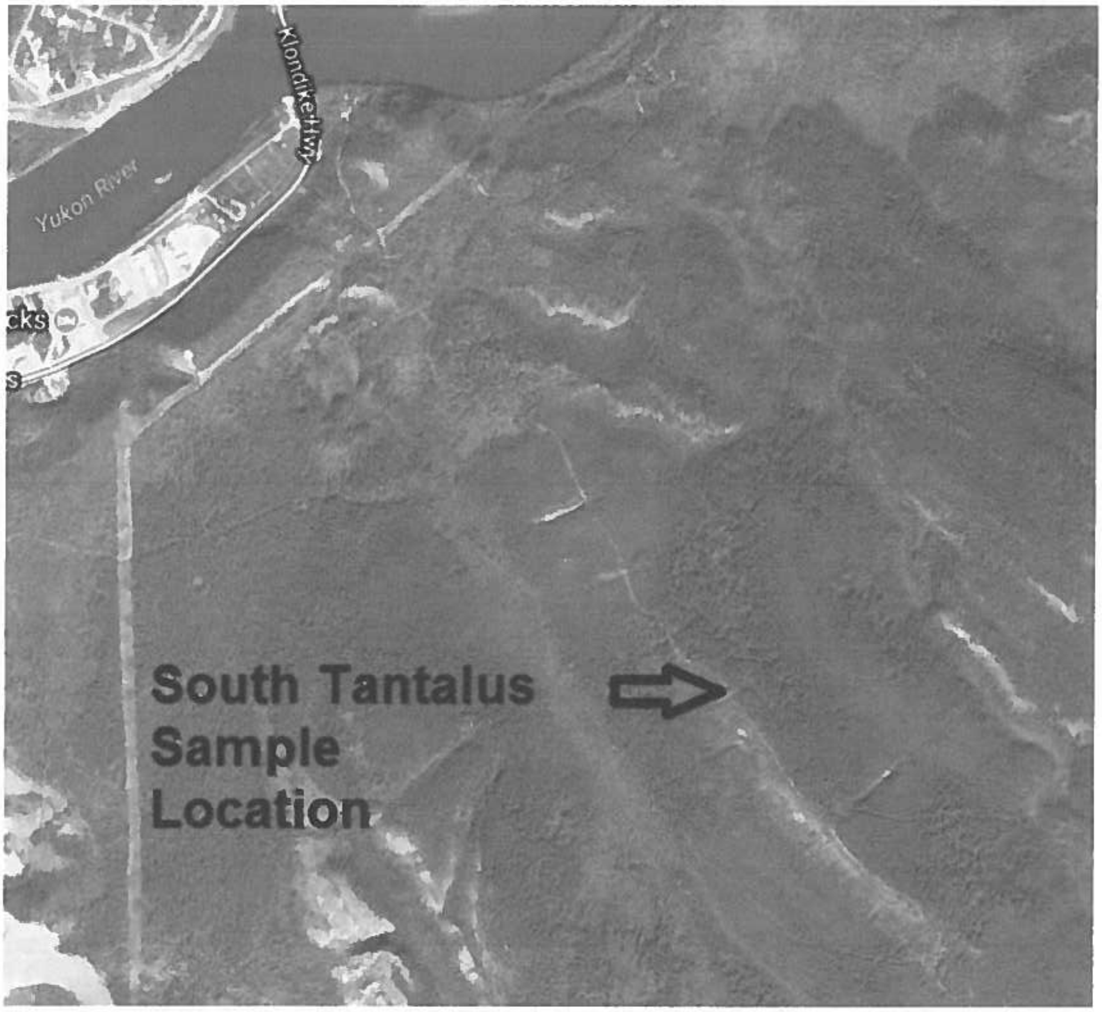


The Tantalus South trenches southwest of Carmacks are shown in this Google satellite image.

# Appendix 4: Historical Physical Property Measurements

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**KERR ADDISON MINES LIMITED**
(FOR INTER-OFFICE USE ONLY)

To D. A. Lowrie From W. M. Sirola

Subject CARMACKS COAL - GEOPHYSICAL RESPONSE Date 28th October 1976

Y-10
4

Enclosed please find a copy of a letter from Chuck Ager regarding some work that he did for us this month on determining the geophysical response of some coal specimens which John Carrington sent from the Anvil Mine. He also included some of the sandstone in which the coal was contained.

The only useable response is in resistivity contrast and in density contrast. Since neither of these parameters can be used from the air, I have asked Chuck to do some tests at Carmacks over locations supplied by Anvil Mines. It is always possible that despite the non-conductivity of the coal samples there may be structures which may prove conductive on one frequency or another. It is not likely that there will be any magnetic contrast, but Ager will run a magnetometer traverse as well. It would not surprise me greatly if he got some VLF response but whether or not this would be meaningful in terms of regional airborne work remains to be determined.

I will f you in as soon as the results are available.

Bill
W.M. Sirola

WMS:lmp

enc:

NOV 1 1976

I.D.B.
A.H.C.
P.S.C.
W.J.
D.A.L.
B.P.
M.D.R.
J.B.S.

FILE

**I.E. Intelligent Exploration**
59 Nicholas Road, RR. 4
Campbellford, ON, Canada K0L 1L0

C. A. AGER & ASSOCIATES LTD.

Telephone ( J4) 536-1154
CONSULTING
GEOPHYSICISTS

15423 34th Ave.
Surrey, B.C. Canada
V3S 4N7

October 13, 1976

Mr Bill Sirola
Kerr Addison Mines Ltd
1112 West Pender St
Vancouver, B.C.

RE: Yukon Coal & Rock Sample Measurements

Dear Bill

Enclosed is a table summarizing the results of our tests conducted on the coal and sandstone rock samples from your Yukon Coal Project. The following geophysical parameters were measured: resistivity, I.P. response, density, E.M. response, susceptibility and radioactivity. Negligable responses are shown as 'zeros' on the table. Each measurement was repeated at least 4 times to insure consistency of results.

Judging from the data, coal and sandstone display a sufficient geophysical contrast only in resistivity and density. All other parameters are not diagnostic of coal in sandstone.

However, it is possible that there are structures and/or other geological units in-situ which may indicate different geophysical responses. This can be tested only in the field over known coal occurrences in the area of interest.

It is therefore recommended that field tests be conducted to augment the lab data. It will then be possible to devise the proper search technique.

Respectfully submitted,

Charles A. Ager
Charles A. Ager, PhD, PEng.
Geophysicist

Mauro Berretta
Mauro G. Berretta, MSc.
Geophysicist

CAA/ca
Encl.

I.E. Intelligent Exploration
59 Nicholas Road, RR. 4
Campbellford, ON, Canada K0L 1L0

## YUKON COAL & ROCK SAMPLE MEASUREMENTS

| GEOPHYSICAL PARAMETER | COAL #1 | COAL #2 | SAMPLE AVERAGE | SANDSTONE #1 | SANDSTONE #2 | SAMPLE AVERAGE |
|---|---|---|---|---|---|---|
| RESISTIVITY (ohm-m) (dry) | 5,700 | 17,600 | 11,600 | 379 | 175 | 277 |
| RESISTIVITY (ohm-m) (wet) | 470 | 1,350 | 910 | 88 | 78 | 83 |
| I.P. RESPONSE (msec) (electrodes in sample) | 1.1 | 1.2 | 1.1 | 0.3 | 0.3 | 0.3 |
| I.P. RESPONSE (msec)<br>(% pfe)<br>(elect. not in sample) | 0.2<br>1 | 0.1<br>1 | 0.1<br>1 | 0.1<br>0 | 0.1<br>0 | 0.1<br>0 |
| DENSITY (g/cc) | 1.93 | 1.72 | 1.82 | 2.42 | 2.36 | 2.39 |
| E.M. RESPONSE (%) (875 htz) | 0 | 0 | 0 | 0 | 0 | 0 |
| SUSCEPTIBILITY (cgs) | 0 | 0 | 0 | 0 | 0 | 0 |
| RADIOACTIVITY (cpm) (Th,K,U) | 0 | 0 | 0 | 0 | 0 | 0 |