Bergvesenet

Postboks 3021, N-7441 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
7218				
Kommer fra ..arkiv	**Ekstern rapport nr**	**Oversendt fra**	**Fortrolig pga**	**Fortrolig fra dato:**
	Sul 463/77/25	Stavanger Staal A/S. NGU		

Tittel

Reports on Raana samples.

Forfatter	Dato År	Bedrift (Oppdragsgiver og/eller oppdragstaker)
Lakefield Research	1977	Falconbridge Nikkelverk AS

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad
Ballangen	Nordland		13311	Narvik

Fagområde	Dokument type	Forekomster (forekomst, gruvefelt, undersøkelsesfelt)
Malmberegning		Råna Bruvannsfeltet
Råstoffgruppe	**Råstofftype**	
Malm/metall	Ni, Cu	

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Består av 4 delrapporter utført ved Falconbridge Nicel Mines Ltd sin lab Lakefield research

1) Mineralogical Examination of the Raana Project Ore Sample, progress report no. 1.
2)An Investigation of the Recovery of Nickel from the Raana Deposit samples., progress report no. 2.
3)Memo on the Lakefield Research Report on Raana Sample.
4)Memo on Raana Project Analysis.

Her gir 1) en mineralogisk beskrivelse og oversikt over mineralgehalten i prøven. I 2) beskrives 10 testforsøk med flotasjon, som viser at koncgehalten kan komme opp i 10 -13 % Ni med utvinning på ca 79%.
Memo 3) diskuterer flotasjonsresultatene og sammenligner med resultater fra NTH.
Memo 4) konkluderer med at det beste alternativet dekker driftskostnadene, men ikke kapitalkostnaden.

Konfidentiellt

A/S SULFIDMALM

TELEGRAMADR.: FALCONBRIDGE
TELEX: 11959 FNA N
TELEFON: (042) 25500

4601 KRISTIANSAND S.
NORWAY
POSTBOKS 457

Undersøkelser av Statens Bergrettigheter
v/Geolog S. Svinndal
Postboks 3006
7001 Trondheim

DERES REF./YOUR REF.	DERES BREV/YOUR LETTER	VÅR REF./OUR REF.	DATO/DATE
			3. januar 1980

Rapporter fra Råna-feltet

Vi ref. til Deres brev av 13.12.79 og kan meddele at vi ikke har noe imot at De får låne våre rapporter angående Ånafeltet.

Vedlagt sendes følgende:

1. Mineralogical examination on a Råna Project ore sample. Progress report 1.
2. An investigation of the recovery of Nickel from Råna deposit samples. Progress report 2.
3. Memo by F.G.T.Pickard on Lakefield Research report on Råna sample.
4. Memo from G.A. Vary on Råna Project Analysis.

Vår rapport om malmberegning er dessverre i Canada, men en kopi er etterlyst.

Med hilsen

Frank Nixon

FOR FALCONBRIDGE NIKKELVERK A/S
A/S SULFIDMALM

PROJECT 905-25

Reports on Raana samples

By
Lakefield Research

Report No. 463/77/25

MINERALOGICAL EXAMINATION

of a Rana Project ore sample

submitted by

FALCONBRIDGE NICKEL MINES LIMITED

Progress Report No. 1

Project No. L.R. 2023

NOTE:

This report refers to the samples as received.

LAKEFIELD RESEARCH OF CANADA LIMITED
Lakefield, Ontario
October 18, 1977

I N T R O D U C T I O N

A sample of Rana Project nickel ore was received in the Mineralogy Laboratory from Falconbridge Nickel Mines Limited. The sample consisted of minus 10 mesh material from Composite Hole 280-140, and was submitted for:

1) Identification of the sulphide and gangue minerals.

2) Determination of the percent distribution by association of the sulphide phases.

LAKEFIELD RESEARCH OF CANADA LIMITED

A.G. Scobie, P. Eng.,
Manager

R.W. Deane, P. Eng.,
Mineralogist

S U M M A R Y

Forsterite-magnesian olivine was the major gangue mineral present. Also identified as gangue constituents were pyroxene, amphibole, chlorite, serpentine and phlogopite. The sulphide minerals were pyrrhotite, chalcopyrite and pentlandite. The sulphide minerals were present as liberated particles, and as fine-grained inclusions in gangue minerals.

PREPARATION AND PROCEDURE

A portion of the sample was briquetted and polished for microscopic examination and for point counting in reflected light. A second portion of the sample was pulverized and submitted for x-ray powder diffractometry.

RESULTS

The host material for the sulphide mineralization was a peridotite of composition intermediate between harzburgite and lherzolite. Olivine the major mineral constituent was accompanied by small amounts of clino and orthopyroxene, together with minor calcic plagioclase, and alteration products of the mafic minerals. These alteration products consisted of chlorite, serpentine and a mica, the optical properties of which were close to those given in standard references for phlogopite.

The sulphide minerals identified were pyrrhotite, chalcopyrite and pentlandite. The sulphide minerals were present as liberated particles, and as fine-grained inclusions in the gangue minerals. The results of the point counting are tabulated below:

Results - Continued

Mineral Association	% Distribution by Association
Pyrrhotite - liberated	1.3
Chalcopyrite - liberated	Trace
Pentlandite - liberated	2.7
Gangue - liberated	76.2
Gangue + Sulphides	14.7
Sulphides + Gangue	0.6
Pyrrhotite + Pentlandite	1.3
Pentlandite + Pyrrhotite	0.5
Chalcopyrite + Pyrrhotite or Pentlandite	2.7
Total	100.0

Mineral Composition	Weight %
Pyrrhotite	3
Chalcopyrite	1
Pentlandite	6
Olivine	7 - 8
Pyroxene	2 - 3
Amphibole	1 - 2
Chlorite	2 - 3
Plagioclase	3 - 4
Supentine	1 - 2
Magnetite	1
Total	100

It has been reported that a pulp of a portion of the head-sample had a relatively high pH. It may be possible that the material contained sufficient brucite $\left[Mg(OH)_2\right]$ to result in a pulp of high pH.

LAKEFIELD RESEARCH OF CANADA LIMITED
Lakefield, Ontario
October 18, 1977 / dmm

An Investigation of

THE RECOVERY OF NICKEL

from Rana deposit samples

submitted by

FALCONBRIDGE NICKEL MINES LIMITED

Progress Report No. 2

Project No. L.R. 2023

NOTE:

This report refers to the samples as received.

LAKEFIELD RESEARCH OF CANADA LIMITED
Lakefield, Ontario
October 18, 1977

I N T R O D U C T I O N

In a meeting at Lakefield on July 27, 1977, Mr. F.G.T. Pickard of Falconbridge Nickel Mines Limited, requested that a program of flotation test-work should be conducted on a composite of drill core samples from the Rana nickel deposit in Norway to investigate the grade and recovery of nickel.

LAKEFIELD RESEARCH OF CANADA LIMITED

A.G. Scobie, P. Eng.,
Manager

K.W. Sarbutt
Project Metallurgist

Investigation by: G.A. Kosick

S U M M A R Y

1. Head SAmple Assays

Composite Hole 280-140

Total Ni	0.43 %, 0.43 %*
Sulphide Ni	0.33 %, 0.35*
Copper	0.086 %, 0.096 %*
Sulphur	1.59 % -

* Average head assay as calculated from test results

$S/D_5 = 4.7$

Total Ni was determined by X-Ray fluorescence techniques

Sulphide Ni was determined by chlorine and alcohol extraction and atomic absorption.

2. Flotation Testwork

2.1. Rougher Flotation

Variables investigated in the rougher flotation included:

(a) fineness of grind

(b) pH

(c) use of CMC as a gangue depressant

(d) collector type

The results and conditions of the rougher flotation are summarized in Table No. 1.

Summary - Continued

2. Flotation Testwork

Table No. 1 - Rougher Flotation

Test No.	Grind % -200 mesh	Reagents, lb/ton				pH	Flotation Time min.	Rougher Concentrate		
		Z-11	Z-6	CMC-6CTE	H_2SO_4			Weight %	Assay % Tot. Ni	% Distribution Total Ni
1	51.8	0.125	0.05	-	-	9.8	6	6.07	4.96	69.9
2	77.8	0.15	0.05	-	1.4	6.5	9	15.46	2.30	80.8
3	77.8	0.15	-	0.50	-	9.6	6	11.41	2.82	76.1
4	51.8	0.15	-	0.50	-	9.6	6	6.76	4.94	73.7
5	51.8	0.15	-	0.50	0.90	7.0	6	8.96	3.52	75.7
6	51.8	0.20	0.04	0.25	-	9.6	12	15.29	2.31	80.6
7	66.4	0.20	0.04	0.25	-	9.6	12	15.57	2.19	80.7
8	51.8	0.20	0.04	0.50	-	9.6	12	16.21	2.03	79.9
9	51.8	-	0.15	0.25	-	9.6	9	7.88	4.29	79.8
10	51.8	-	0.15	-	1.0	6.5	9	10.05	3.39	80.1

Grinding finer than 52 percent minus 200 mesh resulted in no improvement in concentrate grade and recovery.

The use of CMC at 0.25 lb/ton with Z-6 as collector as in Test 9 resulted in the most selective conditions.

A lower-grade rougher concentrate was recovered in Test 10, which was conducted at pH 6.5 without CMC.

Summary - Continued

2. Flotation Testwork

2.2. Cleaner Flotation

The rougher concentrates from Tests 6 to 10 were cleaned twice. The results and conditions of the cleaner flotation are summarized in Table 2.

Table No. 2 - Cleaner Flotation

Test No.	CMC6CTE lb/t	pH	No. of Cleaner Stages	Cleaner Concentrate				
				Weight %	Assays, %		% Distribution	
					Ni(S)	Ni(T)	Ni(S)	Ni(T)
6	0.05	8.9-8.6	2	2.30	11.97	13.0	78.3	68.4
7	0.05	8.9-8.6	2	2.74	10.20	10.9	83.0	70.6
8	0.15	8.9-8.6	2	2.37	11.35	11.6	79.3	66.7
9	0.05	8.9-8.6	2	3.11	9.88	9.93	85.5	72.9
10	-	6.5	2	4.23	7.32	7.34	86.1	73.1

Concentrate grades of 10 - 13 % Ni could be achieved after cleaning with small additions of CMC. Cleaning at pH 6.5 resulted in a concentrate grade of 7.3 % Ni. Tests 6 and 9 were assayed for Cu. The cleaner concentrate from Test 6 assayed 3.49 % Cu with a recovery of 82.3 % Cu, and the cleaner concentrate from Test 9 assayed 2.55 % Cu with a recovery of 83.7 % Cu.

The sulphide Ni and total Ni grade-recovery curves are shown in Figure 1.

Summary - Continued

3. Concentrate Analysis

The cleaner concentrates from Test 6 and 9 were also assayed for Fe, S and Insol.

	Assays, %					
	Total Ni	Sulphide Ni	Cu	Fe	S	Insol.
Test 6 Cleaner Conc.	13.0	11.97	3.49	37.4	30.2	11.3
Test 9 Cleaner Conc.	9.93	9.88	2.55	40.7	29.8	13.0

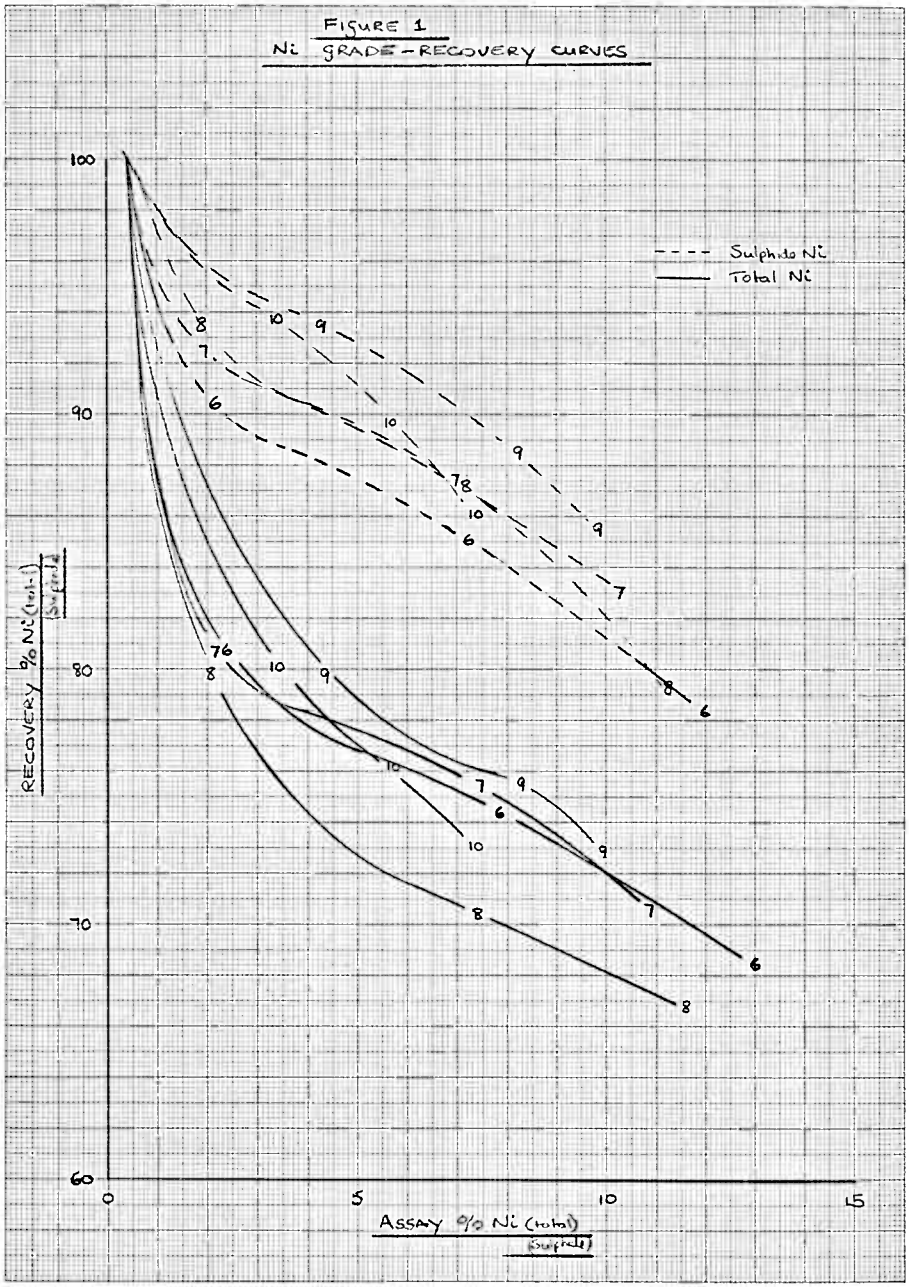
4. Mineralogical Examination of Test 9 Concentrate

	Weight %
Pentlandite - liberated	22.6
Chalcopyrite - liberated	6.2
Pyrrhotite - liberated	45.8
Gangue - liberated	8.0
Pentlandite + Pyrrhotite	2.0
Pentlandite + Chalcooyrite	0.3
Pyrrhotite + Pentlandite	7.2
Pyrrhotite + Pentlandite + Chalcopyrite	0.5
Pyrrhotite + Chalcopyrite	1.5
Pyrrhotite + Pentlandite + Gangue	0.3
Chalcopyrite + Pyrrhotite	0.7
GAngue + Pyrrhotite	2.7
Gangue + Pyrrhotite + Pentlandite	0.9
Pyrrhotite + Gangue	1.3
Total	100.0

The major diluent in this concentrate was free pyrrhotite. Less important were the amounts of liberated chalcopyrite and gangue, followed by the quantity of pyrrhotite and pentlandite middling particles.

FIGURE 1

Ni GRADE-RECOVERY CURVES



SAMPLE PREPARATION

Approximately 100 pounds of crushed drill core was received at Lakefield on June 7, 1977 and given our Reference No. 7721317.

The samples received were from Hole No. 280-140, 280-145 and 290-135. The footages and weights are tabulated below:

Sample No.	Meters	kg.	Sample No.	Meters	kg.
Hole No. 280-140			Hole No. 280-140		
720729	40.0-41.0	0.45	720756	92.0-94.0	0.81
730	41.0-43.3	1.11	757	94.0-96.0	0.88
731	43.3-46.0	1.29	758	96.0-98.0	0.85
732	46.0-48.0	0.92	759	98.0-100.0	0.83
733	48.0-50.0	0.58	760	100.0-102.0	1.06
734	50.0-52.0	0.89	Hole No. 280-145		
735	52.0-54.0	0.84			
736	54.0-56.0	0.83	721464	6.3- 8.0	0.58
737	56.0-58.0	1.02	465	8.0-10.0	0.69
738	58.0-60.0	0.97	466	10.0-12.0	0.54
739	60.0-62.0	0.94	467	12.0-14.0	0.73
740	62.0-64.0	0.77	468	14.0-16.0	0.57
741	64.0-66.0	1.09	469	16.0-18.0	0.68
742	66.0-68.0	1.02	470	18.0-20.0	0.66
743	68.0-70.0	0.96	471	20.0-22.0	0.60
744	70.0-72.0	1.32	472	22.0-24.0	0.69
745	72.0-74.0	0.88	473	24.0-26.0	0.62
746	74.0-76.0	1.16	474	26.0-28.0	0.48
747	76.0-78.0	0.96	475	28.0-30.0	0.75
748	78.0-80.0	0.94			
749	80.0-81.5	0.82	Hole No. 290-135		
750	81.5-82.7	0.44	721335	104.0-105.0	0.28
751	82.7-84.0	0.48	336	105.0-107.1	0.72
752	84.0-86.0	1.05	337	107.1-108.8	0.28
753	86.0-88.0	0.97	338	108.8-110.0	0.16
754	88.0-90.0	1.01	339	110.0-112.0	0.79
755	90.0-92.0	0.90	340	112.0-114.0	0.65
			341	114.0-116.0	1.23

Sample Preparation - Continued

A composite of Ho.e No. 280-140 was prepared for testwork. The weights used for this composite were:

Sample No.	Grams	Sample No.	Grams
720729	400	720745	800
730	920	746	800
731	1080	747	800
732	800	748	800
733	580	749	600
734	800	750	440
735	800	751	480
736	800	752	800
737	800	753	800
738	800	754	800
739	800	755	800
740	770	756	800
741	800	757	800
742	800	758	800
743	800	759	800
744	800	760	800

The samples were mixed, thoroughly crushed to minus 10 mesh, and 1 kg. samples for testwork and a sample for head analysis were riffled out.

DETAILS OF TESTS

Test No. 1

Purpose: To investigate the recovery of Ni from Rona ore by means of flotation.

Procedure: Grind and float a rougher and three scavenger concentrates.

Feed: 1000 gram minus 10 mesh composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton						Time, minutes			pH
	Z - 11	MIBC	DF-250	Z - 6	H_2SO_4	41-G	Grind	Cond.	Froth	
Grind	-	-	-	-	-	-	10	-	-	-
Rougher	0.05	0.03	0.02	-	-	-	-	1	2	9.8
	0.075	-	-	-	-	-	-	1	2	-
Scavenger No. 1	-	-	-	0.05	-	-	-	1	2	9.5
Scavenger No. 2	-	-	-	-	0.62	-	-	2	-	6.5
	-	-	0.04	0.05	-	0.028	-	1	2	-
Scavenger No. 3	-	-	-	0.03	0.40	-	-	1	2	8.5-6.5

Stage: Rougher and Scavenger
Flotation Cell: 500 g D-1
Speed: r.p.m.: 1500 rpm
% Solids: 33

Test No. 1 - Continued

Metallurgical Results

Product	Weight %	Asssays, %			% Distribution		
		Cu	Total Ni	Sulphide Ni	Cu	Total Ni	Sulphide Ni
1. Ni Rougher Conc.	4.89	1.64	5.83	5.80	85.7	66.2	81.1
2. Ni 1st Scav. Conc.	1.18	0.15	1.33	1.25	1.9	3.7	4.2
3. Ni 2nd Scav. Conc.	3.03	0.11	1.35	1.27	3.5	9.5	11.0
4. Ni 3rd Scav. Conc.	1.52	0.073	0.32	0.25	1.2	1.1	1.1
5. Ni 3rd Scav. Tail.	89.38	0.008	0.094	0.010	7.7	19.5	2.6
Head (Calculated)	100.00	0.094	0.43	0.35	100.0	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	6.07	1.35	4.96	4.92	87.6	69.9	85.3
Products 1 to 3	9.10	0.94	3.75	3.70	91.1	79.4	96.3
Products 1 to 4	10.62	0.81	3.26	3.21	92.3	80.5	97.4

Screen Analysis

Composite of All Products

Mesh Size (Tyler)	% Retained		% Passing Cumulative
	Individual	Cumulative	
+ 65	1.9	1.9	98.1
100	7.8	9.7	90.3
150	17.0	26.7	73.3
200	21.5	48.2	51.8
270	11.2	59.4	40.6
400	13.5	72.9	27.1
- 400	27.1	100.0	-
Total	100.0	-	-

Test No. 2

Purpose: To float at a finer grind and lower pH.

Procedure: Grind and float three rougher concentrates, after conditioning the pulp to pH 6.5 with H_2SO_4.

Feed: 1000 grams minus 10 mesh ore composite 240-180.

Grind: 20 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton				Time, minutes			pH
	H_2SO_4	Z - 11	Z - 6	41-G	Grind	Cond.	Froth	
Grind	-	-	-	-	20	-	-	-
Condition	1.4	-	-	-	-	1	-	9.6-6.5
Rougher No. 1	-	0.10	-	0.056	-	1	3	-
No. 2	-	0.05	-	-	-	1	3	7.9
No. 3	-	-	0.05	-	-	1	3	8.0

Stage	Rougher 1, 2 and 3
Flotation Cell	500 g D-1
Speed: r.p.m.	1500
% Solids	33

Test No. 2 - Continued

Metallurgical Results

Product	Weight %	Assays, %		% Distribution	
		Total Ni	Sulphide Ni	Total Ni	Sulphide Ni
1. Ni 1st Rougher Conc.	7.18	3.91	3.83	63.7	77.9
2. Ni 2nd Rougher Conc.	4.05	1.22	0.97	11.2	11.1
3. Ni 3rd Rougher Conc.	4.23	0.62	0.56	5.9	6.7
4. Ni Rougher Tailing	84.54	0.10	0.018	19.2	4.3
Head (Calculated)	100.0	0.44	0.35	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	11.23	2.94	2.80	74.9	89.0
Products 1 to 3	15.46	2.30	2.19	80.8	95.7

Screen Analysis

Composite of All Products

Mesh Size (Tyler)	% Retained		% Passing Cumulative
	Individual	Cumulative	
+ 100	1.0	1.0	99.0
150	5.4	6.4	93.6
200	15.8	22.2	77.8
270	13.4	35.6	64.4
400	20.0	55.6	44.4
- 400	44.4	100.0	-
Total	100.0	-	-

Test No. 3

Purpose: To study the effect of CMC on Ni flotation at natural pH.

Procedure: Grind, float a rougher and two scavenger concentrates according to the conditions below.

Feed: 1000 g minus 10 mesh composite 240-180.

Grind: 20 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton					Time, minutes			pH
	CMC6CTE	Z - 11	DF-250	H_2SO_4	Z - 6	Grind	Cond.	Froth	
Grind	-	-	-	-	-	20	-	-	-
Rougher	0.50	-	-	-	-	-	3	-	9.6
	-	0.10	0.02	"	-	-	1	3	-
	-	0.05	0.02	-	-	-	1	3	-
Scavenger 1	-	-	-	1.0	-	-	3	-	9.6-6.5
	-	-	0.02	-	0.05	-	1	3	-
Scavenger 2	-	-	-	-	0.05	-	1	3	7.8

Stage Rougher and Scavenger
Flotation Cell 500 g D-1
Speed: r.p.m. 1500
% Solids 33

Test No. 3 - Continued

Metallurgical Results

Product	Weight %	Assays, %		% Distribution	
		Total Ni	Sulphide Ni	Total Ni	Sulphide Ni
1. Ni Rougher Concentrate	11.41	2.82	2.66	76.1	90.6
2. Ni 1st Scav. Conc.	4.82	0.39	0.32	4.4	4.6
4. Ni 2nd Scav. Conc.	3.04	0.19	0.13	1.4	1.2
4. Ni Scav. Tailing	80.73	0.095	0.015	18.1	3.6
Head (Calculated)	100.00	0.42	0.34	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	16.23	2.10	1.97	80.5	95.2
Products 1 to 3	19.27	1.80	1.68	81.9	96.4

Test No. 4

Purpose: Repeat Test 3 conditions at coarser grind, and clean the combined rougher concentrates.

Procedure: Grind float a rougher concentrate and two scavenger concentrates. Clean the rougher concentrate once. Refer to conditions below.

Feed: 1000 grams minus 10 mesh ore composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, lb/ton				Time, minutes			pH
	CMC6CTE	Z - 11	DF-250	$CuSO_4$	Grind	Cond.	Froth	
Grind	-	-	-	-	10	-	-	-
Condition	0.50	-	-	-	-	1	-	-
Rougher	-	0.10	0.03	-	-	1	3	9.6
	-	0.05	0.01	-	-	1	3	9.6
Scavenger No. 1	-	-	-	0.20	-	3	-	-
	-	0.05	0.02	-	-	1	3	-
Scavenger No. 2	-	0.05	0.02	-	-	1	3	-
1st Cleaner	0.20	-	0.05	-	-	1	1	-
	-	0.02	-	-	-	1	2	-

Stage	Rougher and Scav.	Cleaners
Flotation Cell	500 g D-1	250 g D-1
Speed: r.p.m.	1500	900
% Solids	33	33

Test No. 4 - Continued

Metallurgical Results

Product	Weight %	Assays, %	% Distribution
		Total Ni	Total Ni
1. Ni Cleaner Conc.	3.47	9.25	70.9
2. Ni Cleaner Tail.	3.29	0.39	2.8
3. Ni Scav. Conc. 1	3.72	0.97	8.0
4. Ni Scav. Conc. 2	2.65	0.15	0.9
5. Ni Scav. Tailing	86.87	0.091	17.4
Head (Calculated)	100.0	0.45	100.0

Calculated Grades and Recoveries

Products 1 and 2	6.76	4.94	73.7
Products 1 to 3	10.48	3.53	81.7
Products 1 to 4	13.13	2.89	82.6

Test No. 5

Purpose: To repeat Test 4, but at a pH of 7.0.

Procedure: Grind, float a rougher and two scavenger concentrates. Clean the rougher concentrate once. Refer to conditions below.

Feed: 1000 grams minus 10 mesh ore composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton					Time, minutes			pH
	CMC6CTE	Z - 11	DF-250	H_2SO_4	$CuSO_4$	Grind	Cond.	Froth	
Grind	-	-	-	-	-	10	-	-	-
Condition	-	-	-	0.90	-	-	1	-	9.6-7.0
	0.50	-	-	-	-	-	1	-	-
Rougher	-	0.10	0.03	-	-	-	1	3	-
	-	0.05	0.01	-	-	-	1	3	-
Condition	-	-	-	-	0.20	-	3	-	8.5
Scavenger No. 1	-	0.05	0.02	-	-	-	1	3	-
Scavenger No. 2	-	0.05	0.02	-	-	-	1	3	-
1st Cleaner	-	0.01	-	-	-	-	1	3	8.5
	-	-	0.01	-	-	-	1	1	-

Test No. 5 - Continued

Metallurgical Results

Product	Weight %	Assays, %	% Distribution
		Total Ni	Total Ni
1. Ni Cleaner Conc.	4.32	6.94	72.0
2. Ni Cleaner Tail.	4.64	0.33	3.7
3. Ni Scav. Conc. No. 1	3.58	0.59	5.0
4. Ni Scav. Conc. No. 2	2.80	0.35	2.4
5. Ni Scav. Tail.	84.66	0.083	16.9
Head (Calculated)	100.00	0.42	100.0

Calculated Grades and Recoveries

Products 1 and 2	8.96	3.52	75.7
Products 1 to 3	12.54	2.68	80.7
Products 1 to 4	15.34	2.26	83.1

Test No. 6

Purpose: Increase the collector level and decrease the amount of CMC. Float at natural pH.

Procedure: Grind, float a rougher concentrate and clean twice.

Feed: 1000 grams minus 10 mesh composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton				Time, minutes			pH
	CMC6CTE	Z - 11	DF-250	Z - 6	Grind	Cond.	Froth	
Grind	-	-	-	-	10	-	-	-
Condition	0.25	-	-	-	-	1	-	9.6
Rougher	-	0.10	0.02	-	-	1	3	9.6
	-	0.05	0.005	-	-	1	3	9.5
	-	0.05	0.01	-	-	1	3	9.5
	-	-	0.005	0.04	-	1	3	-
1st Cleaner	0.05	-	-	-	-	1	4	8.9
2nd Cleaner	-	-	0.005	-	-	1	2	8.6

Stage	Rougher	1st Cleaner	2nd Cleaner
Flotation Cell	500 g D-1	500 g D-1	250 g D-1
Speed: r.p.m.	1500	1200	900

Test No. 6 - Continued

Metallurgical Results

Product	Weight %	Assays, %			% Distribution		
		Total Ni	Sulphide Ni	Cu	Total Ni	Sulphide Ni	Cu
1. Ni Cleaner Conc.	2.30	13.0	11.97	3.49	68.4	78.3	82.3
2. Ni 2nd Cleaner Tail.	1.86	1.39	1.26	0.26	5.9	6.7	4.9
3. Ni 1st Cleaner Tail.	11.13	0.25	0.17	0.048	6.3	5.4	5.4
4. Ni Rougher Tail.	84.71	0.10	0.04	0.0084	19.4	9.6	7.4
Head (Calculated)	100.00	0.44	0.35	0.098	100.0	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.16	7.81	7.18	2.05	74.3	85.0	87.2
Products 1 to 3	15.29	2.31	2.08	0.59	80.6	90.4	92.6

Test No. 7

Purpose: To repeat Test 6, but to investigate the effect of a 15 minute grind.

Procedure: Grind, float a rougher concentrate and clean twice.

Feed: 1000 grams minus 10 mesh composite 240-180.

Grind: 15 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton				Time, minutes			pH
	CMC6CTE	Z - 11	DF-250	Z - 6	Grind	Cond.	Froth	
Grind	-	-	-	-	15	-	-	9.8
Condition	0.25	-	-	-	-	1	-	9.8
Rougher	-	0.10	0.02	-	-	1	3	9.8
	-	0.05	0.005	-	-	1	3	-
	-	0.05	0.01	-	-	1	3	-
	-	-	0.005	0.04	-	1	3	-
1st Cleaner	0.05	0.005	0.015	-	-	1	4	8.9
2nd Cleaner	-	-	0.005	-	-	1	2	8.6

Stage	Rougher	Cleaner
Flotation Cell	500 g D-1	250 g D-1
Speed: r.p.m.	1500	1200
% Solids	33	33

Test No. 7 - Continued

Metallurgical Results

Product	Weight %	Assays, %		% Distribution	
		Total Ni	Sulphide Ni	Total Ni	Sulphide Ni
1. Ni Cleaner Conc.	2.74	10.9	10.2	70.6	83.0
2. Ni 2nd Cleaner Tail.	1.49	1.12	0.99	3.9	4.4
3. Ni 1st Cleaner Tail.	11.34	0.23	0.15	6.2	5.1
4. Ni Rougher Conc.	84.43	0.097	0.03	19.3	7.5
Head (Calculated)	100.00	0.42	0.34	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.23	7.46	6.96	74.5	87.4
Products 1 to 3	15.57	2.19	2.00	80.7	92.5

Screen Analysis

Composite of All Products

Mesh Size (Tyler)	% Retained		% Passing
	Individual	Cumulative	Cumulative
+ 65	0.2	0.2	99.8
100	2.6	2.8	97.2
150	10.4	13.2	86.8
200	20.4	33.6	66.4
270	13.4	47.0	53.0
400	17.6	64.6	35.4
- 400	35.4	100.0	-
Total	100.0	-	-

Test No. 8

Purpose: To repeat test No. 6, but to investigate the effect of greater additions of CMC-6CTE.

Procedure: Grind, float a rougher concentrate and clean twice.

Feed: 1000 g minus 10 mesh composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton				Time, minutes			pH
	CMC 6-CTE	Z-11	DF-250	Z-6	Grind	Cond.	Froth	
Grind	-	-	-	-	10	-	-	-
Condition	0.50	-	-	-	-	1	-	-
Rougher	-	0.10	0.02	-	-	1	3	9.6
	-	0.05	0.01	-	-	1	3	-
	-	0.05	0.01	-	-	1	3	-
	-	-	0.01	0.04	-	1	3	-
1st Cl.	0.10	-	-	-	-	1	4	8.9
2nd Cl.	0.05	-	0.005	-	-	1	2	8.6

Stage	Rougher	1st Cleaner	2nd Cleaner
Flotation Cell	500 g D - 1	500 g D - 1	250 g D - 1
Speed: r.p.m.	1800	1800	-
% Solids	33	-	-

Test No. 8 - Continued

Metallurgical Results

Product	Weight %	Assays, %		% Distribution	
		Total Ni	Sulphide Ni	Total Ni	Sulphide Ni
1. Ni Cl. Conc.	2.37	11.6	11.35	66.7	79.3
2. Ni 2nd Cl. Tail.	1.74	1.60	1.54	6.7	7.9
3. Ni 1st Cl. Tail.	12.10	0.22	0.18	6.5	6.4
4. Ni Rougher Tail.	83.79	0.099	0.026	20.1	6.4
Head (Calculated)	100.00	0.41	0.34	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.11	7.36	7.20	70.4	87.2
Products 1 to 3	16.21	2.03	1.96	79.9	93.6

Test No. 9

Purpose: Float only with Z-6 as collector.

Procedure: Grind, float a rougher concentrat and a scavenger concentrate. Clean the rougher concentrate twice.

Feed: 1000 g minus 10 mesh Composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton			Time, minutes			pH
	CMC 6-CTE	Z - 6	DF-250	Grind	Cond.	Froth	
Grind	-	-	-	10	-	-	-
Condition	0.25	-	-	-	1	-	9.3
Rougher	-	0.05	0.02	-	1	3	-
	-	0.05	0.005	-	1	3	-
	-	0.05	0.02	-	1	3	-
Scavenger	-	0.05	0.01	-	1	3	-
1st Cl.	0.05	-	-	-	1	3	8.9
1st Cl. Scav.	-	0.02	0.01	-	1	1	-
2nd Cl.	-	0.0025	0.005	-	1	2	8.6

Stage	Rougher	Scavenger	1st Cleaner	2nd Cleaner
Flotation Cell	500 g D - 1	500 g D - 1	500 g D - 1	250 g D - 1
Speed: r.p.m.	1200	1200	1200	900
% Solids	33	-	-	-

Test No. 9 - Continued

Metallurgical Results

Product	Weight %	Assays, %			% Distribution		
		Total Ni	Sulphide Ni	Cu	Total Ni	Sulphide Ni	Cu
1. Ni Cl. Concentrate	3.11	9.93	9.88	2.55	72.9	85.5	83.7
2. Ni 2nd Cl. Tail.	0.74	1.47	1.46	0.30	2.6	3.0	2.3
3. Ni 1st Cl. Scav. Conc.	0.07	2.56	2.54	0.61	0.4	0.5	0.4
4. Ni 1st Cl. Scav. Tail.	3.96	0.42	0.41	0.092	3.9	4.5	3.8
5. Ni Scav. Concentrate	1.50	0.40	0.36	0.061	1.4	1.5	1.0
6. Ni Scav. Tailing	90.62	0.088	0.02	0.0091	18.8	5.0	8.8
Head (Calculated)	100.00	0.42	0.36	0.095	100.0	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.85	8.30	8.25	2.12	75.5	88.5	86.0
Products 3 and 4	4.03	0.46	0.45	0.10	4.3	5.0	4.2
Products 1 to 4	7.88	4.29	4.26	1.09	79.8	93.5	90.2
Products 1 to 5	9.38	3.67	3.64	0.92	81.2	95.0	91.2

Test No. 10

Purpose: To repeat test No. 9, but to investigate the effect of flotation at a pH of 6.5. Omit CMC addition.

Procedure: Grind, float a rougher concentrate and a scavenger concentrate. Clean the rougher concentrate twice.

Feed: 500 grams minus 10 mesh Composite 240-180.

Grind: 10 minutes at 65 percent solids in the laboratory ball mill.

Conditions:

Stage	Reagents Added, pounds per ton			Time, minutes			pH
	H_2SO_4	Z - 6	DF250	Grind	Cond.	Froth	
Grind	-	-	-	10	-	-	-
Condition	1.0	-	-	-	1	-	9.3-6.5
Rougher	-	0.05	0.02	-	1	3	-
	-	0.05	0.005	-	1	3	-
	-	0.05	0.02	-	1	3	-
Condition	0.4	-	-	-	1	-	8.0-6.5
Scavenger	-	0.05	0.01	-	1	3	-
Condition	0.3	-	-	-	-	-	8.0-6.5
1st Cl.	-	-	-	-	1	3	-
2nd Cl.	0.06	-	0.005	-	1	2	7.1-6.5

Stage	Rougher	Scavenger	1st and 2nd Cleaner
Flotation Cell	500 g D - 1	500 g D - 1	250 g D - 1
Speed: r.p.m.	1200	1200	900
% Solids	33	33	-

Test No. 10 - Continued

Metallurgical Results

Product	Weight %	Assays, %		% Distribution	
		Total Ni	Sulphide Ni	Total Ni	Sulphide Ni
1. Ni Cl. Conc.	4.23	7.34	7.32	73.1	86.1
2. Ni 2nd Cl. Tail.	1.45	0.92	0.89	3.1	3.6
3. Ni 1st Cl. Tail.	4.37	0.38	0.33	3.9	4.0
4. Ni Scav. Conc.	1.87	0.33	0.27	1.5	1.4
5. Ni Scav. Tail.	88.08	0.089	0.02	18.4	4.9
Head (Calculated)	100.00	0.42	0.36	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.68	5.70	5.68	76.2	89.7
Products 1 to 3	10.05	3.39	3.35	80.1	93.7
Products 1 to 4	11.92	2.91	2.87	81.6	95.1

LAKEFIELD RESEARCH OF CANADA LIMITED
Lakefield, Ontario
October 18, 1977 / dmm

FNM 250-8-72

Bldg 3.

FALCONBRIDGE NICKEL MINES LIMITED

INTER-OFFICE MEMORANDUM

DATE: October 25, 1977

TO: H. T. Berry

COPIES TO: AMC/WDH, GAV, J. Gammon, File

FROM: F. G. T. Pickard

SUBJECT: LAKEFIELD RESEARCH REPORT ON RAANA SAMPLE

The Lakefield Research Report describing bench flotation tests and mineralogical examinations on core from Raana diamond drill hole 280-140, has been received and copies provided to recipients of this memo. Testwork was also conducted on a sample from this drill hole (as well as a large number of other samples) at the Norwegian Technical University at Trondheim. The following comparison of results are of interest:

(1) The Lakefield tests produced a bulk concentrate assaying 3.6% sulphide nickel at 95.0% sulphide nickel recovery when flotation was carried out at the basic natural pH of the ore using CMC as gangue depressant. When flotation was carried out at acid pH, the bulk concentrate assayed 2.9% sulphide nickel at 95.1% sulphide nickel recovery. At Trondheim, the bulk concentrate produced under acid pH conditions assayed 3.8% sulphide nickel at 97% sulphide nickel recovery, which is essentially the same as the Lakefield tests under basic pH conditions.

(2) The bulk concentrate could be cleaned as follows:

Lakefield - Basic pH	9.9% Sulphide Ni	85.5% Sulphide Ni Recovery
	11.3% Sulphide Ni	79.3% Sulphide Ni Recovery
Lakefield - Acid pH	7.3% Sulphide Ni	86.1% Sulphide Ni Recovery
Trondheim - Acid pH	6.9% Sulphide Ni	93.0% Sulphide Ni Recovery

(3) Locked cycle tests would be necessary to accurately predict plant performance, but I estimate recovery of about 88% sulphide nickel at 10% sulphide Ni grade should be obtainable using the basic pH approach.

(4) The higher grade concentrate produced using the basic pH approach should be more readily saleable. More favourable terms for payment of contained metals and for treatment charge should be obtainable from the higher grade concentrate.

(5) The testwork at Lakefield was very limited and better results should be obtainable by a more intensive investigative program into basic pH treatment using CMC as gangue depressant.

.../2

None of the preceding statements is intended to reflect, in any way, on the quality of the work performed by the Norwegian Technical University at Trondheim. Their work was under the direction of Dr. Knut L. Sandvik who was previously employed under me as mill metallurgist at Strathcona Mill. He is a very competent engineer. The use of CMC for treatment of "talcy" nickel ores was not practised during his period of employment with us and it is the use of this reagent which makes satisfactory treatment at basic pH possible.

FGTP:sm

F. G. T. Pickard

FNM 250-8-72

FALCONBRIDGE NICKEL MINES LIMITED INTER-OFFICE MEMORANDUM

DATE: October 19, 1977

TO: AMC/WDH/WBGW/LAW/SNC

COPIES TO: J. B. Gammon

FROM: G. A. Vary

SUBJECT: RANA PROJECT ANALYSIS

Summary

Two cases were considered, both of which used the Stavanger's (1975) costs and Outokumpu's (1975) smelter proposal. No attempt was made to escalate either values.

Metal prices were taken at $2.20/lb. for Ni and $0.60/lb. for Cu U.S. (October 1977).

Case I uses Stavanger metallurgy, 91% recovery for Ni and 80% recovery for Cu to give a concentrate grade of 5.5% Ni and 1.7% Cu and Outukumpu's smelter proposal.

This case, because of the low grade concentrate and smelter penalty, does not generate a sufficient cash flow to pay operating costs. The shortfall being $10,316,001 U.S. or 54,193,633 K.

Case II uses Stavanger's cost but Lakefield's improved metallurgy* (received October 13, 1977) and Outokumpu's smelter proposal.

Lakefield metallurgy suggests an 83% recovery for Ni to give an upgraded concentrate of 11% Ni and 2.55% Cu.

This grade of concentrate improves the net back considerably as Outokumpu pays 60% of the contained Ni instead of 40% in the low grade concentrate.

In Case II the project generates a cash flow profit of $26,000,000 over the life of the project which just equals the estimated capital and pre-production expense of 24 million U.S. dollars before the cost of money or discounting of future cash flows.

This would also have a negative rate of return.

* enclosed

Case IIa is the same as II only the calculations are made in metric tonnes and Kroner.

The project cash flow profit is 138 MK with the capital and pre-production cost estimated at 130 MK before the cost of money or discount of future cash flows.

A Falconbridge smelter proposal, Vic McCallum (October 18, 1977)* was considered and indeed was fractional higher than the Outokumpu one but the transportation costs of $20/ton from Quebec City to Sudbury make the Outokumpu proposal much better for the project. Net back from Outokumpu FOB smelter is $283/short ton or 1544 K per short ton as against net back from Falco of $287/short ton FOB smelter at Sudbury, or 1550 K per short ton.

In metric tonne this would be:

	Outokumpu	Sudbury
FOB Smelter (Shipping costs in operating costs)	1703K/tonne ($315 U.S./tonne)	FOB Sudbury 1709 K/tonne ($317 U.S./tonne)
After shipping	1703 K/tonne ($315 U.S./tonne)	FOB Quebec* 1604 K/tonne ($297 U.S./tonne)

Sensitivity Analysis. There is little point in using hypothetical numbers in that the only variables are operating costs and value of metal and the best we can hope for in the foreseeable future is that metal prices again get and stay ahead of producer costs.

It is doubtful if the grade, - ton relationship of the reserve can be increased and even if the tonnage was doubled it would not significantly alter the negative rate of return situation.

The operating costs generated by Stavanger of $4.82 U.S./short ton are low compared to a similar sized operation in Canada where we would expect costs to be in the 7.50 to $8.00/ton range.

Similarly the capital and pre-production cost of $24 million U.S. would be low by Canadian standards.

The Hudson Bay 3,500 T/day milling complex now under construction at Snow Lake is expected to cost 26 million dollars and this does not include pre-production work for an open pit.

* The cost of the ocean shipping by the Falcon to be deducted.

A comparable capital and pre-production estimate for similar project in Canada would be more in the range of 28 to 30 million dollars. However, there might very well be favourable cost advantages in Northern Norway that we do not have in Canada.

Data Used (Stavanger's costs, metallurgy and Outokumpu's smelter proposal).

Exchange rate 5.4 K to $1 U.S.

Mineable reserves (open pit) - 9,400,000 tonnes or 10,363,600 short tons.

Mining Rate - 1,000,000 tonnes/yr. or 1,102,500 short tons/yr.

Recovery - 91% Ni and 80% Cu

Concentrate grade - 5.59% Ni and 1.7% Cu

Concentrate Production - 55,000 tonnes/yr. or 60,638 short tons/yr.

Life of Project - 9.4 yrs.

Ratio of Concentration - 17 to 1.

Processing Costs (1975)	K/tonne	U.S. $/ton
Mining including waste	15.30	2.57
Milling	8.84	1.49
Miscellaneous	4.54	0.76
Total	28.68	4.82
Concentrate shipping cost	7.26	1.22
Total Cost	35.94	6.04

Case I

Outokumpu/1976 Smelter Proposal

Ni - Concentrate grade less 0.8 units and pay 40% of the contained nickel if under 9% at the quoted market price and if the grade is over 9% pay 60% of the contained nickel.

Cu - Concentrate grade less 0.7 units and pay 75% of the contained copper at LME quoted price.

Value of metals used in this analysis in all cases is $2.20/lb. for nickel and $0.60/lb. for copper (Oct. 1977).

No escalation of costs or metal prices were attempted.

Value of 1 ton of Concentrate

		$ U.S.	K
Ni -	5.5 - 0.8 = 4.7 4.7 X 20 = 94 lbs. Pay 40% @ $2.20/lb. Value/ton = 94 X .40 X 2.20 =	82.72	446.69
Cu -	1.7 - 0.7 = 1 1 X 20 = 20 lbs. Pay 75% LME price $0.60 Value/ton = 20 X .75 X .60 =	9.00	48.60
	Value/ton of Conc. FOB Smelter	$91.72	495.29
Value of Production 9.4 X 60,638 X 91.72		=$52,280,143	282,312,772
Cost of Production 10,363,600 X 6.04		= 62,596,144	336,506,405
Shortfall		$(10,316,001)	(54,193,633)

Case II

Same as I but using Lakefield Metallurgy and Stavanger's costs and Outokumpu's smelter contract,

which was Heads - 0.33% Ni, Recovery 83% and grade of concentrate 11% Ni and 2.55% Cu.

Total pounds of Ni will be reduced compared to Case I but the Outokumpu smelter contract payment will be improved by the increased grade of concentrate.

Ni Production

10,363,600 X 0.33 X 0.83 X 20 = 56,771,801 lbs.
Concentration ratio is 33.3 to 1
Tons of Concentrate = $\frac{10,363,600}{33.3}$ = 311,219 tons

Tons of Concentrate/yr = $\frac{311,219}{9.4}$ = 33,108 tons

Outokumpu pays on 60% of the contained nickel on a concentrate grade over 10% Ni after deducting 0.8 units.

Contained Ni after deductions 11 - 0.8 = 10.2 X 20	= 204 lbs. Ni/ton C.
Paid pounds 204 X 0.6	= 122.4 lbs. Ni/ton C
Value of 1 ton of Conc. @ $2.20/lb. = 122.4 X 2.20	=$269.28/ton C.
Credit for Cu (2.55 - 0.7) X .75 X .60 X 20	=$ 13.95/ton C.
Total value/ton of concentrate	=$283.23

Value of Production = 283.23 X 311,219 = $ 88,146,557
Cost/ton = $6.03 X 10,363,600 = 62,492,508

Operating profit $ 25,654,048

Since the net revenue generated of $26 million is almost equal to the capital and pre-production estimate of 130 MK or $\frac{130}{5.4}$ = $24 million, there would be a negative rate of return after the cost of the money.

Case IIa

Same as II but using metric tonnes and Kroner.

Mineable Reserve 9,400,000 tonnes @ 0.33% Ni and 0.13% Cu

Lakefield Metallurgy Heads - 0.33% Ni, Recovery 83% and grade of concentrate 11% Ni and 2.55% Cu.

Mining rate 1,000,000 tonnes/yr.

Ni Production

Concentration ratio = $\frac{11}{0.33}$ = 33.3 to 1

Metric tonnes of concentrate = $\frac{9,400,000}{33.3}$ = 282,282 tonnes

Yearly tonnes of Conc. = $\frac{282,282}{9.4}$ = 30,030 tonnes

Outokumpu pays 60% of the contained Ni after deducting 0.8 units = 11 - 0.8 = 10.2 metric ton units.

Ni - Pay units = 282,282 X 10.2 X 0.60 = 1,727,566 metric ton units
Value of 1 metric tonne unit = 22.05 X $2.20 X 5.4 = 261.95 K
Value of Ni in concentrate = $\frac{1,727,566 \text{ X } 261.95}{1.55}$ = 452,535,913 K.

Cu - Value of Cu in concentrate = (2.25 - 0.7) X 22.05 X 0.60 X 0.75 X 5.4 X 282,282 = 23,443,894

Total Project Revenue 475,979,807 K

On property cost = 28.68K/tonne
Shipping cost = 7.26K/tonne

Total Operating Cost = 35.94K/tonne

Project Operating Cost = 9,400,000 X 35.94 = 337,836,000 K

Revenue	=	475,979,807 K
Cost	=	337,836,000 K
Operating Profit	=	138,143,807 K

Since the net revenue generated of 138m K is almost equal to the capital and pre-production estimate of 130m K there would be a negative rate of return after the cost of money.

G. A. Vary

GAV:ols