CONCENTRATION OF MAGNETITE, ILMENITE AND ASSOCIATED VANADIUM FROM BRAZEAU - WOOD DEPOSIT

M. Raicevic, R. Lastra and G.I. Mathieu
Mineral Processing Laboratory
February 1990

CONFIDENTIAL

MINERAL SCIENCES LABORATORIES DIVISION REPORT MSL 90-8 (CR)

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MINING LANDS SECTION
CONCENTRATION OF MAGNETITE, ILMENITE AND ASSOCIATED VANADIUM FROM BRAZEAU - WOOD DEPOSIT

by

M. Raicevic, R. Lastra and G.Y. Mathieu

INTRODUCTION

A study was requested by Mr. Wayne Whymark to concentrate the magnetite, ilmenite and associated vanadium values contained in the Brazeau - Wood deposit, near Mattawa, Ontario. The products were to be given to Mr. W. Craigen for extraction of the vanadium metal.

Mineralogical examination was first conducted to identify the main minerals present in the ore, as well as their liberation size. The sample was then crushed and ground to the necessary fineness to liberate the iron and titanium values for their eventual recovery by magnetic, electrostatic and gravity techniques.

SAMPLE PREPARATION, MINERALOGICAL STUDY AND HEAD ANALYSIS

The sample consisted of three pieces of rock weighing a total of 2.6 kg. These were crushed to minus 1 cm from which specimens were selected for mineralogical examination. The objective was to determine the size of the main minerals, namely, magnetite, ilmenite and garnet, and to predict their liberation.

Two polished sections were prepared and the size of the minerals of interest was determined by chord analysis using a Microprobe SEM-IPS image analysis system (SMP-SEM-IPS). Phase discrimination for image analysis was done using backscattered electron images. This method relates the contrast and brightness to phase composition. In black and white images, the whiter a phase appears, the higher its average atomic number.
For each of the minerals of interest the chord measurements were added and the percent of the chord relative to the sum was calculated. The percent chord data were sorted into classes of chord length. Figures 1 to 4 show this correlation and give the cumulative chord percent at different lengths.

Figure 1 - Cumulative chord percent (Y-axis) at different chord sizes (X-axis) for ilmenite.

Figure 2 - Cumulative chord percent (Y-axis) at different chord sizes (X-axis) for magnetite.
Figure 3 - Cumulative chord percent (Y-axis) at different chord paroor.

Figure 4 - Cumulative chord percent (Y-axis) at different chord sizes (X-axis) for garnet plus silicates.
K\textsubscript{80} and/or K\textsubscript{30} can be used as guides to determine the grind required for liberation of the given mineral. In general, if the ore is ground to 80\% minus K\textsubscript{80} then a liberation of \approx 50\% of the mineral will be obtained, whereas if the ore is ground to 80\% minus K\textsubscript{30} then \approx 80 \text{ to } 90\% of the mineral will be free. Table 1 summarizes the values of K\textsubscript{80} and K\textsubscript{30} obtained from Fig. 1 to 4. An estimate of the relative proportion of the main minerals is also given.

Table 1 - Values of K\textsubscript{80} and K\textsubscript{30} for Ilmenite, Magnetite, Ilmenite Plus Magnetite and Garnet Plus Silicates

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Size (\textmu m)</th>
<th>% Content (approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K\textsubscript{80}</td>
<td>K\textsubscript{30}</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>656</td>
<td>200</td>
</tr>
<tr>
<td>Magnetite</td>
<td>544</td>
<td>184</td>
</tr>
<tr>
<td>Ilmenite plus magnetite</td>
<td>696</td>
<td>232</td>
</tr>
<tr>
<td>Garnet (plus silicates)</td>
<td>600</td>
<td>156</td>
</tr>
</tbody>
</table>

In summary, grinding the sample to 80\% minus 200 \textmu m (\approx 65 mesh) will yield a liberation of 80 to 90\% of all the minerals of interest in the sample.

A representative sample from the crushed material was pulverized and analyzed for total iron (Fe), titanium (Ti), vanadium (V), aluminum (Al) and calcium (Ca).

Table 2 - Chemical Analysis of Head Sample

<table>
<thead>
<tr>
<th>%Fe</th>
<th>%Ti</th>
<th>%V</th>
<th>%Al</th>
<th>%Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.2</td>
<td>8.0</td>
<td>0.48</td>
<td>3.76</td>
<td>0.48</td>
</tr>
</tbody>
</table>
CONCENTRATION OF MAGNETITE AND ILMENITE

Magnetic Separation

Various approaches were considered to recover the magnetite and ilmenite values. Magnetite is readily concentrated by low-intensity magnetic separation because of its extremely high magnetic susceptibility, i.e. \(-50,000 \times 10^{-6}\) emu. Conversely, both ilmenite and garnet are paramagnetic with relatively close magnetic susceptibilities at \(-150 \times 10^{-6}\) and \(50 \times 10^{-6}\) emu, respectively. Exploratory testwork was nevertheless done using magnetic separators on a sample of the minus 397 \(\mu\)m (48 mesh) fraction obtained from the crushed material. The magnetite was readily recovered by a Sala low-intensity separator, but the ilmenite and garnet had a strong tendency to concentrate together at high intensity, as shown by the results and observations reported in Table 3.

Table 3 - Results of low and high intensity magnetic separation

<table>
<thead>
<tr>
<th>Separator</th>
<th>Products</th>
<th>Weight %</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-intensity</td>
<td>L-I Magnetics</td>
<td>40.2</td>
<td>Largely magnetite</td>
</tr>
<tr>
<td>Plus: High-gradient (at 0.07 T)*</td>
<td>H-I Magnetics</td>
<td>42.2</td>
<td>Ilmenite and garnet Silicates</td>
</tr>
<tr>
<td></td>
<td>Non-magnetics</td>
<td>17.4</td>
<td></td>
</tr>
</tbody>
</table>

*Lowest setting of the separator.
Low-Intensity Magnetic Separation, Gravity Concentration and Sizing of Tailing

Ilmenite has a specific gravity of 4.7 while that of garnet is in the order of 3.9. Although the difference is rather small, attempts were made to separate the two minerals by tabling after removal of the magnetite by low-intensity magnetic separation.

In preparation for this test, the whole sample was stage-ground to minus 210 μm (65 mesh). The material was then passed over a Sala low-intensity separator. The non-magnetic fraction was subsequently fed to a Deister shaking table. Four distinct bands of material were observed on the table and recovered using adjustable cutters.

The first band was a relatively rich ilmenite concentrate; the second was a mixed product visually composed of approximately half ilmenite and half garnet; the third band comprised fine ilmenite, some garnet and silicate minerals; the remainder (4th band), which is the table tailing, contained essentially micaceous minerals of more than 73 μm (200 mesh) and finer ilmenite and silicates. The mixed product (i.e. rougher table concentrate No. 2) was cleaned by re-tabling in an attempt to improve the ilmenite-garnet separation. Limited success was achieved; however, the ilmenite cleaner table concentrate was still contaminated by garnet; conversely, some ilmenite reported in the garnet cleaner table tailing.

A flowsheet illustrating the various steps of the procedure is shown in Fig. 5; the weight distribution of the products, their specific gravity and their content of iron, titanium, vanadium and aluminum content are also given.
Fig. 5 - Primary Concentration of Magnetite and Ilmenite by Low-Intensity Magnetic Separation, Tabling and Screening
Electrostatic and High-Gradient Magnetic Separation

The results of the primary concentration indicated garnet contamination of all the ilmenite concentrates (see aluminum content). Conversely, the rougher and cleaner table tailings contained sufficient ilmenite to warrant its recovery. Several products were thus re-treated to either upgrade the ilmenite concentrates or to scavenge ilmenite values. The techniques employed were adapted to the composition of the products: i.e., high tension (electrostatic) separation for the removal of the garnet (insulator) from the ilmenite (conductor), high-gradient magnetic separation to scavenge ilmenite from the ilmenite gravity concentrate No. 3 and from the minus 200 mesh table rougher tailing. The upgrading and scavenging operations are illustrated in Fig. 6 along with the corresponding weights and analyses of the products.

Material Balances

Two material balances were computed. The first included all the individual products from the overall treatment. In the second case, the similar concentrates (ilmenite, garnet) and the various tailings were combined for the computation. Both balances are shown in Table 4.
Fig. 6 - Cleaning and Scavenging of Ilmenite by High Tension (HT) Separation and High-Gradient Magnetic Separation (HGMS)
Table 4 - Results of magnetite, ilmenite and garnet concentration

<table>
<thead>
<tr>
<th>Products</th>
<th>Weight</th>
<th>Analysis, %</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Fe</td>
<td>Ti</td>
</tr>
<tr>
<td>A. Magnetite conc</td>
<td>42.9</td>
<td>65.9</td>
<td>1.5</td>
</tr>
<tr>
<td>B. Ilmenite HT conc #1</td>
<td>9.1</td>
<td>37.7</td>
<td>26.4</td>
</tr>
<tr>
<td>C. Ilmenite HT conc #2</td>
<td>6.5</td>
<td>38.8</td>
<td>24.6</td>
</tr>
<tr>
<td>D. Ilmenite HT conc #3</td>
<td>0.8</td>
<td>37.2</td>
<td>22.1</td>
</tr>
<tr>
<td>E. Ilmenite HGMS &amp; HT conc #4</td>
<td>2.0</td>
<td>43.3</td>
<td>25.0</td>
</tr>
<tr>
<td>F. Ilmenite HGMS conc #5</td>
<td>9.3</td>
<td>34.9</td>
<td>18.8</td>
</tr>
<tr>
<td>G. Garnet conc #1</td>
<td>0.9</td>
<td>21.9</td>
<td>0.77</td>
</tr>
<tr>
<td>H. Garnet conc #2</td>
<td>4.3</td>
<td>20.7</td>
<td>0.89</td>
</tr>
<tr>
<td>I. Garnet conc #3</td>
<td>2.1</td>
<td>16.3</td>
<td>1.04</td>
</tr>
<tr>
<td>J. Garnet conc #4</td>
<td>1.7</td>
<td>16.8</td>
<td>1.15</td>
</tr>
<tr>
<td>K. HGMS non-mag #1</td>
<td>6.9</td>
<td>12.2</td>
<td>1.11</td>
</tr>
<tr>
<td>L. HGMS non-mag #2</td>
<td>8.0</td>
<td>15.8</td>
<td>3.5</td>
</tr>
<tr>
<td>M. Gravity tailing (+200M)</td>
<td>5.5</td>
<td>12.9</td>
<td>3.0</td>
</tr>
</tbody>
</table>

II - Material Balance (Combined Products)

<table>
<thead>
<tr>
<th>Products</th>
<th>Weight</th>
<th>Analysis, %</th>
<th>Distribution, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight</td>
<td>Fe</td>
<td>Ti</td>
</tr>
<tr>
<td>A. Magnetite conc</td>
<td>42.9</td>
<td>65.9</td>
<td>1.5</td>
</tr>
<tr>
<td>B. to F. Ilmenite conc</td>
<td>27.7</td>
<td>37.4</td>
<td>23.2</td>
</tr>
<tr>
<td>G. to J. Garnet conc</td>
<td>9.0</td>
<td>19.1</td>
<td>0.96</td>
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<tr>
<td>K. to M. Rejects</td>
<td>20.4</td>
<td>13.8</td>
<td>2.56</td>
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SUMMARY AND CONCLUSIONS

The Brazeau-Wood deposit sample contained magnetite (~40%) and ilmenite (~20%) with associated vanadium values (0.5% V). The iron and titanium oxide minerals were essentially liberated at minus 210 µm (65 mesh). Magnetite was readily concentrated by low-intensity magnetic separation. The ilmenite recovery presented more difficulties than expected due to the presence of garnet, both minerals having comparable density and magnetic susceptibility. High tension (electrostatic) separation was used to achieve their final separation. By a combination of gravity, magnetic and high tension separation techniques, most of the magnetite and the ilmenite were recovered in separate concentrates analyzing 65.9% Fe and 23.2% Ti, respectively. The vanadium reported largely in these concentrates, i.e., 71.6% with the magnetite and 20.9% with the ilmenite. Their respective contents of vanadium were 1.15% and 0.52%. The products were given to Mr. W. Craigen for studies on vanadium extraction.

The methods used to recover the ilmenite in our study were not optimized and might not be the best approach for industrial production. More material and further investigation would be necessary to develop the most effective and economic flowsheet for the treatment of the Brazeau-Wood ore.
**Sample Analysis Report**

**Sample:** Head Sample

<table>
<thead>
<tr>
<th>Element</th>
<th>Fe tot</th>
<th>Ti</th>
<th>Ca</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>PCT</td>
<td>PCT</td>
<td>PCT</td>
<td>PCT</td>
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<tr>
<td>Head Sample</td>
<td>44.24</td>
<td>8.01</td>
<td>0.48</td>
<td>0.54</td>
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</table>

**Certificate of Analysis**

Date Printed: 25-Jan-90

Project: 50163

Page 1

Signed: Joe German, Chief Assayer
<table>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>ELEMENT</th>
<th>AT UNITS</th>
<th>PCT</th>
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<tr>
<td>HEAD SAMPLE</td>
<td>3.76</td>
<td></td>
<td></td>
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</table>

Joe German, Chief Assayer
<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Fe tot</th>
<th>Ti</th>
<th>Al</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAG CONC.</td>
<td>65.90</td>
<td>1.53</td>
<td>1.02</td>
<td>1.15</td>
</tr>
<tr>
<td>RO CONC # 1</td>
<td>37.70</td>
<td>26.40</td>
<td>0.35</td>
<td>0.58</td>
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<tr>
<td>RO CONC # 3</td>
<td>18.50</td>
<td>5.37</td>
<td>5.37</td>
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<td>CL CONC # 2</td>
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<td>24.60</td>
<td>0.58</td>
<td>0.53</td>
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<td>CL TAILS # 2</td>
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<td>22.10</td>
<td>1.25</td>
<td>0.50</td>
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<tr>
<td>RO CONC # 1 TAILS</td>
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<td>1.04</td>
<td>9.34</td>
<td>0.12</td>
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<tr>
<td>RO TAILS - 200</td>
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<td>3.05</td>
<td>8.43</td>
<td>0.21</td>
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<tr>
<td>RO TAILS - 200</td>
<td>25.87</td>
<td>11.30</td>
<td>5.41</td>
<td>0.35</td>
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</table>

Date Printed: 13-FEB-90
Project: BRAZEAU-WOOD
Page 1
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<th>SAMPLE</th>
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<th>PE (P)</th>
<th>LI</th>
<th>AI</th>
<th>W</th>
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<tr>
<td>TABLE CONC 3 MAG</td>
<td>25.98</td>
<td>12.50</td>
<td>5.60</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>TABLE CONC 3 NON MAG</td>
<td>12.22</td>
<td>1.11</td>
<td>9.45</td>
<td>0.20</td>
<td></td>
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<tr>
<td>TABLE TAIL-200 MAG</td>
<td>34.87</td>
<td>18.80</td>
<td>3.81</td>
<td>0.43</td>
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<tr>
<td>TABLE TAIL-200 NONMAG</td>
<td>15.76</td>
<td>3.52</td>
<td>9.92</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>SAMPLE</td>
<td>ELEMENT</td>
<td>Fe tot</td>
<td>Ti</td>
<td>Al</td>
<td>V</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>--------</td>
<td>-----</td>
<td>-----</td>
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</tr>
<tr>
<td>GARNET CONC</td>
<td>43.30</td>
<td>24.98</td>
<td>0.64</td>
<td>0.48</td>
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<tr>
<td>JEMENITE CONC</td>
<td>16.80</td>
<td>1.15</td>
<td>9.92</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>
Report of Work

Ministry of Northern Development and Mines
Ontario

Mining Act
(Expenditures, Subsection 71(2))

Type of Work Performed
Beneficience Study

Received Holder
ARTHUR WILLIAM HENNESSY

Address
41 OAKLY COURT, ANCASTER ONT. L9E 1L7

Work Performed By
CARI F. FORBES 70 MCCAMUS AVE, KIRKLAND LAKE ONT.

All the work was performed on Mining Claim(s).

Instructions
Total days credits may be distributed at claim holder's choice. Information of claim(s) in the expenditure days, credits column (below)

Calculations of Expenditure Days, Credits

Days
Credits

182.2

Total Number of Mining Claims Covered by this Report of Work

Total Number of Days Claimed

Total Number of Days to be Claimed at a Future Date

MINING LANDS SECTION

Total Number of Days Claimed

182.2 days

Certification of Beneficial Interest

I hereby certify that at the time the work was performed, the claims covered in this report of work were held by the current record holder's name or held in a beneficial interest by the current record holder.

Certification Verifying Report of Work

I hereby certify that I have personal and intimate knowledge of the facts set forth in the Report of Work annexed hereto, having performed the work or witnessed same during or after its completion and the submitted report is true.

For Office Use Only

Date Recorded
[stamp]

Received
[stamp]

For Office Use Only

Date Recorded
[stamp]
January 28, 1990

Mr. Wayne Whynark
Premier Exploration Inc.
373 Beachgrove Drive
West Hill, Ontario

Dear Mr. Whynark:

Subject: Farmatt Vegetation-Blocking Magnetite-Laminit Deposit

In reference to a conversation with Mr. W. Gredjen on January 29, 1990 regarding concentration of vanadium-bearing magnetite and laminitite, I am pleased to inform Premier Exploration Inc. hereinafter referred to as "COMPANY" that CANMET is willing to undertake such work. The total cost of this work is estimated at $2,734. The project leader would be G.J. Mathieu.

This work is to be carried out on a 100% cost-recovery basis, with total recoverable costs to CANMET estimated at $2,734. (Additional costs of approximately $200 to cover expenditures for chemical analyses will be invoiced by and should be paid directly to Honour-Gregu.) The scope of work, schedule, breakdown of estimated costs, along with terms and conditions related to this job are stipulated in the attached pages of this letter.

Please review its content. If acceptable to you, please sign where indicated and return the original. This letter will constitute a contract between CANMET and the COMPANY.
If you require additional information or wish to discuss this matter, do not hesitate to contact me at (613) 555-5603 or Mickey Kellepic at (613) 555-5646.

We look forward to working with you.

Sincerely,

[Signature]

G.L. Mathew
Research Scientist
Mineral Sciences Laboratory
GLMRE

G.R. Project Leader
Office of Business Development

Attachments.
# Appendix J

## Contract Award

**Project Dates**

### Labour Costs

<table>
<thead>
<tr>
<th>Employee</th>
<th>Specialisation</th>
<th>Rate/Rate</th>
<th>Estimate Hours</th>
<th>Estimate $</th>
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<td>G.J. Mathews</td>
<td>286.00</td>
<td>$8.80</td>
<td>8</td>
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<tr>
<td>N. Rajasekhar</td>
<td>286.00</td>
<td>$6.66</td>
<td>16</td>
<td>206.66</td>
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<tr>
<td>Mineralogy</td>
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<tr>
<td>S. Green</td>
<td>Gen. Tech.</td>
<td>$6.44</td>
<td>2</td>
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<td>R. Delaney</td>
<td>Int. Prof.</td>
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<td>4</td>
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<td>E. Rinaldo</td>
<td>En. Tech.</td>
<td>$8.80</td>
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<td>46.8</td>
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</table>

**Total Labour**

$27,424

### Machine Costs

<table>
<thead>
<tr>
<th>Machine</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Utrage analysis</td>
<td>$300</td>
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**Other Costs**

*Chemical Analysis costs* - $250 (directly invoiced to contractor)

**Total Costs**

$27,754

**Company Costs**

$2,754
2. Scope of Work

Crushing and grinding of ore to liberation, separation of valuable metal oxides (magnetite and ilmenite), with associated vanadium for its eventual extraction.

Project title:
"Concentration of magnetite, ilmenite and associated vanadium from Prentiss Rod deposit".

Objectives:
To recover the iron and titanium minerals plus the vanadium.

Methods:
1) To determine the liberation size of the magnetite and ilmenite from the gangue (garnet, actinolite and plagioclase etc) and from each other.
2) To crush and grind to the fineness necessary for their combined separation.
3) To concentrate the iron-titanium oxides and associated vanadium values by magnetic and gravity separation techniques and to compute metallurgical balance for the iron, titanium and vanadium.
4) To describe the techniques used to achieve the objectives.
5) To provide the magnetite-ilmenite-vanadium concentrate to Mr. G. Hickey for vanadium extraction studies.
6) To report testwork and results to the client.

Time Schedule:
January 16 to 31.

Prepared by:

[Signature]
Estimated Costs

The estimated total cost for our labour is $2,754. A detailed cost breakdown is given in Appendix 1.

Conditions

The estimated cost of this work is not a firm price quotation. You will be invoiced for actual costs incurred by CANMET up to 10% of estimated costs. Should work beyond the 10% level be required to meet the project objectives, we will seek your authorization prior to proceeding.

Pricing & Payment

On completion, CANMET will submit to you an invoice for hours worked. Payment is to be made thirty (30) days after receipt of the invoice. A cheque or money order made payable to:

Receiver General for Canada
Energy, Mines & Resources
E.P.T., Financial Services
6th South Street
Ottawa, Ontario K1A 0E2

Please refer to the Job number on the cheque. (Costs associated with work done by the sub-contractors will be invoiced directly by and should be paid directly to the sub-contractor).
COMPANY OBLIGATIONS

In addition to paying CANTER for work done under this agreement, the COMPANY shall provide with the following: ex. materials, date, employees, etc.

CANTER PROPRIETARY INFORMATION

The COMPANY acknowledges that it has not provided any COMPANY proprietary information to CANTER in respect to the work to be done under this agreement.

CONFIDENTIALITY

CANTER agrees to keep confidential and not disclose to third parties the information contained in deliverables provided under this agreement for a period of 5 years from the effective date of this agreement except with the written consent of the COMPANY or where the information: (a) is or becomes generally publicly available without the fault of CANTER; (b) is subsequently disclosed to CANTER by any third party not under a duty of confidentiality to the COMPANY; (c) is subsequently developed by or for CANTER independent of any information developed under this agreement.

CANTER reserves the right to use the information contained in the deliverables for policy formulation and internal research purposes, and to publish summary, non-confidential announcements on the project. Such announcements shall not be published without the consent of the COMPANY, which consent shall not be unreasonably withheld.

Should any inventions arise from the work, CANTER will negotiate in good faith a licence agreement authorizing the COMPANY to use the inventions on terms and conditions to be mutually agreed upon.

COMPLETION DATE

CANTER will use best efforts to complete this work on or about January 30, 1980.

TERMINATION

Either party may terminate this agreement upon thirty (30) days written notice to the other party. Upon termination of the agreement CANTER shall be paid for all work done up to the date of termination.

Contact
Amendments

This agreement may be amended by mutual agreement of the parties.

Accepting

By approval hereof, the undersigned acknowledge and hereby accept the terms and conditions of this agreement.

Signature

J. H. Dickey

Name: J. H. Dickey

Title: Senior Analyst

Division: Min. Proc. Lab.

Date: 23/03/80

Company: Independent

Date: 

Address:

Box 2500, 4th Ave.

Ph. (416) 678 7710 (Home)

Office of Business Development
CAMECO, Mineral Sciences Laboratories
Room 126, 888 Booth Street
Ottawa, Ontario K1A 0G1

Please return signed document to