COBALT

MINING CAMP

TAILINGS INVENTORY

COBALT, ONTARIO

by

Pat Anderson

1993

ABSTRACT

The Cobalt mining camp in Northern Ontario became world famous early in the twentieth century as a very rich silver mining area. Initially the high grade ore was hand sorted at each mine and the lower grade ore was discarded. By 1907, area mines and independent companies were building concentrating mills to recover silver from the lower grade ore. The resultant tailings or slimes were deposited, often without thought for the environment, into the nearest water course or land depression.

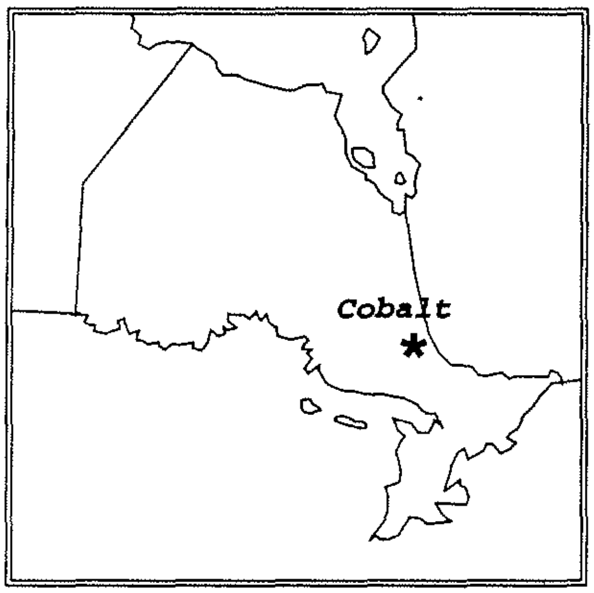


Figure 1: Location of study area.

In more recent years, environmental concerns, mines closures and tailings retreatment raised many questions about the chemistry and safety of the numerous sites. This inventory documents the history of the mills, milling processes and any details of the nature of each mill and tailings site to provided the background information necessary to facilitate further research.

TABLE OF CONTENTS

ABSTRACT i

INTRODUCTION ii
Location ii
Purpose and Scope of Report ii
Methodology ii
Acknowledgements iv

HISTORY OF MILLING 1
Introduction 1
Early Mining Practices 2
Milling and Metallurgical Practices 3
Early Tailings Disposal 6
Tailings Mills 8

TAILINGS DEPOSITS 10
Introduction 10
Cobalt Catchment Area 11
West Arm Deposits 13
Buffalo Tailings 13
Coniagas Tailings 17
Trethewey Tailings 22
Hudson Bay Tailings 26
Cobalt Lake Tailings 28
McKinley-Darragh Mill 28
Cobalt Reduction (Northern Customs Concentrator, Mugglev Concentrator) . . . 32
Cobalt Lake Mill 34
Hellens Mill 34
Ore Reduction Mill (Nipissing Reduction Mill) 37
East Arm Deposits 38
Nipissing Hill Tailings 38
LaRose Tailings 43
Chambers-Ferland Tailings 46
Peterson Lake Catchment Area 48
Cart Lake Tailings 50
Seneca-Superior Mill 50
Cobalt Provincial Mill 50
Savage Mill 52
Silver Summit (Silverfields) Mill 53
Nova Scotia Tailings 57
Nova Scotia (Dominion Reduction) Mill 58
Giroux Lake Catchment Area 62
Mensilvo Tailings 62
Silver Arrow (Mensilvo) Mill 62
Glen Lake Tailings 65
Cobalt Central (Standard Cobalt, Penn Canadian) Mill 65
Bailey Mill 66
Foster (Penn) Mill 67

TAILINGS DEPOSITS, cont.
Giroux Lake Catchment Area, cont.
Canadaka Tailings 70
Canadaka Mill 70
Kirk Lake Catchment Area 72
Beaver Tailings 73
Beaver Mill 73
Temiskaming Tailings 77
Temiskaming Mill 77
Brady Lake (Silver-Miller) Mill 79
Crosswise Lake Catchment Area 80
Cross Lake Tailings 82
King Edward (National) Mill 83
Silver Cliff (Pilliner, Ausic, United Cobalt) Mill 84
Colonial Mill 87
O'Brien Mill 89
Nipissing-O'Brien (Deer Horn) Mill 89
Mile 104 (Northern Customs Concentrator, Bailey, O'Brien, O'Shaughnessy, Cobalt Lode) Mill 90
North Cobalt Catchment Area 92
Cobalt Contact Tailings 92
Cobalt Contact (Green-Meehan) Mill 92
Argyle Property 94
Refinery Sites 94
Temiskaming Testing Laboratory 94
Agnico Refinery (CSR) 95
Cobalt Refinery 96

REFERENCES 99

ADDITIONAL BIBLIOGRAPHY 122

TABLES

1 Water quality tests for arsenic and suspended solids, from Ontario Water Resources Commission, 1967, p.105 . 57

2 Origin of Crosswise Lake Tailings 83

FIGURES

1 Location map of study area iii

2 General flow sheet, Cobalt concentrators, after Corkill, 1910, p.254. 4

FIGURES, cont.

3. Tailings Sites and Catchment Basins, Cobalt 12

4. Buffalo Tailings 14

5 Coniagas Tailings 19

6 Trethewey Tailings 23

7. Hudson Bay Tailings 27

8. Cobalt Lake Tailings, South End 29

9. LaRose and Cobalt Lake Tailings, North End 30

10. Nipissing Tailings 40

11. Cart Lake Tailings 51

12. Nova Scotia Tailings 59

13. Mensilvo Tailings 63

14. Penn Mill Flow Sheet 69

15. Beaver Tailings 74

16. Kirk Lake Tailings 75

17. South End Crosswise Lake Tailings 76

18. Temiskaming Tailings 78

19. Brady Lake Tailings 81

20. Northern Crosswise Lake Tailings, Northern Part 85

21. Northern Crosswise Lake Tailings, Southern Part 86

22. Cobalt Contact Tailings 93

23. Agnico Refinery Tailings 97

APPENDICES

A Milling and Metallurgical Practice in Treatment of Silver Ores in Cobalt, Reid et all, 1924, p.241-244 . . . . A-1

Figure A-1: Comparative flow-chart, Cobalt milling practice, 1914 (Reid et al, 1924, facing p. 274) A-7

Figure A-2: Comparative flow-chart, Cobalt milling practice, 1917 (Reid et al, 1924, facing p.276) A-8

Figure A-3: Comparative flow-chart, Cobalt milling practice, 1923 (Reid et al, 1924, facing p. 278) A-9

Figure A-4: Mill flow-sheet, McKinley-Darragh-Savage Mines, February, 1923 (Reid et al, 1924, p. 264) A-10

Figure A-5: Flow-sheet of Nipissing high grade mill. Tube mill amalgamation, 1911-1918 (Reid et al, 1924, p.308) A-11

B Analytical Results, Mineral Tailings, Silver Operations, excerpts from J. Hawley, 1979, p.179-185 . . . . B-1

C Cobalt Camp Mill Statistics C-1

D The Mills and their Owners D-1

Table D-1: The Mills and their Owners D-2

E The Owners and their Mills E-1

Table E-1: The Owners and their Mills E-2

F Tailings Sites F-1

Table F-1: Tailings Sites F-1

G Reworked Tailings. G-1

Table G-1: Reworked Tailings G-1

H Tailings Grain Size Analysis H-1

Table H-1: Grain Size Analysis Results H-2

I Penn Mill, W. Montgomery, 1987 . . . . I-1

APPENDICES, cont.

J Canadaka Mill, E.C. Blakemore J-1

Canadaka Mill Report, L. Othmer, 1984 . . . . J-3

K The Occurrence of Arsenic and Heavy Metal Contamination from Natural and Anthropogenic Sources in the Cobalt Area of Ontario, Charles G. Dumaresq, 1993 . . . . K-1

Table K-1: Comparison of the As, SO_4, Cl, Na, Ca, Co, Ni and Hg Concentrations in Crust Samples from the NLGM Tailings and the Cart Lake Tailings. (Dumaresq, 1993, Table 3.4, p.92) K-4

Table K-2: Trace Element Concentrations in Concrete and Other Solid Materials. (Dumaresq, 1993, Table 3.5, p.99) K-5

Table K-3: Estimated Rates of Mobilization of Arsenic from Tailings, Soil and Glacial Till (Dumaresq, 1993, Table 5.1, p.170) K-7

L Legend and Symbols for Tailings Maps L-1

INTRODUCTION

Location

The study area is located between Latitudes 47°20'14"N and 47°27'30"N and Longitudes 79°45'22"W and 79°35'34"W approximately 500 km north of Toronto. It encompasses most of the area generally known as the Cobalt mining camp and includes all known tailings within a radius of 6 km of the Town of Cobalt (Figure 1).

Purpose and Scope of Report

Mining and rehabilitation of silver tailings in the Cobalt mining camp has occurred at infrequent intervals since the first veins were discovered in 1903. Little comprehensive information is available today describing these operations, the tailings sites or the mills or milling processes utilized to produce the tails. Most published information is included in early editions of the Ontario Department of Mines Annual Reports which only describe silver production rather than silver lost during milling. Furthermore, most existing tailings are situated on patented grounds and submission of data was, and is not, required by the government. Little systematic documentation has ever been compiled on the tailings in the area and what little information is available is rapidly becoming lost.

The study was initiated by the Cobalt Resident Geologist's Office, Ministry of Northern Development and Mines, primarily to meet the demand by a number of engineering and mining firms requiring information on tailings rehabilitation and milling practices. In addition increasing environmental awareness, advances in processing and a renewed interest in mining reclamation of tailings suggested that a comprehensive report describing the tailings was necessary.

This report encompasses and deals with several facets related to tailings and includes maps, locations, historical mining and milling practices, composition and rehabilitation practices.

Methodology

All known tailings deposits, except three that were inaccessible due to activity, were mapped at a scale of 1:2000 using Ontario Basic Map Sheets as base maps. Wherever possible, aerial photographs were utilized and flagged grids were established on the ground by mapping with pace and compass. These maps served to provide accurate locations, extent and distribution of the tailings and identify any vegetation regrowth. The author has not attempted to establish reserves and grades for individual tailings because of the sensitive nature of the information and the bedded and erratic distribution of elements in the tailings. In some instances, estimated grades and reserves have been calculated by companies and are included.

Information has been compiled from various sources including publications, unpublished assessment information, internal government reports, company reports and personal observations and communications.

Acknowledgements

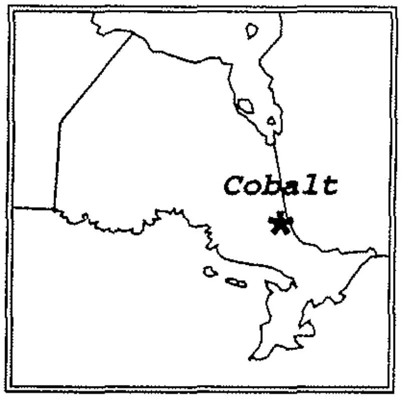
Initial funding for this report was secured and administered by L. Owsiacki, former Cobalt Resident Geologist. His guidance and assistance with the organization and compilation of the original work is greatly appreciated. R. Larsen carried out the bulk of mapping, L. Francis drafted the maps, and K. Larabie typed the original manuscript. Funding for the final revision and publication was provided by the Abandoned Mines Branch, Mining Lands and Rehabilitation Division, MNDM and administered through the Township of Coleman Mine Hazard Abatement Program, 1993.

For many years, the report existed as a loose collection of data and maps often utilized by researchers and ever in danger of going astray. Many thanks are extended to the Township of Coleman and project director, K. Saxton, who facilitated the final compilation of this report. Special thanks are extended to J. Ireland, Cobalt Resident Geologist, and R. Zalnieriunas, Contract Geologist, for their editorial comments and guidance.

The original compilation of this report was done in 1985 with the help of many individuals. The author would like to acknowledge L. Othmer (Canadaka Mining Division of Sulpetro Minerals Ltd.), B. Thorniley, F. Basa and W. Montgomery (Agnico-Eagle Mines Ltd.) and J. Church (Silverfields Mine) who provided valuable information from company files and useful discussions describing area operations. W. Marshall and J. Hawley from the Ontario Ministry of Environment and Energy provided important information on cattail marsh experiments and earlier geochemical and water quality analyses. The staff of the Temiskaming Testing Laboratory, Ministry of Northern Development and Mines located many of the mill and tailings sites and provided valuable information on past operations. Among the many local consultants and prospectors who provided information for this study, special thanks are extended to R. Benner, J. Armstrong, M. Halstead and H. Moore for their assistance and discussions based on their long years of experience in the camp.

In April, 1991, Charles Dumaresq, a graduate student from Carleton University, began field work for his thesis "The Occurrence of Arsenic and Heavy Metal Contamination from Natural and

Anthropogenic Sources in the Cobalt Area of Ontario. Many enjoyable hours of discussion and investigation probing new aspects of the tailings kept the topic alive for me. His thesis concentrates on water quality in and near the tailings and tailings chemical evolution. It answers many questions beyond the scope of this inventory and has sparked many new questions that hopefully can be investigated in the near future. Without his research and interest, this inventory would probably still be languishing in a forgotten filing cabinet. Many thanks, Charles.



HISTORY OF MILLING IN THE COBALT CAMP

Introduction

In 1903, construction of the Temiskaming and Northern Ontario Railway, linking southern Ontario with the fertile clay belt north of Lake Temiskaming, reached Cobalt Lake (formerly Long Lake). No one suspected that the true wealth of this country lay in the tarnished veins that crisscrossed the countryside.

Two railroad men, J.H. McKinley and Ernest Darragh, surveying timber along the proposed right-of-way, staked the initial silver find on the south shore of Cobalt Lake. Other railway men joined the search and further prospecting soon revealed numerous rich veins in the outcrops on the hills surrounding Cobalt Lake. Three more claims were staked that season including the fabled Fred LaRose discovery site, a large block on Nipissing Hill by Tom Hebert and his associates and the O'Brien property by Neil King.

In the summer of 1904, Willet G. Miller, the Provincial Geologist, travelled north to the little railway camp at Mile 103 to survey the extent of the silver discoveries. His subsequent report and word of mouth reports from the camp attracted prospectors from far and wide, sparking a staking rush in 1905. The boom town of Cobalt grew haphazardly on the west side of Cobalt Lake with buildings springing up on every flat outcrop.

As is the case with almost all single resource based towns, Cobalt's history has been one of boom and bust. The initial richness and accessibility of the silver veins resulted in the mining of over 227 million ounces of silver by more than one hundred mining companies before the outbreak of World War I, making Ontario the third largest silver producer in the world. Falling grades, lack of manpower and depressed worldwide silver prices soon slowed the extraction of this precious metal. Fortunately, advancing mining, exploration and milling techniques kept the industry alive. Over the years, Cobalt's fortune has relied on the global price of, and demand, for silver and cobalt. In 1989, the last silver mines closed, not for lack of ore, but because of low silver prices.

Early Mining Practices

The ores of the Cobalt camp occur predominately in veins comprised of a complex assemblage of minerals including native silver, cobalt and nickel arsenides, sulphides, sulph-arsenides, sulph-arsenites, antimonides, sulph-antimonides, sulph-bismuthinites and their secondary alteration products in a predominately carbonate gangue (Reid et al, 1924, p.246). A more extensive description of the mineralogy is presented in studies by Petruk & Jambor (Berry, 1971). In general, ninety-seven percent of the silver occurs in its native form, 85% to 96% pure (Reid et al, 1924, p.246) with the most significant impurities being antimony, arsenic and mercury. These impurities, together with metallurgical problems presented by the complex mineral assemblages, environmental constraints and other factors have resulted in a situation where often only silver, and sometimes cobalt was recovered. As a consequence, milling and processing has changed progressively in order to improve recoveries and to conform to environmental restrictions.

Cobalt camp mine workings are generally narrow and linear in response to the concentrated nature of the silver veins. Wider stopes only occur at vein intersections or where additional space is needed for equipment. Initially the nearly vertical veins were mined economically from narrow open cuts worked downwards on the vein. As the miners followed the silver to greater depths, they had to adopt underground methods for mining and prospecting. Two compartment shafts, measuring 5' x 8' (1.5 m x 2.5 m) were sunk on the vein structures. Stations were cut at 75'- 100' (23 m -31 m) intervals and drifts approximately 6' (2 m) wide followed the horizontal extent of the veins. Wherever ore values permitted, overhand stoping was the general practise (Corkhill, 1913, p.253).

Much of the ore was initially bagged underground and the remaining material was hand-sorted on surface, in simple washing plants where picking belts or tables and jigs were located. The ore was crushed at this stage to 1" - 1 1/2" and then sized on screens and trommels. The oversize from the trommel was again hand-sorted on picking belts and the fines concentrated in Hartz or Richards jigs and subsequently shipped away for further processing (Reid et al, 1924, p.266).

Mining methods were modernized somewhat by 1910 with the advent of hydro-electric power and compressed air power. Cobalt was unique among mining camps by having low cost compressed air centrally supplied to each mine from the Ragged Chutes power plant located 15 km to the south. This factor facilitated expansion of mining activities at reduced costs.

Milling and Metallurgical Practices

In 1907, the first gravity concentrator mill was built to process low grade ore which remained after passing through the washing plants. These mills were specially designed to recover silver, cobalt and copper from the base-metal sulphides most commonly found in the conglomerate and volcanic wall-rock. Initially the washing plants were retained to remove the high grade ore as the first step in the concentrating process. Heavy stamps then crushed the remaining material and the resultant fines were passed on to classifiers, Wilfley tables and Frue vanners for further concentration (Reid et al, 1924, p.266). Figure 2 illustrates a general flow sheet for the earliest Cobalt concentrators (Corkill, 1913, p.254). After 1908, cyanidation was introduced in some of the mills to enhance silver recoveries. It proved to be both cheaper and more efficient than washing and gravity concentration, but the cyanide which was released into the tailings contaminated the surrounding areas. Commonly, the washing plant stage was discontinued after the introduction of cyanidation.

Subsequently, experimentation in the mills continued, in an effort to reduce costs, processing time and losses to tailings. In 1915, a Callow flotation mill was tested at the Buffalo Mill and proved so successful a break-through that similar plants were soon built by other companies to enhance their gravity concentrators. By 1921, most of the high-grade veins were mined out, but concentration methods were effective enough to continue processing lower grade ore (10 - 25 ounces/ton silver).

Few major changes were made in milling after the 1920's. Crushing was later exclusively by ball and rod mills rather than by stamps. Constant refinements in the gravity tables, flotation cells, classifiers and chemical reagents slowly improved the efficiency of recovery.

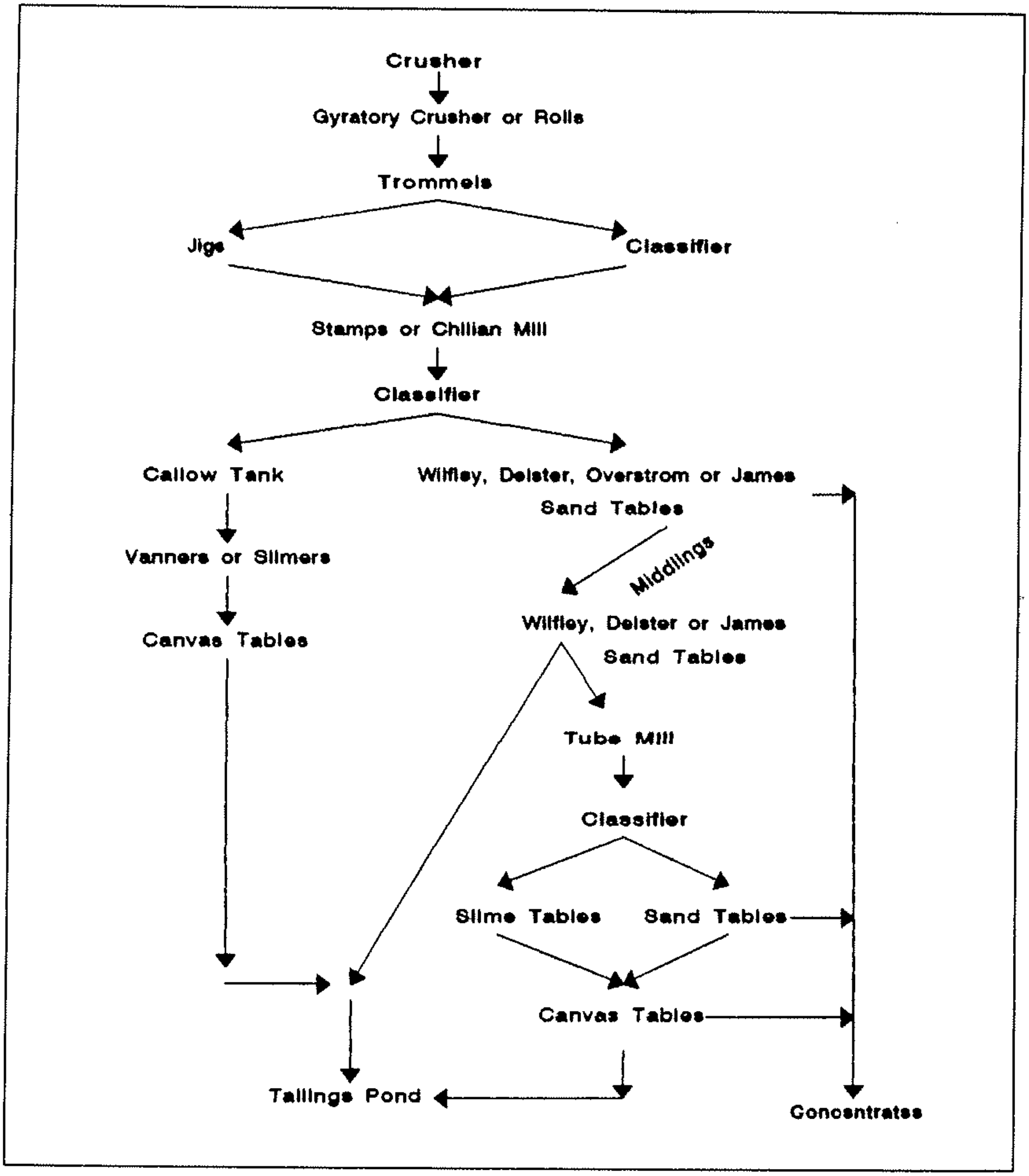


Figure 2: General flow sheet, Cobalt concentrators, after Corkill, 1913, p.254.

Concurrent with the development of increasingly efficient low-grade mills or concentrators was the opening of a few high-grade mills or refineries. The complex nature of the Cobalt camp ore and high arsenic content made it undesirable for refining at ordinary custom smelters. As early as 1908, the Nipissing Mining Company investigated the possibility of refining concentrates within the camp and shipping only the final product - silver bullion. The first high-grade mill was erected by this company in 1911 and used a tube-mill amalgamation process followed by cyanidation. This process proved to be efficient, inexpensive and simple to operate. A few of the other major companies in the camp followed suit and, before long, much of Cobalt's silver was refined locally.

F. D. Reid, J.J. Denny and R.H. Hutchison (1924, pp.239-320) compiled a detailed and comprehensive discussion of metallurgical practices and improvements in the Cobalt camp from 1907 to 1922. Reference should be made to that paper for details beyond the scope of this publication. Due to the fragile nature of the few existing hard copies, the "Summary of the Report" containing the basic details of early Cobalt milling operations is reproduced in Appendix A along with several informative figures. Figures A-1, A-2 and A-3 from this report highlight the similarities and differences in the basic flow charts from the local mills. Figure A-1 (Reid et al, 1924, facing p.274) details the mill operations as they were in 1914 before flotation. Figure A-2 (after Reid et al, 1924, facing p.276) details the mill in 1917 after flotation procedures were introduced. Figure A-3 (after Reid et al, 1924, facing p.278) details the flow sheets of four area mills in 1923. Figures A-4 (after Reid et al, 1924, p.264) is a detailed flow sheet from the McKinley Darragh Mill as of January 1923. It illustrates effectively the advances made in milling during the 16 year history of this mill. Simplification of the processes occurred while technological advances yielded improved recovery. Figure A-5 (Reid et al, 1924, p.308) is the flow-sheet from the Nipissing High Grade Mill where the concentrate was refined to bullion. All the high grade operations used basically the same process. For those inexperienced with mill nomenclature and techniques, J.P. Murphy (1977, p.109-113) describes the early milling in layman's terms.

Milling and refining operations in Cobalt peaked in the years between 1907 and the mid-1920's. With falling silver prices and the onset of the Great Depression, most mines closed and milling and refining activities subsequently slowed to a trickle. Although properties continued to operate from this time until the late 1980's, later mining activity never matched that of the first two decades of this century.

Early Tailings Disposal

Tailings from the mills in the Cobalt camp were initially deposited haphazardly without concern for the environment. Any low-lying area including valleys, lakes and streams adjacent to the mills soon became clogged with this material. Flowing streams would ultimately wash the tailings elsewhere, creating a constantly renewable disposal site. As a result, the tailings, along with the contaminated run-off water, migrated great distances and caused extensive damage to the waterways and natural environment. Today modern legislation, in conjunction with more environmentally-conscious mining companies has led to marked improvement in tailings management. Tailings dams are now built to contain effluent. This allows for the settling of the heavier residues and provides ponded treatment areas to dilute and neutralize toxic elements contained in solution.

Three essential components were derived from the milling process. Concentrates, containing the maximum amount of silver that could be economically recovered from the ore, were sent on to a refinery. Middlings, a form of low grade concentrate, were initially produced in early milling processes as a product of sorting tables. With the advent of flotation in 1916, a similar product was produced from the cleaner cells. In both instances, the material was recycled and, if necessary, re-ground to further concentrate the silver. Tailings were the remaining waste products after no additional silver could be economically extracted. This material was subdivided into a sand component, comprised primarily of a coarse-grained faction, and a slime component, comprised of the fine-grained fraction.

Little is known of the chemical content of the tailings from the early mills. Most companies only reported ounces of silver and other metals recovered, total tonnages processed and the percent of silver lost. The waste product, tailings, was disposed of in the cheapest and most convenient manner and forgotten. Any further details must be inferred from the milling processes.

Mercury, from the amalgamation of high grade ore and from the ore itself, escaped in small amounts to the tailings. Both the Buffalo and Nipissing high grade mill used the Thornhill process (Reid et al, 1924, p.311) after 1914 to recover pure arsenic-free mercury.

Cyanide is present in all the tailings from the Dominion Reduction, O'Brien, Buffalo, Cobalt Reduction and Nipissing mills. During the cyanidation process, the cyanide coats the silver grains allowing them to be filtered out from solution. Cyanide and silver losses to tails were high until the development of an aluminum precipitation and desulphurization processes in 1912. In 1916, precipitation by sodium sulphide was developed at the Nipissing mill to offset the high cost of aluminum due to the war needs. The tailings containing cyanide-coated silver are considered too difficult and expensive] to rework at current prices. The cyanide-silver grains would have to be ground extremely fine to release the particle of silver. Such fine slimes tend to gum up the recovery systems in the mills (L. Othmer, personal communication, Sept. 1984).

Arsenic is an ever present contaminant in all of the tailings due to the high arsenic content of the ore. In The Ontario Water Resources Commission Report, 1967, p. 36, suspended solids and arsenic were found to be the major pollutants. Other metals and pH at the time were within acceptable concentrations. Since virtually all arsenic is carried in an insoluble state, settling of the suspended solids within contained tailings ponds would alleviate any further watercourse pollution. Migration of the arsenic and tailings from contaminated to non-contaminated basins could be prevented by re-routing runoff around, instead of through tailings sites.

The amount of silver escaping into the tailings is due to several interrelated factors: the type of ore processed, the grade of silver in the heads, the particle size after grinding and the types of processes used. Fluctuations occurred in the daily mill output as ores of different grades and from different mines were processed. Early recoveries from low grade ore of approximately 70-85% were improved to 80-95% after the introduction of flotation in 1916 (Reid et al, 1924, p. 285). At this time many of the early tailings were reprocessed profitably and all subsequent high and low grade mill tailings were subjected to flotation treatment to increase recovery considerably. Modern milling techniques produce tailings that usually contain less than one ounce of silver per ton.

Since the introduction of the flotation process in 1916, tailings have been reprocessed in many of the area mills. Often these tailings were added in with low grade ore when more tonnage was needed to keep the mill running at capacity. Thus many of the early tailings sites have been reworked and redeposited somewhere else with scarce mention or no notation at all of the re-processing. The remaining tailings have become a complex assemblage of fine sands and slimes containing varying amounts of silver and other impurities depending on the ore and milling practises used. Several mills have often deposited into the same containment area. Many mills ran intermittently and, where there was a hiatus of several years, re-vegetation often occurred. These organic beds in the tailings created considerable difficulties when Sulpetro was reprocessing the Chambers-Ferland tailings in the early 1980's (L. Othmer, personal communication, 1984).

Tailings Mills

Occasionally mills have been built or redesigned especially for milling tailings. The earliest mill built specifically to re-treat tailings was the small mill on the McKinley-Darragh property. The mill was located at the top of the cliff at the south end of Cobalt lake. It opened in 1919 to process tailings from the course concentrating plant at the Savage property and tailings from the McKinley-Darragh mill which were stockpiled behind a coffer dam in Cobalt Lake. The Hellens mill, used by both A.D. Hellens (1951-1955) and Agnico Mines Ltd. (1964-1969), was designed specifically for reprocessing the tailings from Cobalt Lake. The Canadaka Mill, redesigned to process the tailings from the Chambers-Ferland property at the north end of Cobalt, recovered more silver from tailings than a standard ore mill. The modern mills have generally used a combination of gravity and flotation concentration, which combines efficiency of recovery with relatively non-polluting tailings and effluent. Chemicals commonly used to re-process tailings are:

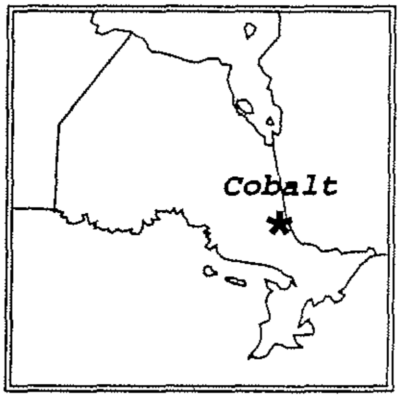
1. Xanthate containing Potassium Amyl was added to the collector at a rate of 0.15 lb/ton.

2. Aeroflot containing Phosphorous Pentasulphide was added to the promoter at a rate of 0.09 lb/ton.

3. Soda Ash was added for pH control at the rate of 1 lb/ton.

The tailings and effluent from a modern mill must now be properly contained according to guidelines and regulations to ensure that no contamination migrates to any clean environment. Tailings from the Penn and Canadaka mills averaged 0.75 ounces of silver per ton and 0.70 ounces of silver per ton respectively. They are virtually clean of any chemicals used in milling and contain only the heavy metals that were present in the original ore in quantities too small to be profitably concentrated. The heavy metals predominantly consist of arsenic, antimony, bismuth, silver, cobalt, copper, nickel, mercury, iron, lead and zinc. Appendix B details the elemental chemistry of the various Cobalt camp tailings sites as sampled in 1977 by J. Hawley, Ministry of the Environment (1980, p.179-185).

The effluent from the tailings mills was dumped into ponds to settle out the suspended solids and then was de-canted or re-used in the mill. Effluent from the mills and the water discharged from the settling ponds to the environment was regularly tested to insure purity. Both Canadaka and Penn mills had frequent beaver control problems in their tailings ponds.



TAILINGS DEPOSITS

Introduction

A thorough search of all the existing records was made along with consultation with many of the area's millmen in order to locate and describe all the mills and their tailings deposits. For each tailings site, details of the mill history as related to the resulting tailings are documented accompanied by a description of the tailings. Further details of the mills and tailings can be found in Appendices C to H. Appendix C details all known tonnages of ore and tailings milled, the ounces of silver per ton in mill heads and tails, and the recovery percentages which indicate how efficient the milling operation was. Appendix D and E are a compilation of the mill names, mill owners or leasers and the dates of operation. Appendix F lists all the tailings sites and the mills that the tailings came from. Appendix G documents all the reworked tailings. Appendix H details the results of grain size analysis experiments conducted on the inactive tailings sites in 1984.

Mill names often changed with new ownership. In the text every effort has been made to simplify the confusion by including the most commonly used name(s) in brackets. Appendix D is organized by mill name and Appendix E is organized by company name. The refineries located with the catchment basin will also be described even though they had little effect on the overall tailings chemistry. In all 28 mills and 6 refineries have operated in the Cobalt camp over an 80 year period from 1907 to 1989.

In the early 1960's, R. Thomson, a former Cobalt Resident Geologist, mapped the mining area surrounding Cobalt and compiled detailed information on the geology of each mine. The mining properties, mills and many of the tailings sites can be found on the 1"=400' scale (ODM, 1960, Preliminary Maps P-61 to P-67A; P-79 to P-83; 1961, P -95 to P-97) and 1"=1,000' scale maps (ODM, 1964, Map 2050, 2051, 2052). The accompanying preliminary reports (ODM, 1960, PR1960-1, PR1960-2, PR1960-3; 1961, PR1961-2, PR1961-3, PR1961-4, PR1961-6, PR1961-7; 1962, PR1962-2).

Tailings from many of the mills were deposited collectively in large catchment areas while other more isolated mills had their own tailings depository. Migration of tailings from one basin to another further amalgamated some of the tailings and generalized their chemical make-up. Appendix B, from J. Hawley (1980, p.179-185), details elemental assays resulting from the sampling of each known tailings deposit in the mid 1970's.

C. Dumaresq (1993) investigated the occurrence of arsenic and heavy metal contamination from natural and anthropogenic sources at several tailings sites in the study area. Excerpts from his Master of Science thesis are reproduced in Appendix K. For further details, the Cobalt Resident Geologist's Office has a copy of the complete thesis.

In order to understand the composition of the modern tailings, the presentation of mill data is organized by tailings catchment areas which in most cases follow the natural drainage basins. Included are 1:2000 scale maps showing the extent and surficial features of each site. Figure 3 outlines the limits of the Catchment Basins and the locations of the individual tailings sites.

The Cobalt Catchment Area historically had the largest accumulation of tailings from a number of mills. A substantial amount of these tailings migrated to the north end of the Crosswise Lake Catchment area as did tailings from Peterson Lake. A few mills on the lake added to the tailings burden. As well, tailings from Kirk Lake migrated to the south end of Crosswise Lake. The other catchment areas, Giroux Lake and North Cobalt, remained essentially isolated.

Cobalt Catchment Area

The Cobalt Catchment Area was both historically and numerically the largest and most active milling area in the Cobalt mining camp. For simplicity, the mills will be detailed by their tailings location in either of four natural drainage features:

> West Arm Deposits - the mills to the west in and near Cobalt whose tailings flowed either directly or via a flume to the Chambers-Ferland area north of town.
>
> Cobalt Lake - the mills on or near Cobalt Lake whose tailings flowed directly into the lake.

East Arm Deposits - the mills to the north and east of Cobalt whose tailings flowed into Mill Creek.

Chambers-Ferland Tailings - where most of the Cobalt Catchment Area tailings migrate to and mix before being washed downstream to the Crosswise Lake tailings.

Natural drainage through Cobalt is northerly from Brief Lake to Short Lake into Cobalt Lake. At the north end, Cobalt Lake flows into Mill Creek which runs along the railroad tracks and into the swampy area of the Chamber-Ferland tailings to join Sasaginaga Creek. Mill Creek then flows easterly into the Crosswise Lake tailings. Cobalt Lake is ringed by hills. Tailings which have been deposited in low spots on the hills have, where drainage routes allowed, migrated via ditches and small creeks into Cobalt Lake or Sasaginaga Creek.

West Arm Deposits

Buffalo Tailings

The Buffalo tailings (Figure 4) were originally deposited within a long, narrow valley extending northeasterly from the Buffalo Mining Company's two mills and subsequently migrated north, to the present location of Prospect Street near the Coniagas open pit. Because flat land is at a premium in Cobalt, this tailings site was first put to recreational use and is presently occupied by the Cobalt Municipal Trailer Park, situated north of the Buffalo Mill. At present, the only exposed tailings occur as a thin layer in the immediate vicinity of the old mill and in small patches along the valley sides. A local resident has undertaken his own reclamation project and has planted the tailings with a variety of indigenous trees. The site was cleaned to conform to government mine closure regulations in 1992.

Buffalo Mill

The Buffalo Mill was located on the Buffalo Mines Limited property in the SW¼ of the S½ of Lot 6, Con. VI, Coleman Tp. about 1000' west of the No. 6 shaft and about 300' from the south end of Pyrite St (Figure 4). The ore was hoisted from the No. 6 shaft (OBM, 1912, p. 118), concentrated and later also refined on site.

The Buffalo Low Grade Mill was the second concentrator to be built in Cobalt. It first started operations in September, 1907. Between 1908 and 1919, the mill underwent a number of modifications which increased both capacity and recoveries. A cyanide plant, added in 1909 (Corkhill, 1913, p. 95) to treat all the tailings and middlings from the gravity concentrator mill, improved overall recoveries by 3% to 7%. With the addition of the high grade mill or refinery in November, 1912, all the product of the Buffalo mine was reduced to bullion (Miller, W.G., 1913, p.36). Included in this upgrading of the facility was a Dorr thickener, additional slime tables and a cyanide plant fully equipped with agitating tanks and precipitating boxes for retreating all the tailings from the slimes tables. It required about 45 tons of mill rock to produce 1 ton of concentrate during that period (OBM 1912, p.118).

Data from 1914 indicates that the low grade mill treated 71,042 tons, the cyanide plant treated 11,744 tons and the high grade mill treated 1,116 tons of ore and concentrate. From this 1,668,763 oz - over 52 tons - of silver bullion was poured into bars (OBM, 1914, p.132). Figure A-1 illustrates how the Buffalo Mill was different from all the other Cobalt mills by 1914.

In 1915, experiments that recovered silver from tailings using the Callow process proved successful. Work was carried out in the 50 ton oil flotation plant which was designed at the Buffalo mill specifically to treat Cobalt area ores. Conversion of the mechanical concentrator to a 600 ton per day flotation plant began immediately (OBM, 1916, p.105). This process, in effect, treated the relatively enriched sand and slime tailings from the gravity concentrator before releasing the final waste product and resulted in a dramatic improvement in recoveries. As a follow-up, middlings at this stage were again re-cycled through a cyanide plant and through flotation cells for a second time to further enhance recoveries. The high grade concentrates from the various methods were processed into bullion in the refinery of the Buffalo High Grade Mill (OBM, 1917b, p.110). In 1917, a project to install a Holt Dern furnace to roast the concentrates was abandoned. The high grade mill section was closed and all subsequent concentrates were shipped to Denver (OBM, 1918, p.116). The mill ran for a further two years (OBM 1919b, p.133, OBM, 1920, p.91) before closure.

The Mining Corporation of Canada Limited acquired controlling interest in Buffalo Mines in 1920. The Buffalo mill was leased to the Cobalt Reduction Limited mill, a wholly owned subsidiary of Mining Corp. (OBM, 1920, p.91). For the next 2 years, both mills were utilized at various stages of concentration and refining to produce the most efficient product. In 1921, tailings from Cobalt Lake were mined and de-slimed in the Cobalt Reduction plant classifier. The finer fraction was cyanided with Buffalo middlings at the Cobalt Reduction plant. The coarser sand fraction was crushed in the tube mill and concentrated by oil flotation at the Buffalo and then shipped back to Cobalt Reduction's high grade mill.

Coniagas Mines also leased the Buffalo cyanide plant during this time and used it to retreat the slime component of their tailings during 1920 and 1921. Coniagas had segregated the coarse and fine fractions of their tailings into separate containment areas, in order to facilitate future reclamation (ODM, 1922b, p. 109, ODM 1923a, p.49).

In 1923, the Buffalo Mill was closed and the flotation equipment was moved to the Cobalt Reduction Mill in order to streamline the recovery process being used on Cobalt Lake tailings. (ODM, 1925c, p.68). In 1935, the mill was cleaned up by Mosher, Richardson and Lafrange. Approximately 46 tons of residue and precipitate rich in silver were recovered and processed (ODM, 1937, p.184).

Notes by R. Thomson dated September 25, 1956 (Coniagas Mines Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines) indicated that during the 1950's, the Buffalo cyanide plant was rented by T. Cawley for a three-year period to re-treat the remaining slimes from the Coniagas tailings. There were many difficulties in both the mining and processing of these cyanided tailings because they had been ground so fine (probably to about -400 mesh). When damp or wet, they became a gooey mass which broke mining equipment and clogged the mill. It is not known where the resultant tailings were deposited or what volume of tailings was extracted.

Little of the Buffalo tailings remain today. They were originally deposited within a long, narrow valley extending northeasterly from the Buffalo Mining Company's two mills and subsequently migrated north, to the present location of Prospect Street near the Coniagas open pit. The tailings were mined-out and re-treated once during World War I and probably re-deposited at the same site. Following

World War II, some of the slime from the Coniagas Tailings was mined and processed at the Buffalo Mill (Thomson, 1956, Coniagas Mines Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The resultant tailings were most likely added to the existing Buffalo tailings.

Because flat land is at a premium in Cobalt, this tailings site was soon put to recreational use. The tailings were first levelled and covered with 6" of gravel and 6" of loam (J. Hawley, Ministry of Environment, personal communication, 1986) for use as a baseball park as early as 1932 (D. Larabie, personal communication, 1986) and later a housing development (Ministry of Revenue, Regional Assessment Office, Timmins, personal communication, 1970). Much of the valley is presently occupied by the Cobalt Municipal Trailer Park, situated north of the Buffalo Mill. Some of the remaining exposed tailings were used by the Cobalt Public Works Office as the sand component for concrete used to lay Cobalt's sidewalks several years ago (J. Fildes, personal communication, 1985).

At present the only exposed tailings occur as a thin layer in the immediate vicinity of the old mill and in small patches along the valley sides. A local resident has undertaken his own reclamation project and has planted the tailings with a variety of indigenous trees. The site was cleaned to conform to government mine closure regulations in 1992.

Coniagas Tailings

Silver was discovered in 1904 by W.G. Trethewey on claims JB6 and JB7. In 1906, Trethewey sold claim JB6 in the NE ¼ of the S½ of Lot 7, Con. VI, Coleman Tp. to The Coniagas Mines Limited. The property was one of the most productive and profitable in the camp. It operated continuously until 1924 when the mine closed after a disastrous fire destroyed most of the buildings on the property.

Coniagas Mines did not practice good tailings or mine rock management from an environmental or human aspect. Their mine muck encroached on and destroyed residential and commercial buildings (Cobalt Mining Museum photos) while the tailings initially were released from the mill and allowed to flow unchecked downhill towards residential buildings (Figure 5). Later tailings practise, based more on economic considerations rather than any concern for the environment, saw the tailings divided into a coarse sand component and a slime fraction for future re-treatment. As these tailings were re-treated, the resulting tailings were transported by flume to the Chambers-Ferland area.

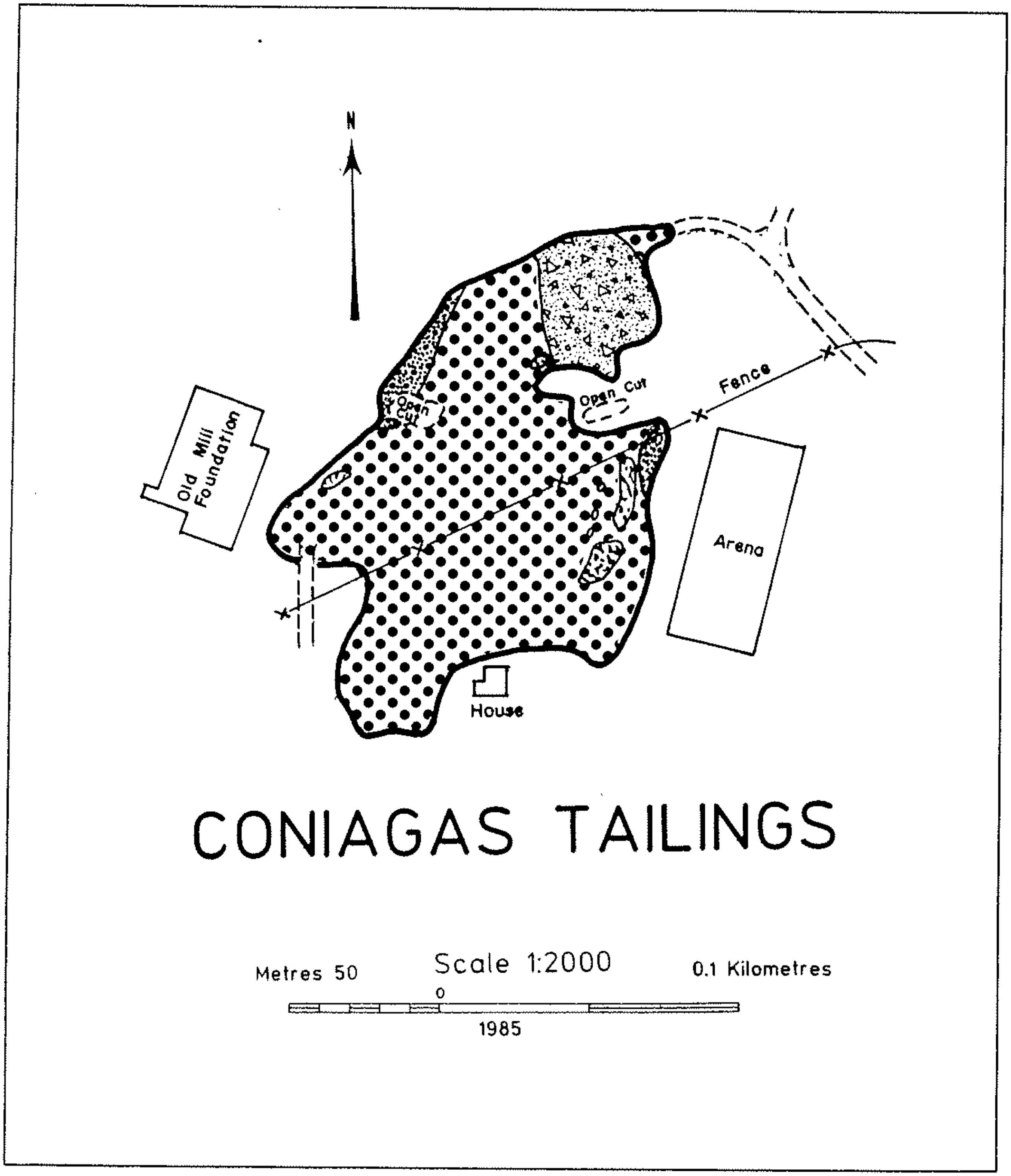


Figure 10: Coniagas Tailings

Coniagas Mill

The mill, located on the hill above the present Cobalt-Coleman Arena, began operation on September 24, 1907. Water was piped from a containment area behind the rock dam that was built across the east arm of Sasaginaga Lake.(J. Armstrong, Cobalt, personal communication, 1984).

The original crusher, rolls, Huntingdon mill and Krupp ball mill used at this time proved to be too light-weight to handle the local ores. The coarseness of the mill feed resulted in an additional loss of about 3% on recovery rates. Following a convincing demonstration of the efficiency of 1,250 pound stamps at the McKinley-Darragh mill, 30 similar stamps were installed in the Coniagas mill in 1908 (Murphy, 1977, p.110, Reid et al, 1924, p. 269). The initial processing rates were also low because the inefficient gas engines could not supply enough power, but the rates rapidly increased to 160 tons/day after the introduction of electricity (The Coniagas Mines Limited, 1909 Annual Report, 1910, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

Gravity concentration was successfully used from 1907 to 1915. Cyanidation of tailings was tested in 1910, but, the tailings contained insufficient silver values to warrant further treatment at this time (The Coniagas Mines Limited, 1910 Annual Report, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). In 1911, further modifications and additions to the mill increased the capacity to 180 tons per day, making the mill the second largest in the camp (The Coniagas Mines Limited, 1911 Annual Report, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). A comparison of the milling processes used at the Coniagas mill and other area mills operating in 1914 are illustrated in Figure A-1.

In 1915, a small cyanide plant was installed to treat the primary slime (fine-grained tailings from the gravity concentration process) originating from milling the oxidized vein ore from the mine (The Coniagas Mines Limited, Annual Report,1915, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). It operated for several years until the veins were mined-out and the grade of the primary slimes was too low to be treated profitably (Reid et al, 1924, p.270).

Early tailings were allowed to migrate down the hill immediately east of the mill, towards the present site of the Cobalt-Coleman Arena (Figure 5). They were constantly encroaching on the company housing. By 1915, the tailings were being divided into a coarse sand fraction, which was deposited in the original containment area, and fine-grained slimes, which were deposited in a depression now housing the Cobalt Public School. It was realized, even at this early date, that the different types of tailings would have to be treated differently to derive the greatest silver recoveries in any future treatment plans. The company estimated reserves of 177,000 tons of coarse sand tailings, averaging 3.5 oz. of silver per ton and 40,000 tons of slimes, averaging 6.0 oz. of silver per ton. Total in-place silver was estimated at 895,500 ounces (The Coniagas Mines Limited, Annual Report, 1917, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

In 1917, a Callow flotation plant was added to the mill circuit to treat sand and slime tailings before discharge to the tailings area (Figure A-2). This further reduced the amount of silver lost in the milling process. From 1917 to 1921, 124,129 tons of coarse sand tailings were re-processed at the mill using the Callow flotation process (The Coniagas Mines Limited, Annual Report, 1922, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The tailings produced during this period were sluiced to Sasaginaga Creek on the Chambers-Ferland property, using the main flume from Cobalt. Spills occurred with regularity along the flume line, due to accidental and deliberate blockage of the line (Cobalt Town Council Minutes, September 9, 1920). In 1983 and 1984, remnants of the flume were discover by Canadaka employees while mining in the Chambers-Ferland tailings (L. Othmer, personal communication, 1984).

In 1920 and 1921, the Buffalo cyanide plant was leased by Coniagas Mines to treat a total of 21,341 tons of slimes mined from their own tailings. A recovery rate of 83.87% was maintained and tailings produced after this treatment averaged only 1.0 ounces of silver per ton. This material was added to the Buffalo containment area (ODM, 1922b, p.109, 1923a, p.49). At this time, 52,871 tons of coarse sand tailings, averaging 3.5 ounces of silver per ton and 18,629 tons of slimes averaging 6.0 ounces of silver per ton remained in the Coniagas tailings.

In 1924, a fire destroyed the concentrator mill, flotation plant, No. 2 hoist room, shaft house and transformer building (The Coniagas Mines Limited, Annual Report, 1924, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The mine continued to operate but because of the high rebuilding costs, the ore was shipped to the Beaver mill for processing (ODM, 1926a, p.12). Figure A-3 shows the 1923 flow-sheet for the mill and Appendix C details the known milling statistics.

In 1926, a final clean-up of the mill floor and sump was completed by the Nipissing Mining Company. The material from this operation was processed at the Nipissing Low Grade mill (The Coniagas Mines Limited, Annual Report, 1926, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

Notes by R. Thomson dated September 25, 1956 (Coniagas Mines Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines) indicated that during the 1950's, the Buffalo cyanide plant was rented by T. Cawley for a three-year period to re-treat the remaining slimes from the Coniagas tailings. Mining of the fine-grained slimes, that probably had been crushed to -400 mesh, took place over a period of three summers. Many difficulties were encountered particularly with the hardness of the slimes when dry and their stickiness when wet. A scraper bucket was used to extract the tailings but was not particularly effective because of a tendency to stick and then break upon sudden release. In addition, the slimes adhered to the bucket which had to be washed after each load. Once in the mill, the fine-grained gooey mass clogged the circuits. There is no record describing the quantity of tailings removed or amount of silver recovered. The remaining slimes, if any, have since been levelled and covered and are now the site of the Cobalt Public School.

In 1960, an individual by the name of Bromley, from Porcupine, expressed an interest in re-mining the remaining sand tailings. Fraser Reid, the owner at the time, offered to sell them for $10,000. Bromley sampled the site using an auger with holes spaced on 25 foot centres. He found the average grade of tailings to be 5.0 ounces of silver per ton, which he considered to be too low too mine profitably at this time (The Coniagas Mines Limited, R. Thomson's notes, 1960, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

In 1974, the Ontario Ministry of Natural Resources re-sampled the tailings prior to accepting bids to the surface and mining rights for JB6 and JB7. Mr. Ralph L. Paul, Inspector of Mining Lands at the time, estimated that 31,500 tons of tailings, averaging 3.7 ounces of silver per ton were in place (Resident Geologist's Files, letter, Ministry of Northern Development and Mines, 1974). The Canadaka Division of St. Joseph's Exploration were eventually awarded the surface and mining rights and in 1977, the company mined 24,780 tons of tailings down to a base layer of fine-grained tails and clay. The tailings were trucked to the Canadaka mill where they were processed (L. Othmer,personal communication, 1984).

Since 1977, the site has remained relatively undisturbed. Possibly because of the steep slope on the tailings site, revegetation is sparse. Deep gulleys carry run-off water and tailings downhill and during a heavy rain, the tailings migrate into the arena parking lot.

Trethewey Tailings

Silver was discovered on claim JB7 on the SE¼ of the N½ of Lot 6, Con. VII, Coleman Tp. in 1904 by W.G. Trethewey who donated the first 9 pounds of ore from his original discovery vein to Willet G. Miller, Provincial Geologist. From 1906 to 1920, the Trethewey Silver Cobalt Mining Company Limited operated this property.

Tailings management on the Trethewey property served as an early example of good planning. Tailings were contained in a valley at the base of the mill by an earth dam built at the valley mouth on the shores of Sasaginaga Lake (Figure 6). However, despite these efforts, some tailings still managed to overflow into the lake (J. Armstrong, personal communication, 1984). Three additional small dams were constructed at the north of the compound and prevented most of the tailings from spilling into the adjacent Hudson Bay tailings area and Sasaginaga Creek (L. Othmer, personal communication, 1985). The largest of the three is now breached and a minimal amount of migration to the Hudson Bay tailings has taken place. The dam may have been breached in 1975 when the Canadaka Division of St. Joseph's Exploration mined much of the tailings. The two smaller dams have since disappeared but a road crossing the tailings restricts the flow and acts as a dam. The main earthen dam, built to prevent contamination of Sasaginaga Lake, remains in place.

Trethewey Mill

A 30 stamp concentrating mill was originally erected in 1910 on the west side of the hill, midway between shafts 1 and 4 (OBM, 1910, p.113) (Figure 6). An earth and rock dam was built at the narrows of the east arm of Sasaginaga Lake. The dam raised the water level to provide water for the mill. It has now been breached in many places and at high water times is under water. The mill used a simple gravity concentration process, similar to that used at the neighbouring Hudson Bay Mill. A flow chart (Figure A-1) illustrating the mill operations as compared to other local mills operating by 1914 is included in Appendix A. No major changes were made to the mill during its operating life. Processing was intermittent during 1915 and 1916 because of low silver prices. Minor modifications during this period led to improved silver recoveries when the mill renewed continuous operations in 1917 (J. Armstrong, personal communication, 1984). Figure A-2 in Appendix A shows the flow-chart for 1917.

In 1916, the tailings were sampled and reserves of 65,000 tons, averaging 4.7 ounces of silver per ton were identified (OBM, 1917b, p.127). By 1918, machinery was installed to process these tailings and recoveries of 3.6 ounces of silver per ton were expected (OBM, 1919b, p.149). A total of 29,416 tons of the tailings were mined by 1919 but no record exists detailing the actual amount of silver recovered (ODM, 1920, p.106).

In 1920, the property was sold to Coniagas Mines Limited and the Trethewey Mill was closed. Appendix C details the known production for this mill. It was estimated at this time that a total of 37,000 tons of tailings still remained in place (ODM, 1922b, p.109).

During the life of the mill, concentration values averaged about 70:1 (Cole, 1911, p.102, 1913, p.55, 1914, p.44, 1916, p.47, 1917, p.19); that is it took 70 tons of ore to produce 1 ton of concentrate. Combining this ratio with production figures suggests that 230,000 tons of tailings should have been produced. However, only 65,000 tons were reported released to the holding area near the mill. It is possible that the missing tailings were sluiced downhill, along Sasaginaga Creek to the Chambers-Ferland property.

The Trethewey property changed hands a number of times between 1920 and 1950. It was leased to J.W. Shaw in 1928, sold to Cobalt Properties in 1932, leased to A. Murphy, A. Landry and R. Mercier from 1937 to 1943 and purchased by Sanymac Mining and Developing Company in 1943. No use was made of the mill during this period and no record was found describing when the mill structure was demolished (R. Thomson's notes, The Trethewey Silver Cobalt Mines Ltd., unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

In 1953, E.B. DeCamp became interested in the tailings after he took a number of random samples (R. Thomson's notes, The Trethewey Silver Cobalt Mines Ltd., unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Grab sampling from one to two foot deep surface pits yielded an average of 3.5 ounces of silver per ton and 0.35% cobalt. No record of any follow-up work exists.

By 1974, both Coniagas and Trethewey properties had reverted back to the Crown. The government chose to retain ownership and lease the surface tailings and dumps and underground workings for clean-up. The Coniagas tailings were extensively sampled but there is no record of a study on the Trethewey tailings. In 1977, 24,780 tons of tailings were removed by St. Joseph's Exploration's Canadaka Mining Division and processed at the Canadaka Mill (L. Othmer, personal communication, 1985). All of the tailings were not removed. It was feared that Sasaginaga Lake might break through the dam into the valley, lower the water level and ultimately threaten the town's drinking water supply (Milt Halstead, Geological Consultant, Cobalt, personal communication, 1985).

A two metre high ridge of tailings now separates the U-shaped valley from the edge of the lake. The remaining tailings form a thin veneer along the sides of the 300 m by 50 m wide valley and also occur adjacent to the old mill foundations. At the north end of the valley, a remnant of a four metre high wooden containment dam still remains. Some tailings have spilled over this structure and migrated across the Hudson Bay property to Sasaginaga Creek. The surrounding woods have since encroached on the undisturbed tailings and, by 1985, weeds were making a comeback on the recently mined sections.

Hudson Bay Tailings

The Hudson Bay's tailings were deposited directly into Sasaginaga Creek, which drains the eastern arm of Sasaginaga Lake (Figure 7). Because of the modest relief and lack of concern for the environment, containment was not practised. The mixing of tailings and tailings migration to other sites commonly occurred. Tailings and effluent were deposited directly from the base of the mill into the stream valley and subsequently re-deposited at the base of the hill in the Chambers-Ferland area. A semi-continuous deposit of tailings still remains along this migration path and represents the only Hudson Bay tailings remaining on the property.

Hudson Bay Mill

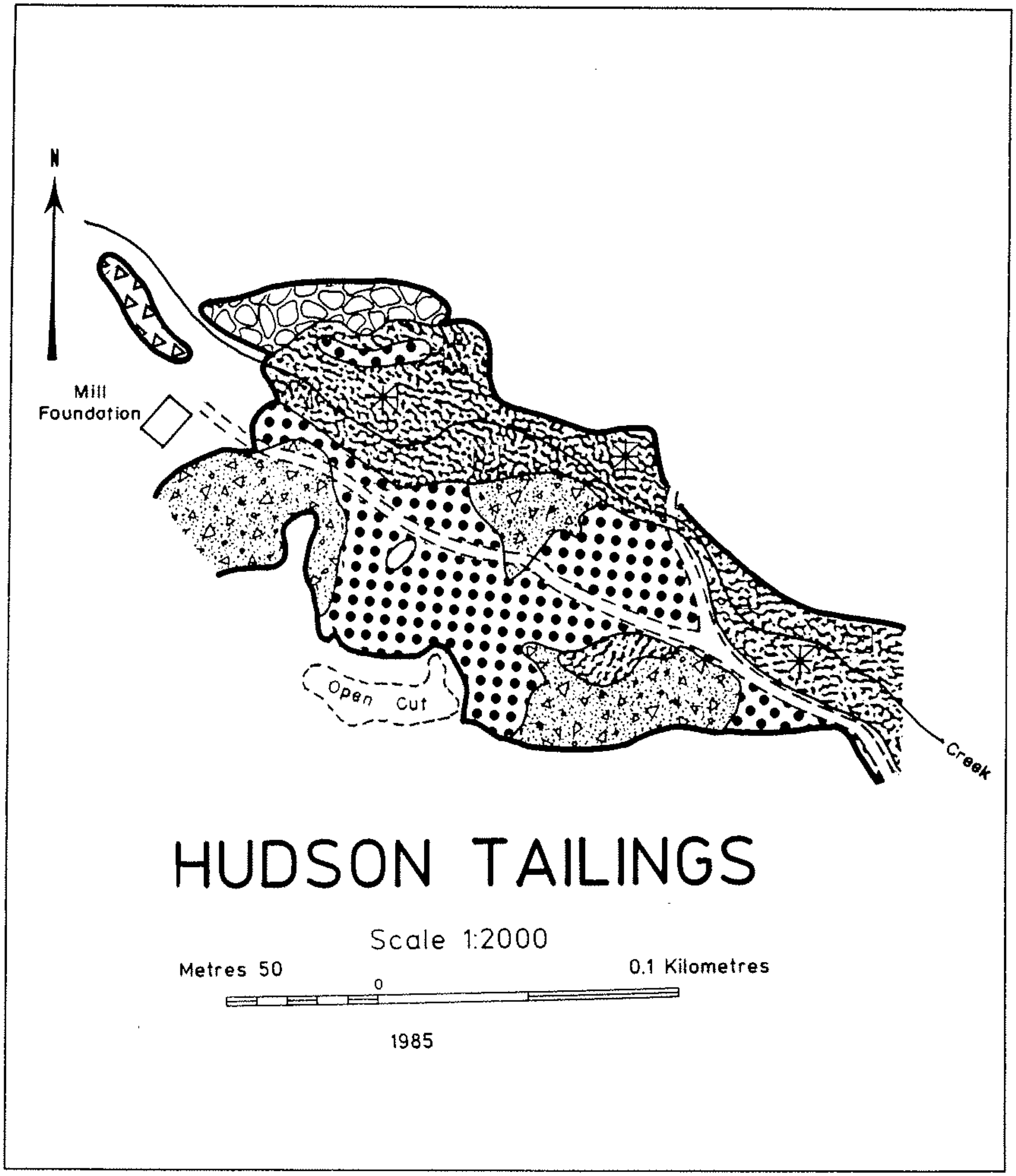


Figure 7: Hudson Bay Tailings

The Hudson Bay Mill was built in 1910, on the north side of a hill between the two shafts of The Hudson Bay Mines Limited property. This mill is located on the N½ of the N½ of Lot 7, Con. VI, Coleman Tp. (Figure 7). The mill processed ore at a relatively uniform rate of 60 to 70 tons per day until 1920 when the mine and mill were closed (ODM, 1920, p.112). Twenty stamps crushed the ore to 20 mesh (OBM, 1912, p.127) and the material was then concentrated using a wet gravity process similar to that used at the Coniagas and Trethewey mills (Figure A-1 and A-2). No major changes were made to the circuits and flotation equipment was never installed.

The tailings, which contained an average of 2 to 3 ounces of silver per ton, were pumped over an area of approximately 240 m by 110 m at the base of the mill and allowed to migrate downstream.

In 1948, 1300 tons of tailings and dump rock were removed and processed at the Silver Cliff by Ausic Mining and Reduction Company Limited (ODM, 1950, P.94). The primary minerals recovered consisted of iron and pyrite. Only very low values of silver were encountered and the operation was subsequently discontinued (M. Halstead, Geological Consultant, Cobalt pers. com., 1985).

In 1972, additional dump rock was removed and used during construction of the Cobalt Public Works Garage (J. Fildes, personal communication, 1985).

Over the years, mine waste rock was also dumped over parts of the tailings. Auger testing along Sasaginaga Creek, during this study, revealed only remnant patches of tailings. Grass and brush have since encroached on the remaining tailings.

Cobalt Lake Tailings

Several mills deposited tailings directly into Cobalt Lake (Figures 8 and 9). Beginning in 1907, the roar of the stamps in the mills could be heard in increasing numbers along the lake shore from the two McKinley-Darragh mills, the Cobalt Lake Mill, the Muggley Concentrator, the Ore Reduction Concentrator and the Nipissing Mills. In later years, only the LaRose Mill and the Hellens Mill were active. The lake has been pumped out three times to accommodate mining of the tailings.

Cobalt Lake is drained at the north end by Mill Creek, which joins Sasaginaga Creek in the eastern portion of the Chambers-Ferland Tailings. Mill Creek continues from a point west of Highway 11b and eventually flows into Crosswise Lake Tailings. Migration of tailings along this route is common.

Appendices B and K contain information about the Cobalt Lake tailings and water quality.

McKinley-Darragh Mill

J.H. McKinley and Ernest Darragh filed the first mining claim that marked the beginning of Cobalt's silver mining history. They, along with a new partner, formed McKinley-Darragh-Savage Mines of Cobalt Limited. The company operated two separate mining properties and three mills in the Cobalt camp. Both the large concentrator and the tailings mill were located on the McKinley-Darragh mine site on the S½ of the N½, Lot 6, Con. V, Coleman Township.

The McKinley-Darragh Concentrator, erected in 1907 at the southeast end of Cobalt Lake, was the one of the first mills built in the Cobalt Camp. It started as a five-stamp operation, handling 15 tons of ore per day (Reid et al, 1924, p.263) and expanded rapidly over the next few years.

In 1907, five specially made 1250 lb. Nissan stamps were installed in this mill. Local mill managers watched as the extra heavy stamps ground the tough Cobalt area ores to the fine powder needed for optimum silver recovery. The experiment was a success and every mill in the area subsequently equipped themselves with 1250 and even 1650 lb. stamps (Murphy, 1977, p.110).

By the end of 1909, mill capacity had increased to thirty stamps. The gravity concentrating circuit had been modified and improved. The 1909 McKinley-Darragh-Savage Annual Report (1910, Unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines) contains excellent sections, pictures and flow charts for the mill. Electricity, installed in April, 1910, increased productivity to 120 tons per day (McKinley-Darragh-Savage 1910 Annual Report, 1911, p.22, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

By 1913, the mill had expanded to fifty stamps, to crush up to 225 tons of ore per day (OBM, 1914, p.129). When the aerial tramway was completed from the Savage property at the southern end of Cart Lake, the Savage Mill was closed (OBM, 1913b, p.118). The Savage ore was subsequently milled at the McKinley-Darragh concentrator. Figure A-1 compares the McKinley-Darragh to the other area mills in 1914. Compared to many of the local mills, this mill had a relatively poor recovery rate and lost 3.5 to 4.8 ounces of silver per ton to tailings in 1914.

In 1916, flotation cells were added to treat all the mill slimes before being released into the lake (OBM, 1917a, p.14, 1917b, p.120). This improved recoveries so that only 1.9 ounces of silver per ton was lost to tailings. Figure A-2 compares the mill operations to the other remaining mills in 1917. The mill continued to operate until 1921, when it was closed because of low silver prices (ODM, 1920, p.98; ODM, 1922b, p.114). It re-opened in 1922, and continued to operate until 1927. Figure A-4 details the mill flow sheet for 1923. A year later, in 1928, it burned to the ground (ODM, 1929, p.171) and only the mill foundation remains today.

Since flotation proved to be an effective method of recovering silver from tailings, McKinley-Darragh built the first mill in Cobalt to specifically re-treat tailings in 1917 (OBM, 1917b, p.120; 1919b, p.140). Rich sand tailings stockpiled at the Savage mine site and behind a coffer dam in Cobalt Lake were mined and processed from the summer of 1918 to the end of 1920. At that time, falling silver prices forced the closure of the mill and mines (OBM, 1920, p.98; OBM, 1922b, p.114). Much of the tailings from behind the coffer dam remained in place. In 1922, the tailings mill was re-started on a trial basis but the company decided that it should remain closed (1922 McKinley-Darragh-Savage Annual Report, 1923. p.4, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). New tailings produced from these operations were re-deposited into Cobalt Lake.

Most of the McKinley-Darragh tailings were deposited into Cobalt Lake. A small amount of tailings cover the ground in and around the base of the mill. These are probably the result of spills.

Cobalt Reduction (Northern Customs Concentrator, Muggley Concentrator)

The Muggley Concentrators Limited Mill was built by the City of Cobalt Mining Company Ltd. in 1907 on the west side of Cobalt Lake at the south end of the Town of Cobalt. The mill ran fairly continuously until 1932 even though ownership changed frequently. The tailings were deposited directly into Cobalt Lake without impoundment.

Initially, the mill had a capacity of twenty stamps and recovered silver using pan amalgamation and cyanidation (Corkill, 1908, p.97). In 1908, it was sold to Northern Customs Concentrators Limited. The mill continued to treat the low grade ores from the LaRose, City of Cobalt, Silver Queen, Townsite, Nova Scotia and Drummond Mines on a custom basis until 1912 (OBM, 1910, p.96, 103, 106; 1912, p.115, 118, 121-122, 131, 145). As mine production increased during these years, the mill capacity was also increased, until the mill became the largest in the camp, processing over 350 tons of ore per day using 120 stamps (OBM, 1912, p.145).

In 1912-1913, Northern Custom Concentrators Limited built a new mill, utilizing the same name, in the Mile 104 community. In 1913, their original mill was sold to the Cobalt Townsite Mining Company Limited, on whose property it was originally built (OBM, 1914, p.136). The mill again changed hands in 1914, when the Mining Corporation of Canada Limited purchased it. They created a wholly owned subsidiary, the Cobalt Reduction Company Limited, to operate it (OBM, 1915, p.118).

Extensive alterations were made to the mill immediately including the addition of a cyanide annex which opened in April, 1915 to treat slimes from all the company mills including the Cobalt Lake Mill and later the Buffalo Mill (OBM, 1915, p.117-118). Silver losses to tailings were subsequently reduced to approximately 3.5

ounces per ton (OBM, 1916, p.107). In 1916, a new high grade mill was built on this same site to produce bullion from the concentrates produced in the low grade mill.

All the tailings were pumped into Cobalt Lake, at its southwest extremity. Since 1907, approximately 329,000 tons of tailings had been deposited in this area (The Mining Corporation of Canada Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines, 1916). These tailings were first mined and processed in 1919 by the Cobalt Reduction Company Limited. Part of the lake was dammed and the water drained. Because of the size of the deposit, the company also leased the Buffalo Mill at this time to process some of the material. Tailings were first taken to the Cobalt Reduction Mill where they were de-slimed in a classifier. The slimes were cyanided on site in the cyanide annex. The coarse-grained sand fraction was transferred to the Buffalo Mill where it was crushed and treated by flotation (ODM, 1920, p.99). Recovery of approximately 80% of the silver was attained. New tailings, returned to Cobalt Lake and the Buffalo tailings, averaged 0.8 ounces of silver per ton (ODM, 1920, p.99). The operation continued until 1920 when low silver prices forced closure.

In 1922, the flotation equipment used at the Buffalo Mill was moved to the Cobalt Reduction Mill. The tailings processing operation resumed and continued until 1930 at this site. From 1930 to 1932, only sporadic production took place. In 1932, blasting at the Cobalt Lake Mine opened up a hole beneath the lake which allowed the tailings to flood the workings. The mill closed at this time because of falling silver prices (ODM, 1933, p.106). There is no record of any subsequent concentration.

In 1934, the company and mill was sold to Cobalt Properties Limited (ODM, 1936, p.142) who, in turn, sold it to Silanco Mining and Refining Company Limited in 1946 (ODM, 1949a, p.108). Only the mill foundation remains today. It was mostly buried in 1990 by rock debris from water and sewer reconstruction in Cobalt.

Cobalt Lake Mill

The Cobalt Lake Mill was built in 1911 by the Cobalt Lake Mining Company. It milled ore from the company mine located under Cobalt Lake. The mill was located on the southeast shore of the lake near Cobalt Lake Mine Shaft #6, on Claim RL 404, Coleman Township (OBM, 1912, p.115, 120), on the present site of the Hellens Tailings Mill foundations. The tailings were deposited into a small bay on the north side of the mill.

The mill used a gravity concentration process similar to that used in other area mills at the time (Figure A-1). Initially, 20 stamps processed 75 tons of ore per day (OBM, 1913b, p.109). In 1913, the capacity was doubled (OBM, 1914, p.129). In 1914, The Mining Corporation of Canada Limited acquired the mill in addition to other local mining properties (OBM, 1917b, p.118).

Between 1911 and 1916, approximately 115,919 tons of ore were processed at the Cobalt Lake Mill (Appendix C). In 1911, the coarse-grained sand fraction of the tailings averaged 4.0 - 4.5 ounces of silver per ton and the fine-grained slimes 8.0 - 10.0 ounces of silver per ton (Cobalt Lake Mining Company Limited, Fifth Annual Report, 1911, p.11, 14, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Improvements at the Cobalt Reduction Mill across the lake made the Cobalt Lake Mill redundant. The mill closed on June 11, 1916 and all the Cobalt Lake Mine ore was processed at the Cobalt Reduction Mill.

The Cobalt Lake Mill tailings were deposited in the small bay at the southeast end of the lake. In 1932, a miscalculation in the bedrock thickness remaining between the mine workings and the lake bed overhead resulted in the mine being flooded after routine blasting in a stope. Saturated tailings from the bay area flowed into the workings and permanently closed the mine. Most of these tailings would have been from the company's own mill.

Hellens Mill

The Hellens Mill was built in 1951 by Hellens Mining and Reduction Company Limited on the former site of the Cobalt Lake Mill and utilized some of the original mill foundations. The mill was built specifically to re-treat tailings from Cobalt Lake and some of the other richer tailings dumps. Tailings from this operation were re-deposited into Cobalt Lake and also into the south end of Peterson Lake.

By the 1940's, tailings from the Cobalt Lake Mill, Cobalt Reduction Mill and the two McKinley-Darragh Mills virtually filled the south end of Cobalt Lake. They were easily seen through the shallow water covering them. In 1946, the Hellens Mining Company Limited sampled the tailings. Reserves of approximately one million tons, with an average grade of 3.6 ounces of silver per ton were identified (Agnico-Eagle Mines Limited, company files). Initial mining plans were designed to drain the south end of the lake. The tailings could then be mined using a Sauerman dragline and conveyor system, designed to handle 30 tons per hour over a 700' haulage distance (The Northern Miner Press, June 21, 1951).

These results encouraged the company to build the new mill dedicated to tailings processing, in 1951. Milling equipment included a 48' x 8' Hardinge ball mill, an Aikens classifier, bowl thickener, agitators and filters with clarifier and precipitating presses. Because of their fine-grained nature, the tailings were also cyanided for optimum recovery. A furnace was housed in an adjacent building to pour bullion from the resulting concentrates (ODM, 1953b, p.100). Initial construction and equipment cost $350,000 (The Northern Miner Press, October 18, 1951). A new ball mill was added in 1952 to increase the potential to 700 tons per day.

While the lake was being prepared for mining, tailings from the Temiskaming Mill (Cobalt Properties Limited, Silanco) were processed at a rate of 300 tons per day in 1952. These tailings were too coarse for the designed system. They required initial grinding in the ball mills to reduce the grain size to 28% -200 mesh to optimize silver recovery by cyanidation (The Northern Miner Press, March 27, 1952).

Draining Cobalt Lake began in August, 1951 and continued until several of the shafts surrounding the lake were also dewatered. This extensive pumping was undertaken to provide access along the Cobalt Lake Fault for future cobalt exploration. Mining of these tailings finally started in 1952, but, problems were almost immediately encountered with the mining methods. The Sauerman scraper proved ineffective, especially where the line passed under the water. To resolve the problem, the company loaded and trucked tailings from the lake bed (Hellens Mining and Reduction Company Limited, 1952, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines; The Northern Miner Press, July 14, 1952). Additional problems were encountered with the fine-grained slime fraction of the tailings. They became extremely adhesive when wet and tended to ball-up into large difficult-to-handle masses when frozen (The Northern Miner Press, October 30, 1952). The colloidal nature of these slimes also retarded settling in the mill. Extensive flocculation experiments proved unsuccessful. New cyclone units had to be installed in December, 1952 to solve the problem (The Northern Miner Press, January 1, 1953).

At first, the new tailings from this mill were deposited in the north end of Cobalt Lake. However, the high cyanide content resulted in many complaints of wildlife poisoning downstream. The company was forced to pump the tailings over to the Cart Lake tailings containment area (J. Armstrong, personal communication, 1984). This only served to avoid the immediate contamination problem, since these tailings drained into Mill Creek via an alternate route (Brian Mason, Ministry of the Environment, North Bay, personal communication, 1985).

The mill operated very profitably at a rate of 600 tons per day (The Northern Miner Press, January 15, 1953). In 1953, it was bought by Cobalt Consolidated Mining Corporation (ODM, 1956, p.128) who also owned the Colonial and Cobalt Lode (104) mills. In 1954, Quebec Metallurgical Industries suggested, and began development of, a change from cyanidation to a flotation gravity circuit in order to improve silver recoveries (The Northern Miner Press, July 8, 1954). The mill was closed in 1955 after further problems with handling the slimes and fouling of solutions were encountered (The Northern Miner Press, January 20, 1955).

Financial difficulties following the fire at the 104 Mill in 1956 led to bankruptcy for Cobalt Consolidated and a re-organization under the name of Agnico Mines Limited (The Northern Miner Press, November 7, 1957). The Hellens Mill sat idle until 1964 when various flotation methods were tested (The Northern Miner Press, November 19, 1964). In 1966, the company decided to pump the lake and re-open the mill. Mining and milling started on a seasonal basis in mid-1967. A new mining method involving initially spraying the surface of the tailings with water to create a slurry was tested. This slurry, comprised of 40-50% solids, was then pumped to the mill where it was sized by cyclone-type classifiers. The coarse-grained material was separated for further grinding in ball mills and the fine-grained slimes were processed. The silver was eventually recovered using jigs and flotation (The Northern Miner Press, September 15, 1966). Test runs indicated silver recoveries of 75.7% (The Northern Miner Press, December 1, 1966).

During the 1967 mining season, a recovery rate of 71.68% yielded 2.71 ounces of silver per ton (The Northern Miner Press, November 23, 1967). At this time, the company estimated that the deposit contained 7 to 9 years of reserves. Additional tailings were also brought from elsewhere in the camp as needed to keep the mill functioning at maximum (The Northern Miner Press, June 1, 1968). In 1969, tailings were trucked rather than pumped to increase handling efficiency (The Northern Miner Press, July 3, 1969). The mill operated at a rate of 906 tons per day (ODMNA, 1971. p.105) although the recovery rate dropped to 63.35% or 1.78 ounces per ton (The Northern Miner Press, June 5, 1969). The mill closed later in 1969 because of the lower grades of tailings from Cobalt Lake. It was demolished in 1984-1985.

Tailings originating from this operation between the years 1967 and 1969 were impounded in the north end of the Cobalt Lake. They did not pose a major environmental problem because no cyanide was used in the milling process. The new tailings formed a peninsula which was converted into the Lion's Club Park and a baseball field in 1976-77. This peninsula increased in acreage with the deposition of the rock fill from the reconstruction of numerous homes after the 1977 fire which ravaged the northern third of Cobalt. In 1983, this section was levelled, covered with fill and a second baseball field was established.

Today, the south end of the lake still contains a significant amount of tailings and remnants occur sporadically along the shore of the entire lake.

Ore Reduction Mill (Nipissing Reduction Mill)

A patch of tailings lies on the north side of Coleman Road near the entrance to the Heritage Silver Trail Little Silver Vein Site and within sight of the Kendall Shaft to the south. The site contains a thin skim of tailings and remnants of a concrete foundation in a swampy depression close to Cobalt Lake. Early photos show this is the site of the Ore Reduction Mill, but there is no other documentation for this ground. No mapping was done for this project.

Early records indicate that in 1907, an 80 to 100 ton per day mill was constructed near the Kendall shaft to concentrate the low grade ore from the Nipissing mines (Corkill, 1908, p.105). Some confusion exists as to the original name of this mill. Records describing the unique pneumatic process used in this mill refer to both the Ore Reduction Company and Cobalt Concentrators Limited (Corkill, 1908, p.104-105; Cole, 1907, p.99).

Cole (1909, p.81) reports that, by 1908, the mill was owned and operated as a custom mill by the Nipissing Reduction Company. Several recovery processes were tested at this time and by 1909, a wet process, similar to that used by other area mills, was incorporated (OBM, 1909, p.115). An average of 80 tons of ore per day was crushed by two 6 x 10" jaw crushers, 6 sets of rolls and a Hardinge ball mill. The concentrator consisted of 4 double compartment jigs, 2 Wilfley tables, 7 James tables and a James skimmer (Figure A-1).

Between 1908 and 1912, the Nipissing Reduction Company, concentrated a total of 143,357.16 tons of Nipissing ore recovering only 70% of the silver (Nipissing Mines Company Limited Assessment

File, Seventh and Eighth Annual Reports, Cobalt, 1911, 1912). No further information relating to this mill is available. Considering its location, the tailings presumably flowed into the south eastern bay of Cobalt Lake and mixed with the Cobalt Lake Mill tailings.

East Arm Deposits

Nipissing Hill Tailings

A loophole in the mining act in 1903 allowed prospector Tom Hebert and his partners to claim 846 acres of Coleman Township including claims RL 404, 405, 406, 407, 408 and parts of RL 400, 401 (Parcels No. 1 and 2) and 402 W½. Subsequently, numerous shafts, open cuts and mills were established on the widespread claims which were acquired by the Nipissing Mining Company Limited in 1905 (Murphy, 1977, p.65).

There are three tailings sites on the Nipissing claims. Two of them are small remnant patches of tailings. Little documentation is available for them. The first patch of tailings lies on the north side of Coleman Road near the entrance to the Heritage Silver Trail Little Silver Vein Site and within sight of the Kendall Shaft to the south. The site contains a thin skim of tailings and small remnants of a concrete foundation in a swampy depression close to Cobalt Lake. Early photos show this as the site of the Ore Reduction Mill, but there is no other documentation for this ground. No mapping was done for this project. This site and the corresponding mill are discussed as part of the Cobalt Lake tailings containment area.

South of the Lion's Club baseball park on the east side of Cobalt Lake, a remnant patch of tailings and an old concrete dam mark another migration channel or possibly a tailings sluiceway from one of the Nipissing mills.

By far the largest Nipissing property tailings site is the linear depression (400 m x 150 m) at the base of Nipissing hill running parallel to Cobalt Lake (Figure 10). The tailings from the Nipissing Low Grade and High Grade Mills were deposited in this site from 1913 to 1932. About half of the original tailings migrated from the north end of the containment area (Dumaresq, 1993, p.197), along a small creek into Mill Creek. A dam was eventually built (date unknown) to restrict this migration. During mapping for this report, three old dams were discovered at this location but information relating to their construction was not available. Dumaresq (1993, p.197) estimates that about 123,000 tonnes of tailings (75% of the total originally present) has migrated from the area south of dam #1 and that a significant amount of erosion has also taken place north of dam #1. Today, a culvert diverts the flow away from the nearby LaRose Mine to prevent the tailings from filling the underground workings.

Dumaresq did extensive investigation of the geochemistry of the Nipissing tailings and surface run-off contamination. Excerpts from his thesis can be found in Appendix K. Appendix B details the tailings elemental chemistry by J. Hawley (1980).

Nipissing Low Grade and High Grade Mills

In 1911, the Nipissing High Grade Mill was built utilizing a new process invented by Charles Butters and G.H. Clevenger.

> "The process consists essentially of amalgamation in cyanide solution in a tube mill, where more than 97% of the ore is recovered as an amalgam. The residue then undergoes the regular cyanide treatment whereby an additional extraction is made. During the summer a refinery was erected, since which time the whole product of the mill has been shipped as fine bullion" (Nipissing Mining Company Limited, Seventh Annual Report, p. 9, 1911, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines)

Details describing the design and operation of this mill are available in a report by R.B. Watson (1912). Between 1911 and 1918, the mill processed 11,331 tons of ore which averaged 2,615 ounces of silver/ton. Figure A-5 details the high grade mill processes during this period.

The Nipissing Low Grade Mill was built in 1912 and began operations in early 1913. It replaced the Nipissing Reduction plant and provided concentrates to the Nipissing High Grade Mill. The mill incorporated a new silver recovery process developed by E.M. Hamilton (1914). This involved placing the crushed ore into a cyanide solution and precipitating the silver using aluminum dust (Nipissing Mining Company Limited, Eighth Annual Report, 1912, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The 1914 flow chart (Figure A-

1) serves to illustrate this unique process. Two Callow screens were also added in 1914 to recover the high grade silver. Because of its shape and softness, the high grade silver tended to become flattened during the crushing cycle and often was lost to tailings early in the process.

Experiments with oil flotation treatment of ore and tailings began in 1915. By 1916, the ore from the lower levels of the mine was more difficult to treat and required greater amounts of cyanide. Flotation experiments, begun a year earlier, continued and sodium sulphide replaced aluminum dust during precipitation (Nipissing Mining Company Limited, Twelfth Annual Report, p. 13, 1916, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). These difficulties in processing are reflected in an increased loss of silver to tailings during this period (Appendix C). During 1917, concentrating tables were installed to precede the cyanide treatment so that the resulting concentrates could be treated with the high grade ore (Nipissing Mining Company Limited, Fifteenth Annual Report, p. 15, 1919, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). These changes are reflected in the flow-sheet illustrated in Figure A-2.

Further refinements in 1918 reduced the loss to tailings to 12% or 2.84 oz/ton (Nipissing Mining Company Limited, Fourteenth Annual Report, p. 13, 1918, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). That year, the amalgamation process was discontinued because of increasing costs. Also, new information suggested that equivalent recoveries could be obtained by treating the material with bleaching powder prior to cyanidation (Nipissing Mining Company Limited, Fourteenth Annual Report, 1918, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). As a result, the new process was installed at the Nipissing Low Grade Mill and the Nipissing High Grade Mill was closed. Tailings from the Nipissing High Grade may have gone into the main tailings dump or have been sluiced down to the small reservoir by Cobalt Lake. A small amount of concentrated material still remains on site. It contains 218,000 ppm arsenic and 526.88 ppm mercury along with other contaminants (Dumaresq, 1993, p.98-99). Dumaresq found the mercury contamination in the high grade mill foundations to be 56.06 ppm.

A new re-grinding plant was added to the Low Grade Mill in 1920 saving an addition ounce per ton of silver. In 1923, rubber liners in the tube mills were tested and found to increase efficiency and the life of the tube mill (Nipissing Mining Company Limited, Twentieth Annual Report, p. 13, 1924, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Figure A-3 details the flow sheet as of 1923. The combination of gravity concentration, very fine grinding and cyanidation proved successful. Consequently, the preliminary hand-sorting and jigging to recover high grade ore before milling was abandoned in 1921 (Reid et al, 1924, p. 281). Operations continued at this rate until 1932, when an exhausted ore supply and depressed silver prices forced the mill to close. Within a month of closure, the mines and both mills were cleaned-up. In 1934, the Nipissing Low Grade Mill burned to the ground (ODM, 1935a, p.16). The site was cleaned-up the following summer (ODM, 1936, p.163).

Between 1932 and 1944, the company undertook sporadic mining operations on their properties. The ore was milled, during the summer months at an unknown site in the camp.

The tailings have not been re-treated to date, although inferred tonnages and grades appear to be attractive. Material comprising the lowest beds of the deposit may prove particularly interesting. These tailings would have been deposited during a period when silver losses to tailings were quite high. Unfortunately, the later cyanidation and mercury amalgamation treatments used in the mills have resulted in the deposition of a thick cap of fairly toxic tailings, contaminated with both cyanide and mercury. Appendix B details J. Hawley's elemental assays of each tailings site. This toxicity is reflected today by the lack of growth on the surface of the tailings. Dumaresq (1993) conducted sampling, groundwater and tailings analyses which revealed considerable environmental contamination emanating from this area. Appendix K summarizes some of these results.

Future silver extraction would require both the recovery of mercury and re-grinding to free the silver particles from their cyanide coating. The resulting very fine-grained material would clog the flotation cells used in the current mills (L. Othmer, personal communication, 1984). Agnico-Eagle Mines Limited presently own this deposit and have evaluated grade and reserves. However this information remains confidential and is not available for this report.

Attempts of a basic nature were made to seed the tailings in the early 1990's. They have been unsuccessful so far. The tailings did not receive any "soil conditioning" prior to seeding and may be low in organics needed for successful growth. In the latest attempt, a mixture of seed and fertilizer was sprayed over the tailings. Tailings sites are, in general, a relatively hostile environment. Lack of water can stunt growth and wind blown sand can cut down the seedlings before they're established.

LaRose Tailings

Originally the tailings from the LaRose Mill went through a culvert under the railway tracks to be land deposited in a flat area near 5th Avenue, Cobalt so that they wouldn't plug up Mill Creek (Figure 9). Some build-up of the surrounding land was necessary to contain them. In the mid 1970's, they were sampled and found to be very low in silver (M. Halstead, personal communication, February 14, 1985). Within the first year of the use of this tailings site, Ontario Northland complained of tailings along the railroad tracks. In order to solve this problem, the tailings were subsequently pumped over to the north end of Peterson Lake. This was allowed since Nipissing had previously deposited tailings in there, so essentially the system was already contaminated (M. Halstead, personal communication, February 14, 1985 and L. Othmer, February 15, 1985).

Migrating Nipissing tailings that had gradually seeped into the workings of the LaRose Shaft by Mill Creek were cleaned out in 1951-1952. Now a galvanized pipe runs under the railway tracks carrying the migrating tailings away from the shaft area to the 1st Street, Cobalt area (L. Othmer, personal communication, February 15, 1985).

LaRose Ore Picking Plant

The LaRose mine property at the north end of Cobalt Lake on Claim JS14, Lots 8 and 9, Conc VI, Coleman Township, has been the site of three different milling and refining operations. Initially in 1952, tailings were land deposited in a flat area near 5th Avenue, Cobalt and the railway tracks. Some of these tailings migrated toward the Chambers-Ferland tailings area. Little is known of their true extent. By the next year (1953), tailings were deposited into the north end of Peterson Lake. The full extent of these tailings is not known. The submerged tailings can be seen on air photos but they have not been evaluated.

The earliest mill on this property was erected in 1911-1912 by LaRose Mines Limited (OBM, 1912, p.115). The mill consisted of a small coarse concentrating or ore picking plant which was fairly typical of those found at most of the area mines during this period. Using a series of picking belts or tables and jigs, high grade ore was separated from low grade ore and waste rock. The high grade was shipped directly to a refinery. The low grade ore was shipped to a custom concentrator, in this case, the Northern

Customs Concentrator. Waste rock went to the dump. As concentration methods improved, these dumps often proved rich enough to re-work.

This procedure led to a major dispute in 1920 between this company and the Mining Corporation of Canada Limited, who, by this time, had acquired the former Northern Customs Concentrator (re-named Cobalt Reduction Mill). Cobalt Reduction began to mine and process tailings which had been deposited without segregation into Cobalt Lake. LaRose Mines Limited believed that they should receive a percentage of the profits since their ore was milled at this site and produced a portion the tailings now being mined (The Daily Nugget, August 6, 1920). The solution to the dispute is unknown.

LaRose Mill, Silver Miller Mines Ltd.

In 1952, Silver-Miller Mines Ltd. built a 150 ton gravity and flotation cobalt concentration mill on the LaRose site. It processed ore from the LaRose mine and their other area holdings (ODM, 1954b, p.119). Appendix C details the mill production. In 1953, the mill capacity was doubled to 300 tons/day (Globe & Mail, August 14, 1953) and a two-storey addition to house a 13 ton concentrator bin was constructed in 1956 (ODM, 1958b, p.134).

The mill was closed in 1956 when a strike limited the availability of cobalt ore about the same time that the cobalt prices fell (The Northern Miner Press, December 13, 1956). Changes were made to the mill circuit to recover copper for a while until the copper prices fell (The Northern Miner Press, November 21, 1957). The mill was closed until May 1, 1958 to allow the build-up of mill feed (The Northern Miner Press, April 3, 1958). Operations continued to be intermittent until 1964 or 1965 when declining ore reserves forced closure.

In 1966, it was purchased and rehabilitated by Silver Town Mines Limited (ODM, 1968b, p.162). The mill proved to be too big for their needs so it was leased to Hiho (a wholly owned subsidiary of Glen Lake Mines). In exchange, Silver Town ore was milled at the Bailey Mill (The Northern Miner Press, July 27, 1967; L. Othmer, personal communication, February 5, 1985).

In November, 1969, Silver Town Mines Limited merged with Glen Lake Mines Limited under the name of Glen Lake (ODM, 1970, p.108). The mills ran steadily until 1971 when both Glen Lake Mines and Hiho Mines including the LaRose Mill and the Bailey Mill were put up for sale (The Northern Miner Press, March 11, 1971) as a result of foreclosure on loans (Toronto Star, February 19, 1972). The mill was eventually sold and converted to a refinery in 1974 at which time release of tailings to this area was discontinued.

In 1974, the mill was purchased by Intsel of Canada and St. Joseph Explorations Limited. The mill was converted into a custom refinery called the Canadian Smelting and Refining (1974) Limited. It was subsequently purchased by Agnico-Eagle Mines Limited to refine company concentrates. These operations are described more fully later in this chapter under Refinery Sites.

Chambers-Ferland Tailings

The Chambers-Ferland tailings area represents one of the largest accumulation of tailings in this part of the camp. It is located on claims RL400 E ½ in the NE ¼ of Lot 8, Con. VI and RL402 W part and JB4 in the NW ¼ of Lot 9, Con. VI, Coleman Tp. There was never a mill on this property. The "containment area" is actually a flood plain formed at the confluence of Sasaginaga Creek and Mill Creek which served as a dumping ground for material originating from various sources. Tailings from the Coniagas Mill and raw sewage from the Town of Cobalt, which were transported here by flume, make up the bulk of this deposit. Tailings also migrated to this location from the Trethewey and Hudson Bay tailings containment sites. These tailings may include original sand produced by the simple gravity process first used in these mills. Migration of tailings also occurs from Cobalt Lake and the LaRose tailings to the south via Mill Creek at the eastern limit of the site. Approximately 200,000 tons of tailings from these sources have accumulated over the years to an average depth of 4 to 5 feet (1.2 m -1.5 m).

Both the variable grain size and sporadic additions of tailings in solution to the area resulted in the development of a well-bedded sediment exhibiting many primary sedimentary features. The beds vary in composition and grade and include layers of very fine-grained clay-size particles with minor silver values, coarse-grained layers carrying free silver and organic layers which developed during interruptions in tailings deposition. The raw sewage from town provides ample nutrients to encourage natural re-vegetation of the area during any quiescent period.

The tailings were first sampled as a prospect for re-treatment in the 1960's, but, the results of the survey are unknown (L. Othmer, Mine Manager, Canadaka Mining Corporation, 1986). During 1975, St.

Joseph's Exploration sampled the area to determine the mineability of the tailings. A grid was laid out and samples collected on 50 foot centres using an auger. Assays were determined by the Temiskaming Testing Laboratory, Ministry of Northern Development and Mines, Cobalt. Based on the work, reserves were initially calculated at 250,000 tons grading 3.5 ounces of silver per ton to a depth of 5 feet (L. Othmer, Mine Manager, Canadaka Mining Corporation, 1986). The property was subsequently acquired from Mastermet Mines Limited in 1980.

In early 1981, with silver selling at U.S.$16.26 (Northern Miner, January 8, 1981, p.11), St. Joseph's Exploration began mining and processing the tailings. A new extraction method was developed by the company's U.S. parent in an attempt to avoid problems encountered by others in earlier tailings mining operations. Initially a Marconaflo Pump was suspended from a crane at the eastern margin of the deposit. At this point, a slurry, comprised of 50% water and 50% tailings, was sucked up and pumped via a pipeline, approximately 400 m to the western margin of the deposit. Here, the slurry entered a cyclotron which separated the solids (80%), which were dumped into cones to dry, from the flotation residue (20%) which was deposited in an adjacent settling pond. Solids that precipitated in these ponds were ultimately removed by backhoe and trucked to the Canadaka Mill (see Giroux Lake Catchment Area). This system was tried over a 3 to 4 month period but proved unusable because of the continuous clogging of the Marconaflo Pump by vegetation and debris from the tailings.

In 1983, with silver prices at U.S.$12.05 per ounce (Northern Miner, January 13, 1983, p.11), the company (now Sulpetro Minerals Limited), decided that another attempt was warranted. This time, a much simpler mining plan was proposed. Only a steam shovel, two small bulldozers and a haulage truck were utilized. The mining procedure involved scraping the top two feet of vegetation and organic matte from the surface of the tailings with the bulldozers. This material was then pushed into piles and left to dry in the hopes that the tailings could be sieved out at a later date. Although the company continued to stockpile this material, later recoveries proved ineffective because the densely packed, weedy vegetation continued to grow and retain moisture after deposition. Approximately 30% of the reserves were estimated to be in this organic matte.

Following the stripping stage, the steam shovel extracted the underlying, partially dry tailings to the water table (approximately 4 feet down) and loaded it onto haulage trucks. The tailings had to be relatively dry for the heavy equipment to be effective. Because of this, mining could only take place during the drier summer months and a particularly wet summer could hinder operations greatly. To further reduce moisture content, Sasaginaga and Mill Creeks, which cross the mine site, were diverted by trenching or pumped where necessary. After mining operations actually began, grades were found to vary between 1.9 and 4.0 ounces of silver per ton. A total of 78,743 tons of tailings were mined yielding 192,458 ounces of silver. Operations were suspended at the end of 1984 due to depressed silver prices. Approximately 170,000 tons of mineable reserves remain.

With the completion of mining activities, a proposal was made to convert the area into a controlled marshland environment. Experiments with cattail plantings as a natural filtering mechanism were planned and the Town of Cobalt hoped to eventually establish a natural sewage treatment area on the site (North Bay Nugget, September 1, 1984). Two plots were established and monitored. Unfortunately, one plot was soon washed out because of flooding. The process seems to be effective during the summer months, but once freeze up occurs, there is no filtration. Dumaresq (1993, p. 133-137, 198) found that arsenic levels in the surface water dropped as they passed through the wetlands. Presumably, the wetlands act as a filtering system. The town is presently planning to build a sewage treatment facility in the near future.

This site has remained relatively undisturbed since 1984. The large areas where the organic matte was stripped have once again turned green. Algae, water loving plants and many other weeds invaded the area within two or three years. Fertilized by the sewage, they thrived and multiplied. Ducks use the area as a resting ground on their migrations and often nest there in the spring. Tailings migration continues at a slow pace towards the Crosswise Lake tailings.

Peterson Lake Catchment Area

Peterson Lake is located centrally within the camp on Lot 4, Con. V, Coleman Township. Drainage through this system is from the Cart Lake area in the south, northerly through Peterson Lake to Crosswise Lake. A swamp south of Cart Lake empties into the lake via a small creek. No photographs or records of Cart Lake in its original state could be found. Apparently, it was a shallow lake with an island near the western shore. Water flow from the north end of Cart Lake to the southern end of Peterson Lake is through a tailings-choked swamp that may have originally been a creek. Peterson Lake is split by a large peninsula which divides it into a western and eastern arm. Drainage is from the northern tip of the eastern arm via a small creek and swamp system, called Peterson Creek, to Crosswise Lake.

Tailings migration is evident all along the system. Cart Lake is virtually full of tailings with only shallow water at its northern extent. Cobalt Provincial, Seneca-Superior, Savage and Silver Summit (Silverfields) all milled on the shores of Cart Lake. Migrating tailings choke the swamp leading to Peterson Lake. The Hellens Tailings Mill dumped cyanided tailings somewhere into this section of the system as did the Seneca-Superior Mill.

The LaRose Mill deposited tailings into the north end of the west arm of Peterson Lake after their tailings encroached on the Ontario Northland tracks in Cobalt. Vague references have also been made to Little Nipissing tailings going into the lake, but no proof could be found in the government or company records. However, this was the justification that LaRose used for depositing their tailings in this end of the lake.

The Nova Scotia (Dominion Reduction) Mill deposited its tailings into the east arm of Peterson Lake at least twice. Most of these tailings were removed for re-treatment and re-deposited in an elevated swampy system directly south of the mill. They are held back by an old wooden dam which has been breached many times. The whole area surrounding the mill and mine site is covered in tailings. Often spring run-offs or a heavy summer thunderstorm will erode a ditch across the road and carry tailings from the property into Peterson Lake.

Tailings migrate from the Nova Scotia mine site to Crosswise Lake along two routes. Peterson Creek drains the east arm of Peterson Lake carrying tailings slowly along its swampy route past the Colonial property, into the swamp on the Violet property and then easterly downhill to the lake. The last section was also the route of the lower part of the pipeline that carried Nipissing-O'Brien (Deer Horn) tailings to Crosswise Lake. From the Nova Scotia tailings containment area, tailings migrate slowly along the creek which empties into Crosswise Lake near the King Edward Mill site.

Dumaresq (1993, p.136) details the trace element concentrations throughout the Peterson Lake system. Arsenic concentrations increase at the north end of Cart Lake and in the east lobe near the Nova Scotia Mine. However, arsenic levels decrease in the wetlands of the system (Dumaresq, 1993, p.147, 198). Dumaresq (1993, p.197) estimates that the groundwater from the Cart Lake tailings discharges about 365 kg of arsenic into Cart Lake each year. Leaching experiments indicated that some of this arsenic is mobilized from natural elements as well as the tailings.

Cart Lake Tailings

Cart Lake is virtually full of tailings deposited between 1910 and 1983 (Figure 11). A complete description of these tailings and the re-vegetation experiments on them is included at the end of the report on the Silver Summit (Silverfields) Mill

Seneca-Superior Mill

Seneca-Superior Mines Limited acquired three mining leases on Peterson and Cart Lakes from the Peterson Lake Silver Cobalt Mining Company. The mill was located on the beach on the western shore of Cart Lake. Today it is marked only by a few remaining concrete stumps from the stamp pads.

Initially, only a basic milling operation was needed. The ore was hand sorted. The undersize that was too small to be sorted, was milled (Knight, 1924, p.152). In 1913, the rock house, consisting of a bumping table and jig to isolate high grade ore, was built (Seneca-Superior Silver Mines Ltd., 1st Annual Report, 1913, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). This ore dressing plant developed into a small but complete mill in 1914 to concentrate the fines from the picking table.(OBM, 1915, p.123). The mill operated until 1916 when the operation shut down because the mine was worked out (OBM, 1917b, p.125).

The claims then reverted back to Peterson Lake. They re-opened the mill for the summers of 1918 and 1919 to re-treat the Seneca-Superior tailings from Peterson Lake and to clean up the dump rock (OBM, 1919a, p.19; 1919b, p.146; 1920, p.104). The tailings reportedly carried about 5 ounces of silver per ton (OBM, 1915, p.123). A wooden dam was constructed at the south end of the lake to lower the water level to recover the tailings (Cobalt Nugget, September 15, 1920, p.1). Remnants of this dam, located near the Cobalt Provincial mill, still exist. No further use was made of this mill after 1919.

Cobalt Provincial Mill

The Cobalt Provincial property is located in the north end of Gillies Limit Township at the south end of Cart Lake. The claim is designated as the Provincial Claim and has no claim number or block number associated with it. The mill foundations can be found west of the Provincial # 2 Headframe on the former lake shore.

In 1911, a small plant for coarse concentration using picking tables, jigs and Wilfley tables was installed (OBM, 1912, p.115, 120). It was similar to many of the ore dressing plants for other area mines. In the winter of 1917-1918, the plant was enlarged into a gravity concentrator that treated 1,000 tons of tailings (OBM, 1918, p.126). There are no details concerning this operation, but, presumably, the tailings feed was the accumulated jig tailings. In 1918, a Callow flotation unit was added (OBM, 1919b, p.147). Further additions of a Hardinge ball mill, a Wilfley sand table, 2 Deister slime tables and a Callow thickener were made in 1919. The mill processed both jig tailings and mine ore (ODM, 1920, p.92) until it closed in 1920. In this two-year period, approximately 7,000 tons of ore and tailings (Appendix B) grading 10-11 ounces of silver per ton passed through the mill. Recoveries averaged 7.15 ounces of silver per ton suggesting a loss to tailings of 3.0-3.5 ounces of silver per ton (ODM, 1922b, p.108).
In 1938, George Martin operated the mine and refurbished the 50 ton mill. Records indicate that 31 tons of ore and concentrate were shipped (ODM, 1939, p.232).

The tailings were deposited at the south end of Cobalt Lake. They may have been land deposited along the creek draining the swamp to the south. Original maps of the lake show the shore line to be slightly north of these tailings. This is also the area that was dammed to lower the lake level to facilitate the recovery of the Seneca-Superior tailings. This part of the tailings is now swampy, rich in organics and has sections with weak quicksand texture.

Savage Mill

The Savage Mill, built in 1910, was the earliest mill on Cart Lake. It was located on the same site as the Silver Summit (Silverfields) Mill in the S½, N½, Lot 6, Con.V, Coleman Township at the south end of the lake. The mill was owned by McKinley-Darragh-Savage Mines of Cobalt Limited and served the Savage mine property.

The mill was originally designed as an elaborate ore sorting plant (McKinley-Darragh-Savage Mines of Cobalt Limited, Annual Report for

1909, 1910, p. 30, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The high grade ore was first sorted on the grizzly. All the rejects were crushed and further sorted. The oversize went to the dumps to be treated later at the McKinley-Darragh concentrator. The middlings were concentrated and stored, along with the fines, for re-treatment at McKinley-Darragh. The tailings were stored if they ran greater than 8 ounces of silver per ton and rejected if they contained less silver (McKinley-Darragh-Savage Mines of Cobalt Limited, Annual Report for 1911, p.37, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). A description with sections and a flow-sheet are included in the 1910 McKinley-Darragh-Savage Mines of Cobalt Limited Annual Report, p.30-33 (unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

The mill operated for a three year period between 1910 and 1912. It processed a total of 38,371 tons of ore (Appendix C). In 1913, an aerial tramway was built to carry Savage ore and tailings to the recently enlarged McKinley-Darragh Mill. The Savage Mill was subsequently closed (OBM, 1913b, p.118; OBM, 1914, p.144).

Silver Summit (Silverfields) Mill

The Silver Summit Mill was built on, or very close to, the Savage Mill near the Savage No. 4 Shaft on the S½, N½, Lot 6, Con.V, Coleman Township. Silver Summit Mines Limited owned the 50 ton mill on the adjoining Mensilvo property, but decided it was going to be too small for their needs. Exploration had indicated that their mine would be highly productive.

The new 200 ton per day mill opened on August 6, 1965. The following excerpt from the report written by Milton C. Halstead, general manager, designer and builder of the mill, provides an excellent description of the mill. In The Northern Miner Press, August 1, 1963, he explains that the ore first passed through the jaw crusher and was screened to size. The oversize went to the cone crusher and the undersize went to the ball mill. The ore entered the milling circuits when it reached an average size of about 65% minus 200 mesh. The silver was separated from the ore by both gravity and flotation. The slurry passed through jigs and classifiers to the tables and flotation cells. The Denver jig recovered about 80% of the coarse silver. About 3-4% of the silver in the fines was recovered on the concentrating tables. Flotation got most of the balance. There was only about a 3% loss to tailings. The concentrate from the mineral jig averaged about 80%

silver. It was cleaned on a Wilfley table, classified and sent back into the circuit.

Reagents used in the flotation cells to collect and float off the silver were Zanthate 76, Aeroflot Frother No. 225 and soda ash to maintain proper Ph. The Zanthate coated the silver and enabled the silver grains to stick to the fine bubbles created by the frother. Reagents were also added at the No.1 ball mill and the conditioner. In the conditioner, the pulp was mixed and conditioned before it went to flotation. This pulp contained about 17% silver. The froth was floated off and pumped into the thickener and filtered. The resulting flotation concentrate carried 500 ounces of silver per ton. The total concentrate averaged 3,500 ounces of silver per ton. It was sampled at the Temiskaming Testing Laboratory and refined at the Cobalt Refinery.

In August, 1964 the mill ceased production due to lack of ore. The Silver Summit mine had not produced the hoped for silver. Silverfields Mining Corporation Limited was simultaneously mining on the Alexandra property 1.2 km away. They were producing more ore than they could get custom milled, so they bought the mill in July, 1965. Part of the sale agreement also included joint exploration ventures on the Savage and Mensilvo claims (Silver Summit Mines Limited, 1966 Prospectus, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

Appendix C details the production figures that were available. The silver lost to tails was quite low throughout the mill's history. The mill closed in July, 1983 after the Alexandra mine was worked out.

J. Church (personal communication, 1984) reported that there are about 1.2 million tons of tailings in Cart Lake averaging 0.3 to 0.5 ounces of silver per ton. He estimated that there might be 0.02% cobalt, a little copper and a very little arsenic, since arsenic would have been carried in the flotation concentrates. Only a trace of other heavy metals was recorded. The results of J. Hawley's sampling and assaying of the Cart Lake tailings can be found in Appendix B. Samples of waste water were regularly taken at the creek into Peterson Lake to check for pollutants. No pH regulators were ever needed. Most of the additives in the flotation process such as xanthate and frother are biodegradable, thus limiting downstream contamination. Mill water was pumped from the east side of Cart Lake near the Seneca Shaft No. 2. Tailings were discharged into the southwest end of the lake. This created a relatively closed water system.

The tailings have almost completely filled the lake. Remnants of rich tails from the Provincial and Savage possibly remain in the south end. The outflow at the north end would carry the cyanided tailings from the Hellens Mill and Seneca-Superior tailings. Both of these north end deposits are re-treated tailings. The tailings from Silverfields carry less than one ounce of silver per ton. Re-treatment of these tailings is unlikely.

The tailings are quite fine and easily windblown. Dune formation is prevalent away from the protection of the shoreline. The prevailing winds blow the sand to the west burying struggling vegetation and relics. The dust is carried two to three kilometres during heavy winds.

A small tailings reclamation project began in the summer of 1979. A total of 16,350 square feet was divided into 13 different plots which were tested by varying seed type, fertilizer and top soil.

The tailings were first analyzed for mineral content and potential growth by Dr. Watkins from Mine Waste Reclamation in Guelph, Ontario. His recommendations for soil preparation and optimum seed types were followed. There was only minimal pollutants in the tailings. Therefore, only top soil and fertilizer, to add organic content, and mulch, to stabilize the tailings and protect the seedlings, was needed. The ground was first prepared by levelling the tailings and creating drainage channels. About 2" of top soil was added to some plots and the surface cultivated to a depth of 4". Fertilizing with 5-20-20 was done on the appropriate plots followed by cultipacking. Seeding took place with 48 hours. Two mixtures of seeds were tested: 1) meadow mixture - 40% annual rye grass, 30% tall fescue, 30% creeping red fescue; 2) 50% tall fescue, 50% trefoil. The seeds were then covered with a light layer of top soil and watered. The 40:30:30 seeds germinated first, in 4 days, and produced a thicker ground cover than the 50:50 seed. Plots without top soil or fertilizer had feeble growth. Heavily fertilized plots did not progress any faster than lightly fertilized plots.

Details of the experiment can be found in two reports by A. Tshwenygo (August 15, 1979) and J. Church (June 22, 1982) (Cobalt Resident Geologist's Files, Resident Geologist's Office, Ministry of Northern Development and Mines). Tshwenygo's recommendations for large scale re-vegetation were:

1. Sow during the wettest month to avoid the need for irrigation.

2. Top soil should cover the windward side of the slimes to avoid tailing's dust being blown over the plot.

3. A fairly deep layer of top soil allows the grass to mature before the roots reach the relatively infertile tailings.

On July 23, 1979, the water line broke and irrigation of the plots ended. Since then, the plants have had to adapt to the natural weather and environmental conditions.

These plots were planted in just about the severest environment on the tailings. They are located on the east side where they are constantly bombarded with wind blown sand. There is no water source nearby so that plants are dependent on absorbing rain water before it sinks through the sandy tailings to depths beyond the reach of their roots.

An inspection of the plot in the fall of 1984 showed that most of the plots were covered with vegetation to different extents. Weedy grasses and small bushes predominated. The plots had not encroached on the surrounding tails indicating that natural re-vegetation in that site would take many years to establish.

In the early 1990's, there have been numerous small ad hoc investigations of, and experiments on, the tailings. The Silverfields plots are flourishing within their original boundaries. A pin cherry tree (not part of the original seeding) has taken hold and is about 5 feet tall. Other windblown seeds have also expanded the varieties of plants growing there. The wind blown sand has formed a dune and buried part of the western edge of the plots. Much of the vegetation is now growing below the level of the dune crest and is better protected from the cutting action of the blowing sand.

In 1990, grab sampling of the tailings was done by Environmental Youth Corps workers for the Town of Cobalt. A number of surface samples were taken from the western side of the lake between the shore and the island. It was felt that this would be the easiest area to establish new vegetation because water was plentiful and the area was relatively protected from wind blown material. The tailings were tested for pH and organic content with the assistance of the staff of the New Liskeard College of Agriculture. The news was very positive. Not only were the tailings high in organics, but also the pH was basic enough for environmentally friendly growth. Grains, that could provide feed for indigenous wildlife, would be safe for consumption because the heavy metal contaminants would not be absorbed by the roots. This prediction was born out by investigations undertaken by C. Dumaresq, Carleton University. As part of his research, he dug a pit in the Silverfields plot to observe the chemical actions taking place at root level. A hard pan layer of chemicals had formed at root level indicating that these chemicals had not been absorbed by the roots.

In 1992, G. Gamble established a number of plots scattered about the tailings to test seeds and planting requirements. In the fall of 1993, the tailings were cultivated and seeded as part of Teck Corporation's closure plan on the property.

Water quality tests for arsenic and suspended solids were released by the Ontario Water Resources Commission (1967, p.105). Table 1 below shows the results for the Cart Lake area.

Sample #	Location	Solids (ppm)			Ph	Arsenic (ppm)		COD
		total	suspended	dissolved		total	soluble	
11	Silver Summit mill tails	132,200	131,960	240	8.4	320	0.34	3640
12	flow from Cart Lake to Peterson Lake	198	12	186	7.6	0.96	0.96	4

Table 1: Water quality tests for arsenic and suspended solids from Ontario Water Resources Commission, 1967, p.105.

Nova Scotia Tailings

The Nova Scotia (Dominion Reduction) Mill deposited tailings both in the east arm of Peterson Lake and in the valley directly north of the mill.

It is estimated that there are 50,000 tons of tailings in the 700' x 100' tailings site behind the dam (Figure 12). The site grades from barren tailings with a few patchy weeds in the south, progressing northwards through weedy grasses to cattails as more water is available. These tailings have been sampled and are not rich enough in silver to be worthwhile re-treating with today's technology. Tailings have migrated both north and south from this site for many years. To the north, they migrate down the creek draining the marsh to Crosswise Lake. To the south, they flooded through a long standing breach in the dam and were washed into Peterson Lake. The dam was repaired in the early 1990's.

A skim of tailings covers the mine site below the tailings dam. Run-off gradually carries the tailings into Peterson Lake. Most of the tailings originally deposited into the lake have been removed for reprocessing. Near shore, the lake bed still appears to have a covering of tailings. These tailings gradually migrate down Peterson Creek since the mouth of the creek is in close proximity to the tailings. This creek works its way through a series of swamps and empties into Crosswise Lake in the area where the O'Brien Mill deposited tailings.

Nova Scotia (Dominion Reduction) Mill

The property of the Nova Scotia Silver-Cobalt Mining Company Limited was situated on the SW¼ of the N½ of Lot 3, Con. V, Coleman Township. The Nova Scotia Mill was built in 1908-1909 just south of No.3 shaft on the east side of Peterson Lake. The 20 stamp mill began operation in May, 1910 with an average through-put of 75 tons per day. E.T. Corkill provides a description of the mill in OBM, 1910, p.107:

> "The ore is first put through a crusher, over screens, and the oversize through rolls and then to the stamps. The product from the stamps is classified, and the sands run over tables. The whole product is then re-ground in two 18-foot tube mills and then cyanided. A complete equipment of agitating tanks, filter presses and precipitating tanks has been installed."

By 1911, the mill had been increased in size with 40 stamps processing 120 tons per day. The mill handled custom ore as well as company ore (OBM, 1912, p.115).

In 1912, when operations proved unprofitable, the mill closed and subsequently was sold to the Dominion Reduction Company to be used as a custom mill (OBM, 1912, p.137). The mill ran steadily over the next few years as the production figures in Appendix C show. Ore came from several area mines, with the majority from Crown Reserve and Kerr Lake (Cole, 1911, p.102). Figure A-1 compared the Dominion Reduction flow chart to the other area mills in 1914. In 1916, flotation equipment was installed in the mill to make it more versatile so it could handle ore from any Cobalt mine (OBM, 1917b, p.114). Figure A-2 compares this flow chart with other area mills.

In 1918, the Peterson Lake Company claimed and won the rights to the tailings in Peterson Lake (OBM, 1919a, p.19). These were treated by flotation at the Silver Cliff mill (J. Armstrong, personal communication).

R. Thomson (Nova Scotia Silver-Cobalt Mining Company Limited, 1953, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines) records a report from K. Emerson that the Nova Scotia No. 3 shaft drifts and crosscuts filled with tailings when the mill's tailing's dam broke in 1919. Thomson's inspection of the shaft in 1954 revealed the workings to be half filled with tailings. In the same report, he recorded a story that between 1900 and 1920 a Mr. Thurston from Nevada successfully pumped the original tailings from Peterson Lake with a sand pump by first loosening the sand and then driving in a 2" air pipe. The sands were re-treated at a mill beside the tailings dam. This probably occurred in 1920 when a contract was signed with Peterson Lake Mining Company to treat 220,000 tons of slimes from the lake. It was estimated that the slimes contained 4 to 5 ounces of silver per ton which would yield well over 3 ounces of silver per ton or $750,000 (The Daily Nugget, April 8, 1920, p.5). A further report raised the estimate to 300,000 to 400,000 tons with Dominion Reduction receiving one third of the profit (The Daily Nugget, May 3, 1920, p.7). Four thousand tons of tailings form Peterson Lake were milled in 1920 (ODM, 1922b, p.111) and 21,770 T with an average head of 3.825 oz in 1922 (ODM, 1923b, p.70).

The mill was closed in 1920 due to low silver prices and operated intermittently in 1921 and 1922. In 1934, the mill was leased to A. Wood who recovered 10,694 ounces of silver and 165 ounces of gold during the clean-up (ODM, 1937, p.187).

The tailings were investigated in 1953 by E.B. deCamp (R. Thomson's notes, Nova Scotia Silver-Cobalt Mining Company Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Near the dam, a pit was dug into an area of fine sand, described as loose and easily worked with some bedding and occasional narrow patches of very fine grained tailings. It assayed at 1.2 ounces of silver per ton and 0.05% cobalt. The tails (Figure 12) cover an area of approximately 700' x 100' and 10" deep and contain roughly 40,000 to 50,000 tons. Another small 5,000 ton tailings pile near shaft No.3 assayed at 20 ounces of silver per ton. The whole deposit was considered to small to mine profitably at the time.

In 1965, a sampling study of the tailings in the eastern lobe of Peterson Lake and behind the dam at the Nova Scotia was made by Silver Town Mines Limited, the owners at that time. A report by

J.G. Willars in the September 27, 1956 company prospectus, p.11 (unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines) concluded that there was 275,242 tons of Peterson Lake tailings carrying an average of 3.63 ounces of silver per ton or 1,010,286.51 ounces of silver. The company had originally planned to run these tailings through their newly renovated United Cobalt (Silver Cliff) Mill (The Northern Miner Press, July 11, 1968). However, the results from the Nova Scotia sampling were disappointing and no reworking was undertaken at that time.

The area behind the dam was sampled in 1978 by Sulpetro for 1300' north of the dam. Beyond this, there were too many tree stumps, cattails and garbage for any reasonable recovery. Silver averaged 1.77 ounces of silver per ton with an average depth of 5 feet. A total of 18,000 tons of tailings lie within the sampling area, but they cannot be profitably re-treated (L. Othmer, personal communication, 1985).

The eastern arm of Peterson Lake was dammed. drained and dug out to a depth of 50' early in 1968. A total of 24,400 tons of tailings were removed from August to September, 1968 (ODM, 1970, p.116). These were milled at Silver Town's United Cobalt (Silver Cliff) Mill. Glen Lake Mines Limited and Silver Town Mines Limited merged in October 31, 1968. Throughout 1969, a further 30,431 tons of tailings with 3.04 ounces of silver per ton were processed yielding a 72.3% recovery (ODMNA, 1971, p.109-110). The tailings yielded a good profit until falling silver prices forced the cancellation of the project at the end of the 1969 season (M. Halstead, personal communication, 1985)

At present it is difficult to estimate how far the tailings have migrated. About 400 m from the dam, a marshy cattail area extends north, then east following a creek which empties into Crosswise Lake. Organic sediments have built up deeply over the years masking the extent of the original tailings.

For many years the tailings dam was breached near its centre. This may be the original reported break (1919) or a later one. Below the dam, patchy remnants are mixed with dump rock and some weedy overgrowth. The more southerly portion of the tailings drained into Peterson Lake for many years. The tailings often flooded across the road washing out the culvert during heavy rainstorms or spring run-offs. In the early 1990's, this breach was repaired. These tailings entered Peterson Lake very close to the mouth of the creek that drains the lake. The tailings have slowly migrated down Peterson Creek over the last eighty years. The creek and its swamps are so covered with vegetation that tailings cannot be seen.

Giroux Lake Catchment Area

The Giroux Lake Catchment Area consists of all tailings sites that could possibly contaminate Giroux Lake. The Mensilvo tailings flow directly into the northwestern part of Giroux Lake. The Glen Lake and Canadaka tailings near the northeast shores are contained in tailings ponds. After settling, effluent water was generally recycled through the mills. Now runoff flows slowly through the systems.

Mensilvo Tailings

The Mensilvo tailings were deposited across the road to the south of the mill (Figure 13). The original deposition site appears to have been a relatively flat or possibly shallow valley. A small creek drains the site from the southeast corner of the tailings carrying them downhill to Contact Bay, in Giroux Lake.

Silver Arrow (Mensilvo) Mill

In 1974, Silver Arrow Mines Limited installed a small mill at the headframe of the old Silver Bar Mine in the SW¼ of the N½ of Lot 5, Con. IV, Coleman Township.

The original mill was basically an ore sorting plant. The fines were separated and concentrated for treatment at the Temiskaming Testing Laboratory. The coarse product went to the United Cobalt Mill (Silver Cliff) to be concentrated (Silver Arrow Mines Limited, March 26, 1952, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). A 250 ton trial run was milled in December, 1947 (ODM, 1949b, p.109) and was followed by intermittent milling in 1948.

Mensilvo Mines Limited optioned the mine and mill in 1949. It ran relatively steadily at a rate of 25 tons per day from 1949 to 1952 (ODM, 1951, p.95; ODM, 1952a, p.30; ODM, 1952b, p.95; ODM, 1954b, p.42).

In January, 1953, the long awaited additions were made to the mill. Four flotation cells and filters were installed to handle all the mill ore (The Northern Miner Press, January 15, 1953). Although

10,800 tons were milled in 1953, the operation was haphazard and inefficient according to L.J. Cunningham in his report on the Mensilvo Mine. He recommended getting a millman in to train the men and improve efficiency (Silver Arrow Mines Limited, October 6, 1953 report, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The mill was increased in size in late 1955 (The Northern Miner Press, November 30, 1955) but the new 4' x 10' ball mill was too small in diameter to effectively crush the hard cobalt ore (Silver Arrow Mines Limited, Cawley report to R. Thompson, October 17, 1956, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

R. Thompson reports that the Mensilvo closed and the machinery was removed on September 19, 1957. However, there was some milling recorded in 1959 (The Northern Miner Press, January 14, 1959, August 27, 1959). In 1961, the mill was acquired by J.J. Gray who added new equipment during the renovation (ODM, 1971, p.126). In 1963, Silver Summit Mines Limited bought the property but never used the mill because it was too small for their needs.

The tailings were deposited across the road immediately south of the mill. The site appears to have been a flat or slightly shallow, dry area with a small creek running through it or a spring nearby. Dead tree trunks still stick out of slightly wet tailings. An intermittent creek flows southerly from the tailings to Giroux Lake. The thin skim of tailings tapers off to odd pockets of tailings along the creek. Growth on the main tailings site is progressing slowly with weeds and small bushes beginning to reclaim the ground. The migration route to Giroux Lake is now so overgrown that it becomes difficult to follow at the lower end.

It would appear that about 30,000 tons of milling was performed at the Mensilvo Mill. No records could be found indicating recovery rate or silver lost to tailings, but, indications are that the efficiency was poor. No record could be found of any testing of these underwater tailings.

Glen Lake Tailings

Glen Lake is located in the E½ of Lot 4, Con. IV, Coleman Township on the West Coleman Road. Three mills have contributed tailings to this site since 1907. The Cobalt Central Mill deposited tailings initially in the northwestern corner of the lake. In the 1950's, the Foster Mill on the east side of the lake started depositing tailings in the northeastern section. In the 1960's, the Bailey Mill, built on Diabase Hill on the western side, added to the tailings load. Today the lake is more than full and the land around has been elevated to contain the tailings. The effluent ran from the main tailings pond through two more settling ponds before it was released to Giroux Lake. The tailings were not mapped at the time of the study because the site was active at the time.

Cobalt Central (Standard Cobalt, Penn Canadian) Mill

The Cobalt Central Mill was the first of the Glen Lake mills. It was built in 1907 by Standard Cobalt Mines Limited (a wholly owned subsidiary of Cobalt Central Mines Company). The mill was erected on the east shore of Glen Lake, 50 m from the Big Pete Mine main shaft on the NW¼ of the N½ of Lot 4, Con. IV, Coleman Township. It was intended mainly for processing ore from this property.

The ore was treated using a wet gravity concentration method (Corkill, 1908, p.79) similar to that used at the Nipissing Reduction Mill in 1914. In 1908, mill capacity was increased to 75 tons per day to accommodate custom ore from the Kerr Lake area mines (Corkill, 1913, p.253). The mill continued to operate at this rate until it was closed at the end of 1910 (OBM, 1912, p.115). In 1912, both the mine and mill were acquired by Penn Canadian Mines Limited and reactivated (OBM, 1913b, p.120). The mill underwent minor modifications in 1914. The pebble mills were changed to ball mills and six new Wilfley tables were added (ODM, 1915, p.122). It operated continuously until a strike in 1919 contributed to the decision to shut the operation down (ODM, 1920, p.104). The mill was cleaned up in 1921 (ODM, 1924, p.9). Figures A-1 and A-2 show the flow chart for this mill in 1914 and 1917.

A fan of tailings at the base of mill foundations indicate the direction of tailings flow. In 1920, Penn Canadian Mines Limited estimated reserves of 135,000 tons. At this time the company was negotiating to sell these tailings to The Mining Corporation of Canada Limited but the deal apparently was not completed (The Daily Nugget, July 16, 1920, p.5). The milling process used at this time suggests that grades averaged approximately 5 ounces of silver per ton.

Bailey Mill

The Bailey Mill was built in 1962 by Glen Lake Silver Mines Limited. It was located on the SW¼ of the N½ of Lot 9, Con. IV, Coleman Township on Diabase Hill directly across Glen Lake from, the Foster Mill. Some confusion is created by this name because the same name was used by Bailey Silver Mines Ltd. when they owned the mill at Mile 104 (1920-1922). Throughout this report, the two mills are referred to in brackets by their respective locations, Glen Lake and Mile 104.

The mill included a typical gravity and flotation concentration process which processed ore from the Glen Lake and Hiho properties at a rate of 74 tons per day (ODM, 1964, p.128) until 1965. At this time, a ball mill was added to increase capacity to 150 tons per day (The Northern Miner Press, June 24, 1965). Operations continued at this rate until 1967 when Hiho Mines (a wholly owned subsidiary of Glen Lake Silver Mines Limited) traded mills with Silver Town Mines Limited in order to process increasing tonnages (The Northern Miner Press, July 27, 1967). Subsequently, ore mined by The Silver Town Mines Limited at Peterson Lake was milled at the Bailey Mill and ore mined by Hiho Mines from the Crown Reserve and Kerr Lake Mines was milled at the newly renovated LaRose mill (L. Othmer, personal communication, 1985). In 1968, the two companies merged under the name of Glen Lake Mines Limited (ODM, 1970, p.108).

Milling continued until 1971, when the mill was closed and put up for sale along with the company (The Northern Miner Press, March 11, 1971). All the Glen Lake, Hiho and Silver Miller properties were acquired by Silver Shield Mines Incorporated (Silver Shield Mines Incorporated, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). This company processed approximately 18,776 tons at the Bailey Mill the following year (1972) (Appendix C).

In 1974, the mill was purchased and re-activated by Canadaka Mines Limited (a wholly owned subsidiary of St. Joseph Explorations Limited). It operated until May, 1975 when it was destroyed by fire. The Canadaka Mill east of Glen Lake was built to replace this mill.

Foster (Penn) Mill

Construction of the Foster Mill started in 1952 by Penn Cobalt Silver Mines Limited. The mill was located on the SW¼ of the N½ of Lot 9, Con. IV, Coleman Township. Construction stopped in 1953, when the company became part of Cobalt Consolidated Mining Corporation. The new company already owned a number of mills in the camp and did not require additional capacity (ODM, 1954b, p.115).

In 1956, after the Cobalt Lode (Mile 104) mill was destroyed by fire, the Foster mill was needed to process the company's ore. It was redesigned to recover cobalt, copper, and nickel in addition to silver and its capacity was increased to 500 tons per day. Trial runs began in July, 1957 (The Northern Miner Press, August 1, 1957). A combination of the fire and high construction costs forced the company into bankruptcy, from which it emerged as a rejuvenated Agnico Mines Limited (The Northern Miner Press, October 10, 1957).

The mill used a standard gravity and flotation process. It operated continuously at a rate of 200 tons per day from 1957 until 1965 (The Northern Miner Press, September 15, 1966). From 1966 to 1969, the mill, now renamed the Penn Mill, operated only during the winter months. In the summer, the same millhands operated the Hellens tailings mill. Depressed silver prices resulted in the closure of the mill for most of 1972. During this time the company merged with Eagle Mines Limited to become Agnico-Eagle Mines Limited (The Northern Miner Press, April 20, 1972). In 1973, the mill re-opened and operated on a seasonal basis up to the present, except in the years 1980, 1984 and 1985 when the ore was processed year round. Ore from a number of mines throughout the area was processed at this time. In 1980, four flotation cells and a dust collector were added to the mill to increase capacity to 300 tons per day with a rated recovery of 96% (The Northern Miner Press, November 27, 1980). Tailings were sent by launder and a 6" plastic pipe, by gravity, a distance of 1200' and deposited in the northeast corner of Glen Lake (B. Montgomery, personal communication, 1987). The concentrates were refined at the Agnico Refinery on the former LaRose property.

Minor amounts of tailings were added to the ore being treated in the mill during different periods. In 1980, a small amount of tailings was extracted from the Beaver-Temiskaming containment area and treated at the mill. Results were quite poor and the test was discontinued (W. Montgomery, personal communication, 1985). In 1984 tailings were removed from the Castle tailings near Gowganda and added to ore in a ratio of one scoop to one truck. The material was subsequently treated at the Penn Mill.

Figure 14 shows a simplified flow sheet for the Penn Mill. There are several basic differences, which are directly related to the mill feed, between the Penn Mill and its nearby contemporary, the

Canadaka Mill. The first difference is in the amount of crushing needed. The crusher plant reduces the feed to ¼" and the grinding circuit to -200 mesh. Because of the coarser grain size, the jig in the ore grinding circuit removes 55 to 60% of the total silver as opposed to only 10% in a tailings operation. Also, gravity tables are not used in the tailings operation because of the fineness of the feed. They are quite effective, however, in sorting out the heavier concentrates from ore feed.

The old Penn Mill and part of the shop burned to the ground on February 22, 1986. The mill was re-built in 1986-1987. Details of the milling process are provided in a report by W. Montgomery, former Penn Mill Superintendent, in Appendix I.

In addition to the estimated 135,000 tons of tailings deposited in the lake by the Cobalt Central Mill, an estimated 300,000 tons of tails were added by the Bailey Mill and approximately 1.6 million tons by the Penn Mill to the end of 1985.

The original lake is almost filled now, in some places to a thickness of 60' (B, Montgomery, personal communication, 1985). The black muck from the bottom has floated above the heavier tailings enriching them organically so revegetation will occur quickly. Two overflow areas were used. The beaver pond to the south often filled from overflow much to the consternation of the beavers. They continually tried to raise the dam to save their pond. This would upset the water level for the whole system and could have caused tailings to escape into Giroux Lake. The situation is still constantly monitored in an effort to prevent spills.

The deposit has been mapped and sampled in detail by Agnico-Eagle Mines Limited but the information remains confidential. The original Cobalt Central tailings may run as high as 5 ounces of silver per ton, while the Bailey and the Penn Mill tailings contained less than one ounce of silver per ton. The deposit as a whole may contain an average of 0.75 ounces of silver per ton (W. Montgomery, personal communication, 1985). Considering the average assay and the problems associated with very fine particles like the black muck, these tailings could not be retreated profitably with today's technology.

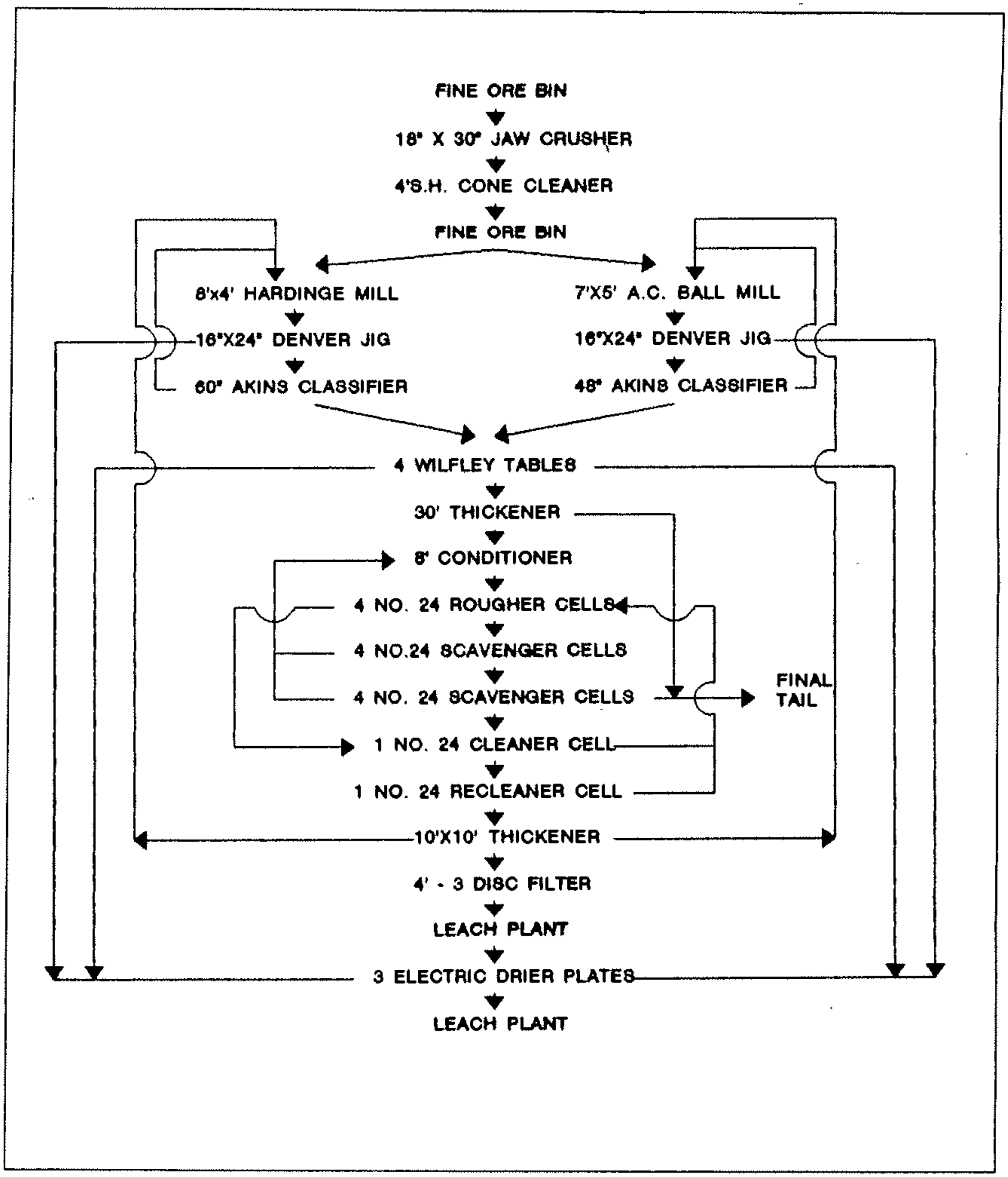


Figure 14: Penn Mill Flow Sheet

Canadaka Tailings

The Canadaka mill tailings were deposited in an area located at the northeast tip of Giroux Lake in Coleman Township. They are contained in a series of three ponds that were formed by damming a small creek flowing from Kerr Lake to Giroux Lake. The tailings were not mapped at the time of the project because the site was still active.

The tailings from the Canadaka Mill are currently filling a natural valley created by a small creek draining from Kerr Lake into Giroux Lake. The basin has been isolated from Giroux Lake by a series of terraced dams. It is estimated to contain 347,870 tons of tailings averaging 0.7 ounces of silver per ton (L. Othmer, personal communication, 1985). Space still exists for the addition of a further 500,000 tons of tailings.

The tailings were deposited in a large contained area at the highest elevation. Overflow and run-off from that basin flowed into a lower, polishing basin where suspended solids settled out. The water was pumped back into the mill from this basin and re-cycled. A lower, third contained area caught any overflow or run-off due to heavy rains or rapid spring melting before it reached Giroux Lake. Once solids settled out here, the water was allowed to enter the lake. Measured elemental values were well below the Ontario Ministry of the Environment maximums. The only problems encountered were with beavers. As at the Penn Mill, they persisted in building dams in the tailings area and interfering with the normal water flow.

Canadaka Mill

The Canadaka Mill was built in 1977 by St. Joseph Exploration Limited. It was designed to have a through-put of 500 tons of ore per day, but actually ran at 350 tons per day (L. Othmer, personal communication, 1985). The first report in Appendix J, by E.C. Blakemore, describes the mill's original operation as an ore concentrator. The mill combined gravity and flotation methods to process ore from the company's area mines. In 1980, the mill closed when the mines ceased production.

In 1983, the company was bought by Sulpetro Minerals. The mill was modified at this time to re-treat tailings being mined at the Chambers-Ferland tailings containment area. Actual milling rates averaged 450 - 500 tons per day (L. Othmer, personal communication, 1985). The second report in Appendix J, by L. Othmer, describes the Chambers-Ferland tailings re-treatment project and the mill processes used. The mill was subsequently re-activated in the summer of 1983 for two seasons.

In the modified mill, dried tailings were first screened in the crusher house to remove rocks, wood and clumps of the grassy vegetation. Because of their size and shape, individual blades of vegetation passed through the screens. The tailings then passed to the fine ore bin where the acidity was reduced to a pH of 8 by the addition of soda ash. The material subsequently moved by conveyor to a rod mill for polishing to remove oxidation. Improvements to the process may have been possible at this stage. A furnace to burn off the vegetation, would free the silver contained in it for recovery and alleviate clogging problems further along the system. Additionally, an attrition machine, instead of a rod mill, would polish the grains without reducing grain size. The fine-grained slimes also tended to cake and clog the system (L. Othmer, personal communication, 1985).

The material passed from the rod mill to the jigs. Here, approximately 10% of the free silver was recovered as a concentrate which was sent directly to the dryers. The remaining material was pumped to the classifier to be separated by size. The heavy fraction was returned to the ball mill for re-grinding and passed over another set of jigs. The concentrate recovered from the second pass also went to the dryers and the rest of the material rejoined the system in the classifier. The lighter fraction from the classifier was pumped to a conditioner where xanthate was added in preparation for flotation. The flotation circuit consisted of six rougher cells, where aeroflot was added, six scavenger cells where more xanthate and aeroflot was added as required, two cleaner cells and two recleaner cells. Xanthate and aeroflot aided in the creation of a mineralized froth which could be skimmed from the slurry as it passed through the flotation cells. The froth was passed through a thickener and then filters to produce a concentrate containing between 800 to 1,000 ounces of silver per ton. The water recovered at this stage from the concentrate was recycled through the mill. The remaining residue was pumped to the tailings pond.

The main difference between processing tailings and ore is the fineness of the mill feed. Normally the grain would be 60-80% minus 60 mesh, but, the tailings, after polishing, run 80-90% minus 200 mesh. The cyclone and gravity tables are not used because the material is too fine for effectiveness.

Tailings mill heads from the Chambers-Ferland property averaged 1.9 to 4.0 ounces of silver per ton. Silver recovery averaged 68-75% with only 0.70 ounces of silver per ton lost to tailings. Unfortunately, falling silver prices made the tailings recovery operation uneconomical and Othmer's suggestions remain untested. The mill was closed at the end of the 1984 season. Appendix C details the milling activity.

Kirk Lake Catchment Area

Tailings are scattered throughout the Kirk Lake Catchment Area. The main tailings deposits are located at the Beaver-Temiskaming mine site covering parts of Lots 1 of Con. III and IV, Coleman Township. The more southerly Temiskaming tailings are stable. However, the Beaver tailings have been migrating since their deposition. There is a trail of Beaver tailings leading from their original deposition site through to the southern end of Crosswise Lake

A small amount of tailings can also be found around the Brady Lake Mill. Originally the tailings were deposited into Brady Lake. There is no record of the amount or how long this occurred. Tailings, confined by a small depression and a dam, are found beside the mill. There is also no record of their deposition. Most of the Brady Mill tailings were sent by pipeline or flume to the Temiskaming tailings site.

Farther south on the east side of the Brady Lake Road, mounds of orange tailings can be seen. These are the stockpiled cyanided tailings or leach residue from the Agnico Refinery. This deposit contains about 30,000 tons. Most of the cyanide used in the refining process was recovered by vacuum filtering before disposal.

Beaver Tailings

The Beaver tailings (Figure 15) are also known as the Fisher Eplett tailings. For the most part, the remaining tailings are barren. Grasses have re-established only around the edges and lower down in the valley. The Beaver tailings have been migrating since their deposition. There is a trail of Beaver tailings leading from their original deposition site in a valley, down a fast moving stream to a bay at the north end of Kirk Lake (Figure 16). From here, they enter Kirk Creek, the nearby water course that drains Kirk Lake. Patches of tailings can be seen caught in the many beaver dams along this creek. This creek empties into the south end of Crosswise Lake where tailings fill part of the bay and form the beach (Figure 17).

Beaver Mill

The Beaver Mill is located in the NE¼ of the N½ of Lot 1, Con. III, Coleman Township within sight of the old Temiskaming Mill and the Beaver-Temiskaming Mine. It was built in 1911-1912 by Beaver Consolidated Mines Limited to mill ore from their Beaver Mine. Crushing was done by crushers, rolls and pebble mills. Concentration methods were similar to the Nipissing Reduction, Penn Canadian and Silver Cliff as illustrated in Figure A-1 (OBM, 1912, p.117). Capacity increased to 90 tons per day in 1913 (OBM, 1914, p.129) and to 120 to 150 tons per day in 1915 (OBM, 1916, p.105). Production continued until 1920 when falling prices forced the closure of both the mine and the mill (ODM, 1922b, p.107). Appendix C details the mill production.

In 1923, Coniagas Mines leased the property. Many alterations and new machines were needed to bring it back into production (ODM, 1925b, p.70). The next year, 1924, the mill was shut down in July as the ore vein ran out (ODM, 1926b, p.135-136).

The Beaver tailings spilled out and filled a valley crossing the Fisher Eplett property close by the mill. In 1920, it was estimated that there was 40,000 to 50,000 tons of tailings on site. A large, but unknown, amount, locally known as the Fisher-Eplett tailings (Figure 15), still remain there, but there has also been considerable migration. An unnamed, swift moving stream carries the tailings into Kirk Lake and from there downstream into the south end of Cross Lake. The bay in the northeast corner of Kirk Lake at the mouth of the stream is full of tails (Figure 16). Tailings also line the beach and extend out into the bay at the south end of Cross Lake (Figure 17).

A trial run of tailings was put through the Penn Mill in 1980, but recovery was too low to be worth continuing (B. Montgomery, personal communication, 1985). L Othmer (personal communication, 1985) reported the tailings in Kirk Lake were sampled by Silver-Miller several years ago. Their silver content was also very low and not worth recovering by today's standards.

Temiskaming Tailings

The Temiskaming tailings (Figure 18) form a thin skin over mine rock for most of their extent. The original Temiskaming mill tailings were reprocessed. Most of the remaining tailings were sent by pipeline or flume from the Brady Lake Mill.

The tailings are for the most part barren of vegetation. Water has collected in low spots and mine rock is prevalent. Grasses grow only along the creek which touches the southern fringes on the deposit. There are signs of some tailings migration along the creek, but the tailings do not go very far.

Temiskaming Mill

The Temiscamingue (Temiskaming) Mining Company Limited claimed several properties in the Cobalt camp in 1906. The mill is located on the northwest corner of the Temiskaming mine site in the S½ of the NW¼ of the N½ of Lot 1, Con. IV, Coleman Township.

Construction of the mill was authorized in June, 1909. It was completed and in use early in 1910. Jigs were used to separate the coarse material for grinding by stamps, while James tables and slimers extracted the silver from the slimes. An extraction rate of 85% of the silver was estimated by the company (Temiskamining Annual Report for 1909, 1910, p.16, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Appendix C details the available production statistics from the mill. Figure A-1 shows the general flow sheet in 1914 and Figure A-2 shows the 1917 flow sheet. It appears that no changes had been made during that time.

The tailings occupy an area west of the mill within sight of the Beaver/Temiskaming mine. From 1918 to 1920, the company directors considered re-treatment of the accumulated tailings. There were 20,000 tons containing an estimated 84,000 ounces of silver on the Temiskaming property and 40,000 to 50,000 tons that might be acquired from the Beaver property. A total of 1,227,737 cu feet of tailings at 4.2 ounces of silver per ton could contain 250,000 to 300,000 ounces of silver. Equipment was purchased and one flotation unit was installed and successfully tested in 1920 (Temiskaming Annual Report, 1921, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). Falling silver prices and lack of sufficient mine ore forced the closure of the mine and mill.

In 1928, Richard Sandoe and Associates leased the property to sort ore from the stopes and clean the mill. A total of 7,791 tons of ore and 59 tons of sand tailings were processed at another mill (ODM, 1930, p.181).

In late 1951, the Hellens tailings mill on Cobalt Lake began treating the Temiskaming tailings for Silanco who was the current owner, at the rate of 300 tons per day (ODM, 1953b, p.100). No record of tonnage or recovery rate is available. Most of the tailings were removed leaving a skin of tailings mixed with waste rock from the Beaver-Temiskaming operation near the mill. There has been very little regeneration of vegetation. From 1948 to 1956, tailings from the Brady Lake (Silver-Miller) Mill were sluiced over to this area. The remaining tailings are most likely from this operation.

Brady Lake (Silver-Miller) Mill

The Silver-Miller or Brady Lake Mill was built by Silver-Miller Mines in 1948-1949. The company utilized the brick and concrete former Northern Ontario Power Company sub-station on Brady Lake to house the mill (Cobalt Concentrator, December 23, 1948). The 50 ton mill consisted of two-stage crushing followed by tables and flotation to produce cobbed high grade ore (silver and cobalt), table concentrates (silver) and flotation concentrates (silver and cobalt) (Cobalt Concentrator, October 21, 1948). Milling began in 1949 and was soon working at capacity. In 1952, a Narcy ball mill and Atkins classifier were added to the system to increase the capacity to 100 tons per day (ODM, 1954b, p.118). The same year, the company also built the LaRose Mill to concentrate its cobalt ore. The Brady Mill was then reserved for silver ore.

Milling was suspended in 1953 for several months due to a shortage of water (The Northern Miner Press, December 24, 1953). In August, 1956 the mines and mills were closed by a wild-cat strike (North Bay Nugget, August 3, 1956). The mill opened for a few months after the strike but closed permanently in 1957 due to a shortage of mill feed. All the company milling was done at the LaRose Mill after this (Northern Miner Press, November 21, 1957) Appendix C details the production of the Brady Lake Mill.

The tailings were sluiced through the woods to the east to the Temiskaming tailings dump (H. Moore, personal communication, 1984) after having been impounded in Brady Lake (J. Armstrong, personal communication, 1984). No sign of tailings were observed in Brady

Lake in the fall of 1984. A small tailings deposit held back by a dam still exists of the north side of the mill (Figure 19). There are no records to indicate the amount of silver lost in the tailings, but probably the level is around one ounce of silver per ton or less considering the type of concentration and the age of the mill. The mill was demolished in the late 1980's.

Crosswise Lake Catchment Area

The Crosswise or Cross Lake catchment area is the final resting place for migrating tailings produced by the majority of the Cobalt camp mills. The north end of the lake and the Mill Creek flood plain are full of tailings. Migrated tailings can also be found in the south end of the lake.

Four creeks flow into Crosswise Lake. These carried heavy loads of excess tailings migrating downstream in the days when the mills were operating. Now the migration has slowed and only small pockets of tailings can be observed along these creeks.

Kirk Creek flows into the southern end of Crosswise Lake carrying tailings from the Kirk Lake Catchment Area (Figure 17). A tailings beach has formed along the lake shore and tailings can be seen underwater near the beach. It is not known how far out this tailings fan extends.

Peterson Creek drains Peterson Lake from its east arm through the Violet property to Mill Creek. Most of the migrating tailings would have come from the Nova Scotia (Dominion Reduction) Mill although any unstable tailings from as far away as the south end of Cart Lake or the north part of the western arm of Peterson Lake might eventually flow through the system. A small unnamed creek also drains from the Nova Scotia dammed tailings directly into the west side of Crosswise Lake near the King Edward Mill.

To the west of Cobalt, Sasaginaga Creek flows into Mill Creek at the Chambers Ferland tailings. Tailings from almost every mill in Cobalt migrate through this area, downstream past the Mile 104 Mill to Crosswise Lake. On some maps, this part of Mill Creek is referred to as Sasaginaga Creek. Since Canadaka's tailings mining project in the mid-1980's, the Chambers-Ferland tailings have quickly re-vegetated. This will stabilize the tailings once more and slow migration along this path.

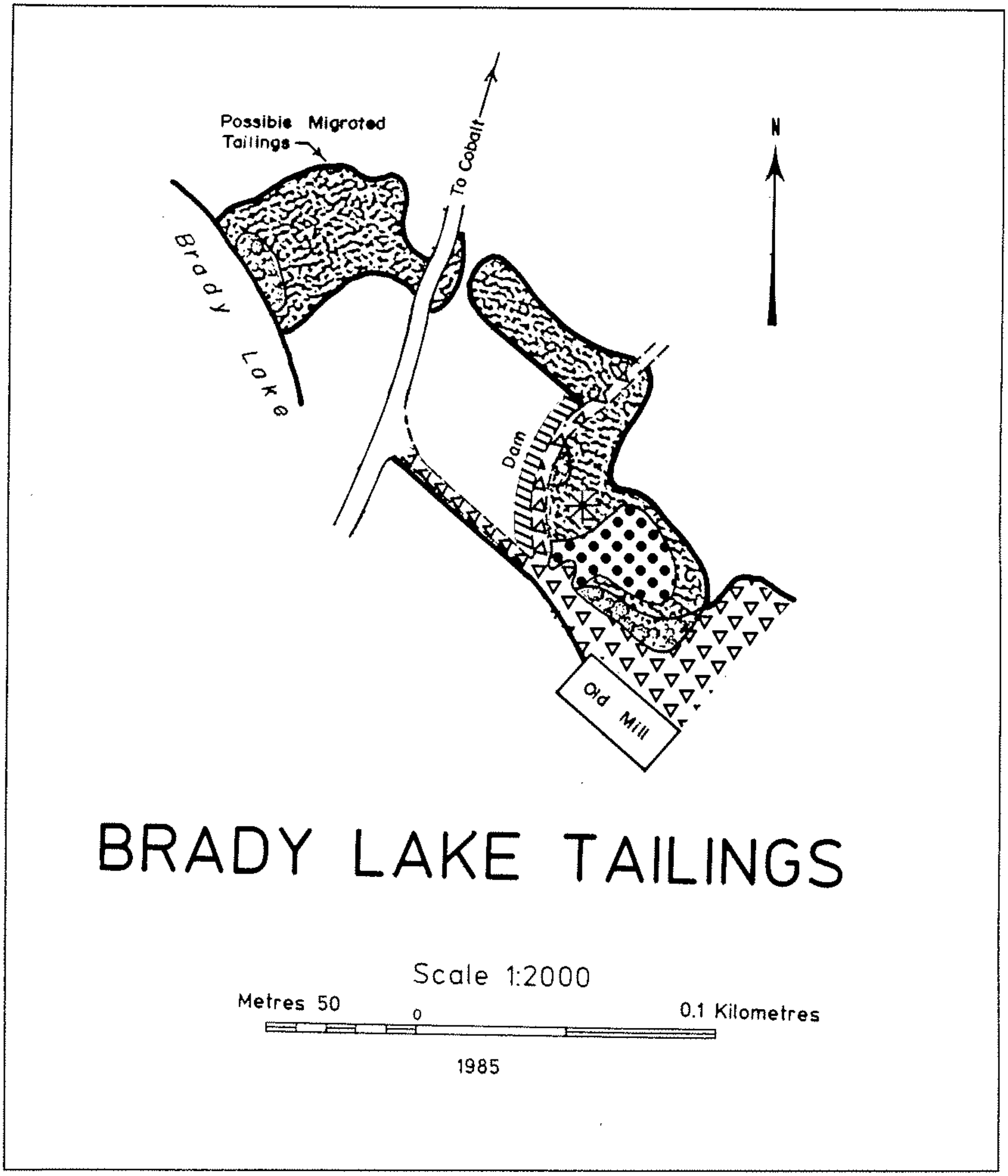


Figure 19: Brady Lake Tailings

Cross Lake Tailings

Crosswise Lake's shape has changed dramatically since the first tailings deposition. The northern half of the lake is completely filled with tailings. The lake used to drain into Mill Creek, or Farr Creek as this section is often called, at a point near the present location of the tailings dam in the SE¼ of the S½ of Lot 11, Con. II, Bucke Township (Figure 20). Now the creek starts back at the Silver Cliff Mill area (Figure 21).

The tailings have stabilized behind the dam built in the 1950's by the Ontario Ministry of the Environment. The tailings at the south end of the present Mill Creek (Figure 21) are mostly barren, but lichens have taken hold near the mouth of the lake and sparse grasses grow along the outer perimeter of the lake and flood plain. Grasses and scrub bushes are gaining a hold on the tailings along Peterson Creek on the Violet claim.

Moving north, the tailings deposit widens out (Figure 20) to fill the flood plain of the original lake. The central part of the tailings form a cattail marsh, favoured by moose, with areas of open water for wildfowl. The creek meanders through this area often changing its course. At the northern extent, the creek is well established in its bed and the organic rich tailings have drained to become pasture land.

Mill or Farr Creek continues north through North Cobalt and drains into Lake Temiskaming near Farr Island.

C. Dumaresq (1993) sampled both the tailings and Mill Creek looking for concentrations of arsenic and other heavy metals. Results of his work are summarized in Appendix K.

Direct Tailings	Migrated Tailings		
	Via Kirk Creek	Via Mill Creek	Via Peterson Creek
Mile 104	Beaver	McKinley-Darragh (2)	Nova Scotia
O'Brien (claim RL403)	Temiskaming	Hellens	Cobalt Provincial
Colonial	Brady Lake	Cobalt Lake	Seneca-Superior
Silver Cliff		Cobalt Reduction	Silverfields
King Edward		Nipissing (2)	Hellens
		Ore (Nip.) Reduction	LaRose
		Coniagas	Savage

		Trethewey	
		Hudson Bay	
		LaRose	

Table 2: Origin of Crosswise Lake Tailings

King Edward (National) Mill

King Edward Mines owned all of the Edward Cobalt Mines Limited and most of the Watts Mines Limited in 1909 (Davis Handbook, p.67). A 10-stamp mill was built in 1908 on the Watts property in the NE¼ of the N½ of Lot 3, Con. V, Coleman Township, just south of the main adit on Crosswise Lake. Ore, which was trammed from the mine, was crushed to 30 mesh to prepare for gravity concentration. The extraction rate was only 70%, therefore, tailings from this mill would have been relatively rich. Cyanide tests on the tailings yielded a further 77% extraction, but plans to build a small plant did not materialize (Davis, 1910, p.81). The mill ran continuously in 1909 (OBM, 1910, p.103) but there is no further mention of it in the records until 1913 when it was leased by the City of Cobalt Silver Mining Company for five months. Later in the same year, it was run by York Ontario Silver Mines Limited to treat production from the King Edward Mine (OBM, 1914, p.154). A total of 1,975 tons was milled (Cole, 1914, p.88). Figure A-1 compares the 1914 flow sheet to other local mills.

In 1915, National Mines Limited took over the property (OBM, 1916, p.117) and treated both the King Edward and Silver Cliff tailings from Crosswise Lake by Callow flotation in 1916 and 1918 (OBM, 1917b, p.121-122; OBM, 1919a, p.19; 1919b, p.141). At least 13,244 tons of tailings were treated in 1918 (OBM, 1919a, p.18-19). Figure A-2 shows the comparable flow chart for 1917. There is no further mention of the mill after this time. Appendix C details the known production statistics.

The tailings are mixed with the Silver Cliff tailings because of the close proximity of the two mills. They were deposited directly into Crosswise Lake.

Silver Cliff (Pilliner, Ausic, United Cobalt) Mill

The Silver Cliff property which includes part of the northern end of Crosswise Lake consists of one claim in the SE¼ of the S½ of Lot 3, Con VI, Coleman Township. The Silver Cliff Mining Company began developing the property in 1907. They sold the mine to

Trinity Cobalt Mining Corporation in 1908 or 1909 (R. Thomson notes, Silver Cliff Mining Company, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

Trinity erected a 100 ton per day gravity concentrating mill in April, 1910 (OBM, 1910, p.111) and milled 15,402 tons of ore that year (Cole, 1911, p.102). The mill operated for only part of 1911. The property was then taken over by Orion Realty and Investments Limited, but was not operated during 1912 (OBM, 1913b, p.120). Figure A-1 compares the Silver Cliff flow sheet to other 1914 area mills.

The tailings, were deposited directly into Crosswise Lake. They were re-treated at the King Edward Mill from April to November, 1918 (OBM, 1919a, p.19; 1919b, p.141). No data is available on the profitability of this recovery.

In 1943, the property was acquired by the Austin Mining Syndicate which started reconditioning the mill (ODM, 1946c, p.189) after Ausic Mining and Reduction Company Limited bought the property in 1944 (ODM, 1948a, p.113). The name was formally changed to the Ausic Mill but was also referred to as Pilliner's Mill reflecting the company owner. Production began in November, 1944 with the milling of 1,882 tons from the Ausic-owned Genesee Mine (ODM, 1948a, p.11). The mill closed in 1948. During 1949, a work crew was hired to re-line the ball mills and recondition the mill. Recovery of silver had been low by the standards of the day thereby reducing profits (D. Larabie, personal communication, 1984). Consequently, the grade of tailings in that part of Crosswise Lake should be higher than the norm.

In 1951, United Cobalt Mines bought the mill to run both custom and company ore. In 1956, the mill was leased to Cobalt Consolidated Mining Corporation Limited until their new mill could be built to replace the 104 mill which burned down. The mill was unsatisfactory and milling was terminated after 5,450 tons were run.

In 1956, R. Thomson noted that a Mr. Duesling intended to work on the tailings, but no further record exists.

In 1968, Silver Town Mines bought the mill from United Cobalt to process Peterson Lake tailings. A $100,000 renovation was needed to rehabilitate the mill (Northern Miner Press, July 11, 1968). During early 1968, the southeast arm of Peterson Lake was dammed, drained and dug out to a depth of 50 feet. In 1968, 24,400 tons were treated from August to December. Operations closed for the season in December (ODM, 1970, p.116). The project continued after the merger of Silver Town Mines and Glen Lake Mines Limited on October 31, 1968. From June to November, 1969, 30,341 tons of tailings carrying 3.04 ounces of silver per ton were processed with a recovery rate of 72.3% (ODMNA, 1971, p.109-110). The tailings were rich and a good profit was made initially (M. Halstead, personal communication, 1985). But, silver prices were falling and cutting into profits and there is no mention of the project beyond 1969.

Colonial Mill

The Colonial property is located on the SW¼ of the S½ of Lot 3, Con. VI, Coleman Township. Silver bearing veins were discovered in 1904 and the property was subsequently purchased by the Colonial Mining Company in 1906 (Colonial Mining Company, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

In 1908, a 10-stamp, 30 tons per day concentrating mill was constructed about 100' from the mine adit.

> "The ore is trammed from the adit and dumped into the crusher, from which it passes into rolls and over trommels, the fine product going direct to the classifier, while the coarse product goes to a Hartz jig. The tailings from the jig go to the 10 stamp mill, and thence to a classifier. The several products from the classifier are led to a Wilfley table, Deister table and Deister slimer. A tube mill is being put in to re-crush the tailings from the sand tables". (OBM, 1910, p.98)

Figure A-1 compare the mill to other area mills in 1914.

Few production figures are available for the early years of the Colonial Mill. The amount of silver in the tailings is estimated at 5.20 ounces of silver per ton, using the average from the similar Coniagas Mill during this time period (Reid et al, p.276) These earliest tailings, produced before flotation, are the richest of the deposit. These were probably the tails reworked in 1948 (ODM, 1950, p.97)

From 1922-1926, Menago Mining Company operated both the mine and the mill (Colonial Mining Company, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). In 1935, the mill was cleaned up by Donald E. Sirola (ODM, 1937, p.186). In November, 1938, the mill was acquired by Cobalt

Products Limited to treat the ore from their mines as well as custom ore (ODM, 1940a, p.32; 1940b, p.229). The mill was reconditioned and additions made. No production figures are available for this period but the Ontario Department of Mines Annual Reports indicate only part time use from 1938 - 1943.

In September 1943, Silanco Mining and Refining Corporation purchased the claim and the mill (ODM, 1946c, p.190) which was then capable of treating 90 to 100 tons per day. No data regarding silver recovery efficiency or the amount of silver in the millheads is available during this period. The milling ore came from several mines owned by Silanco as well as custom milling from other small producers. In 1948, the early Colonial gravity tailings were re-treated (ODM, 1950, p.97). In 1953, mill ownership was transferred to Cobalt Consolidated Mining Corporation Limited as part of a merger of Silanco and four other companies. All the silver-bearing ores from the mines belonging to Cobalt Consolidated were milled at the Colonial while the cobalt-bearing ores were processed at the Mile 104 mill (ODM, 1955, p.131). The Colonial Mill was sold to Coballoy Mines and Refineries Limited in December, 1954 (ODM, 1956, p.124) and was used intermittently for the next four years.

Hespanola Mines Limited bought the mill in 1962 (ODM, 1964, p.128). A new 200 tons per day tailings treatment plant was installed using wet gravity separation. Tests were run in October and November, 1962 but the mill was destroyed by fire November 16, 1962. Plans were announced, but not acted on, to re-build in 1963. Appendix C documents the milling statistics for the Colonial Mill.

O'Brien Mill

Silver was discovered on Claim RL403 on the S½ of Lot 4, Con. VI, Coleman Township in 1903. The property, purchased by M.J. O'Brien Limited, became the longest producing mine in the Cobalt camp, successfully operating full time until 1937. In 1909, a 30 stamp combined cyanide and wet treatment concentrator was built (OBM, 1910, p.108). It was the first mill in the camp to treat all the mill ore with cyanide. Even the tailings were re-ground and cyanided (1923b, p.76) again. By 1913, the mill was increased to 140 tons per day (OBM, 1914, p.129) with the addition of a new tube mill and more tanks in the cyanide plant. Figure A-1 shows the flow sheet as of 1914 and Figure A-2 shows the changes made by 1917 when the entire tailings product was slimed and cyanided (OBM, 1918, p.125). Sodium sulphide replaced aluminum dust precipitation in the cyanide plant in 1916 to lower costs. Production figures for this time are scarce, although the mill operated continuously. The tailings probably contained from 3-4% silver. They were run through an underground pipeline to the bottom of the hill and deposited in the mouth of Peterson Creek where it empties into Mill Creek.

On September 4, 1922, the mill was destroyed by fire. Over 600,000 tons of ore had been treated during the lifetime of the mill (Appendix C). Figure A-3 shows the O'Brien flow sheet for 1922 with the proposed additions for 1923. Rather than re-building, the mill at Mile 104 was purchased to process the O'Brien mine ore.

The mine was leased from M.J. O'Brien from 1940 to 1952 by a group of former employees who formed a partnership called the Cross Lake Lease. They operated intermittently, but profitably, using the mill at Mileage 104 (O'Shaughnessy).

Nipissing-O'Brien (Deer Horn) Mill

In January, 1952, the Nipissing Mining Company Limited and M.J. O'Brien merged to form the Nipissing-O'Brien Mines Limited. A 100 ton gravity and flotation mill was built and equipped on the foundation of the old O'Brien Mill. It began operation in September, 1954 (ODM, 1956, p.131). This mill was generally referred to as the Nipissing-O'Brien Mill. The tailings were again sluiced through the original underground tailings system from the old O'Brien mill (B. Price, personal communication, 1985).

In 1958, the property and mill were sold to Agnico Mines Limited who, in turn, leased it to Deer Horn Mines Limited in 1959 (ODM, 1961, p.98). The mill then became locally known as the Deer Horn. Company ore from the Deer Horn Mine on the east side of Crosswise Lake and custom ore were milled. During this time, the silver lost to tailings never exceeded one ounce of silver per ton according to former millworker, Q. Paoletti (personal communication, 1984).

The mill changed ownership several times after 1970 but was never operated. The machinery has long since been removed and final demolition of the mill has recently been completed.

Mile 104 (Northern Customs Concentrator, Bailey, O'Brien, O'Shaughnessy, Cobalt Lode) Mill

The large mill just east of Highway 11b at Mile 104 was built by Northern Customs Concentrators Limited in 1913 to replace their original mill in the south end of Cobalt. The new 80 stamp mill, called the Northern Customs Concentrator, was designed to process 225 tons per day of custom ore (OBM, 1914, p.129). Initially, the system used gravity concentration similar to their first mill which was sold to Cobalt Reduction Company (Figure A-1). Most of the ore came from the LaRose properties but Seneca-Superior, Chambers-Ferland (Aladdin), Right-of-Way and Green-Meehan (Edwards & Wright) were steady customers as well.

Callow flotation was added to the plant in 1916 to improve efficiency as shown in the flow sheet in Figure A-2. In 1917, the cyanide plant opened to further treat all the tailings (OBM, 1917b, p.109).

In 1919, Northern Customs bought the Chambers-Ferland property from Aladdin, leased the Silver Cliff Mine (ODM, 1920, p.91) and, in 1920, bought the Bailey Mine. Following these acquisitions, the Northern Customs Company was liquidated and reorganized as Bailey Silver Mines Limited (ODM, 1922b, p.119) and the mill at Mile 104 became known as the Bailey Mill. Production was steady until the Bailey Mine closed in April, 1922. The mill was put up for sale by the original bond holders because the company had defaulted on the interest payments (LaRose Mines Limited Annual Report for 1922, 1923, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines).

When the O'Brien Mill on the O'Brien mine property was destroyed by fire in Septmeber, 1922, the mill at Mile 104 was bought by M.J. O'Brien as a replacement and the name was changed to the O'Brien Mill (Reid et al, p.76). All custom contracts were automatically cancelled or renegotiated, but the LaRose contract was not renewed probably because LaRose and O'Brien had recently been involved in a court case over the Violet mine boundary (LaRose Mines Limited Annual Report for 1922, 1923, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). The mill ran at, or near, capacity from 1922 to 1940 when the O'Brien mine closed. Occasionally small amounts of custom ore were processed.

In 1940, M.J. O'Brien Limited was disbanded and its properties acquired by a group of local men organized under the name, Cross Lake Lease ODM, 1942, p.160). The mill, which was renamed the O'Shaughnessy Mill (ODM, 1942, p.160), augmented company ore production with small amounts of custom ore. It operated mostly during the mild months from 1940 to 1943. Silanco Mining and Smelting Company Limited acquired the mill from September to November, 1940 to mill their own and custom ore (ODM, 1949a, p.107).

In 1950, the mill was bought by Cobalt Lode Silver Mines to treat Adanac ore and once again its name changed to Cobalt Lode to reflect the new ownership (ODM, 1952a, p.30). Although no production figures are available, the mill seems to have run steadily from 1950 to 1953. A new 7' x 5' Allis-Chambers ball mill was added to increase capacity in 1952 (ODM, 1954a, p.45). In January, 1953, the mill along with all the Cobalt Lode properties was incorporated into the newly formed Cobalt Consolidated Mining Corporation Limited (ODM, 1955, p.128). The mill at Mile 104 became basically a cobalt producing mill for the company while their silver ore was processed at the Colonial mill (ODM, 1955, p.131) and tailings were reprocessed at the Hellens Mill (ODM, 1955, p.132). The mill ran at full capacity with new equipment being added to increase production (ODM, 1956, p.127) until it was destroyed by fire on October 15, 1956 (ODM, 1958b, p.128).

All the Mile 104 mill tailings were sluiced out into Cross Lake. There is no record of any reworking of these tails. All but the earliest tailings should be relatively low in silver because the tailings were all treated by flotation and cyanidation. No mill heads or tailings sampling records have been published to estimate the amount of silver in Cross Lake. The earlier silver tailings are buried under a layer of cobalt tailings.

North Cobalt Catchment Area

While the concentration of mines was not as great as in Cobalt, there were still a number of active mining properties in the North Cobalt area. Access to these properties is by Highway 567 from Highway 11b in North Cobalt (Haileybury). This highway winds through South Lorrain Township to access the numerous mining properties of Silver Centre.

Cobalt Contact Tailings

Only one mill foundation and tailings site was recorded in the North Cobalt area at the Green-Meehan or Cobalt Contact Mine in the SW¼ of the N½ of Lot 14, Con. I, Bucke Township.

The tailings are located on the east side of Highway 567 (Figure 22). The roadway into the tailings is covered with fines. The tailings were deposited on relatively flat land and spread out as a large thin ground cover. The stumps of the original trees on the site stick up through the tailings. There is also a considerable amount of dump rock mixed in with the tailings. At present, they are covered by vegetation which returned naturally. Unfortunately, this site has also become an unofficial dumping ground for large household articles, garbage and cars. The nearby shaft was the repository of household garbage for many years (G. Quevillion, 1993, personal communication). The site is within close proximity (approximately 860 m) of Lake Temiskaming. Surface water run-off would drain directly into the lake.

Cobalt Contact (Green-Meehan) Mill

The mill foundation on the Green-Meehan property is located on the west side of Highway 567 in the southeast corner of the claim. No official name could be found for this mill, but, it is known locally as the Green-Meehan or Cobalt Contact and was built by Cobalt Contact Mines Limited.

The mill, with a capacity of 60 - 100 tons per day began operation in July, 1926 treating 7,883 tons that year by concentration and flotation of slimes (ODM, 1928, p.156). In 1927, 17,808 tons of ore were milled producing both silver and cobalt concentrates (ODM, 1929, p.168). Milling operations were suspended in February, 1928 (ODM, 1930, p.170).

Argyle Property

A small blast furnace operation was reported on the Argyle property in the N½ of Lot 15, Con. II, Bucke Township in 1942. Apparently, small amounts of ore and rejects were mixed and speiss produced (ODM, 1946b, p.225). No sign of this minor operation could be found in 1984.

Refinery Sites

There have been a number of refineries associated with Cobalt's mills over the years. The earliest refineries were often part of the concentrating mill or on site very close to the mills. Cobalt Reduction, Buffalo, Nipissing, and Dominion Reduction all produced silver bullion as their final product. These operations are described with the respective mills.

In later years, three refinery operations served the Cobalt mining camp. The Temiskaming Testing Laboratory was originally a private company, but, for most of its history, was owned and operated by the Ontario government. The three services provided were assaying, ore sampling and refining. The Agnico Refinery, formerly the Canadian Smelting and Refining Limited, initially provided custom refining and minting services. The Cobalt Refinery was built to offer smelting and minting services. In the past years, it has been modified numerous times for metallurgical research projects.

Temiskaming Testing Laboratory

The Campbell and Dyell custom mill was constructed in 1909 at the northwest corner of Cobalt Lake beside the railway tracks. The mill was designed specifically for sampling high grade ores from the Cobalt mining camp. Small mine operators, without milling facilities of their own, could utilize this mill. The ore was crushed, sampled and assayed to determine its silver and cobalt content. With this guaranteed assay, the mine owner could then sell the ore to a concentrator or refinery and receive payment for its metallic content immediately.

Although the mill thrived initially, the volume of ore available to process declined throughout World War I. This forced its closure in 1919 leaving the local mines without any local source of sampling. The government-owned Temiskaming and Northern Ontario Railway purchased the operation and subsequently transferred ownership to the Ontario Department of Mines in 1921. Milling and sampling continued until July, 1941 when fire destroyed the mill. Sampling continued by manual methods in various locations for the next two years until a new mill could be assembled in the former Cobalt Municipal Office Building on Presley Street.

The TTL is unique in North America. It utilized a dry milling process which could handle 500 pound to 100 ton loads. A working model of the mill can be seen at the Cobalt Mining Museum. The ore was ground to 14 mesh in the mill, then fed to an automatic sampler which cut out four samples representing 1% of the total. Four more samples were cut from each of the initial samples by hand. One was prepared for assaying while the others were kept in reserve. The assay sample was ground to 100 mesh and then cut once more into four samples. One of these final samples was fire assayed to determine the silver content. The rest were returned to the owner for future proof if needed. The combined fines and scale assay had to check to within 1½% of the average of the average assays.

The mill proved its versatility in recent years when it was used by one customer for recovering gold, copper and other metals from discarded electronics boards. If required by the customer, the high grade concentrates could be smelted and poured into bars.

The TTL closed in 1993. A private company is currently interested in reviving the operation on a custom basis while maintaining the historical integrity of the mill. The Ontario Ministry of Northern Development and Mines Cobalt Resident Geologist's Office is still located in this building.

There were no tailings produced by this mill because all the ore was returned to the customer or shipped directly to the concentrator or smelter. There was no additional refining of concentrates in this mill before bars were poured.

Agnico Refinery (CSR)

In 1974, Intsel of Canada and St. Joseph Explorations Limited formed Canadian Smelting and Refining (1974) Limited after a long and complicated series of stock promotions, grants awarded and lost and company reorganizations (Silver Shield News Clipping File, Resident Geologist's Office, Ministry of Northern Development and Mines). Additions were made the LaRose Mill building while it was being converted to a refinery.

The plant was designed specifically to treat the complex silver concentrates from the local mines using acid and cyanide leaching circuits to recover silver bullion and gold and lead as a by-product (The Northern Miner Press, April 8, 1982; Canadian Smelting & Refining (1974) Limited, unpublished Assessment File, Resident Geologist's Office, Ministry of Northern Development and Mines). St. Joseph became the full owner in 1977 (The Northern Miner Press, December 29, 1977).

The refinery was sold to Agnico-Eagle Mines Limited, its present owner, in April 1982 (The Northern Miner Press, April 8, 1982). It handled both company and customs concentrates until 1984 when processing was restricted only to company concentrates. The refinery closed in 1989 and a plant cleanup is now in progress.

The tailings, referred to as leach residue, are being stockpiled for possible future silver recovery. Most of the cyanide used in the refining process has been recovered by AVR. A small amount of the leach residues are piled just east of the refinery (Figure 23) and a further 13,000 tons are stored at the Canadaka Mill.

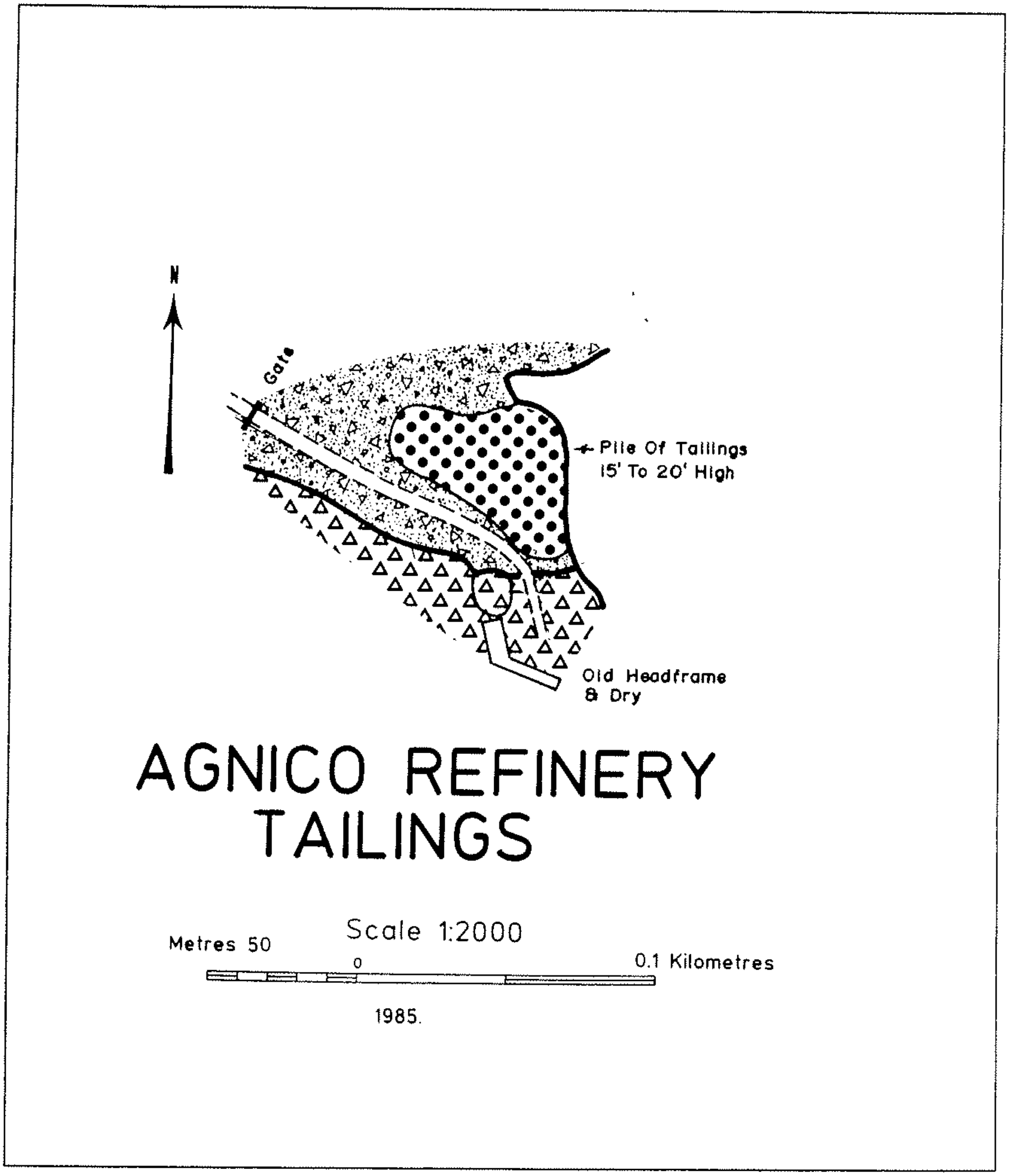


Figure 23: Agnico Refinery Tailings

Cobalt Refinery

Construction of the Cobalt Refinery, located at Gillies Depot on Lot 13, Con. III, Coleman Township, was first begun by Silanco Mining and Refining Company in 1949. The smelter was completed and opened by Cobalt Chemical and Refinery Company in 1949. Unfortunately, it was destroyed by fire in May, 1950. By March, 1954, it was rebuilt under the direction of Quebec Metallurgical Industries but soon closed again to make changes in the refining process (Northern Miner Press, January 6, 1955).

The operation really never got established until J.J. Gray bought it in 1961. Several modifications were completed to profitably recover silver, gold, bismuth and lead from the local concentrates (ODM, 1963, p.120). Several steady contracts including a 5 year contract with the Royal Canadian Mint (Northern Miner Press, August, 1963) kept the refinery operating steadily from 1961 to 1968 (ODM, 1964, p.126; 1965, p.125-126; 1966, p.124; 1968a, p.126; 1968b, p.151; 1969, p.139, 1970, p.111). The operation ran into difficulties when they were required to lessen their arsenic emissions from the smokestack. Since that time, several companies have owned the plant under several names and tried to utilize it as a refinery in a variety of ways.

At present, it is a research facility called Cobalt Refinery Limited. Research has included the stability of metal ions in tailings effluent and the production and manufacture of ferric sulphate which is used for water treatment.

A dammed pond for the tailings was established adjacent to the southwest corner of the refinery. The tailings apparently cover an area of approximately 1.75 acres at an average thickness of six feet. They were buried under three feet of silica sand and clay and are now completely covered by vegetation. Most of the tailings were produced from the extraction of cobalt and are comprised mostly of iron, copper, arsenic, FeO and minor cobalt, nickel and arsenic (B. Rice, personal communication, 1984).

REFERENCES

Berry, L.G.
1971: The Silver-Arsenide Deposits of the Cobalt-Gowganda Region, Ontario; The Canadian Mineralogist, Vol. 11, pt.1, 429p.

Church, J.
1982: A Report on a Visit to Noranda Mines, June 22, 1982; Cobalt Resident Geologist's Files, Resident Geologist's Office, Ministry of Northern Development and Mines.

Cobalt Concentrator
1948: Silver Miller Plans to Erect New Mill to Process Output (article); Cobalt Concentrator, Cobalt, October 21, 1948.

Cobalt Concentrator
1948: Preparation is Under Way for New Mill (article); Cobalt Concentrator, Cobalt, December 23, 1948.

Cole, A.A.
1907: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1909: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1910: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1911: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1913: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1914: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1916: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Cole, A.A.
1917: The Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway; Report of the Temiskaming and Northern Ontario Railway Commission.

Corkill, E.T.
1908: The Working Mines at Cobalt, Ontario Bureau of Mines Annual Report, 1907, Vol. 16, pt.2, p.68-116.

Corkill, E.T.
1913: Mining and Concentrating Methods at Cobalt, Ontario, Ontario Bureau of Mines Annual Report, 1910, Vol. 19, pt.2, Appendix 4, p.253-279.

(The) Daily Nugget
1920a: Pete Lake said to have contract for treating of slimes (article); The Daily Nugget, Cobalt, April 8, 1920, p.5.

(The) Daily Nugget
1920b: (article); The Daily Nugget, Cobalt, May 3, 1920, p.7.

(The) Daily Nugget
1920c: (article); The Daily Nugget, Cobalt, July 16, 1920.

(The) Daily Nugget
1920d: LaRose and Mining Corp. Dispute (article); The Daily Nugget, August 6, 1920, p.5.

(The) Daily Nugget
1920e: (article); The Daily Nugget, September 15, 1920, p.1.

Davis, H.P.
1910: The Davis Handbook of the Cobalt Silver District with a Manual of Incorporated Companies; Canadian Mining Journal, 112p.

Dumaresq, C.G.
1993: The Occurrence of Arsenic and Heavy Metal Contamination from Natural and Anthropogenic Sources in the Cobalt Area of Ontario, Master of Science Thesis, Department of Earth Sciences, Carleton University, Ottawa, Ontario.

Globe and Mail
1953: Silver Miller Expanding Mill by New Financing (article); The Globe and Mail, August 14, 1953.

Hamilton, E.M.
1914: Aluminum Precipitation at Nipissing; in Cyanide Precipitates, Engineering and Mining Journal, 1914, p.32-45.

Hawley, J.R.
1980: The Chemical Characteristics of Mineral Tailings in the Province of Ontario; 1979, Ontario Ministry of the Environment.

Knight, C.W.
1924: Geology of the Mine Workings of Cobalt and South Lorrain Silver Areas, Timiskaming District, Ontario; Ontario Department of Mines Annual Report, 1922, Vol. 31, Pt.2, p.1-238.

Miller, H.G.
1913: Cobalt-Nickel Arsenides and Silver (Cobalt and Adjacent Areas); Ontario Bureau of Mines Annual Report, 1910, Vol. 19, pt.2, ch.1, p.1-133.

Murphy, John P.
1977: Yankee Takeover at Cobalt; Highway Book Shop, Cobalt, 200p.

North Bay Nugget
1956: 200 Cobalt Miners in Wildcat Strike (article); North Bay Nugget, August 3, 1956, p.1.

North Bay Nugget
1984: Artificial Cattail Marshes Help Purify Waste Water (article); North Bay Nugget, September 1, 1984.

(The) Northern Miner Press
1951a: New Cyanide Mill for Cobalt Area (article); The Northern Miner Press, June 21, 1951.

(The) Northern Miner Press
1951b: Hellens Mining and Reduction Producing Next Month (article); The Northern Miner Press, October 18, 1951.

(The) Northern Miner Press
1952a: Raise Capacity Hellens Plant (article); The Northern Miner Press, March 27, 1952.

(The) Northern Miner Press
1952b: Milling Rate Rising at Hellens Mining (article); The Northern Miner Press, April 24, 1952.

(The) Northern Miner Press
1952c: Hellens Boosts Tailings Plant (article); The Northern Miner Press, July 17, 1952.

(The) Northern Miner Press
1952d: Over the Hump at Hellens (article); The Northern Miner Press, September 25, 1952.

(The) Northern Miner Press
1952e: Tough Sledding for Hellens (article); The Northern Miner Press, October 30, 1952.

(The) Northern Miner Press
1953a: Say Hellens Solving Retreatment Problem (article); The Northern Miner Press, January 1, 1953.

(The) Northern Miner Press
1953b: Cobalt Area Consolidation Is Ratified By Shareholders (article); The Northern Miner Press, January 15, 1953.

(The) Northern Miner Press
1953c: Up Cobalt Mill Silver-Miller (article); The Northern Miner Press, December 24, 1953.

(The) Northern Miner Press
1954a: Cobalt Consolidated First Year (article); The Northern Miner Press, July 8, 1954.

(The) Northern Miner Press
1954b: Strategic Uses Bolster Demand For Cobalt From Canada's Mines (article); The Northern Miner Press, July 8, 1954.

(The) Northern Miner Press
1955a: (article); The Northern Miner Press, January 6, 1955.

(The) Northern Miner Press
1955b: Cobalt Con. Output Rises (article); The Northern Miner Press, January 20, 1955.

(The) Northern Miner Press
1955c: (article); The Northern Miner Press, November 30, 1955.

(The) Northern Miner Press
1956: Swing LaRose Mill of Silver-Miller Cobalt to Copper (article); The Northern Miner Press, December 13, 1956.

(The) Northern Miner Press
1957a: Cobalt Consolidated Ups Mill Capacity Contemplates Merger (article); The Northern Miner Press, August 1, 1957.

(The) Northern Miner Press
1957b: Cobalt Cons. Okays Reorganization Has Operating Loss (article); The Northern Miner Press, October 10, 1957.

(The) Northern Miner Press
1957c: (article); The Northern Miner Press, November 7, 1957.

(The) Northern Miner Press
1957d: Resume Milling at Silver-Miller Using LaRose Plant (article); The Northern Miner Press, November 21, 1957.

(The) Northern Miner Press
1958: Find Rich New Vein At Silver-Miller Resume Mill Soon (article); The Northern Miner Press, April 3, 1958.

(The) Northern Miner Press
1959a: (article); The Northern Miner Press, January 14, 1959.

(The) Northern Miner Press
1959b: (article); The Northern Miner Press, August 27, 1959.

(The) Northern Miner Press
1961: (article); The Northern Miner Press, June 29, 1961.

(The) Northern Miner Press
1962: Loss on Year for Silver-Miller Resume Mill Soon (article); The Northern Miner Press, October 18, 1962.

(The) Northern Miner Press
1963: (article); The Northern Miner Press, August, 1963.

(The) Northern Miner Press
1964: New Ore Findings Spur Agnico Work on Cobalt Holdings (article); The Northern Miner Press, November 19, 1964.

(The) Northern Miner Press
1965a: Glen Lake Output Heading Higher (article), The Northern Miner Press, June 24, 1965.

(The) Northern Miner Press
1965b: Silver Summit Sells Mill Clears Debt Ready for Program (article); The Northern Miner Press, August 19, 1965.

(The) Northern Miner Press
1966a: Agnico Developing Several Properties To Treat Tailings (article); The Northern Miner Press, September 15, 1966.

(The) Northern Miner Press
1966b: Operating Profit Down for Agnico First Nine Months (article); The Northern Miner Press, December 1, 1966.

(The) Northern Miner Press
1967a: Silver Town Mines Now In Production Making Mill Swap (article); The Northern Miner Press, July 27, 1967.

(The) Northern Miner Press
1967b: Agnico's Tailings Net $2 Per Ton (article); The Northern Miner Press, November 23, 1967.

(The) Northern Miner Press
1968a: (article); The Northern Miner Press, June 1, 1968.

(The) Northern Miner Press
1968b: Agnico Developing New Silver Sources (article); The Northern Miner Press, June 6, 1968.

(The) Northern Miner Press
1968c: (article); The Northern Miner Press, July 3, 1968.

(The) Northern Miner Press
1968d: Silver Town Mines Tailings Program Nearing Start-up (article); The Northern Miner Press, July 11, 1968.

(The) Northern Miner Press
1969a: Agnico Profit Cut By Higher Costs Lower Production (article); The Northern Miner Press, June 5, 1969.

(The) Northern Miner Press
1969b: Silver Output Up But Low Prices Affect Agnico (article); The Northern Miner Press, July 3, 1969.

(The) Northern Miner Press
1971: Glen Lake Silver Mines Ltd., Hiho Silver Mines Limited, Receiver's and Manager's Sale By Tender (advertisement); The Northern Miner Press, March 11, 1971.

(The) Northern Miner Press
1972: Agnico, Eagle to merge (article); The Northern Miner Press, April 20, 1972.

(The) Northern Miner Press
1977: Latest Approval (article); The Northern Miner Press, December 29, 1977.

(The) Northern Miner Press
1979: Silverfields production limited by size of property small shaft (article); The Northern Miner Press, October 18, 1979.

(The) Northern Miner Press
1980: Agnico-Eagle now big gold-silver producer; Silver operations doing better (article); The Northern Miner Press, November 27, 1980, p.A19.

(The) Northern Miner Press
1981: Roundup of Metal Prices (article); The Northern Miner Press. January 8, 1981, p.11.

(The) Northern Miner Press
1982: (article); The Northern Miner Press. April 8, 1982.

(The) Northern Miner Press
1983: (article); The Northern Miner Press. January 13, 1983, p.11.

OBM
1907: Mines of Ontario, by E.T. Corkill, Ontario Bureau of Mines Annual Report, 1907, Vol. 16, pt.1, p.55-91.

OBM
1909: Mines of Ontario, by E.T. Corkill, Ontario Bureau of Mines Annual Report, 1909, Vol. 18, pt.1, p.79-140.

OBM
1910: Mines of Ontario, by E.T. Corkill, Ontario Bureau of Mines Annual Report, 1910, Vol. 19, pt.1, p.78-130.

OBM
1912: Mines of Ontario, by E.T. Corkill, Ontario Bureau of Mines Annual Report, 1912, Vol. 21, pt.1, p.100-168.

OBM
1913a: Statistical Review, by T.W. Gibson, Ontario Bureau of Mines Annual Report, 1913, Vol. 22, pt.1, p.5-61.

OBM
1913b: Mines of Ontario, by E.T. Corkill, Ontario Bureau of Mines Annual Report, 1913, Vol. 22, pt.1, p.98-145.

OBM
1914: Mines of Ontario, by T.F. Sutherland, Ontario Bureau of Mines Annual Report, 1914, Vol. 23, pt.1, p.110-193.

OBM
1915: Mines of Ontario, by T.F. Sutherland, E.A. Collins, J.G. McMillan and J. Bartlett, Ontario Bureau of Mines Annual Report, 1915, Vol. 24, pt.1, p.94-170.

OBM
1916: Mines of Ontario, by T.F. Sutherland, E.A. Collins, J.G. McMillan and J. Bartlett, 1916, Vol. 25, pt.1, p.66-162.

OBM
1917a: Statistical Review of the Mineral Industry of Ontario for 1916, by T.W. Gibson, Ontario Bureau of Mines Annual Report, 1917, Vol. 26, p.1-66.:

OBM
1917b: Mines of Ontario, by T.F. Sutherland, E.A. Collins, J.H. Stovel and J. Bartlett, Ontario Bureau of Mines Annual Report, 1917, Vol. 26, p.74-156.

OBM
1918: Mines of Ontario, by T.F. Sutherland, E.A. Collins, and J.H. Stovel, Ontario Bureau of Mines Annual Report, 1918, Vol. 27, pt.1, p.86-154.

OBM
1919a: Statistical Review of the Mineral Industry of Ontario for 1918, by T.W. Gibson, Ontario Bureau of Mines Annual Report, 1918, Vol.28, pt.1, p.1-95.

OBM
1919b: Mines of Ontario, by T.F. Sutherland, E.A. Collins, J.H. Stovel, and A.R. Webster, Ontario Bureau of Mines Annual Report, 1919, Vol. 28, pt.1, p.104-186.

ODM
1920: Mines of Ontario, by T.F. Sutherland, J.G. McMillan, J. Bartlett and A.R. Webster, Ontario Department of Mines Annual Report, 1920, Vol. 29, pt.1, p.66-141.

ODM
1922a: Statistical Review of Ontario's Mineral Industry in 1920, by W.R. Rogers, Ontario Department of Mines Annual Report, 1921, Vol. 30, pt.1, p.1-54.

ODM
1922b: Mines of Ontario, by T.F. Sutherland, J.G. McMillan, J. Bartlett and A.R. Webster, Ontario Department of Mines Annual Report, 1921, Vol. 30, pt.1, p.63-158.

ODM
1923a: Mines of Ontario, by T.F. Sutherland, J.G. McMillan, J. Bartlett, A.R. Webster, and G.E. Cole, Ontario Department of Mines Annual Report, 1921, Vol. 31, pt.10, p.11-86.

ODM
1923b: Mines of Ontario, by T.F. Sutherland, J.G. McMillan, J. Bartlett, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1923, Vol. 32, pt.6, p.6-92.

ODM
1924: Statistical Review of Ontario's Mineral Industry in 1921, by W.R. Rogers, Ontario Department of Mines Annual Report, 1922, Vol. 31, pt.1, p.1-52.

ODM
1925a: Statistical Review of Ontario's Mineral Industry in 1922, by W.R. Rogers, Ontario Department of Mines Annual Report, 1923, Vol.32, pt.1.

ODM
1925b: Statistical Review of Ontario's Mineral Industry in 1923, by W.R. Rogers, Ontario Bureau of Mines Annual Report, 1924, Vol. 33, pt.1.

ODM
1925c: Mines of Ontario, by T.F. Sutherland, J.G. McMillan, J. Bartlett, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1924, Vol.33, pt.7, p.6-98.

ODM
1926a: Statistical Review of Ontario's Mineral Industry in 1924, by W.R. Rogers and A.C. Young, Ontario Department of Mines Annual Report, 1925, Vol. 34, pt.1, p.1-60.

ODM
1926b: Mines of Ontario in 1924, by T.F. Sutherland, J.G. McMillan, Jas. Bartlett, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1925, Vol. 34, pt.1, p.66-169.

ODM
1926c: Mines of Ontario in 1925, by T.F. Sutherland, J.G. McMillan, D. G. Sinclair, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1926, Vol. 35, pt.1, p.73-168.

ODM
1928: Mines of Ontario in 1926, by T.F. Sutherland, J.G. McMillan, D. G. Sinclair, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1927, Vol. 36, pt.1, p.75-178.

ODM
1929: Mines of Ontario in 1927, by T.F. Sutherland, J.G. McMillan, D. G. Sinclair, G.E. Cole and A.R. Webster, Ontario Department of Mines Annual Report, 1928, Vol. 37, pt.1, p.73-184.

ODM
1930: Mines of Ontario in 1928, by D.G. Sinclair, R.H. Cleland, E.C. Keeley, G.S. Jarrett and A.R. Webster, Ontario Department of Mines Annual Report, 1929, Vol. 38, pt.1, p.69-183.

ODM
1931: Mines of Ontario in 1930, by D.G. Sinclair, R.H. Cleland, E.C. Keeley, D.F. Cooper and A.R. Webster, Ontario Department of Mines Annual Report, 1931, Vol. 40, pt.1, p.63-126.

ODM
1932: Mines of Ontario in 1931, by D.G. Sinclair, R.H. Cleland, E.C. Keeley, D.F. Cooper and A.R. Webster, Ontario Department of Mines Annual Report, 1932, Vol. 41, pt.1, p.63-114.

ODM
1933: Mines of Ontario in 1932, by D.G. Sinclair, R.H. Cleland, E.C. Keeley, D.F. Cooper and A.R. Webster, Ontario Department of Mines Annual Report, 1933, Vol.42 pt.1, p.61-112.

ODM
1935a: Statistical Review of Ontario's Mineral Industry in 1933, by W.R. Rogers and A.C. Young, Ontario Department of Mines Annual Report, 1934, Vol 43, pt.1, p.1-46.

ODM
1935b: Mines of Ontario in 1933, by D.G. Sinclair, R.H. Cleland, D.F. Cooper, E.C. Keeley and A.R. Webster, Ontario Department of Mines Annual Report, 1934, Vol. 43, pt.1, p.59-120.

ODM
1936: Mines of Ontario in 1934, by D.G. Sinclair, E.C. Keeley, D.F. Cooper, E.B. Weir and A.R. Webster, Ontario Department of Mines Annual Report, 1935, Vol.44, pt.1, p.67-167.

ODM
1937: Mines of Ontario in 1935, by D.G. Sinclair, E.C. Keeley, D.F. Cooper, E.B. Weir and A.R. Webster, Ontario Department of Mines Annual Report, 1936, Vol.45, pt.1, p.77-188.

ODM
1939: Mines of Ontario in 1937, by D.G. Sinclair, W.O. Tower, J.B. Taylor, D.P. Douglass, A.S. Bayne, A.E. Cave, D.F. Cooper, E.B. Weir and A.R. Webster, Ontario Department of Mines Annual Report, 1938, Vol.47, pt.1, p.80-249.

ODM
1940a: Statistical Review of Ontario's Mineral Industry in 1938, by M. Tremblay, Ontario Department of Mines Annual Report, 1939, Vol. 48, pt.1, p.1-54.

ODM
1940b: Mines of Ontario in 1938, by D.G. Sinclair, A.E. Cave, W.O. Tower, J.B. Taylor, D.P. Douglass, A.S. Bayne, D.F. Cooper, E.B. Weir and A.R. Webster, Ontario Department of Mines Annual Report, 1939, Vol.48, pt.1, p.72-239.

ODM
1941: Mines of Ontario in 1939, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1940, Vol. 49, pt.1, p.72-242.

ODM
1942: Mines of Ontario in 1940, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1941, Vol. 50, pt.1, p.1-166.

ODM
1946a: Mines of Ontario in 1941, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1942, Vol. 51, pt.1, p.64-236.

ODM
1946b: Mines of Ontario in 1942, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1943, Vol. 52, pt.1, p.68-230.

ODM
1946c: Mines of Ontario in 1943, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1944, Vol. 53, pt.1, p.66-198.

ODM
1948a: Mines of Ontario and List of Mines, Quarries and Works Operating in 1944, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1945, Vol. 54, pt.2, p.1-127.

ODM
1948b: Mines of Ontario and List of Mines, Quarries and Works Operating in 1945, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1946, Vol. 55, pt.2.

ODM
1949a: Mines of Ontario in 1946, by the Staff of the Mines Inspection Branch, 1947, Vol.56, pt.2.

ODM
1949b: Mines of Ontario in 1947, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1948, Vol. 57, pt.2.

ODM
1950: Mines of Ontario in 1948, compiled by I. Williams, Ontario Department of Mines Annual Report, 1949, Vol. 58, Pt.2.

ODM
1951: Mines of Ontario in 1949, compiled by I. Williams, Ontario Department of Mines Annual Report, 1950, Vol. 59, pt.2.

ODM
1952a: Statistical Review of Ontario's Mineral Industry in 1950, by M.G. Arnoldi, Ontario Department of Mines Annual Report, 1951, Vol. 60, pt.1, p.1-52.

ODM
1952b: Mines of Ontario in 1950, by M. Reade, Ontario Department of Mines Annual Report, 1951, Vol. 60, pt.2.

ODM
1953a: Statistical Review of Ontario's Mineral Industry for 1951, by M.G. Arnoldi, Ontario Department of Mines Annual Report, 1952, Vol. 61, pt.1, p.1-54.

ODM
1953b: Mining Operations in 1951, by M. Reade, Ontario Department of Mines Annual Report, 1952, Vol. 61, pt.2.

ODM
1954a: Statistical Review of Ontario's Mineral Industry for 1952, by M.G. Arnoldi, Ontario Department of Mines Annual Report, 1953, Vol. 62, pt.1, p.1-66.

ODM
1954b: Mining Operations in 1952, by D.J. Field, Ontario Department of Mines Annual Report, 1953, Vol. 62, pt.2.

ODM
1955: Mining Operations in 1953, by D.J. Field, Ontario Department of Mines Annual Report, 1954, Vol.63, pt.2.

ODM
1956: Mining Operations in 1954, by D.J. Field, Ontario Department of Mines Annual Report, 1955, Vol. 64, pt.2.

ODM
1957: Mining Operations in 1955, by D.J. Field, Ontario Department of Mines Annual Report, 1956, Vol. 65, pt.2.

ODM
1958a: Statistical Review of Ontario's Mineral Industry for 1956, by M.G. Arnoldi, Ontario Department of Mines Annual Report, 1957, Vol.66, pt.1, p.1-41.

ODM
1958b: Mining Operations in 1956, by D.J. Field, Ontario Department of Mines Annual Report, 1957, Vol.66, pt.2.

ODM
1960a: Mining Operations in 1957, by D.J. Field, Ontario Department of Mines Annual Report, 1957, Vol.67, pt.2.

ODM
1960b: Mining Operations in 1958, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1959, Vol. 68, pt.2.

ODM
1961: Mining Operations in 1959, by the Staff of the Mines Inspection Branch, Ontario Department of Mines Annual Report, 1960, Vol. 96, pt.2.

ODM
1962: Statistical Review of the Mineral Industry for 1960 Combined with Mining Operations, by T.J. Kelly and G.S. Riddell, Ontario Department of Mines Annual Report, Vol. 70.

ODM
1963: Statistical Review of Ontario's Mineral Industry and Mining Operation for 1961, by T.J. Kelly and G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1961, Vol. 71.

ODM
1964: Statistical Review of Ontario's Mineral Industry and Mining Operation for 1962, by T.J. Kelly and G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1962, Vol. 72.

ODM
1965: Statistical Review of Ontario's Mineral Industry and Mining Operation for 1963, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1963, Vol. 73.

ODM
1966: Statistics of the Mineral Industry and Mining Operations in Ontario for 1964, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1964, Vol. 74.

ODM
1968a: Statistics of the Mineral Industry and Mining Operations in Ontario for 1965, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1965, Vol. 75.

ODM
1968b: Statistics of the Mineral Industry and Mining Operations in Ontario for 1966, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1966, Vol. 76.

ODM
1969: Statistics of the Mineral Industry and Mining Operations in Ontario for 1967, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1967, Vol. 77.

ODM
1970: Report on Mining Operations in Ontario, by G.S. Riddell, Ontario Department of Mines Annual Report for the Year 1968, Vol. 78.

ODMNA
1971: Report on Mining Operations in Ontario, by G.S. Riddell, Ontario Department of Mines and Northern Affairs Annual Report, 1969, Vol. 79.

ODMNA
1972: Report on Mineral Industry Operations in Ontario during Calendar Year 1970, by E.E. Matten, Ontario Department of Mines and Northern Affairs Annual Report, 1970, Vol. 80.

Ontario Water Resources Commission
1967: The Cobalt Camp: A Preliminary Assessment of Water Pollution by Mining Wastes in the Cobalt Area; Government of Ontario, Toronto.

Reid, F.D., Denny, J.J. and Hutchison, R.H.
1924: Milling and Metallurgical Practice in Treatment of Silver Ores at Cobalt, Timiskaming District, Ontario, Ontario Department of Mines Annual Report, 1922, Vol. 31, pt.2, p.239-320.

Thomson, R.
1960: Part of Lorrain Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-61, 1"-400'.

Thomson, R.
1960: Part of Lorrain Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-62, 1"-400'.

Thomson, R.
1960: Part of Lorrain Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-63, 1"-400'.

Thomson, R.
1960: Part of Lorrain Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-64, 1"-400'.

Thomson, R.
1960: Part of Lorrain Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-65, 1"-400'.

Thomson, R.
1960: Part of Bucke Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-66, 1"-400'.

Thomson, R.
1960: Part of Bucke Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-67, 1"-400'.

Thomson, R.
1960: Underground Workings, Southeastern Part, Bucke Township, and Profile Across Lake Timiskaming Fault Zone, Ontario, Ontario Department of Mines Map P-67A, 1"-400'+ 1"-160'.

Thomson, R.
1960: Part of Coleman Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-79, 1"-400'.

Thomson, R.
1960: Part of Coleman Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-80, 1"-400'.

Thomson, R.
1960: Part of Coleman and Gillies Limit Townships, District of Timiskaming, Ontario, Ontario Department of Mines Map P-81, 1"-400'.

Thomson, R.
1960: Part of Coleman and Gillies Limit Townships and Part of Latchford Townsite, District of Timiskaming, Ontario, Ontario Department of Mines Map P-82, 1"-400'.

Thomson, R.
1960: Part of Gillies Limit Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-83, 1"-400'.

Thomson, R.
1960: Geology of the North Part of Lorrain Township, Concessions 7 to 12, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1960-1.

Thomson, R.
1960: Bucke Township, Timiskaming District, Ontario, with Descriptions of Mining Properties, Ontario Department of Mines Preliminary Report 1960-2, Reprinted with minor corrections 1964.

Thomson, R.
1960: Parts of Coleman Township and Gillies Limit to the South and Southwest of Cobalt, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1960-3, Reprinted with minor corrections 1965.

Thomson, R.
1961: Coleman and Gillies Limit Townships and Part of Latchford Townsite, District of Timiskaming, Ontario, Ontario Department of Mines Map P-95, 1"-400'.

Thomson, R.
1961: Underground Workings and Structural Contours of the Top Contact of Nipissing Sill, Coleman Tp. + Gillies Limit Tp, Timiskaming District, Ontario Department of Mines Map P-95A, 1"-400'+ 1"-160'.

Thomson, R.
1961: Coleman and Gillies Limit Townships, District of Timiskaming, Ontario, Ontario Department of Mines Map P-96, 1"-400'.

Thomson, R.
1961: Part of Underground Workings and Approximate Structural Contours, Coleman Township, District of Timiskaming, Ontario Department of Mines Map P-96A, 1"-400'+ 1"-160'.

Thomson, R.
1961: Coleman Township, District of Timiskaming, Ontario, Ontario Department of Mines Map P-97, 1"-400'.

Thomson, R.
1961: Part of Underground Workings and Approximate Structural Contours, Coleman Township, District of Timiskaming, Ontario Department of Mines Map P-97A, 1"-400'+ 1"-160'.

Thomson, R.
1961: Parts of Coleman Township and Gillies Limit near New Lake Southeast of Cobalt, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1961-2.

Thomson, R.
1961: Part of Coleman Township, Concession 6, Lots 1 to 6, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1961-3.

Thomson, R.
1961: Part of Coleman Township, Concession 5, Lots 1 to 6, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1961-4.

Thomson, R.
1961: Parts of Coleman Township, Concession 4, Lots 1 to 5 and Gillies Limit, the Eastern A Claims, District of Timiskaming, Ontario, Ontario Department of Mines Preliminary Report 1961-6.

Thomson, R.
1961: Parts of Coleman Township, Concession 3, Lots 1-5 and Gillies Limit, Blocks 1+2, Claims A48-58 and A88-100, Timiskaming District, Ontario, Ontario Department of Mines Preliminary Report 1961-7.

Thomson, R.
1962: Indexes for PRS Issued in 1960-1 Covering Parts of Bucke + AL 3 Tps in Vicinity of Cobalt, District of Timiskaming, Ontario, Ontario Department of Mines Preliminary Report 1962-2.

Thomson, R.
1964: Cobalt Silver Area, Northern Sheet, Timiskaming District, Ontario, Ontario Department of Mines Colour Map 2050, 1"-1,000'.

Thomson, R.
1964: Cobalt Silver Area, Southwestern Sheet, Timiskaming District, Ontario, Ontario Department of Mines Colour Map 2051, 1"-1,000'.

Thomson, R.
1964: Cobalt Silver Area, Southeastern Sheet, Timiskaming District, Ontario, Ontario Department of Mines Colour Map 2052, 1"-1,000'.

Toronto Star
1972: (article); The Toronto Star, February 19, 1972.

Tshwenygo, A.
1979: Tailings Revegetation Plot Update, August 15, 1979; Resident Geologist's files, Resident Geologist's Office, Ministry of Northern Development and Mines).

Watson, R.B.
1912: Nipissing High Grade Mill, Cobalt; The Engineering and Mining Journal, Vol. 94, No.23, p.1077-1080, December 7, 1912.

ADDITIONAL BIBLIOGRAPHY

The following historical and scientific references are offered for further information not covered in the scope of this paper.

Baldwin, D and Dunn, J.A.
1988: Cobalt: a pictorial history of the development of silver mining; Highway Book Shop, Cobalt, Ontario.

Barlow, A.E.
1899: Geology and Natural Resources of the Nipissing and Timiskaming map-sheets; Geological Survey of Canada, Annual Report, 1897, Vol. 10.

Barnes, M
1986: Fortunes in the ground: Cobalt, Porcupine & Kirkland Lake; Boston Mills Press, Erin, Ontario.

Boyle, R.W. and Dass, A.S.
1971: The Geochemistry of Supergene Process in the Native Silver Veins of the Cobalt-South Lorrain Area; in the Silver-Arsenide Deposits of the Cobalt-Gowganda Region, Ontario; The Canadian Mineralogist, Vol. 11, pt.1, p.358-390.

Denny, J.J.
1913: Desulphurizing Silver Ores at Cobalt; Mining and Scientific Press, September 27, 1913, p.484-485.

Fancy, P.
1985: Silver Centre: The Story of an Ontario Mining Camp; Highway Book Shop, Cobalt

Fancy, P.
1987: Silver Centre Rediscovered; Highway Book Shop, Cobalt

Fancy, P.
1992: Temiskaming Treasure Trails, Highway Book Shop, Cobalt.

Gard, A.A.
1908: The Real Cobalt; The Emerson Press, Toronto

Gard, A.A.
1909: Silverland and Its Stories; The Emerson Press, Toronto.

Hawley, J.R.
1977: Unpublished field notes from Cobalt mine tailings field surveys; Available in the Cobalt Resident Geologist's Office.

Hawley, J.R.
1977: The Problem of Acid Mine Drainage in the Province of Ontario; Ontario Ministry of the Environment.

Hawley, J.R.
1982: The Physical, Chemical and Radiological Characteristics of the Surface Layers of Ontario Uranium Tailings Deposits 1982; Ontario Ministry of the Environment.

Hawley, J.R.
1984: Levels of Metals and Non Metals in Vegetation Growing on Deposits of Mineral Tailings in the Province of Ontario 1984; Water Resources Branch, Ontario Ministry of the Environment.

Higgins, E.
1909: Operations in the Cobalt District, Ontario; The Engineering and Mining Journal, Vol. LXXXVII, No. 26, p.1268-1272.

Jambor, J.L.
1971: General Geology. in Berry, L.G. (ed); The Silver-Arsenide Deposits of the Cobalt-Gowganda Region, Ontario; The Canadian Mineralogist, Vol. 11, pt.1, p.12-33.

Livermore, R.
1914: Draining Kerr Lake, Cobalt, Ontario; Journal of the Canadian Mining Institute, p.165-191.

Miller, W.G.
1903: Cobalt-nickel arsenides and silver; Ontario Bureau of Mines Annual Report for 1903, Vol. 13, pt.1, p.96-103.

Miller G. and Young, M.
1985: The use of cattails to treat sewage in Northern Ontario; Ontario Ministry of the Environment, unpublished report.

Thomson, R.T.
1965: Casey and Harris Townships, District of Timiskaming, Ontario, Ontario Department of Mines Geological Report 36, 77p.

APPENDICES

APPENDIX A
MILLING AND METALLURGICAL PRACTICE IN TREATMENT OF SILVER ORES AT COBALT
Fraser D. Reid, J.J. Denny, and R.H. Hutchison . A-1

APPENDIX B
TAILINGS ANALYSIS
J. Hawley B-1

APPENDIX C
COBALT CAMP MILL STATISTICS C-1

APPENDIX D
THE MILLS AND THEIR OWNERS D-1

APPENDIX E
THE OWNERS AND THEIR MILLS E-1

APPENDIX F
TAILINGS SITES F-1

APPENDIX G
REWORKED TAILINGS G-1

APPENDIX H
COBALT TAILINGS GRAIN SIZE ANALYSIS H-1

APPENDIX I
PENN MILL
W. Montgomery I-1

APPENDIX J
CANADAKA MILL
E.C. Blakemore J-1
CANADAKA MILL REPORT
L. Othmer J-3

APPENDIX K
THE OCCURRENCE OF ARSENIC AND HEAVY METAL CONTAMINATION FROM NATURAL AND ANTHROPOGENIC SOURCES IN THE COBALT AREA OF ONTARIO
Charles G. Dumaresq K-1

APPENDIX L
Legends and Symbols for Tailings Maps L-1

APPENDIX A

MILLING AND METALLURGICAL PRACTICE IN TREATMENT OF SILVER ORES AT COBALT

By

Fraser D. Reid, J.J. Denny, and R.H. Hutchison

SUMMARY OF THE REPORT

The important points in the milling and metallurgical treatment of Cobalt[1] ores are summarized below. These are developed in greater detail in the discussion which follows. (See page 246 *et seq.*)

The Ore

1. The ores of the Cobalt area are a complex assemblage of minerals of which silver, and to a lesser extent, cobalt and arsenic, are the valuable elements.

2. It is estimated that 97 per cent. of the silver is found in the form of more or less impure native silver. The chief impurity is antimony, together with arsenic and smaller amounts of other elements.

3. The remaining 3 per cent. of the silver is found in various minerals, some of them complex, in which the silver is chemically combined with sulphur, arsenic, antimony, and bismuth. The more important of these minerals are argentite, and the ruby silvers, proustite and pyrargyrite.

4. The valuable minerals have a high specific gravity, and for the most part are readily recovered by standard methods of gravity concentration.

5. The concentrates produced by table concentration and flotation operations are much higher in base-metal sulphides than are the products from jigging and hand-sorting.

6. Gravity concentration will effect a recovery of 80 per cent. of the values from an ore containing 25 ounces of silver to the ton.

[1] The reader will bear in mind that the word "Cobalt" when spelled with a capital "C" refers to the area, not to the metal.

7. Early attempts to cyanide the complex ores of Cobalt were unsatisfactory, owing to the heavy consumption of cyanide, the fouling of the working solution, and the prolonged treatment required.

8. The early difficulties were solved by adoption of the practice of fine grinding, by precipitation with aluminum, and later sodium sulphide, and under some conditions, by a preliminary desulphurization treatment.

9. Of the various cyanides present, nickel is the most troublesome in the treatment of high-grade ore and table concentrates. The low-grade wall-rock contains, in addition, sulphides of copper and iron that are cyanide-consuming minerals.

10. The cyanidation of high-grade ores and table concentrates requires a preliminary treatment for the removal or oxidation of the various cyanides present.

11. Flotation concentrates, for the most part, cannot be treated locally by cyanidation, owing to the large amount of base-metal cyanides present.

12. Processes used to recover the silver from the high-grade ore include the amalgamation-cyanidation treatment, the hypochlorite-cyanidation treatment, and the acid-wash cyanidation treatment.

13. Argentite, the ruby silvers, and pure leaf-silver float readily. Antimonial silver, oxidized ores, and cobalt arsenides are floated with difficulty.

Crushers and Crushing

1. The general practice is to use a Blake or jaw crusher as the primary breaker, followed by a medium-size gyratory crusher.

2. The use of the gravity stamp as an intermediate crusher predominates throughout the camp.

3. Fine-grinding is done in tube-mills, the present tendency being to substitute iron balls for flint pebbles.

4. The economic limit of crushing is about 16 mesh for gravity concentration, a minus 80 mesh for flotation, and minus 200-mesh for cyanidation.

Gravity Concentration-Low Grade Ore

1. The early practice was to give the ore a preliminary washing treatment by jigging and hand-sorting, to recover portions of high-grade vein matter broken into the mill-rock.

2. Table concentration is effective on sizes from one-quarter inch to minus 200-mesh sands. The sand tables recover a high-grade concentrate, and discharge a low-grade tailing. The fines are treated or re-treated on slime tables.

3. With the introduction of the flotation process, the preliminary washing treatment was discontinued. Coarser battery screens are used, the battery-discharge is given a roughing treatment on sand tables, and classified, the coarser portion being re-ground in tube-mills, with iron balls. The tube-mill discharge after classification is concentrated on slime tables, the tailing from which goes to the flotation plant.

4. The concentrates from the tables are re-cleaned on a separate table.

5. The middling from the re-cleaning table in some cases is re-ground, but usually is returned in closed circuit to the cleaning table.

Cyanidation

1. Cyanidation was first used as an accessory treatment to recover the values in the slime tailing, the first plant to operate being the Buffalo.

2. Concentration followed by re-grinding and cyanidation was first used at the O'Brien mill, where precipitation with aluminum dust was developed.

3. In the early Nipissing practise, the ore below the stamps was treated by straight cyanidation, after a preliminary desulphurizing treatment. Precipitation was with aluminum dust.

4. Sodium sulphide in 1916 was introduced in place of aluminum as the precipitant.

5. Flotation following cyanidation was not successful.

6. The present Nipissing practise is gravity concentration in cyanide solution, followed by cyanidation after extremely fine grinding.

7. The pulp is agitated for 50 hours in tanks provided with mechanical agitators, in a solution containing 0.25 per cent. KCN, with a dilution of 2.5:1. Aeration is effected by means of 6-inch air-lifts.

8. At the Cobalt Reduction Company, 45 per cent. of the feed to mill is rejected as a 40-mesh and finer sand tailing from table concentration. The remaining 55 per cent. is slime which is treated by cyanidation.

9. Extremely fine grinding is essential to dissolution of the silver values in a reasonable time of treatment.

10. Desulphurization is effective only on ores containing considerable amounts of the complex silver minerals, and is not applicable to the general ore of the camp.

11. The precipitate of silver sulphide is desulphurized with aluminum in a solution of caustic soda. It is then melted and refined in a reverberatory furnace and cast into bars.

12. Sampling of wet concentrates, by coning and quartering, gives accurate results.

Flotation

1. The flotation process was adapted to the treatment of Cobalt ores as a result of the work at the Buffalo experimental plant.

2. Flotation plays a useful part in the re-treatment of fines, following gravity concentration.

3. The Callow pneumatic system of flotation is used throughout the camp.

4. The oil mixture in general use is 70 per cent. coal tar creosote, 20 per cent. pine oil, and 10 per cent. coal tar. At the Coniagas plant, in order to treat oxidized minerals, the mixture is sulphidized by distilling the oil, under pressure with sulphur.

5. Grinding is done to 80 to 100 mesh in tube-mills, or Hardinge mills, using iron balls.

6. The concentrate made by the rougher cells is low in grade, containing about 50 ounces of silver to the ton. This is raised to from 400 to 600 ounces to the ton by re-treatment in re-cleaning cells.

7. The tailing from the cleaner cells is the middling. This is either returned to the rougher cell, or is treated in a separate circuit by flotation or cyanidation.

8. The recovery of undissolved mineral from cyanide tailing by flotation was not successful at the Nipissing mine.

9. The attempt to recover the silver from the flotation concentrate by means of a chloridizing roast in Holt-Dern furnaces, followed by an acid salt-leach or by cyanidation, was not a commercial success.

10. Owing to the high cost of marketing flotation concentrates, the production of high-grade concentrate is essential.

High-Grade Treatment

1. By the amalgamation-cyanidation treatment, 95 to 96 per cent. of the silver was recovered by amalgamating the ore with mercury in a tube-mill. The remaining 4 to 5 per cent. was recovered by agitating the residue from amalgamation for 36 hours in 0.75 per cent. KCN solution.

2. The amalgam was retorted in oil-fired retorts, and the resulting sponge melted and refined in an oil-fired reverberatory furnace.

3. The Thornhill process was used successfully at the Buffalo mill to recover the mercury from the residues. It consisted of leaching the residues with a solution containing 4 per cent. sodium sulphide, which is a solvent for mercuric sulphide.

4. Various means were tried at the Nipissing plant to recover the mercury volatilized during the retorting and refining process. These included a system of flues, a bag-house, and the Cottrell system of fume precipitation.

5. The process now used to recover the silver from high-grade ore and table concentrates involve a preliminary treatment for the removal or oxidation of base-metal cyanides, followed by cyanidation.

6. In the hypochlorite treatment, the ore is ground to 200 mesh in tube-mills, using 2-inch iron balls. Calcium hypochlorite is added to the amount of 50 to 75 lbs. per ton of ore. The tube-mill discharge is classified, and the classifier overflow, after

settling and decanting, is filtered on Oliver filters, and washed free of chlorides.

7. In the acid-wash treatment, the pulp, after being ground to 200 mesh is agitated with a 3 per cent. solution of sulphuric acid at dilution of 2:1. The pulp is washed several times by dilution and decantation, and lime is added to neutralize the acidity.

8. Cyanidation of the pulp is effected by agitating it for 8 to 14 hours with a solution containing 0.5 per cent. KCN at a dilution of 20-35:1.

9. Both treatments give a recovery of 98 per cent. of the silver.

APPENDIX B

TAILINGS ANALYSIS

after J. Hawley, 1979, p.179-185

TAILINGS AREAS	COBALT AREA	BUFFALO	CONIAGAS	TRETHEWEY
PRODUCTION BEGAN	1904	1905	1905	1904
Sodium as Na	27,113	23,600	38,900	31,200
Magnesium as Mg	9,113	13,200	8,670	14,400
Aluminum as Al	40,995	60,400	47,200	50,000
Phosphorus as P	1,155	868	465	475
Potassium as K	8,779	9,900	6,520	6,720
Calcium as Ca	4,406	9,900	4,670	4,190
Titanium as Ti	1,038	1,270	190	267
Iron as Fe	50,121	56,700	43,500	40,900
Sulphate as SO4	12,714	11,100	40,300	6,010
Carbonate as CO3	5,203	9,000	<1,000	<1,000
Cobalt as Co	426	490	95	95
Nickel as Ni	166	278	76	76
Copper as Cu	309	699	419	419
Zinc as Zn	314	913	107	107
Arsenic as As	4,275	6,800	594	594
Molybdenum as Mo	<1.1	<0.6	<0.6	<0.6
Cadmium as Cd	1.5	2.9	1.1	1.9
Tin as Sn	74	72	76	87
Antimony as Sb	267	468	99	93
Barium as Ba	34	42	27	42
Mercury as Hg	1.335	3.310	0.723	0.288
Lead as Pb	101	961	19	33
Bismuth as Bi	26	<10	12	15
Chromium as Cr	151	155	263	369
Manganese as Mn	644	680	400	360
Fluorine as F	257	226	78	113
Nitrogen as N	48.0	36.2	<2.8	14.0
Boron as B	95	84	85	145
Chlorine as Cl	<1.3	<10	<10	<10
Selenium as Se	<1.3	<1	<1	<1
Strontium as Sr	59	82	77	93
Vanadium as V	216	971	195	156

TAILINGS AREAS	HUDSON BAY	SASAGINAGA CREEK	COBALT LAKE MINE	COBALT LAKE BASEBALL
PRODUCTION BEGAN	1905		1908	
Sodium as Na	33,100	68,900	17,500	63,400
Magnesium as Mg	15,000	5,720	6,350	6,340
Aluminum as Al	46,600	53,800	39,300	47400
Phosphorus as P	511	617	4,460	564
Potassium as K	8,016	8,240	10	5,940
Calcium as Ca	3,310	2,420	2,880	5,940
Titanium as Ti	244	582	1,200	1,650
Iron as Fe	41,100	41,900	60,400	47,700
Sulphate as SO4	11,500	10,000	6,170	7,790
Carbonate as CO3	<1,000	2,500	5,400	2,000
Cobalt as Co	264	84	4,060	80
Nickel as Ni	52	88	2,070	64
Copper as Cu	650	262	1,390	40
Zinc as Zn	361	194	347	99
Arsenic as As	952	718	1,170	41
Molybdenum as Mo	<0.6	<0.6	2.2	<0.6
Cadmium as Cd	1.9	1.4	0.9	0.6
Tin as Sn	78	47	69	84
Antimony as Sb	148	143	531	229
Barium as Ba	50	20	30	35
Mercury as Hg	0.340	0.421	2.540	0.581
Lead as Pb	107	370	75	11
Bismuth as Bi	20	<10	106	<10
Chromium as Cr	110	116	119	119
Manganese as Mn	401	369	516	455
Fluorine as F	161	243	263	212
Nitrogen as N	16.7	55.5	86.5	33.4
Boron as B	2	57	115	95
Chlorine as Cl	<10	<10	10	10
Selenium as Se	1	<1	10	<1
Strontium as Sr	74	61	27	82
Vanadium as V	160	116	142	971

TAILINGS AREAS	LAROSE	NIPISSING 404	RIGHT OF WAY MINE	NOVA SCOTIA
PRODUCTION BEGAN	1904	1904	1906	1905
Sodium as Na	23,700	25,400	23,900	2,500
Magnesium as Mg	106,000	7,730	6,740	9,700
Aluminum as Al	50,400	40,400	36,200	46,000
Phosphorus as P	691	2,800	2,020	1,440
Potassium as K	10,800	4,060	6,840	14,000
Calcium as Ca	3,260	4,260	2,832	10,400
Titanium as Ti	1,200	681	1,040	307
Iron as Fe	49,100	51,200	46,900	46,400
Sulphate as SO4	13,600	9,700	15,700	2,980
Carbonate as CO3	3,600	7,200	2,000	9,150
Cobalt as Co	173	2,100	1,490	8
Nickel as Ni	103	10,000	862	182
Copper as Cu	159	813	693	210
Zinc as Zn	801	545	342	200
Arsenic as As	1,040	11,700	4,700	8,330
Molybdenum as Mo	<0.6	<0.6	<0.6	<0.6
Cadmium as Cd	3.2	2.4	1.2	1.6
Tin as Sn	55	81	65	233
Antimony as Sb	19	445	234	1,590
Barium as Ba	63	14	25	57
Mercury as Hg	0.608	16.6	8.36	0.769
Lead as Pb	1,130	91	66	267
Bismuth as Bi	<10	90	<10	<10
Chromium as Cr	99	89	107	130
Manganese as Mn	455	624	566	509
Fluorine as F	315	236	243	258
Nitrogen as N	14.0	38.9	100.0	25.1
Boron as B	88	88	73	115
Chlorine as Cl	<10	<10	10	<10
Selenium as Se	1	4	1	<1
Strontium as Sr	46	67	57	58
Vanadium as V	198	159	167	120

TAILINGS AREAS	CANADAKA MILL	GLEN LAKE	TEMISKAMING	CROSS LAKE SW CORNER
PRODUCTION BEGAN	1908	1906	1907	
Sodium as Na	25,800	15,700	8,650	24,400
Magnesium as Mg	6,170	8,560	12,300	7,680
Aluminum as Al	51,900	29,400	18,100	42,700
Phosphorus as P	451	519	1410	933
Potassium as K	13,600	8,370	9,130	12,800
Calcium as Ca	1,540	5,080	6,150	4,030
Titanium as Ti	354	2,470	190	943
Iron as Fe	30,400	60,700	68,000	42,700
Sulphate as SO4	2,760	11,900	28,900	12,600
Carbonate as CO3	<1,000	5,400	5,400	9,000
Cobalt as Co	24	189	559	286
Nickel as Ni	<10	103	174	100
Copper as Cu	68	159	134	192
Zinc as Zn	86.8	229	298	346
Arsenic as As	174	876	8,600	5,120
Molybdenum as Mo	3.8	1.1	2.1	<0.6
Cadmium as Cd	0.6	0.9	1.1	1.2
Tin as Sn	71	67	3	64
Antimony as Sb	141	239	10	10
Barium as Ba	19	40	<10	38
Mercury as Hg	0.052	0.154	0.485	2.54
Lead as Pb	8	46	22	69
Bismuth as Bi	<10	<10	19	<10
Chromium as Cr	106	239	143	106
Manganese as Mn	251	1,170	1,330	490
Fluorine as F	276	148	178	834
Nitrogen as N	53.0	36.1	19.6	61.5
Boron as B	88	93	98	103
Chlorine as Cl	17	10	17	17
Selenium as Se	<1	<1	<1	1
Strontium as Sr	58	63	36	49
Vanadium as V	138	256	246	192

TAILINGS AREAS	CROSS LAKE SE CORNER	COBALT LODE	DATA RANGE
PRODUCTION BEGAN		1917	
Sodium as Na	21,000	10,300	8,650 - 68,900
Magnesium as Mg	7,370	9,960	4,940 - 15,000
Aluminum as Al	30,900	26,600	18.100 - 60, 400
Phosphorus as P	985	386	386 - 4,460
Potassium as K	9,020	9,660	4,060 - 14,000
Calcium as Ca	3,200	6,180	1,540 - 10,400
Titanium as Ti	1,580	1,500	190 - 2,470
Iron as Fe	56,500	49,300	30,400 - 68,000
Sulphate as SO4	20,100	10,300	2,760 - 40,300
Carbonate as CO3	9,000	9,000	<1,000 - 9,150
Cobalt as Co	566	189	8 - 4,060
Nickel as Ni	88	39	<10 - 10,000
Copper as Cu	281	139	40 - 1,390
Zinc as Zn	233	159	86.8 - 913
Arsenic as As	7,110	1,180	41 - 11,700
Molybdenum as Mo	<0.6	1.1	<0.6 - 3.8
Cadmium as Cd	1.2	0.6	0.6 - 3.2
Tin as Sn	80	82	3 - 233
Antimony as Sb	176	222	10 - 1,590
Barium as Ba	29	5	5 - 63
Mercury as Hg	2.37	0.28	0.052 - 16.6
Lead as Pb	314	27	8 - 1,130
Bismuth as Bi	53	14	<10 - 106
Chromium as Cr	38	129	38 - 369
Manganese as Mn	592	1,150	251 - 1,400
Fluorine as F	352	134	78 - 834
Nitrogen as N	143.0	47.3	<2.8 - 143
Boron as B	100	90	2 - 145
Chlorine as Cl	17	<10	<10 - 35
Selenium as Se	<1	<1	<1 - 10
Strontium as Sr	55	52	27 - 93
Vanadium as V	222	199	116 - 971

APPENDIX C

COBALT CAMP MILL STATISTICS

Ontario government annual reports, research papers, assessment files, newspaper reports and many other sources were searched to compile as complete a record of milling statistics as possible.

The records are presented in the same order as the corresponding mill appears in the text

Tailings Area: COBALT CATCHMENT AREA, WEST ARM **Mill: BUFFALO**

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	5,480		38.78	80.50	7.6	Buffalo Mines Ltd., Semi-Annual Report, 1908	Buffalo Mines Ltd.
1908	10,200					Cole, 1909, p.82	Buffalo Mines Ltd.
1909	33,708		40.00	78.60	8.5	Buffalo Mines Ltd., Fourth AnnualReport, 1910	Buffalo Mines Ltd.
1909		6,424	12.92	66.08	4.4	Buffalo Mines Ltd., Fourth Annual Report, 1910	Buffalo Mines Ltd.
1910	41,484		36.07	80.07	7.2	Buffalo Mines Ltd., Fifth Annual Report, 1911	Buffalo Mines Ltd.
1910		11,700	13.06	67.62	4.2	Buffalo Mines Ltd., Fifth Annual Report, 1911	Buffalo Mines Ltd.
1911	46,801		32.35	80.63	6.3	Buffalo Mines Ltd., Sixth Annual Report, 1912	Buffalo Mines Ltd.
1911		7,744	10.01	65.54	3.4	Buffalo Mines Ltd., Sixth Annual Report, 1912	Buffalo Mines Ltd.
1912	55,783	46	82.64	8.00		Buffalo Mines Ltd., Sevent Annual Report, 1913	Buffalo Mines Ltd.
1912		10,320	15.45	74.70	3.9	Buffalo Mines Ltd., Sevent Annual Report, 1913	Buffalo Mines Ltd.
1913	77,616		23.81	76.14	6.0	Buffalo Mines Ltd., Eighth Annual Report, 1914	Buffalo Mines Ltd.
1913		13,388	10.13	77.80	2.2	Buffalo Mines Ltd., Eighth Annual Report, 1914	Buffalo Mines Ltd.
1914	51,667		19.50	72.22	5.4	Buffalo Mines Ltd., Ninth Annual Report, 1915	Buffalo Mines Ltd.
1914		8,385	9.86	82.86	1.8	Buffalo Mines Ltd., Ninth Annual Report, 1915	Buffalo Mines Ltd.
1915	30,079		19.80		5.5	OBM, 1916, p.105	Buffalo Mines Ltd.
1915	7,073	1,005	25.46		1.0	OBM, 1916, p.105	Buffalo Mines Ltd.
1915		6,340			1.9	OBM, 1916, p.105	Buffalo Mines Ltd.
1916	14,452	38,545				OBM, 1917b, p.110	Buffalo Mines Ltd.
1917		82,328				OBM, 1917b, p.116	Buffalo Mines Ltd.
1918	30,572	77,239				Buffalo Mines Ltd, 13th Annual Report, 1919	Buffalo Mines Ltd.
1919	21,612	66,734				ODM, 1920, p.91	Buffalo Mines Ltd.
1920		71,476	3.92	51.06	1.9	ODM, 1922b, p.117	The Cobalt Reduction Co. Ltd.
1920	slimes	6,440	6.10	83.87	1.0	ODM, 1922b, p.109	The Coniagas Mines Ltd.
1921	slimes	14,932				Coniagas Mines Ltd., 1921 Report, p.8	The Coniagas Mines Ltd.
1922		54,362				ODM, 1923b, p.72-73	The Cobalt Reduction Co. Ltd
	426,527	477,408	15.38	40.22	2.8		

Tailings Area: COBALT CATCHMENT AREA, WEST ARM   Mill: CONIAGAS

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	14,064		34.50		6.10	Reid et al, 1924, p.276	The Coniagas Mines Ltd.
1909	19,038		37.00		5.50	Reid et al, 1924, p.276	The Coniagas Mines Ltd.
1910	33,539		33.60		5.30	Reid et al, 1924, p.276	The Coniagas Mines Ltd.
1911	52,320		36.30	87.00	4.75	Reid et al, 1924, p.276	The Coniagas Mines Ltd.
						The Coniagas Mines Ltd., 1911 Annual Report, p.7	
1912	53,627		34.12	sand	4.12	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	7.29	1912 Annual Report, p.8	
1913	54,890		28.30	sand	3.52	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	6.13	1913 Annual Report, p.7	
1914	54,522		24.00	sand	3.18	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	6.66	1914 Ann. Report, p.9-10	
1915	55,437		23.00	sand	2.89	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	6.36	1915 Ann. Report, p.10-11	
1916	56,973		25.76	sand	3.33	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	4.90	1916 Ann. Report, p.10-11	
1917	60,929	969	18.56	sand	3.30	The Coniagas Mines Ltd.,	The Coniagas Mines Ltd.
				slime	2.46	1917 Ann. Report, p.9-10	
1918	68,597		15.94		1.75	The Coniagas Mines Ltd., 1918 Annual Report, p.10	The Coniagas Mines Ltd.
1918		21,887			1.50	The Coniagas Mines Ltd., 1918 Annual Report, p.10	The Coniagas Mines Ltd.
1919	71,744		13.07			The Coniagas Mines Ltd., 1919 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1919		20,683	3.27	65.99	1.38	The Coniagas Mines Ltd., 1919 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1920	97,634		10.22			ODM, 1922b, p.109	The Coniagas Mines Ltd.
1920		37,965		62.75	1.43	ODM, 1922b, p.109	The Coniagas Mines Ltd.
1921	113,280		11.30			The Coniagas Mines Ltd., 1921 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1921		19,125	3.62	68.29	1.62	The Coniagas Mines Ltd., 1921 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1922	121,954		10.45			The Coniagas Mines Ltd., 1922 Annual Report, p.8	The Coniagas Mines Ltd.
1922		24,739	3.52	73.27	2.00	The Coniagas Mines Ltd., 1922 Annual Report, p.8	The Coniagas Mines Ltd.
1922	23,217	Trethewey ore				ODM, 1925, p.68	The Coniagas Mines Ltd.
1923	165,290		8.38			The Coniagas Mines Ltd., 1923 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1923		all mill tails		63.78	1.49	The Coniagas Mines Ltd., 1923 Ann. Report, p.7-8	The Coniagas Mines Ltd.
1924	62165		9.97			ODM, 1926a, p.12	The Coniagas Mines Ltd.
1924		all mill tails		69.21	1.34	ODM, 1926a, p.12	The Coniagas Mines Ltd.
	1,179,220	125,368	18.33	23.35	3.40		

Tailings Area: COBALT CATCHMENT AREA, WEST ARM Mill: TRETHEWEY

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1910	21,000					Cole, 1911, p.102	Trethewey Silver Cobalt Mining Co. Ltd.
1911	33,339					Trethewey Silver Cobalt Mining Co. Ltd. Annual Report for 1911	Trethewey Silver Cobalt Mining Co. Ltd.
1912	26,804					Cole, 1913, p.55	Trethewey Silver Cobalt Mining Co. Ltd.
1913	35,294					Cole, 1914, p.44; OBM, 1914, p.149	Trethewey Silver Cobalt Mining Co. Ltd.
1914	25,216					OBM, 1915, p.122	Trethewey Silver Cobalt Mining Co. Ltd.
1915	6,113					Cole, 1916, p.47; OBM, 1916, p.122	Trethewey Silver Cobalt Mining Co. Ltd.
1916	18,541					OBM, 1917b, p.127	Trethewey Silver Cobalt Mining Co. Ltd.
1917	34,722					OBM, 1918, p.128	Trethewey Silver Cobalt Mining Co. Ltd.
1918	34,546					OBM, 1919b, p.149	Trethewey Silver Cobalt Mining Co. Ltd.
1919		29,416				ODM, 1920, p.106	Trethewey Silver Cobalt Mining Co. Ltd.
	235,575	29,416	0.00	0.00	0.0		

Tailings Area: COBALT CATCHMENT BASIN, WEST ARM Mill: HUDSON BAY

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1912	21,439					OBM, 1913b, p.115	The Hudson Bay Mines Ltd.
1913	22,286					OBM, 1914, p.139	The Hudson Bay Mines Ltd.
1914	18,581		19.05	86.30	2.7	OBM, 1915, p.112; The Hudson Bay Mines Ltd., 5th Annual Report	The Hudson Bay Mines Ltd.
1916	5,022					OBM, 1917b, p.116	The Hudson Bay Mines Ltd.
1918	20,540		9.51	72.00	2.4	The Hudson Bay Mines Ltd., 9th Ann. Rept, 1917,1918	The Hudson Bay Mines Ltd.
1919	21,102		6.27	79.30	1.3	ODM, 1920, p.96	The Hudson Bay Mines Ltd.
1920	20,308		6.00			ODM, 1922b, p.112	The Hudson Bay Mines Ltd.
	129,278	0	5.10	29.70	0.8		

Tailings Area: COBALT CATCHMENT AREA, COBALT LAKE Mill: MCKINLEY-DARRAUGH

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	450					Cole, 1909, p.81	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1909	18,703		49.47	83.87	7.06	McK-D-S. Mines, Report for the Year 1910, p.21	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1910	37,016		48.36	87.61	5.99	McK-D-S. Mines, Report for the Year 1911, p.22	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1911	46,497		39.69	89.61	4.12	McK-D-S. Mines, Report for the Year 1912, p.3,4,11	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1912	52,897					OBM, 1913b, p.118	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1913	63,057					Cole, 1914, p.44	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1914	45,098 McK-D 21,656 Savage		24.10 13.37	85.14 64.13	3.54 4.85	OBM, 1915, p.118	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1915	63,661		17.17	80.90	3.37	McK-D-S. Mines, Report for the Year 1915, p.3, 7	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1916	62,676		6.78	71.37	1.91	OBM, 1917a, p.14; 1917b, p.120	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1917	68,142					OBM, 1918, p.121-124	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1918	67,020		12.92	87.23	1.71	McK-D-S. Mines, Report for the Year 1918, p.3,5,7	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1919	56,631					ODM, 1920, p.98	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1920	63,892		9.00	75.77	2.03	McK-D-S. Mines, Report for the Year 1920, p.7	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1922	25,848		12	83.97	1.95	McK-D-S. Mines, Report for the Year 1922, p.3,4,7	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1923	45,573		9.58	83.59	1.59	McK-D-S. Mines, Report for the Year 1923, p.3,5,7	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1924	56,121		7.28	82.54	1.28	McK-D-S. Mines, Report for the Year 1924	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1925	55,363		8.12	85.08	1.24	McK-D-S. Mines, Report for the Year 1925, p.8, 11	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1926	42,739		8.56	86.00	1.21	ODM, 1928, p.163	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
1927	9,605					ODM, 1929, p.171	McKinley-Darraugh-Savage Mines of Cobalt Ltd.
	902,645	0	16.66	71.68	2.62		

Tailings Area: COBALT CATCHMENT AREA, COBALT LAKE

Mill: COBALT REDUCTION (MUGGLEY CONCENTRATORS, NORTHERN CUSTOM CONCENTRATORS (FIRST MILL), TOWNSITE)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1907						Corkill, 1908, p.97	Muggley Concentrators Ltd
1908	7,947					Cole, 1909, p.82	Northern Custom Concentrators Ltd.
1909	14,815					Cole, 1910, p.99	Northern Custom Concentrators Ltd.
1910	41,679					Cole, 1911, p.102	Northern Custom Concentrators Ltd.
1912	65,000				4.00	OBM, 1913b, p.122-123	Northern Custom Concentrators Ltd.
1914	107,384					OBM, 1915, p. 118	Cobalt Reduction Co.
1915	97,133				3.50	OBM, 1916, p.107	Cobalt Reduction Co.
1916	99,480					OBM, 1917b, p.118	Cobalt Reduction Co.
1917	83,488				2.92	OBM, 1918, p.123	Cobalt Reduction Co.
1918	42,356					OBM, 1919b, p.147	Cobalt Reduction Co.
1919	38,467	28,494 tails 32,904 slimes			2.00 0.80	ODM, 1920, p.99; 1922b, p.116	Cobalt Reduction Co.
1920	63,416	36,664 slimes			0.84	ODM, 1922b, p.116-117	Cobalt Reduction Co.
1921	72,664	35,986 slimes				ODM, 1922a, p.51	Cobalt Reduction Co.
1922	91,730	? slimes				ODM, 1923a, p.72-73	Cobalt Reduction Co.
1923	80,575	12,135				ODM, 1925b, p.74-76	Cobalt Reduction Co.
1924	81,508	59,961			2.20	ODM, 1926b, p.142	Cobalt Reduction Co.
1925	82,581	84,533				ODM, 1926c, p.158	Cobalt Reduction Co.
1926	73,422	72,628				ODM, 1928, p.166-167	Cobalt Reduction Co.
1927	54,360	53,927			2.60	ODM, 1929, p.174-175	Cobalt Reduction Co.
1928	57,969	?				ODM, 1930, p.175	Cobalt Reduction Co.
1929	50,933	50,142				ODM, 1930, p.156-157	Cobalt Reduction Co.
1930	21,565					ODM, 1931, p.113	Cobalt Reduction Co.
1931	6,185					ODM, 1932, p.107	Cobalt Reduction Co.
1932	1,222					ODM, 1933, p.106	Cobalt Reduction Co.
	1,335,879	467,374	0.00	0.00	1.89		

Tailings Area: COBALT CATCHMENT AREA, COBALT LAKE

Mill: COBALT LAKE

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1911	380			sand	4.25	Cobalt Lake, 5th Annual	Cobalt Lake Mining Co.Ltd
				slimes	9.00	Report, 1911, p.11,14	
1912	23,410					OBM, 1913b, p.112	Cobalt Lake Mining Co.Ltd
1913	37,616		25.40			OBM, 1914, p.136	Cobalt Lake Mining Co.Ltd
1915	34,719					OBM, 1916, p.117	Cobalt Lake Mining Co.Ltd
1916	16,374					Cole, 1917, p.19	Cobalt Lake Mining Co.Ltd
	112,499	0	8.47	0.00	4.42		

Tailings Area: COBALT CATCHMENT AREA, COBALT LAKE

Mill: HELLENS

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1951						ODM, 1953b, p.100	Hellens Mining & Reduction Co. Ltd.
1952		109,029	4.40		1,20	ODM, 1954b, p.110; The Northern Miner Press, Apr 24, 1952, Sept. 25, 1952	Hellens Mining & Reduction Co. Ltd.
1953		86,121				ODM, 1955, p.128, 132	Cobalt Consolidated Mining Corporation Ltd.
1954		33,457				The Northern Miner Press, July 8, 1954	Cobalt Consolidated Mining Corporation Ltd.
1967		70,395	3.78	71.69	1.07	ODM, 1969, p.132	Agnico Mines Ltd.
1968		81,530	2.81	63.35	1.03	ODM, 1970, p.105	Agnico Mines Ltd.
1969		151,323				ODMNA, 1971, p.105	Agnico Mines Ltd.
	0	531,855	2.20	33.76	0.66		

Tailings Area: COBALT CATCHMENT AREA, COBALT LAKE

Mill: NIPISSING REDUCTION (ORE REDUCTION, COBALT CONCENTRATORS)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	2,110					Cole, 1909, p.82	Nipissing Reduction Co.
1909	9,899					Cole, 1910, p.99	Nipissing Reduction Co.
1910	13,836					Cole, 1911, p.102	Nipissing Reduction Co.
	25,845	0	0.00	0.00	0.00		

Tailings Area: COBALT CATCHMENT AREA, EAST ARM **Mill: NIPISSING LOW GRADE**

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1913	77,240		27.18	91.85	2.20	Nipissing Mines Co. Ltd. 9th Ann. Rpt., 1913, p.9	Nipissing Mines Co. Ltd.
1914	79,125		30.82	89.64	3.20	Nipissing Mines Co. Ltd. 10th Ann Rpt. 1914, p.9	Nipissing Mines Co. Ltd.
1915	77,183		31.49	87.52	3.90	Nipissing Mines Co. Ltd. 11th Ann Rpt, 1915, p.9	Nipissing Mines Co. Ltd.
1916	76,957		31.96	86.76	4.23	Nipissing Mines Co. Ltd. 12th Ann Rpt, 1916, p.12	Nipissing Mines Co. Ltd.
1917	73,108		32.78	80.64	6.35	Nipissing Mines Co. Ltd. 13th Ann Rpt, 1917, p.15	Nipissing Mines Co. Ltd.
1918	80,317		25.24	87.95	2.84	Nipissing Mines Co. Ltd. 14th Ann Rpt, 1918, p.13	Nipissing Mines Co. Ltd.
1919	65,392		27.09	88.71	3.06	Nipissing Mines Co. Ltd. 15th Ann Rpt, 1919, p.13	Nipissing Mines Co. Ltd.
1920	81,700		27.38	90.55	2.60	Nipissing Mines Co. Ltd. 16th Ann Rpt, 1920, p.13	Nipissing Mines Co. Ltd.
1921	80,720		41.58	93.98	2.48	Nipissing Mines Co. Ltd. 17th Ann Rpt, 1921, p.13	Nipissing Mines Co. Ltd.
1922	80,025		44.01	93.82	2.77	Nipissing Mines Co. Ltd. 18th Ann Rpt, 1922, p.13	Nipissing Mines Co. Ltd.
1923	82,243		44.78	94.62	2.45	Nipissing Mines Co. Ltd. 19th Ann Rpt, 1923, p.13	Nipissing Mines Co. Ltd.
1924	85,734		36.36	96.36	1.32	Nipissing Mines Co. Ltd. 20th Ann Rpt, 1924, p.13	Nipissing Mines Co. Ltd.
1925	91,044		25.78	95.74	1.09	Nipissing Mines Co. Ltd. 21st Ann Rpt, 1925, p.13	Nipissing Mines Co. Ltd.
1926	84,555		23.53	95.30	1.11	Nipissing Mines Co. Ltd. 22nd Ann Rpt, 1926, p.14	Nipissing Mines Co. Ltd.
1927	78,767		23.65	95.99	0.95	Nipissing Mines Co. Ltd. 23rd Ann Rpt, 1927, p.14	Nipissing Mines Co. Ltd.
1928	63,592		30.68	96.66	1.03	Nipissing Mines Co. Ltd. 24th Ann Rpt, 1928, p.14	Nipissing Mines Co. Ltd.
1929	45,421		35.38	96.22	1.35	Nipissing Mines Co. Ltd. 25th Ann Rpt, 1929, p.14	Nipissing Mines Co. Ltd.
1930	40,406		40.29	94.89	2.09	Nipissing Mines Co. Ltd. 26th Ann Rpt, 1930, p.14	Nipissing Mines Co. Ltd.
1931	39,173		29.20	94.00	1.77	Nipissing Mines Co. Ltd. 27th Ann Rpt, 1931, p.8	Nipissing Mines Co. Ltd.
	1,382,702	0	32.06	92.17	2.46		

Tailings Area: COBALT CATCHMENT AREA, EAST ARM Mill: LAROSE

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1952	11,588					ODM, 1954b, p.119	Silver-Miller Mines Ltd.
1953	49,364					ODM, 1955, p.139	Silver-Miller Mines Ltd.
1954	52,641					ODM, 1956, p.135	Silver-Miller Mines Ltd.
1955	87,982					General Manager's Report, Silver-Miller Mines, 1955	Silver-Miller Mines Ltd.
1956	28,152					ODM, 1958b, p.134	Silver-Miller Mines Ltd.
1957	?					ODM, 1960a, p.138	Silver-Miller Mines Ltd.
1958	28,345					ODM, 1960b, p.102	Silver-Miller Mines Ltd.
1959	4,082					ODM, 1961, p.102	Silver-Miller Mines Ltd.
1960	35,519					ODM, 1962, p.117-118	Silver-Miller Mines Ltd.
1961	6,320 from Conisil					ODM, 1963, p.129-130	Silver-Miller Mines Ltd.
	48,925 from Kerr Lake						
	55,247 from Lawson		9.78	91.31	0.83		
1962	2,115 from Conisil					The Northern Miner Press October, 18, 1962	Silver-Miller Mines Ltd.
	4,209 from Kerr Lake						
	12,053 from Lawson					ODM, 1964, p.138-139	
1963	2,420 from Beaver-Temiskaming					ODM, 1965, p.136, 141	Silver-Miller Mines Ltd.
	1,435 from Conisil & Princess		15.73		0.87		
1964	1,008					ODM, 1966, p.137	Silver-Miller Mines Ltd.
1967	6,350		5.70	83.72	5.91	ODM, 1969, p.136	Silver-Miller Mines Ltd.
1968	50,041		3.22	84.25		ODM, 1970, p.110	Silver-Miller Mines Ltd.
1969	40,726 from Crown Reserve		3.38	88.87		ODMNA, 1971, p.110	Glen Lake Mines Ltd.
	6,311 from Kerr Lake		7.27	86.20			
1970	46,082					ODMNA, 1972, p.96	Glen Lake Mines Ltd.
	580,915	0	5.64	62.05	1.52		

Tailings Area: PETERSON LAKE CATCHMENT AREA, CART LAKE Mill: COBALT PROVINCIAL (PROVINCIAL)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1917		1,000				OBM, 1918, p.126	Cobalt Provincial Mining Co, Ltd.
1919	3,384 ore + tailings		11.00			ODM, 1920, p.92	Cobalt Provincial Mining Co, Ltd.
1920	3,680		10.65	67.13	3.50	ODM, 1922b, p.108	Cobalt Provincial Mining Co, Ltd.
	7,064	1,000	5.41	22.38	1.17		

Tailings Area: PETERSON LAKE CATCHMENT AREA, CART LAKE Mill: SENECA-SUPERIOR

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1914	2,526				5.00	OBM, 1915, p.123	Seneca-Superior Silver Mines Ltd.
1915	25,194					OBM, 1916, p.121	Seneca-Superior Silver Mines Ltd.
1916	2,459					Cole, 1917, p.19	Seneca-Superior Silver Mines Ltd.
1918		?	5.00			OBM, 1919b, p.146	Peterson Lake Silver Cobalt Mining Co.
1919		5,720	5.00			ODM, 1920, p.104	Peterson Lake Silver Cobalt Mining Co.
	30,179	5,720	2.50	0.00	2.50		

Tailings Area: PETERSON LAKE CATCHMENT AREA, CART LAKE Mill: SAVAGE

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1910	6,566					McK-D-S Mines of Cobalt Ltd. Rpt. 1910, p.24	McKinley-Darraugh-Savage Mines of Cobalt, Ltd.
1911	13,917					McK-D-S Mines of Cobalt Ltd. Rpt. 1911, p.3,15	McKinley-Darraugh-Savage Mines of Cobalt, Ltd.
1912	17,888					OBM, 1913a, p.21	McKinley-Darraugh-Savage Mines of Cobalt, Ltd.
	38,371	0	0.00	0.00	0.00		

Tailings Area: PETERSON LAKE CATCHMENT AREA, CART LAKE   Mill: SILVERFIELDS (SILVER SUMMIT)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1936	21,027					ODM, 1965, p.143	Silver Summit Mines Ltd.
1964	24,581					ODM. 1966, p.134-135	Silver Summit Mines Ltd.
1965	53,334		33.96	97.97	0.69	Northern Miner Press, Dec. 1, 1966	Silverfields Mining Corp. Ltd.
1966	65,084		22.29	98.10	0.41	ODM, 1968b, p.158	Silverfields Mining Corp. Ltd.
1967	76,030		18.68	98.10	0.34	ODM, 1969, p.144	Silverfields Mining Corp. Ltd.
1968	80,707		14.57	98.30	0.25	ODM, 1970, p.114	Silverfields Mining Corp. Ltd.
1969	79,556		13.70			ODMNA, 1971, p.114	Silverfields Mining Corp. Ltd.
1970	78,583		13.20			ODMNA, 1972, p.99	Silverfields Mining Corp. Ltd.
1971	76,149		13.20			Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1972	79,319					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1973	96,556					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1974	87,891					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1975	48,411					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1976	77,150					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1977	84,468					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1978	85,150					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1979	83,105		9.12	95.10		Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1980	83,821					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1981	86,418					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1982	79,187					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
1983	?					Mineral Statistics Section MNR	Silverfields Mining Corp. Ltd.
	1,446,527	0	13.87	69.65	0.28		

Tailings Area: PETERSON LAKE CATCHMENT AREA Mill: NOVA SCOTIA (DOMINION REDUCTION)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1910	10,887					Cole, 1911, p.102	Nova Scotia Silver-Cobalt Mining Co. Ltd.
1912	21,687					Cole, 1913, p.55	Dominion Reduction Co.
1913	18,252					OBM, 1915, p.141	Dominion Reduction Co.
1914	31,347					OBM, 1916, p.111	Dominion Reduction Co.
1915	78,047					Cole, 1916, p.47	Dominion Reduction Co.
1916	68,611					OBM, 1917b, p.114	Dominion Reduction Co.
1917	56,558					OBM, 1918, p.118-119	Dominion Reduction Co.
1918	28,285 partial					OBM, 1919b, p.132,136,137, p.147	Dominion Reduction Co.
1919	16,615					ODM, 1920, p.95	Dominion Reduction Co.
1920	42,182	4,000				ODM, 1922b, p.111	Dominion Reduction Co.
1921	11,235					ODM, 1923a, p.50	Dominion Reduction Co.
1922		21,770				ODM, 1923b, p.10	Dominion Reduction Co.
	383,706	25,770	0.00	0.00	0.00		

Tailings Area: GIROUX LAKE CATCHMENT AREA Mill: MENSILVO (SILVER ARROW)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1949	3,000					ODM, 1951, p.95	Mensilvo Mines Ltd.
1950	1,500					ODM, 1952b, p.95	Mensilvo Mines Ltd.
1952	9,057					ODM, 1954b, p.112	Mensilvo Mines Ltd.
1953	10,800					ODM, 1955, p.136	Mensilvo Mines Ltd.
1955	5,253					ODM, 1957, p.134	Mensilvo Mines Ltd.
1961	400					ODM, 1963, p.125-126	J.J. Gray
	30,010	0	0.00	0.00	0.00		

Tailings Area: GIROUX LAKE CATCHMENT AREA, GLEN LAKE Mill: PENN-CANADIAN (STANDARD COBALT COBALT CENTRAL)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	14,078					Cole, 1909, p.83	Cobalt Central Mines Ltd.
1909	25,439					Cole, 1910, p.99	Cobalt Central Mines Ltd.
1910	22,452					Cole, 1911, p.102	Cobalt Central Mines Ltd.
1912	5,946					Cole, 1913, p.55	Penn-Canadian Mines Ltd.
1913	19,998					OBM, 1914, p.149	Penn-Canadian Mines Ltd.
1914	24,510					OBM, 1915, p.122	Penn-Canadian Mines Ltd.
1916	33,095					Cole, 1917, p.19	Penn-Canadian Mines Ltd.
1917	31,000					OBM, 1918, p.126	Penn-Canadian Mines Ltd.
1918	29,910					OBM, 1919b, p.146	Penn-Canadian Mines Ltd.
1919	29,910					OBM, 1920, p.104	Penn-Canadian Mines Ltd.
	236,338	0	0.00	0.00	0.00		

Tailings Area: GIROUX LAKE CATCHMENT AREA, GLEN LAKE

Mill: BAILEY (GLEN LAKE)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1962	12,813					ODM, 1964, p.128	Glen Lake Silver Mines Lt
1963	28,011					ODM, 1965, p.129	Glen Lake Silver Mines Lt
1964	23,889					ODM, 1966, p.126	Glen Lake Silver Mines Lt
1965	1,336 from Bailey		70.28	96.40		ODM, 1968a, p.128	Glen Lake Silver Mines Lt
	23,562 from Hiho & Cleopatra		31.93	96.80		ODM, 1968a, p.149	Glen Lake Silver Mines Lt
1966	4,010 from Bailey		70.53	97.64		ODM, 1968b, p.149	Glen Lake Silver Mines Lt
	32,085 from Hiho		34.57	97.21			
1967	7,078 from Glen L		43.57	97.87		ODM, 1969, p.136	Silver Town Mines Ltd.
	30,983 from Hiho		25.80	96.97			
	6,350 from Kerr L		5.70	83.72			
1968	8,797 from Glen L		43.57	97.87		ODM, 1970, p.110	Silver Town Mines Ltd.
	41,765 from Hiho		23.79	96.49			
1969	7,624 from Bailey		8.72	94.90		ODMNA, 1971, p.110	Glen Lake Silver Mines Lt
	6,311 from Kerr L		7.27	86.20			
	43,195 from Hiho		19.51	96.63			
	40,726 from Crown Reserve		3.38	88.87			
	5,031 from Peterson Lake		18.28	96.69			
	Peterson L tailings	5,031	3.04	72.30			
1970	26,887 from Hiho					ODMNA, 1972, p.96	Glen Lake Silver Mines Lt
1972	18,776					Mineral Statistics Section MNR	Silver Shields Mines Ltd.
1974	17,470					Mineral Statistics Section MNR	Canadaka Mines Ltd.
1975	10,920	4,985				Mineral Statistics Section MNR	Canadaka Mines Ltd.
	397,619	10,016	24.11	82.15	0.00		

Tailings Area: GIROUX LAKE CATCHMENT AREA, GLEN LAKE

Mill: PENN (FOSTER)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1957	46,270					ODM, 1960a, p.129	Agnico Mines Ltd.
1958	116,155					ODM, 1960b, p,96	Agnico Mines Ltd.
1959	102,820					ODM, 1961, p,97	Agnico Mines Ltd.
1960	95,940		14.26			ODM, 1962, p.112; The Northern Miner Press, June 29, 1961	Agnico Mines Ltd.
1961	97,125					ODM, 1963, p.117	Agnico Mines Ltd.
1962	66,125		17.28	90.92	1.57	ODM, 1964, p.125	Agnico Mines Ltd.
1963	76,752		10.57	90.82	0.97	ODM, 1965, p.122	Agnico Mines Ltd.
1964	80,611		11,18	91.32	0.97	ODM, 1966, p,120-121	Agnico Mines Ltd.
	24,581		38.69	97.61	0.96	ODM, 1966, p.135	Agnico Mines Ltd,
1965	109,026		16.40	94.64	0.87	ODM, 1068a, p.121	Agnico Mines Ltd.
1966	49,340		17.69	95.36	0.82	ODM, 1968b, p.143	Agnico Mines Ltd.
1967	38,360		13.67	93.78	0.85	ODM, 1969, p,132-133	Agnico Mines Ltd.
1968	45,565		14.36	91.36	1,24	ODM, 1970, p.105-106	Agnico Mines Ltd.
1969	36,740					Penn Mill Log Book	Agnico Mines Ltd.
1970	64,695					Penn Mill Log Book	Agnico Mines Ltd.
1971	29,960					Penn Mill Log Book	Agnico Mines Ltd.
1973	27,028					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1974	38,721					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1975	17,410					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1976	41,405					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1977	44,362					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1978	42,986					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1979	44,370					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1980	66,338					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1981	48,576					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1982	38.415					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1983	43,250					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1984	58,270					Penn Mill Log Book	Agnico-Eagle Mines Ltd.
1985	59,720		28.93	97.60	0.70	Penn Mill Log Book	Agnico-Eagle Mines Ltd.
	1,650,916	0	15.25	76.67	0.81		

Tailings Area: GIROUX LAKE CATCHMENT AREA Mill: CANADAKA

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1977	52,736	24,780				Mineral Statistics Section MNR, L. Othmer, pers com	Canadaka Mines Ltd.
1978	77,839					Mineral Statistics Section MNR	Canadaka Mines Ltd.
1979	29,826					Mineral Statistics Section MNR	Canadaka Mines Ltd.
1980	19,918	4,573				Mineral Statistics Section MNR	Canadaka Mines Ltd.
1981	3,106					Mineral Statistics Section MNR	Canadaka Mines Ltd,
1982	8,356					Mineral Statistics Section MNR	Canadaka Mines Ltd.
1983		39,000				L. Othmer, Mine Manager Canadaka Mines Ltd.	Canadaka Mines Ltd.
1984		50,000	1.9-4.0		0.70	L. Othmer, Mine Manager Canadaka Mines Ltd.	Canadaka Mines Ltd.
	191,781	118,353	0.00	0.00	0.23		

Tailings Area: KIRK LAKE CATCHMENT AREA Mill: BEAVER

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1912	17,842					OBM, 1913b, p.111	Beaver Consolidated Mines Ltd.
1913	25,256		13.60		3.65	OBM, 1914, p.132	Beaver Consolidated Mines Ltd.
1914	26,724					OBM, 1915, p.109	Beaver Consolidated Mines Ltd.
1915	30,093					OBM, 1916, p.105	Beaver Consolidated Mines Ltd.
1916	34,766					OBM, 1917b, p.110	Beaver Consolidated Mines Ltd.
1919	26,974					ODM, 1920, p.91	Beaver Consolidated Mines Ltd.
1923	16,161		7.70		2.00	ODM, 1925b, p.70	Coniagas Mines Ltd.
1924	19,882		7.74		1.93	ODM, 1926b, p.135-136	Coniagas Mines Ltd.
	197,698	0	5.81	0.00	1.52		

Tailings Area: KIRK LAKE CATCHMENT AREA

Mill: TEMISKAMING

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1910	21,945					Cole, 1911, p.102	The Temiskaming Mining Co. Ltd.
1911	34,720			80.00		The Temiskaming Mining Co. Ann. Report, 1911, p.16	The Temiskaming Mining Co. Ltd.
1912	40,057					OBM, 1913b, p.109	The Temiskaming Mining Co. Ltd.
1913	22,307					OBM, 1914, p.149	The Temiskaming Mining Co. Ltd.
1915	26,927					Cole, 1916, p.47	The Temiskaming Mining Co. Ltd.
1917	16,639				3.64	The Temiskaming Mining Co. Ann. Report, 1918, p.10	The Temiskaming Mining Co. Ltd.
1918	11,759				3.28	The Temiskaming Mining Co. Ann. Report, 1918, p.10	The Temiskaming Mining Co. Ltd.
1919	17,024					ODM, 1920, p.105	The Temiskaming Mining Co. Ltd.
1920	34,911					ODM, 1922b, p.122	The Temiskaming Mining Co. Ltd.
	226,289	0	0.00	26.67	1.73		

Tailings Area: KIRK LAKE CATCHMENT AREA

Mill: BRADY LAKE (SILVER-MILLER)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1949	3,275					ODM, 1951, p. 97	Silver-Miller Mines Ltd.
1950	19,041					ODM, 1952b, p.98	Silver-Miller Mines Ltd.
1951	22,990					ODM, 1953b, p.106-107	Silver-Miller Mines Ltd.
1952	22,143					ODM, 1954b, p.118	Silver-Miller Mines Ltd.
1953	29,266					ODM, 1955, p.138-139	Silver-Miller Mines Ltd.
1954	38,323					Silver-Miller Ann Rpt, April 1954 - April 1955	Silver-Miller Mines Ltd.
1955	40,067					ODM, 1957, p.135-136	Silver-Miller Mines Ltd.
1956	31,112					ODM, 1958b, p.133-134	Silver-Miller Mines Ltd.
1957	13,402					ODM, 1960a, p.137-138	Silver-Miller Mines Ltd.
	219,619	0	0.00	0.00	0.00		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: KING EDWARD (NATIONAL)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1908	1,043					Cole, 1909, p.82	King Edward Silver Mines
1909	4,770					Cole, 1910, p.99	King Edward Silver Mines
1910	8,794					Cole, 1911, p.102	King Edward Silver Mines
1912	9,896					Cole, 1913, p.55	King Edward Silver Mines
1913	1,975					Cole, 1914, p.44	City of Cobalt Silver Mining Co. & King Edward Silver Mines
	1,918		13244.00			OBM, 1919a, p.19	National Mines Ltd.
	28,396	0	4414.67	0.00	0.00		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: SILVER CLIFF (PILLINER, AUSIC, UNITED COBALT)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1910	15,402					Cole, 1911, p.102	Trinity Cobalt Mining Corp.
1944	1,992					ODM, 1948a, p.114	Ausic Mining & Reduction Co. Ltd.
1945	3,305					ODM, 1948b, p.94	Ausic Mining & Reduction
							Ausic Mining & Reduction
1946	3,012					ODM, 1949a, p.104,105,109	Ausic Mining & Reduction
							Ausic Mining & Reduction
1947	4,291					ODM, 1949b, p.106	Ausic Mining & Reduction
							Ausic Mining & Reduction
1948	1,384					ODM, 1950,p.94	Ausic Mining & Reduction
							Ausic Mining & Reduction
1951	6,597					ODM, 1953b, p.98,99,108	United Cobalt Mines Ltd.
1952	29,523					ODM, 1954b, p.120	United Cobalt Mines Ltd.
1953	37,567					ODM, 1955, p.133,141	United Cobalt Mines Ltd.
1954	17,128					ODM, 1956, p.94	United Cobalt Mines Ltd.
1956	5,480					ODM, 1960a, p.131	Cobalt Consolidated Mining Corp. Ltd.
1968		24,400				ODM, 1970, p.116	Silver Town Mines Ltd., Glen Lake Mines Ltd.
1969		30,431				ODMNA, 1971, p.109-110	Glen Lake Mines Ltd.
	125,681	54,831	0.00	0.00	0.00		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA Mill: COLONIAL

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1909	1,500					Cole, 1910, p.99	Colonial Mining Co.
1910	7,388					Cole, 1911, p.102	Colonial Mining Co.
1912	7,962					Cole, 1913, p.55	Right of Way Mines Ltd.
1913	1,500					Cole, 1914, p.44	Right of Way Mines Ltd.
1943	9,474					ODM, 1946c, p.194	Silanco Mining and Refining Co. Ltd.
1944	21,747					ODM, 1948a, p.115	Silanco Mining and Refining Co. Ltd.
1945	27,545					ODM, 1948b, p.95	Silanco Mining and Refining Co. Ltd.
1946	29,701					ODM, 1949a, p.107	Silanco Mining and Refining Co. Ltd.
1947	2,040					ODM, 1949b, p.109	Silanco Mining and Refining Co. Ltd.
1948	9,604					ODM, 1950, p.96	Silanco Mining and Refining Co. Ltd.
1950	22,687					ODM, 1952b, p.32	Silanco Mining and Refining Co. Ltd.
1951	32,973					ODM, 1953b, p.103,105,106	Silanco Mining and Refining Co. Ltd.
1952	30,241					ODM, 1954b, p.45	Silanco Mining and Refining Co. Ltd.
1953	34,946					ODM, 1955, p.128-131	Cobalt Consolidated Mining Corp. Ltd.
1954	21069					ODM, 1956, p.125-127	Coballoy MInes and Refineries Ltd.
1955	8872					ODM, 1957, p.126	Coballoy MInes and Refineries Ltd.
1957	2664					ODM, 1960a, p.133-134	Coballoy MInes and Refineries Ltd.
1958	3875					ODM, 1961, p.99	Coballoy MInes and Refineries Ltd.
	275,788	0	0.00	0.00	0.00		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: NIPISSING O'BRIEN (DEER HORN)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1954	11,840					ODM, 1956, p.131	Nipissing-O'Brien Mines Ltd.
1955	26,856					ODM, 1957, p.133	Nipissing-O'Brien Mines Ltd.
1956	29,393					ODM, 1958b, p.130	Nipissing-O'Brien Mines Ltd.
1957	28,826					ODM, 1960a, p.136	Nipissing-O'Brien Mines Ltd.
1958	12,899					ODM, 1960b, p.100	Nipissing-O'Brien Mines Ltd.
1959	13,996					ODM, 1961, p.98	Deer Horn Mines Ltd.
1960	8,725					ODM, 1962, p.121	Deer Horn Mines Ltd.
1962	22022					ODM, 1964, p.127	Deer Horn Mines Ltd.
1963	29,584		26.00	97.40	0.70	ODM, 1965, p.128	Deer Horn Mines Ltd.
1964	32,513		16.30	95.80	0.97	ODM, 1966, p.125-126	Deer Horn Mines Ltd.
1965	26,328		13.20	96.30	0.50	ODM, 1968a, p.126-127	Deer Horn Mines Ltd.
1966	13,695					ODM, 1968b, p.147-148	Deer Horn Mines Ltd.
1967	19,909					ODM, 1969, p.185	Deer Horn Mines Ltd.
1968	37,824					ODM, 1970, p.108	Deer Horn Mines Ltd.
1970	13,207					ODM, 1972, p.96	Deer Horn Mines Ltd.
	327,617	0	18.50	96.50	0.72		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: O'BRIEN Deer Horn)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1909	3,750					Cole, 1910, p.99	M.J. O'Brien Ltd.
1910	25,688					Cole, 1911, p.102	M.J. O'Brien Ltd.
1913	40,000					OBM, 1914, p.129	M.J. O'Brien Ltd.
1915	52,883					Cole, 1916, p.47	M.J. O'Brien Ltd.
1916	45,000					Cole, 1917, p.19	M.J. O'Brien Ltd.
1917	47,850					OBM, 1918, p.125	M.J. O'Brien Ltd.
1919	47,800					ODM, 1920, p.104	M.J. O'Brien Ltd.
	262,971	0	0.00	0.00	0.00		

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: MILE 104 (NORTHERN CUSTOM CONCENTRATOR, BAILEY O'BRIEN, SHAUGHNESSY, COBALT LODE)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1913	1,158					Cole 1914, p.44, OBM, 1914 p.129	Northern Customs Concentrators Ltd.
1914	54,020		13.12	79.50	2.75	OBM, 1915, p.107, 110, 114	Northern Customs Concentrators Ltd.
1915	79,598		17.42			OBM, 1916, p.119	Northern Customs Concentrators Ltd.
1916	65,770					Cole, 1917, p.19, OBM, 1917b, p.109, 117, 127	Northern Customs Concentrators Ltd.
1917	47,850		14.18	82.57		OBM, 1918, p.115,119, 125 OBM, 1919b, p.132, 139	Northern Customs Concentrators Ltd.
1918	56,006		18.30	86.98		OBM, 1919b, p.132, 136, p.138, 139	Northern Customs Concentrators Ltd.
1919	53,526		11.18			ODM, 1920, p.91, 97, 103, p.104, 106	Northern Customs Concentrators Ltd.
1920	60,413					ODM, 1922b, p.107, 113	Northern Customs Concentrators Ltd. & Bailey Silver Mines Ltd
1921	49,547		15.70			ODM, 1923a, p.47,50	Bailey Silver Mines Ltd.
1922	29,284		15.89			ODM, 1923b, p.67, 70, 76	Bailey Silver Mines Ltd. & M.J. O'Brien Ltd.
1923	51,026					ODM, 1925c, p.82	M.J. O'Brien Ltd.
1924	55,880					ODM, 1926b, p.149	M.J. O'Brien Ltd.
1925	56,006					ODM, 1926c, p.164	M.J. O'Brien Ltd.
1926	54,571					ODM, 1928, p.173	M.J. O'Brien Ltd.
1927	53,015					ODM, 1929, p.182	M.J. O'Brien Ltd.
1929	55,617					ODM, 1930, p.161	M.J. O'Brien Ltd.
1930	56,248					ODM, 1931, p.123	M.J. O'Brien Ltd.
1931	51,558					ODM, 1932, p.111	M.J. O'Brien Ltd.
1933	28,751					ODM, 1935b, p.117	M.J. O'Brien Ltd.
1934	31,056					ODM, 1936, p.163	M.J. O'Brien Ltd.
1935	694					ODM, 1937, p.186	M.J. O'Brien Ltd.
1937	70					ODM, 1939, p.240, 243, 246 p.247	M.J. O'Brien Ltd.
1938	26,268					ODM, 1940a, p.32, 1940b, p.230, 233, 234, 236	M.J. O'Brien Ltd.
1939	30,369					ODM, 1941, p.233	M.J. O'Brien Ltd.
1941	1,100					ODM, 1946a, p.160-162,165	Cross Lake Lease
1942	6,200					ODM, 1946b, p.221-223,225 p.226	Cross Lake Lease
1943	5,498					ODM, 1946c, p.189,193,195	Cross Lake Lease
1951	28,526					ODM, 1953a, p.32, 1952b, p.97	Cobalt Lode Silver Mines Ltd.
1952	35,394					ODM, 1954a, p.45, 1954b, p.107	Cobalt Lode Silver Mines Ltd.

Tailings Area: CROSSWISE LAKE CATCHMENT AREA

Mill: MILE 104 (NORTHERN CUSTOM CONCENTRATOR, BAILEY O'BRIEN, SHAUGHNESSY, COBALT LODE)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1953	57,293					ODM, 1955, p.128-132	Cobalt Consolidated Mining Corp. Ltd.
1954	76,182					ODM, 1956, p.125-127	Cobalt Consolidated Mining Corp. Ltd.
1955	75,932					ODM, 1957, p.127-129	Cobalt Consolidated Mining Corp. Ltd.
1956	75,265					ODM, 1958a, p.19, 1958b, p.126, 128	Cobalt Consolidated Mining Corp. Ltd.
	1,409,691	0	8.82	31.13	0.46		

Tailings Area: NORTH COBALT CATCHMENT AREA

Mill: COBALT CONTACT (GREEN MEEHAN)

Year	Ore Milled	Tailings (tons/yr)	Mill Heads (oz Ag/T)	Recovery (%)	Tails (oz Ag/T)	Reference	Owner/Leasor
1926	7,883					ODM, 1928, p.156	Cobalt Contact Mines Ltd.
1927	17,808					ODM, 1929, p.168	Cobalt Contact Mines Ltd.
	25,691	0	0.00	0.00	0.00		

APPENDIX D

THE MILLS AND THEIR OWNERS

Sorting out mill names and ownerships often becomes very confusing for the researcher. Mines and mills were bought, sold and leased often. Companies were re-organized under new names when under financial pressure. New players entered the field under a variety of new and sometimes variations of old names. Mines and mills were often re-named with new ownership. Sometimes the new owner transferred the name from another property. While he was calling property "B" by the name "*****", the rest of the camp was still referring to property "A" by that name. Many of the mines and mills had common names such as "104 mill" which reflected their location rather than the actual company name. The records are often lacking in detail. A company will report that their ore was milled at the "company mill" without naming the mill.

When using this table, be advised:

1. Dates may reflect the use of the mill more than the length of actual ownership.
2. Name changes show a reflecting change in ownership.
3. In the cases where the same structure had multiple names, the most common name is highlighted in italics.
4. Only owners who used or cleaned up a mill after closure are listed.
5. Alternate names or distinctions are given in brackets.
6. Mills are arranged in alphabetical order by first mill name.
7. Properties with multiple mills are grouped together starting with the oldest mill

Table D-1: The Mills and their Owners

MILL	OWNERS	YEARS
Bailey (Glen Lake)	Glen Lake Silver Mines Silvertown Mines Ltd. (merged with Glen Lake, 1968) Silver Shield Mines Inc. Canadaka Mines Ltd.	Built 1962, 1962-1967 1967-1971 1972-1973 1974-1975
Beaver	Beaver Consolidated Mines Ltd. Coniagas Mines Ltd.	Built 1911, 1911-1920 1923-1924
Buffalo Concentrator (low grade)	The Buffalo Mines Ltd. Mining Corporation of Canada Ltd. - operated by subsidiary company, Cobalt Reduction Ltd. Mosher, Richardson, LaFrange (clean-up)	Built 1907 1907-1920 1920-1923 1935
Buffalo cyanide plant	The Buffalo Mines Ltd. Coniagas Mines Ltd. (lease) T. Cawley	Built 1912 1912-1916 1920-1921 early 1950's for 3 years

MILL	OWNERS	YEARS
Campbell & Dyell	Campbell & Dyell	Built 1909 1909-1919
Temiskaming Testing Laboratory	Temiskaming & Northern Ontario Railway	1919-1921
	Department of Mines, Ontario	1921-1941 (fire)
Canadaka	Sulpetro Minerals Ltd.	Built 1977 1977-1984
	Canadaka Mining Corp. Ltd.	1984-???
Cobalt Central	Standard Central Mines Ltd.	Built 1907 1907-1911
Penn Canadian	Penn Canadian Mines Ltd.	1912-1921
Cobalt Contact (Green Meehan)	Cobalt Contact Mines Ltd.	Built 1926 1926-1928
Cobalt Lake	Cobalt Lake Mining Co. Ltd.	Built 1911 1911-1914
	Mining Corporation of Canada Ltd.	1914-1916
Hellens Mill	Hellens Mining & Reduction Co. Ltd.	Built 1951 1951-1953
Agnico	Cobalt Consolidated Mining Corp. Ltd.	1953-1956
	Agnico Mines Ltd. (Agnico-Eagle Mines Ltd.)	1956-1969
Cobalt Provincial (Provincial)	Cobalt Provincial Mining Co.	Built 1911 1911-1920

MILL	OWNERS	YEARS
Colonial	Colonial Mining Co.	Built 1908 1908-1913
	Right-of-Way Mines Ltd (lease)	1913-1914
	Menango Mining Co.	1922-1926
	Donald E. Sirola (lease)	1935
	Cobalt Products Ltd.	1938-1943
	Silanco Mining & Refining Co. Ltd.	1943-1953
	Cobalt Consolidated Mining Corp. Ltd.	1953-1954
	Coballoy Mines & Refineries Ltd.	1954-1959
	Hespanola Mines Ltd.	1962 (fire)
Coniagas	Coniagas Mines Ltd.	Built 1907 1907-1924 (fire)
Foster	Penn Cobalt Silver Mines Ltd.	Partially built 1952
	Cobalt Consolidated Mining Co. Ltd.	1953-1957
Foster/*Penn*	Agnico Mines Ltd.	completed 1957 1957-1972
Penn	Agnico-Eagle Mines Ltd.	1972-198* (fire)
Penn (new mill)	Agnico-Eagle Mines Ltd.	Re-built 198* 198*-198* closed 198*

MILL	OWNERS	YEARS
Hudson Bay	Hudson Bay Mines Ltd.	Built 1910 1910-1920
King Edward	King Edward Silver Mines	Built 1909 1909-1915
	City of Cobalt Silver Mining Co. (lease)	1913
National	National Mines Ltd.	1915-1918
LaRose	LaRose Mines Ltd. (ore sorting plant)	Built 1911 1911-1912
LaRose (Silver Miller)	Silver Miller Mines Ltd. (concentrator)	Built 1952 1952-1966
	Silver Town Mines Ltd.	1966-1969
	Glen Lake Mines Ltd.	1969-1971
Canadian Smelting & Refining Ltd.	St. Joseph Explorations Ltd. (later Sulpetro)	1974-1982
Agnico Refinery	Agnico-Eagle Mines Ltd.	1982-present
McKinley-Darragh Concentrator	Mc-Kinley-Darragh-Savage Mines of Cobalt Ltd.	Built 1907 1907-1928 (fire)
McKinley-Darragh tailings	Mc-Kinley-Darragh-Savage Mines of Cobalt Ltd.	Built 1917 1917-1920

MILL	OWNERS	YEARS
Muggley Concentrators Ltd.	City of Cobalt Mining Co. Ltd.	Built 1907 1907-1908
Northern Customs Concentrator	Northern Customs Concentrators Ltd.	1908-1913
Townsite	Cobalt Townsite Mining Co. Ltd.	1913
Cobalt Reduction Co. Ltd.	Mining Corporation of Canada Ltd.	1914-1934
	Cobalt Properties Ltd.	1934-1946
	Silanco Mining & Refining Co. Ltd.	1946 - ?
Nipissing Low Grade	Nipissing Mining Co. Ltd.	Built 1912 1912-1932
Nipissing High Grade	Nipissing Mining Co. Ltd.	Built 1911 1911-1918
Northern Customs Concentrators (Mile 104)	Northern Custom Concentrators Ltd.	Built 1913 1913-1920
Bailey (Mile 104)	Bailey Silver Mines Ltd.	1920-1922
O'Brien (Mile 104)	M.H. O'Brien Ltd.	1922-1940
O'Shaughnessy	Cross Lake Lease	1940-1950
	Silanco Mining & Refining Co. Ltd. (lease)	1940
Cobalt Lode	Cobalt Lode Silver Mines Ltd.	1950-1953
	Cobalt Consolidated Mining Corp. Ltd.	1953-1956 (fire)

MILL	OWNERS	YEARS
Nova Scotia	Nova Scotia Silver-Cobalt Mining Co. Ltd.	Built 1908 1908-1912
Dominion Reduction	Dominion Reduction Co.	1912-1922
	A. Wood	1934
O'Brien	M.J. O'Brien Ltd.	Built 1909 1909-1922 (fire)
Nipissing-O'Brien	Nipissing-O'Brien Mines Ltd.	Built 1952 1952-1958
Deer Horn	Agnico Mines Ltd. - leased by Deer Horn Mines Ltd.	1958-1970
	Location and relationships of this property and companies uncertain	
Ore Reduction	Ore Reduction Co.	1907
Cobalt Concentrators	Cobalt Concentrators Ltd.	1907
Nipissing Reduction	Nipissing Reduction Co.	1908-1912
Savage	McKinley-Darragh-Savage Mines Cobalt Ltd.	Built 1910 1910-1912
Silver Summit	Silver Summit Mines Ltd.	Built 1963 1963-1965
Silverfield	Silverfields Division (Teck Corporation)	1965-1983 demolished 1993
Seneca-Superior	Seneca-Superior Silver Mines Ltd.	Built 1913 1913-1916
	Peterson Lake Silver Cobalt Mining Co.	1918-1919

MILL	OWNERS	YEARS
Silver Arrow	Silver Arrow Mines Ltd.	Built 1947 1947-1949
Mensilvo	Mensilvo Mines Ltd.	1949-1957
	J.J. Gray	1961
Silver Cliff	Trinity Cobalt Mining Corp.	Built 1910 1910-1911
	Orion Realty & Investments Ltd.	1912-1917?
	National Mines Ltd.	1918-1942
	Austin Mining Syndicate	1943-1944
Ausic (Pilliner)	Ausic Mining & Reduction Co. Ltd.	1944-1951
United Cobalt	United Cobalt Mines Ltd.	1951-1968
	Cobalt Consolidated Mining Corp. Ltd. (lease)	1956
	Silver Town Mines Ltd. (Glen Lake Mines Ltd.)	1968-1971
Silver Miller (*Brady Lake*)	Silver Miller Mines Ltd.	1948-1957
Temiskaming	Temiscamingue (Temiskaming) Mining Co. Ltd.	Built 1909 1909-1920
	Richard Sandoe & Assoc. (clean-up)	1928
Temiskaming Testing Laboratory	Ministry of Northern Development & Mines	1941-1993
Trethewey	Trethewey Silver Cobalt Mines Ltd.	Built 1910 1910-1920

APPENDIX E

THE OWNERS AND THEIR MILLS

Sorting out mill names and ownerships often becomes very confusing for the researcher. Mines and mills were bought, sold and leased often. Companies were re-organized under new names when under financial pressure. New players entered the field under a variety of new and sometimes variations of old names. Mines and mills were often re-named with new ownership. Sometimes the new owner transferred the name from another property. While he was calling property "B" by the name "*****", the rest of the camp was still referring to property "A" by that name. Many of the mines and mills had common names such as "104 mill" which reflected their location rather than the actual company name. The records are often lacking in detail. A company will report that their ore was milled at the "company mill" without naming the mill.

When using this table, be advised:

1. Dates reflect the use of the mill more than the length of actual ownership.

2. In the cases where the same structure had multiple names, the most common name is highlighted in italics.

3. Only owners who used or cleaned up a mill after closure are listed.

4. Alternate names or distinctions are given in brackets.

5. Owners are arranged in alphabetical order.

Table E-1: The Owners and their Mills

MINING COMPANY	MILL OPERATED	YEAR
Agnico Mines Ltd. (Agnico-Eagle Mines Ltd.)	Deer Horn (leased) (Nipissing-O'Brien)	1958-1970
	Colonial	1957-1962 (fire)
	Hellens	1956-1969
	Foster (Penn)	1958-1970
	Penn (builder)	1970-1989
Ausic Mining & Reduction Co.	Ausic (Pilliner) (*Silver Cliff*)	1944-1951
Austin Mining Syndicate	Silver Cliff	1943-1944
Bailey Silver Mines Ltd.	Bailey (*Mile 104*)	1920-1922
Beaver Consolidated Mines Ltd.	Beaver	1911-1920
(The) Buffalo Mines Ltd.	Buffalo concentrator (builder)	1907-1920
	Buffalo cyanide plant (builder)	1912-1916
Campbell & Dyell	Campbell & Dyell (*TTL*) (builder)	1909-1919
Canadaka Mines Ltd. (St. Joseph Exploration Ltd.)	Bailey (*Glen Lake*)	1974-1975
Canadaka Mining Corp.	Canadaka	1984 -?
Cawley, T.	Buffalo cyanide plant	1950's - 3 years

MINING COMPANY	MILL OPERATED	YEAR
City of Cobalt Mining Co. Ltd.	Muggley Concentrators Ltd. (*Cobalt Reduction*) (builder) King Edward (lease)	1907-1908 1913
Coballoy Mines & Refineries Ltd.	Colonial	1954-1959
Cobalt Concentrators Ltd.	Cobalt Concentrators (Ore Reduction)	1907
Cobalt Consolidated Mining Corp. Ltd.	Cobalt Lode (*Mile 104*) Silver Cliff (lease) Colonial Hellens Foster	1953-1956 (fire) 1956 1953-1954 1953-1957 1953-1957
Cobalt Contact Mines Ltd.	Cobalt Contact (*Green Meehan*) (builder)	1926-1928
Cobalt Lake Mining Co. Ltd.	Cobalt Lake (builder)	1911-1914
Cobalt Lode Silver Mines Ltd.	Cobalt Lode (*Mile 104*)	1950-1953
Cobalt Products Ltd.	Colonial	1938-1943
Cobalt Properties Ltd.	Cobalt Reduction	1934-1936
Cobalt Provincial Mining Co.	Cobalt Provincial (builder) (*Provincial*)	1911-1920

MINING COMPANY	MILL OPERATED	YEAR
Cobalt Reduction Co. Ltd.	Cobalt Reduction concentrator Cobalt Reduction high grade Buffalo	1914-1934 1916-1928 1919-1922
Cobalt Townsite Mining Co.	Townsite (*Cobalt Reduction*)	1913
Colonial Mining Co.	Colonial (builder)	1908-1913
(The) Coniagas Mines Ltd.	Coniagas (builder) Buffalo cyanide plant (lease) Beaver	1907-1924 (fire) 1920-1921 1923-1924
Cross Lake Lease	Shaughnessy (*Mile 104*)	1940-1950
Deer Horn Mines Ltd.	Deer Horn (*Nipissing O'Brien*) (lease)	1959-1970
Dominion Reduction Co.	Dominion Reduction (Nova Scotia)	1912-1922
Glen Lake Mines Ltd.	Silver Cliff Bailey (*Glen Lake*) (builder) LaRose	1968-1970 1962-1967 1969-1971
Gray, J.J.	Mensilvo	1961
Hellens Mining & Reduction Co. Ltd.	Hellens (builder)	1951-1953
Hespanola Mines Ltd.	Colonial	1962 (fire)
(The) Hudson Bay Mines Ltd.	Hudson Bay (builder)	1910-1920
King Edward Silver Mines	King Edward (builder)	1908-1915

MINING COMPANY	MILL OPERATED	YEAR
Koza, Jack	Deer Horn (*Nipissing-O'Brien*) (clean-up & demolish)	mid-1980's
McKinley-Darragh-Savage Mines of Cobalt Ltd.	McKinley-Darragh concentrator (builder) McKinley-Darragh tailings (builder) Savage (builder)	1907-1928 (fire) 1917-1920 1910-1912
Manango Mining Co.	Colonial	1922-1926
Mensilvo Mines Ltd.	Mensilvo	1949-1957
Mining Corporation of Canada Ltd.	Cobalt Reduction Cobalt Lake Buffalo	1914-1934 1914-1916 1920-1923
Ministry of Northern Development & Mines, Ontario	Temiskaming Testing Laboratory	1921-1993
Mosher, Richardson & LaFrange	Buffalo (clean-up)	1935
National Mines Ltd.	Silver Cliff National (*King Edward*)	1918-1942 1915-1918
Nipissing Mining Co. Ltd.	Nipissing low grade (builder) Nipissing high grade (builder)	1912-1932 1911-1918
Nipissing O'Brien Mines Ltd.	Nipissing O'Brien (Deer Horn)	1952-1958
Nipissing Reduction Co.	Nipissing Reduction	1908

MINING COMPANY	MILL OPERATED	YEAR
Northern Customs Concentrators Ltd.	Northern Customs (*Cobalt Reduction*) Northern Customs (*Mile 104*) (builder)	1908-1913 1913-1920
Nova Scotia Silver Cobalt Mining Co. Ltd.	Nova Scotia (*Dominion Reduction*) (builder)	1908-1912
O'Brien, M.J.	O'Brien (builder) O'Brien (*Mile 104*)	1909-1922 (fire) 1922-1940
Ore Reduction Co.	Ore Reduction Co. (Cobalt Concentrators Ltd.?) (builder?)	1907
Orion Realty & Investments Ltd.	Silver Cliff	1912-1917?
Penn Canadian Mines Ltd.	Penn Canadian (Cobalt Central)	1912-1921
Penn Cobalt Silver Mines	Foster	1952
Peterson Lake Silver Cobalt Mining Co.	Seneca-Superior	1918-1919
Right-of-Way Mines Ltd.	Colonial (lease)	1913-1914
Sandoe, Richard & Assoc.	Temiskaming (clean-up)	1928
Seneca-Superior Silver Mines Ltd.	Seneca-Superior (builder)	1913-1916
Silanco	Cobalt Reduction Colonial Shaughnessy (*Mile 104*) (lease)	1946-late 1950's 1943-1953 1940
Silver Arrow Mines Ltd.	Silver Arrow (*Mensilvo*) (builder)	1947-1949

MINING COMPANY	MILL OPERATED	YEAR
Silverfields Division (Teck Corporation)	Silverfield	1965-1983 demolished 1993
Silver Miller Mines Ltd.	LaRose Silver Miller (*Brady Lake*)	1952-1956 1948-1957
Silver Shield Mines Inc.	Bailey (*Glen Lake*)	1972-1973
Silver Summit Mines Ltd.	Silver Summit (*Silverfield*) (builder)	1963-1965
Silver Town Mines Ltd.	Silver Cliff Bailey (*Glen Lake*) LaRose	1968-1971 1967-1971 1966-1969
Sirola, Donald E.	Colonial (clean-up)	1935
Standard Cobalt Mines Ltd. (Cobalt Central Mines Ltd.)	Cobalt Central (*Penn Canadian*) (builder)	1907-1911
Sulpetro Minerals Ltd.	Canadaka (builder)	1977-1984
Temiskaming (Temiscamingue) Mining Co. Ltd.	Temiskaming (builder)	1909-1920
Temiskaming & Northern Railway	Temiskaming Testing Laboratory	1919-1921
Trethewey Silver Cobalt Mines Ltd.	Trethewey (builder)	1910-1920
Trinity Cobalt Mining Corp.	Silver Cliff (builder)	1910-1911
United Cobalt Mines	United Cobalt (*Silver Cliff*)	1951-1968
Wood, A.	Dominion Reduction (clean-up)	1934

APPENDIX F

TAILINGS SITES

The mills listed with each tailings site represent only the mills that deposited directly into that site or allowed their tailings to migrate primarily to that site.

Table F-1: Tailings Sites

TAILINGS SITE	MILL
Beaver-Temiskaming → Kirk Lake	Beaver Temiskaming Silver Miller (Brady Lake)
Brady Lake	Silver Miller (Brady Lake)
Canadaka Pond	Canadaka
Cart Lake	Cobalt Provincial Savage Hellens Silver Summit (Silverfield)
Chambers-Ferland	Coniagas

TAILINGS SITE	MILL
Cobalt Lake	Cobalt Lake Cobalt Reduction (Muggley, Northern Customs, Townsite) McKinley-Darragh concentrator McKinley-Darragh tailings Ore Reduction (Cobalt Concentrator, Nipissing Reduction?) Hellens
Cobalt Public School	Coniagas (slimes)
Cobalt Trailer Park	Buffalo
Crosswise Lake	Colonial King Edward (National) Silver Cliff (Ausic, Pilliner, United Cobalt) Mile 104 (Northern Customs Concentrator, Bailey, O'Brien, Shaughnessy) O'Brien Nipissing O'Brien (Deer Horn)
Glen Lake	Cobalt Central (Penn Canadian) Glen Lake (Bailey) Foster (Penn)
Gillies Depot	Cobalt Refinery
Giroux Lake	Mensilvo (Silver Arrow)
Green Meehan	Cobalt Contact
Mill Creek → Chambers-Ferland	LaRose

TAILINGS SITE	MILL
Nipissing Hill	Nipissing Low Grade Nipissing High Grade
Nova Scotia	Dominion Reduction (Nova Scotia)
Peterson Lake	Dominion Reduction (Nova Scotia) LaRose Nipissing Seneca-Superior
Sasaginaga Creek → Chambers-Ferland	Trethewey Hudson Bay

APPENDIX G

Table G-1: REWORKED TAILINGS

TAILINGS FROM	MILLED AT	TAILINGS TO	YEAR
Beaver	Foster	Glen Lake	1980
Buffalo	Buffalo	Cobalt Trailer Park	1916-1923
	Cobalt Reduction	Cobalt Lake	1920-1923
	Coniagas	Chambers-Ferland	1924
Chambers-Ferland	Canadaka	Canadaka Pond	1983-1984
Cobalt Lake (south end)	Cobalt Reduction (sand)	Cobalt Lake	1919-1932
	Buffalo (slimes)	Cobalt Lake	1919-1920
Cobalt Lake (south end)	Hellens	Cobalt Lake (north end)	1951-1955 1964-1969
Cobalt Provincial - Cart Lake	Cobalt Provincial	Cart Lake	1917-1918
Colonial (Crosswise Lake)	Colonial	Cross Lake	1948
Coniagas	Coniagas sand)	Chambers-Ferland	1917-1921
	Buffalo (slimes)	Cobalt Trailer Park	1920-1921
	Buffalo (slimes)	Cobalt Trailer Park	1950's
	Canadaka	Canadaka Pond	1977

TAILINGS FROM	MILLED AT	TAILINGS TO	YEAR
Hudson Bay	Silver Cliff	Crosswise Lake	late 1940's, early 1950's
King Edward & Silver Cliff (Crosswise Lake)	King Edward (National)	Crosswise Lake	1916, 1918
McKinley-Darragh (Cobalt Lake)	McKinley-Darragh Tailings	Cobalt Lake	1918-1920
Dominion Reduction (Peterson Lake)	Silver Cliff	Crosswise Lake	1918
	Dominion Reduction	Peterson Lake	1920, 1922
	United Cobalt (Silver Cliff)	Crosswise Lake	1968-1969
O'Brien	O'Brien	Crosswise Lake	1909-1922
Savage	McKinley-Darragh Tailings	Cobalt Lake	1918-1920
Silver Miller	Hellens	Cobalt Lake	1951
Temiskaming	Hellens	Cobalt Lake	1951
Trethewey	Trethewey	Trethewey	1918-1919
	Canadaka	Canadaka Pond	1977

APPENDIX H

COBALT TAILINGS GRAIN SIZE ANALYSIS

The tailings were sampled in 1985 to gain a rough approximation of the average grain size. Generally one 500 gram sample was collected from each site. At any site where definite fine and coarse grained segregation was prominent, two samples were taken. The samples should give an indication of the character of the tailings, but should not be considered as representative of the whole site. Active tailings were not sampled.

The samples were either oven-dried for two to three hours or sun-dried for 24 to 36 hours. Many of the coarse samples were unconsolidated, however the samples containing large amounts of clay generally remained clumped after drying. Disaggregation was accomplished by gently pounding with a porcelain mortar. The clay rich samples often tended to recluster into small lumps after disaggragation because of their flaky character and surface electrical charges.

Each sample was initially weighed and then placed in Tyler sieves and shaken by machine for 20 minutes to 1 hour. The finer samples were shaken the longest to give ample time for the fines to pass through all the sieves. Heavier samples were also shaken longer than lighter samples. The faction remaining in each sieve was weighed on a Dial-O-Gram balance. The weights were rounded off to 0.1 grams. Finer tolerance could not be gained due to vibration from the Temiskaming Laboratory Mill.

Dry sieving using Tyler sieves produces an accurate result for coarse samples consisting mainly of grains over 4 phi (230 mesh). If there is a predominance of fines, dry sieving does not give accurate results because the clumps of clay gum up the screens. This was noted with many samples. Since the purpose of this grain size analysis exercise was to determine which samples were amenable for concentration by flotation, only dry sieving was used. If the sample contained too many fines for dry sieving, it would also cause problems during flotation. As an example, the Beaver fines contained so much clay particles that most of the sample would not pass through 60 and 80 mesh sieves.

The following Canadian Standard Tyler sieves were used for the analysis:

Meshes/inch	Millimetres	Phi
60	0.246	2.0
80	0.210	2,25
100	0.150	2.75
150	0.104	3.25
200	0.074	3.75
325	0.043	4.5

In the results presented all the material passing through the 200 mesh sieve is given as one total due to the inaccuracies inherent from the clay particles. Any samples where excessive clay particles plugged the larger sieves holes are noted as poor results. Results of samples containing about 30% <200 mesh mostly as fine sands rather than clay and therefore not exhibiting clogging in the coarse pans are marked as fair. Fine particles adhering to the coarser grains will still give anomalous results in this case. Results of samples containing clean, coarse grains with relatively few fines are classed as good. The results are presented as a percentage of the whole sample.

TABLE H-1: GRAIN SIZE ANALYSIS RESULTS

CATCHMENT AREA: Cobalt, West Arm

Meshes /inch	Buffalo (Coarse)	Buffalo (Fine)	Trethewey (Coarse)	Trethewey (Fine)	Hudson Bay	Coniagas
60	30.93	5.20	53.79	31.13	58.96	65.83
80	8.25	3.57	9.60	5.83	9.09	11.89
100	6.28	6.70	5.47	0.03	7.88	6.10
150	12.01	12.10	10.11	4.80	4.40	8.51
200	9.98	23.22	5.98	9.41	8.51	3.70
<200	32.54	49.20	14.96	45.84	10.27	3.98
Reliability	Fair	Poor	Good	Fair	Good	Good

CATCHMENT AREA: Cobalt, East Arm

Giroux Lake

Meshes /inch	Nipissing	Cobalt L. North	Cobalt L. LaRose	Mensilvo

TABLE H-1: GRAIN SIZE ANALYSIS RESULTS

60	2.80	42.93	8.91		24.98
80	15.96	18.64	9.82		19.54
100	4.09	11.00	6.07		12.23
150	9.15	11.84	10.97		15.27
200	22.48	4.86	7.82		7.97
<200	46.72	7.73	56.41		20.11
Reliability	Poor	Good	Fair		Poor

CATCHMENT AREA: Kirk Lake

Meshes /inch	Temisk-aming	Brady Lake	Beaver	Fisher-Eplett	Crosswise Lake South
60	74.10	33.43	33.80	69.51	0.52
80	6.55	21.85	21.70	13.42	1.85
100	3.76	13.84	16.83	7.02	7.55
150	5.98	14.43	13.86	6.86	27.17
200	4.45	7.39	6.73	1.79	39.93
<200	5.18	9.08	7.07	1.30	22.98
Reliability	Good	Good	Good	Good	Poor

TABLE H-1: GRAIN SIZE ANALYSIS RESULTS

CATCHMENT AREA:

	North Cobalt		Peterson Lake		Crosswise Lake
Meshes /inch	Cobalt Contact (Coarse)	Cobalt Contact (Fine)	Cart Lake	Nova Scotia	Crosswise Lake North
60	51.75	9.02	0.42	0.82	4.67
80	12.27	2.58	10.93	15.88	17.34
100	11.00	4.42	24.71	14.29	7.88
150	12.26	2.93	33.87	20.21	16.07
200	4.99	14.52	16.64	22.54	20.15
<200	7.78	66.52	13.43	26.26	33.89
Reliability	Good	Poor	Fair	Poor	Poor

APPENDIX I

PENN MILL

Agnico-Eagle Mines Ltd.
Silver Division
Cobalt, Ontario

W. Montgomery
Mill Superintendent
1987

The concentrator which operates at 280 tons per day is located in Coleman Township 1.5 miles southeast of the Town of Cobalt in Northern Ontario and is locally known as the Penn Mill.

The mine manager is John Young and the mill superintendent is William Montgomery.

The silver-cobalt ore is concentrated by gravity means (jigs and tables) to produce a high grade product, and by flotation where a lower grade product is obtained.

Ore

The ore contains native silver with calcite and cobalt, and also arsenides of cobalt, nickel which are associated with lead, zinc and copper. The host rocks are mainly sediments, diabase and lavas.

History

Agnico-Eagle Mines Limited is a consolidation of a group of mines and companies dating back to the early years of this century.

The present company controls 154 claims and 14 other properties totalling about 5500 acres and was known under such names as Silanco Mining and Refining, Cobalt Consolidated, and Agaunico Mines.

The present company also controls the Langis Mine in Casey Township northeast of New Liskeard and the Castle Trethewey Mine in Gowganda.

Milling Practise

Crushing

The ore is trucked from various mines and is dumped into a 75 ton grizzly. A Utah Magnetic Feeder feeds an 18 x 30 in. Hadfield jaw-crusher set at 1.5 in. and driven at 250 r/min. by a 60 hp motor. Crusher discharge goes over a double deck Dillon vibrating screen which is in closed circuit with the cone crusher. The top deck has 2 in. square openings, and the bottom deck has .25 in. slotted openings, oriented across the flow of the rock. The screen undersize is fed directly to the fine ore bin. The screen oversize is conveyed to a 4 ft. Symons short head cone crusher which is driven by a 125 hp motor at 1165 r/min. The crusher is set at .25 in. and is protected by a suspended rectangular Dings magnet for trapping iron. The conveyor system throughout the plant is 24 in. wide.

Fine Ore Bin

The fine ore bin is a circular steel bin 24 feet in diameter and 32 feet high. It has a capacity of 400 live tons.

Grinding

The grinding circuit consists of a 9' x 10' Marcy ball mill in a closed circuit with a 15" Krebs cyclone and a 24 x 36 in. duplex mineral jig. Feed from the fine ore bin is conveyed on a 24" conveyor belt to the ball mill, which is driven at 25.2 r/min. by a 400 hp electric motor.

Ball mill discharge goes over the mineral jig, where 60-80% of the silver is recovered. The jig concentrates average between 3000-4000 oz. per ton. The jig overflows into a pump box connected to a Allis-Chalmers 8 x 6 in. SRL pump.

The pump discharge is pumped to a 15 in. Krebs cyclone situated 10 ft over the feed end of the ball mill. The cyclone underflow goes back to the ball mill for regrinding and the cyclone overflow at 55-60% minus 200 mesh flows by gravity to a distributing box with a .125" thrash screen, from which it is fed by gravity to 4 Holman tables driven by 2 hp motors at 250 r/min, with a .5 in. stroke. The table concentrates average between 300-1000 oz. per ton.

The table tails are pumped to a 30 x 10 ft thickener tank for further processing.

Flotation

A flocculent is added to the well of the thickener tank to aid settling. The underflow at 40% solids, is pumped by a Allis Chalmers 3 x 3 in. SRL pump to the 8 x 10 ft conditioner tank where zanthate at 0.35 lb/ton, aerofroth 65 at 0.085 lb/ton, and aerofroth 25 at 0.002 lb/ton are added. The 8 x 10 ft Denver conditioner tank is driven by a 10 hp motor at 200 r/min.

Conditioning time is about 8 minutes. The discharge slurry is fed into the back of the third cell of a bank of ten No. 24 Denver Sub A cells. Cells #3,4,5, and 6 are rougher cells, and the rougher concentrate goes to the #2 cell fro recleaning, which is the final concentrate. The flotation concentrate averages between 250-600 oz. per ton. Cells #7, 8, 9, and 10 are scavenger cells, and concentrate from these cells is pumped back to the conditioner tank. The tailings from these cells is pumped to another set of four No. 24 Denver air cells, and a second set of four No. 24 Denver Sub A cells. The concentrate from these cells is pumped back to the conditioner tank.

The tailings from the last set of cells joins up with the overflow from the 30 ft thickener which is automatically sampled every half hour for final tails.

Filtering

The recleaned flotation concentrate flows to a 10 x 10 ft concentrate thickener for settling. The overflow goes back to the scavenger cell pump box and is pumped back into the circuit.

The underflow from the concentrate thickener is pumped by a ODS pump to a 4 ft - 3 disc Oliver filter. The cake at 10 - 17% moisture is discharged into a boxed trailer fro shipment to the refinery. The filter filtrate flows back to the concentrate thickener.

Drying and Handling

The jig and table concentrates are dried to 0.01% moisture on three 4 x 8 ft steam plates heated by a 20 hp electric boiler, and put into drums, sealed and weighed. These are shipped on a weekly basis to the refinery.

General

The old Penn Mill and part of the shop burned down on Feb. 22, 1986. The present mill was built on the same site. The construction of the new mill was started in September of 1986, and completed and began operating on July 1, 1987. The Penn Mill is situated on a plateau of high ground between Giroux and Glen Lake. The supply water pump house is on Giroux Lake, and fresh water is pumped by a 40 hp, 480 r/min pump through a 6 in. water line to a 50,000 gallon storage tank at the mill site. A 40 hp 6000 r/min pump hooked up to a 6 in. water main, connected to hydrants is used for fire protection.

Tailings are sent by gravity through a 6 in. plastic pipe a distance of 1200 ft to the north east corner of Glen Lake. An overflow weir pipe at the south end of the lake ensures clean water emissions into the water shed of the area. Samples of the overflow water are taken on a weekly basis and the analysis is sent to the Ministry of the Environment on a monthly basis. No recycling of the water is being done.

Power is supplied by Ontario Hydro by means of a 12,500 volt line passing directly through the mill site.

APPENDIX J

CANADAKA MILL

CANADAKA MINES LTD.

E.C. Blakemore
MILL SUPERINTENDENT

CRUSHING PLANT:

The crushing plant consists of a 18" x 36" surface grizzly. The rock is dumped onto the grizzly and falls into a coarse ore bin. The rock is then taken away by a Robins Pan Conveyor to the primary crusher.

The primary crusher is a Kennedy Van Saun #22. This crusher is capable of taking up to 22" feed and reducing it to -6".

The discharge from this crusher is fed to single dick screen. This screen is made up of two ½" x ½" screens with square holes and one ⅝" x ⅝" screen with square holes.

The oversize from the screens goes to the Kennedy Van Saun secondary gyratory crushers. These crushers then reduce the material to -½" and return it to the screens. The undersize from the screens goes to the fine ore bin. The oversize returns to the secondary crushers. The material is now ready for the milling process.

MILL:

Grinding:

The material from the fine ore bins is fed to Allis Chalmers Rod Mill by a series of conveyors. This mill is a 6' x 12' rod mill and it uses 11'8" x 3" rods as a grinding media. The ½" material fed to the mill is then reduced to -¼" and smaller. At the discharge end of the mill is a 18" x 24" Denver Mineral Jig. The purpose of the jig is to separate any heavy metallics from the rod mill discharge before it is pumped to the classifier.

The classifier which is a Wemco is 32' long and has a 72" diameter. The sands or oversize is spiralled up the classifier tank to a discharge chute which feeds the Ball Mill. The undersize or classifier overflow is pumped up to two cyclones for tabling and flotation.

The Ball Mill which is a Allis Chalmers 7' x 8' uses 3" balls as a grinding media. There is a set of Denver Mineral Jigs at the discharge end of the ball mill. These jigs are 8" x 12" and the purpose of these jigs is to catch any small metallics still left after passing over the bigger jigs. The ball mill discharge empties into the classifier and any material that is still oversize returns to the ball mill to be reground. The undersize or classifier overflow goes to the cyclones for tabling and flotation. This overflow is 60-70% -200 mesh.

Tabling:

The material fed to the cyclones is separated and the sands or underflow is fed to two rougher tables. One table is a single deck while the other is a triple deck table. These tables separate any fine silver from the sands. This fine silver concentrate is further cleaned and then is dried, weighted and shipped for refining. The middlings or tailings go to the conditioner to be sent to the flotation circuit.

Flotation:

The material in the conditioner is treated with Xanthate 350 which is a collecting agent for precious and base metals. This reagent is added at the rate of o.25 lb/ton. When the flotation feed enters the flotation circuit Aero 25 is added at a rate of 0.18 lb/ton. Aero 25 is a collecting agent and it also has frothing capabilities. A very little amount of Dowfroth 250 is added to the circuit when required. Xanthate 350 is also added to the flotation circuit at the rate of 0.05 lb/ton. Aero 620 which is a gangue depressant is added to the cleaning circuit to clean and upgrade the concentrates.

The rougher concentrate or first stage flotation is sent to a set of cells called cleaner cells. The cleaner cells clean the froth and upgrade the value of the concentrate. The tailings are rejects from these cells return to the rougher cells. The concentrate from these cells go to a set of re-cleaner cells to be cleaned and upgraded. The tailings from these cells return to the cleaners. The concentrate goes either to another cleaning process (if needed) or directly to the thickener. The concentrate in the thickener is then filtered to remove as much water as possible. The material is now ready to be sent for refining.

The tailings or rejects from the rougher cells is sent to scavenger cells to try and remove any remaining silver left in the material. The concentrate from the scavengers is sent back to the head end of the circuit for upgrading. The tailings from the scavengers is then sent out to the tailings pond as a waste material.

....

CANADAKA MILL REPORT

Sulpetro Minerals Limited
Canadaka Division

L. Othmer
1984

CANADAKA MILL

Location:	Kerr Lake Property, Lot 3, Con. IV, Coleman Tp.
Ownership:	Sulpetro Minerals Ltd.
History:	500 ton mill built in 1976-77 Operated from 1977-1980 on surface rock and underground ore. Dormant 1981-82. Operated 1983-84 on reprocessing tailings material.

TAILINGS

Location:	Presently worked tailings are on our property known as the Chambers Ferland property, Lots 4 and 5, Conc. VI, Coleman Tp.
Tonnage:	The calculated tonnage of available material is approximately 200,000 tons with an average depth of 4-5 feet. Water control is accomplished by trenching, natural flow and pumping. The grades of the material varies from 1.9 to 4.0 ounces of silver per ton[2]. The tailings have been deposited over a long period of time so bedding exists in the material, consisting of very fine particles with the appearance and consistency of clay. This material does not usually assay very high but the coarse material contains free silver due to the milling process when it was originally processed , pre 1930. Material directly beneath the tailings is black muck.

[2]. The method used in sampling the tailings area was a grid system of 50 foot intervals at which point an auger was used to drill the lowest depths of tailings material. The resultant material from the auger was tagged, depth indicated, plotted and assayed at the Temiskaming Testing Laboratory.

Milling: Canadaka processes approximately 450 tons of material per day 7 days a week. Milling operations commenced in June of 1984 and it is hoped will continue until well into November depending on the weather.

Problems in milling are mainly in handling the material at the mill due to the moisture content and the amount of vegetation that the tailings contain[3]. This vegetation tends to foul up the grinding and flotation system and has to be continually removed. If it is removed at the classifier overflow no harm is done but if goes into the flotation circuit it must be left, as it collects some silver values, approximately 100 ounces per ton, and so is collected with the concentrates.

The material when arriving at the mill is screened in the crusher house and passed on to the fine ore bin. The screening removes the rocks, wood and some of the grassy vegetation. It is removed from the fine ore bin and fed by conveyor to a 6 x 12 rod mill for polishing. From the Rod Mill on to the classifier then to a second 7 x 8 Ball mill for further polishing. The overflow from the classifier foes to the conditioner and on to the flotation cells, a bank of 6 rougher cells, 6 scavenger cells, 2 cleaner cells and 1 recleaner cell. From this last cell the concentrate is pumped to a thickener. It is removed from the thickener and filtered producing a flotation concentrate of approximately 650 to 700 ounces of silver per ton.

---

[3]. Vegetation problems. Over the period of years (50+) in which the tailings have been deposited there were intervals in which no tailings were laid down and grass etc. started to grow. As a result there is a layer and sometimes several of vegetation in the tailings material. The latest layer consisting of a very coarse grass is from twenty to thirty inches thick. This material has to be removed to get to the profitable tailings material. The material is stockpiled to allow it to dry and the tailings to separate from it, but it is virtually impossible to be rid of all the vegetation.

Our recovery is from 68 to 75 per cent of the silver entering the mill as feed and the tailing effluent contains approximately 0.70 ounces of silver per ton. Economy of the operation depends entirely on the price of silver. It is doubtful if a profit could be made if the price were to go below $7.00 US per ounce.

We are fortunate that the tailings we are reprocessing are circa 1920 era and they did not at that time use flotation methods in the Cobalt camp, only gravity recovery. With flotation methods were are able to recover silver that was lost in gravity recovery. Very few other tailings disposal areas in the camp are this type of deposit.

Reclamation: As this area was an original marsh with two creeks flowing through from Sas Lake and Cobalt Lake it is felt that contouring the reclaimed area is suitable. In removing the tailings the existing environmental problems of arsenic etc. will be removed and the overall area improved.

APPENDIX K

Excerpts from

THE OCCURRENCE OF ARSENIC AND HEAVY METAL CONTAMINATION FROM NATURAL AND ANTHROPOGENIC SOURCES IN THE COBALT AREA OF ONTARIO

by Charles G. Dumaresq, 1993

Abstract (Page iii)

In the ore deposits of Cobalt, Ontario, silver is associated with arsenide and sulfarsenide minerals. These minerals occur in mine tailings, and oxidation of these minerals in tailings mobilizes As. Groundwater in tailings contains high As concentrations, and this groundwater discharges into surface waters. During the summer, water soluble As-rich crusts form on the tailings, and heavy rains dissolve these crusts, flushing As into surface waters. Erosion of tailings, and redeposition of tailings in downstream water bodies also contributes to surface water contamination. Thus, tailings are an important source of contamination for local surface waters. Surface waters around Cobalt contain high concentrations of As. Except for one lake, As concentration in local water bodies range from 0.040 to 6.510 ppm, and the maximum acceptable concentration for freshwater aquatic life in 0.050 mg/L. Since As occurs naturally in the rock, some of the contamination is of natural origin. One lake unaffected by mining has a mean As concentration of 0.048 ppm. Some local groundwater also contains As, due to high As concentrations in various rock units. Most groundwaters used for consumption contain acceptable concentrations of As and heavy metals. Water from one well, in a campground, which is finished in a rock unit associated with high As concentrations in groundwater, has a mean As concentration of 6.970 ppm. Environmental contamination in the Cobalt area puts local ecosystems at risk, and there are a number of potential health threats to local residents including: inhalation of dust from tailings, handling tailings and other solid materials, swimming in local lakes and eating fish from these lakes.

3.5.2) Tailings Stratigraphy

3.5.2.1) Nipissing Low Grade Mill Tailings (Page 66)

In the spring, the surface of the NLGM tailings is very wet, and the moisture content of the tailings is very high so that liquefaction will occur if the tailings are vibrated.

In the summer, the tailings surface becomes very hard and desiccated, and surface crusts form on the tailings (see Plate 3.2). These crusts are water soluble, and are redissolved in heavy rains. South of dam #1, and in the area between dam #1 and dam #2, the crusts are white to light grey, hard and brittle. Different textures occur: some crusts are very thin (< 1 mm), and occur around desiccation cracks in the tailings surface; some crusts are thicker (≈ 1 to 1.5 mm), and occur as flaky layers over large areas of tailings; and other crusts occur as scale like patches up to a few centimetres in diameter. North of dam #2, and just south of dam #2, in areas where the tailings surface is flatter, thicker (up to 1 cm) crusts occur which range in colour from light grey to orange to reddish brown. These crusts tend to have a powdery or blister like appearance, and they crumble when touched.

Three cores were collected from the NLGM tailings, and one trench was dug, in order to examine the stratigraphy of the top 1 m of the tailings (core logs are included in Appendix 6). In addition, the drill logs from the piezometer installations include some information on the tailings stratigraphy, as well as the nature of the underlying material, where holes were deep enough to penetrate this material.

The tailings are generally very fine grained, but some coarser grained tailings are present, and fragments of waste rock and slag are present near the surface of the tailings. The tailings are well laminated with only minor soft sediment deformation features. Much of the tailings are brownish grey to greyish brown colour, but some zones of altered tailings are present particularly in the upper 50 cm of the tailings. Alteration zones are present in all three cores and the trench, and the altered tailings were frequently observed in the cuttings from drill holes. ......

3.5.2.2) Nipissing High Grade Mill Tailings (Page 77)

One trench was dug in the NHGM tailings, and one core was collected. Like the NLGM tailings, these tailings are very fine grained. The tailings surface is dark grey in colour, with no surface crusts evident. The tailings are lighter in colour below the surface. The tailings are underlain by a layer of coarse sand to fine gravel. After the opened cores had dried, some erythrite was observed in the core surfaces.

3.5.2.3) Cart Lake Tailings (Page 78)

The Cart Lake tailings are coarser grained than the NLGM tailings, and so the infiltration rate is high and the tailings surface is dry throughout the year, except very close to the lake. Crusts form on the tailings during the summer (see Plate 3.6). These crusts are white to light grey in colour, but they are much thicker than those occurring on the NLGM tailings (up to 5 cm). The crusts occur in patches up to several square metres in area.

Two trenches were dug in the Cart Lake tailings; one along the bank of the stream along the western edge of the deposit (see Plate 3.6), and the other in the vegetated area in the southeast portion of the deposit. In the trench along the stream bank, the top 30 cm of tailings are well laminated, with clay layers alternating with sandy layers. There is little evidence of alteration. Below this upper portion, the tailings are laminated, but are more uniform in grain size and colour.

Alteration material similar to that occurring in the NLGM tailings was observed in the cuttings for several of the piezometers installed nearest the lake. Very close to the lake, in an area where cattails are growing, some altered tailings occur about 6 to 7 cm below the surface.

In the vegetated area in the southeast portion of the deposit, a trench was dug to examine the soil horizons developed in the vegetated area. This area was originally tailings with a layer of topsoil added as a cover. There are now three distinct soil horizons above the tailings (see Plate 3.7). The A horizon (≈ 7 cm thick) is high in organic content, but also contains a high proportion of tailings because of wind transport. Below the A horizon is a light grey, silty to clayey horizon (≈ 7 cm thick) with a well developed microstructure consisting of fine laminations, less than 1 mm thick, with more porous intervals in between. On the basis of colour, this horizon was identified in the field as an E horizon, or zone of metal leaching, but as will be discussed in Section 3.5.6, this horizon is actually a zone of metal enrichment. Below the "E" horizon is a sandy, reddish brown B horizon (≈ 10 cm thick). Tailings (the C horizon) underlie the B horizon.

3.5.4) Trace Element Concentrations in Surface Crusts (3 samples) (Page 91)

Two crust samples from the NLGM tailings and one from the Cart Lake tailings were submitted for analysis. The trace element concentrations in these three samples are compared in Table 3.4. There are significant variations in the concentrations of major constituents in these crusts, particularly SO_4, Cl, Na, and Ca. The crusts from the NLGM tailings contain very high As concentrations. ....

Table K-1: Comparison of the As, SO_4, Cl, Na, Ca, Co, Ni and Hg Concentrations in Crust Samples from the NLGM Tailings and the Cart Lake Tailings. (Dumaresq, 1993, Table 3.4, p.92)

Element	NLGM Crusts		Cart Lake Crust (ppm)
	NLGM Crust #4 (ppm)	NLGM Crust #10 (ppm)	
As	19060.0	17999.0	696.0
SO_4	2880.0	56000.0	44.0
Cl	24.0	3632.0	0.48
Na	0.12%	4.80%	0.04%
Ca	8.63%	1.96%	1.67%
Co	664	1100	534
Ni	559	652	397
Hg	23.0	35.0	15.0

3.5.7) Trace Element Concentrations in Other Solid Materials (5 samples) (Page 98)

The trace element concentrations in concrete from mill foundations, and other solid material collected in the Cobalt area, are given in Table 3.5. Of the three concrete samples, the sample form the NHGM contains the highest concentrations of As, Sb, Cl, SO_4, Hg, Co, Ni, Bi and Ag (see Figure 3.10).

Concrete samples were collected because of concerns about Hg contamination. The Hg concentration in these samples range from

0.90 ppm in concrete form the McKinley-Darragh mill foundation, to 56.06 ppm in concrete from the NHGM foundation. The Hg concentration in the NHGM foundation is slightly higher than the mean Hg concentration in samples from the NLGM tailings, but much lower than the mean Hg concentration in samples from the NHGM tailings.

The sample identified as NHGM "stuff" contains the highest concentrations of As, Sb, Co, Ni, Cu, Pb and Zn of any sample collected in this study, and it also has a very high Hg concentration. The origin of this material is not known, but one possibility is that it is particulate matter collected in the bag house of the refinery. Normally, such material would have been resmelted, but some would have been left when the refinery shut down in 1932.

Table K-2: Trace Element Concentrations in Concrete and Other Solid Materials. (Dumaresq, 1993, Table 3.5, p.99)

Element	NLGM Concrete	NHGM Concrete	McKinley Darragh Concrete	NLGM Slag	NHGM "Stuff"
Al (%)	2.94	1.89	2.06	5.79	1.52
Fe (%)	4.86	2.62	3.02	6.54	3.51
Mg (%)	4.17	1.23	1.46	5.35	1.52
Ca (%)	8.28	9.77	15.30	11.83	2.56
Na (%)	0.13	0.14	0.17	1.22	0.12
K (%)	0.11	0.14	0.18	0.49	0.09
As (ppm)	1320.0	10400.0	880.0	14500.0	218000.0
Sb (ppm)	36.0	770.0	17.9	208.0	6200.0
Mn (ppm)	804	547	583	1742	1127
Cl (ppm)	4.22	390.0	122.0	57.0	175.0
SO_4 (ppm)	194	3440	1498	415	1050
Hg (ppm)	18.0	56.06	0.90	6.62	526.88
Cu (ppm)	1039	364	700	459	1241

Element	NLGM Concrete	NHGM Concrete	McKinley Darragh Concrete	NLGM Slag	NHGM "Stuff"
Pb (ppm)	342	199	222	221	1448
Zn (ppm)	579	239	843	752	3342
Mo (ppm)	7	10	8	213	82
Co (ppm)	250	5530	174	9288	53660
Ni (ppm)	287	3947	91	2513	38990
Cd (ppm)	<0.2	<0.2	<0.2	<0.2	<0.2
Cr (ppm)	141	118	137	159	73
Bi (ppm)	47	349	<5	237	711
Ba (ppm)	68	112	129	246	84
V (ppm)	136	71	65	104	49
Sr (ppm)	67	236	649	206	36
Y (ppm)	7	5	6	45	9
Sc (ppm)	13	7	7	17	5
Ag (ppm)	201.5	346.7	68.1	435.5	356.0

Table K-3: Estimated Rates of Mobilization of Arsenic from Tailings, Soil and Glacial Till (Dumaresq, 1993, Table 5.1, p.170)

	Leaching Solution	Rate of As mobilization mg/kg/yr	Surface Area m^2	Assumed depth of alteration m	Mass of reactive tailings kg	Total As mobilized kg/yr
NHGM tailings	"Natural Rain" "Acid Rain"	507 588	2,500	0.5	337,500	171 198
NLGM tailings	"Natural Rain" "Acid Rain"	236 238	600,69	0.5	81,091,800	19,350 19,300
Cart Lake tailings	"Natural Rain" "Acid Rain"	15 20	164,668	1	444,603,600	6,669 8,892
Soil, A-horizon	"Natural Rain" "Acid Rain"	2.1 1.5	4.8×10^7 (75% of area)	0.10 (assumed average thickness)	7.2×10^9 (assumed density of 1.5 g/cm^3)	15,120 10,800
Glacial till	"Natural Rain" "Acid Rain"	0.15 0.22	3.2×10^8 (50% of area)	0.5 (assumed thickness of reactive till)	4.32×10^{10} (assumed density of 2.7 g/cm^3)	6,480 9,504

5.2) Surface Water Contamination (Page 173)

5.2.1) Natural Contamination

The surface waters in the Farr Creek basin contain high levels of As and other contaminants. A substantial portion of the contamination load in the drainage basin is related to mine wastes, but there may also be natural contamination inputs. With their high concentration of heavy metals, mineral deposits can be regarded as naturally occurring hazardous waste sites. In many cases, these natural hazardous waste sites, particularly those close to the surface, are leaking, resulting in natural contamination. Such natural contamination has been documented in many areas, such as the MacMillan Pass area of the Yukon, where natural acid rock drainage and associated high metal loadings are occurring at an as yet unmined mineral deposit (Kwong and Whitley 1992).

In the early days of Cobalt, many rich ore veins were right at the surface. These veins were rich not just in Ag, but in As and other potential contaminants. Often, the surfaces of these veins were oxidized, with only Ag and secondary minerals left in place. As a result of this oxidation, the ore deposits of Cobalt, like those of MacMillan Pass, were leaking contaminants into the environment, prior to any mining activity. While much of the Ag has now been mined, the potential for natural contamination still exists.

Determining natural contaminant levels in an area with such strong input of contamination from anthropogenic sources is difficult, but important. Knowing the natural contamination levels could have legal implications for Agnico-Eagle Mines, who hold most of the mining properties in the Cobalt area. There are also potential implications for the way future mining regulations are drafted and applied, since background levels are not considered in current regulations.

5.2.4) Effect of Wetlands on Contaminant Levels in Surface Waters (Page 185)

Sasaginaga Creek flows through an extensive wetland which is underlain by the Chambers-Ferland tailings. Samples were collected at two points within this wetland, one about 75 m downstream of the confluence of the two arms of the creek (Site #38), and another about 500 m further downstream (Site #37). Despite the fact that the creek is flowing across tailings, the As concentrations at Site #37 are lower than they are at Site #38. Similarly, the As concentrations are lower in samples from the outlet of the small wetland between Cart Lake and Peterson Lake (Site #23) than they are in samples from Cart Lake (Site #9). A similar trend occurs in a wetland downstream from Peterson Lake. In Farr Creek, the As concentrations in samples collected at the northern limit of tailings migration (Site #33) are similar to those in samples collected further upstream (Site #13), despite input from Mill Creek, and from the tailings which underlie the wetland.

From these results it is evident that wetlands are having an effect on the As concentrations in the streams which pass through them. This may be related to three factors: the coprecipitation of As with iron oxides and hydroxides; the adsorption of As into iron oxides, hydroxides, and organic matter in sediments; and biotransformations of As (CCREM 1987, Cullen and Reimer 1989). (Note that in the Sasaginaga Creek wetland, and the wetland between Cart Lake and Peterson Lake, there is little if any surface water input between the sampling points.) Under most conditions, coprecipitation or sorption of As with iron oxides or hydroxides is the dominant process in the removal of As from water (CCREM 1987). Based on the data collected in this study, it is not possible to determine which of these processes are occurring in the wetlands of the Farr Creek basin, and which is responsible for most of the removal of As from the water column.

6.1) Conclusion (Page 196)

6.1.1) Tailings Alteration and Contaminant Mobilization

Supergene alteration reactions are occurring in the top 1 m of the tailings. In these reactions, arsenide, sulfarsenide and sulfide minerals are oxidizing, releasing sulfuric acid, arsenic acid and metal ions. These acids are reacting with carbonate minerals and albite in the tailings, raising the pH of the tailings groundwater, and releasing Ca^{+2} and Na^{+} ions, while producing secondary clay minerals. The rise in pH lowers the solubility of the metal ions, causing the precipitation of secondary iron oxides and possibly arsenate minerals within the alteration zone. At the tailings surface the evaporation of water draws solute laden water in the vadose zone to the surface. As further evaporation occurs, supersaturation is reached, and sulphate and arsenate minerals are precipitated at the surface as water soluble crusts.

These oxidation reactions are responsible for the mobilization of contaminants in tailings, particularly As. Based on laboratory experiments, the estimated rates of mobilization of As as a result of oxidation and dissolution of secondary minerals in the NLGM, NHGM and Cart Lake tailings are 236,507 and 15 mg As per kilogram of tailings each year, respectively. Much of the mobilized As is fixed in secondary minerals, and as a result, estimates of the amounts of As released to surface water are much lower than the estimated mobilization concentrations. For the NLGM tailings, it is estimated that the discharge of tailings groundwater, and surface waters which have dissolved surface crusts, results in the release of about 550 kg of As into Mill Creek each year. For the Cart Lake tailings, it is estimated that the discharge of tailings groundwater into the lake releases about 365 kg of As into Cart Lake each year. Leaching experiments, conducted on soil and glacial till, also indicated that As is mobilized from these natural materials.

The erosion of tailings also results in the release of contaminants to surface water. It is estimated that erosion of the Nipissing low grade mill tailings south of dam #1 has resulted in the removal of about 123,000 tonnes of tailings (75% of the total originally present), and a significant amount of erosion has also occurred north of dam #1. Most of these tailings are now in Mill Creek, further contributing to the contamination of that water body.

6.1.2) Surface Water Contamination in the Farr Creek Drainage Basin

All of the surface waters in the Farr Creek drainage basin, except Sasaginaga Lake, contain As concentrations close to or in excess of the maximum acceptable As concentration for freshwater aquatic life (0.050 mg/L). Arsenic concentrations are highest in the Mill Creek system, and some samples from Mill Creek also contain Hg and Ni concentrations in excess of the maximum acceptable concentrations for fresh water aquatic life for these metals. It is estimated the mean annual discharge of As in Farr Creek is 18000 kg.

Arsenic occurs naturally in the rocks in the Cobalt area, and some of the As contamination may be due to natural inputs. Short Lake has been relatively unaffected by mining activity, and it is south of the main zone of mineralization, yet the As concentrations in the lake are very close to the maximum acceptable concentration for freshwater aquatic life. Significant natural input may also be occurring due to groundwater discharge in the LaRose tailings, and in Farr Creek around North Cobalt.

Tailings deposits such as the NLGM and NHGM tailings, the tailings in Cobalt Lake, and the Cart Lake tailings are an important source of anthropogenic contamination. Another source of anthropogenic contamination is a mine shaft adjacent to Sasaginaga Creek which is discharging naturally contaminated groundwater into the creek. Contamination attributable to waste rock was observed at one location, and waste rock piles may also be important sources of contamination.

Using the water chemistry modelling program WATEC4F, it is predicted that As in surface waters is in the As(+V) oxidation state. However, this program does not take into account biological activity. Biotransformations of As can occur in surface waters, so the actual As speciation may be different than that predicted by WATEC4F, particularly in wetlands.

Wetlands appear to be having a remedial effect upon contaminant levels in surface water. In the wetland on Sasaginaga Creek, there is a decrease in the As concentration over a distance of about 500 m, despite the fact that tailings underlie the wetland. Decreases in As concentrations were also reported in wetlands in the Peterson Lake, Peterson Creek system. In Farr Creek, As concentrations in samples taken upstream and downstream from a large wetland are similar, despite the fact that the wetland is underlain by tailings, and the confluence of Mill Creek and Farr Creek is between the two sampling points.

Appendix K References

CCREM. (1987): Canadian Water Quality Guidelines. Prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Resource and Environment Ministers.

Cullen, W.R. and K.J. Reimer (1989): Arsenic speciation in the environment, *Chemical Reviews*, Vol. 89, pp. 713-764.

Kwong, Y.T.J. and W.G. Whitley (1992): Natural Acid Rock Drainage at MacMillan Pass, Yukon, Inland Waters and Lands Directorate, Environment Canada. NHRI Contribution No.92046, Saskatoon, Saskatchewan.

APPENDIX L

LEGEND AND SYMBOLS FOR TAILINGS MAPS