Northern Ontario Mining Tour

October 24 to 26, 2007

Field Trip Guide
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Introduction

Leaving Sudbury at approximately 5:30 pm on Wednesday October 24th, field trip participants will travel by bus to Timmins in Northern Ontario for an overnight stay at the Cedar Meadows Resort (see route map).

The Timmins portion of the tour (October 25) will include visits to the abandoned Kam Kotia Mine (copper), one of the most studied acid mine drainage sites in Ontario, and undergoing extensive remedial work under the direction of the Ontario Ministry of Northern Development and Mines (MNDM). Other stops will include reclamation efforts at the closed Coniaurum Mine of Goldcorp Canada (gold), the unique thickened tailings “cone” waste management system at Xstrata's Kidd Creek mine (copper/zinc), and reclamation efforts undertaken by MNDM to address the extensive subsidence that has occurred in the area. In addition, participants will go on a one hour wilderness tour at the Cedar Meadows Resort featuring up-close encounters with moose and elk.

From Timmins, participants will travel to New Liskeard for a second overnight stay. On day two (October 26), the bus will travel to the nearby historic mining town of Cobalt, the “Birthplace of Mining” in Canada. The group will start the day at the Cobalt Welcome Centre to view a 1920s film on the Cobalt Silver mines, made by the Canadian government to document the silver mining in its heyday. The group will then visit a number of sites in the town and outlying areas. These sites will provide an opportunity to learn more about the environmental and human health risks posed by arsenic-bearing tailings and waste rock from these early mining operations. The tour will also provide an opportunity to learn more about some of the unique mine hazards and associated remediation in the Cobalt area. The tour will include various mine sites to see the reclamation efforts and alternate land uses after mining ceased, and to discuss the challenges to reclamation efforts in Cobalt. Participants will also have an opportunity to visit the Cobalt Mining Museum and take an underground tour at the Colonial Adit to see a typical (of the time) Cobalt silver mine and the conditions under which miners worked.

The tour will then return to Sudbury, arriving early Friday evening.
Field Trip Itinerary

**Wednesday, October 24 – Travel from Sudbury to Timmins**

4:45 PM  - Board bus and depart for Timmins.
5:15 PM  - Pick up pizza
6:30 PM  - Washroom break and coffee at Watershed restaurant
6:50 PM  - Leave Watershed
8:30 PM  - Arrive Timmins (Cedar Meadows Resort)

**Thursday, October 25 – Timmins, then travel to New Liskeard**

6:30 AM  - Breakfast at Cedar Meadows Resort
7:30 AM  - Depart for Kam Kotia
8:00 AM  - Arrive Kam Kotia
10:00 AM - Depart Kam Kotia
10:30 AM - Arrive Cedar Meadows
10:45 AM - Wilderness tour at Cedar Meadows
12:00   - Lunch (Cedar Meadows), discussion of subsidence issues
1:00 PM - Depart Cedar Meadows and Tour subsidence sites
2:00 PM - Travel to and tour of Coniaurum Mine
3:00 PM - Arrive at Kidd Creek and tour tailings/treatment
4:30 PM - Depart Kidd Creek and travel to New Liskeard
6:00 PM - Arrive New Liskeard

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1 Breakfast is at participants’ expense.
2 Lunch is included in the field trip registration fee
3 Dinner in New Liskeard, at participants’ expense
Friday, October 26 – Cobalt, then return to Sudbury

7:00 AM  - Breakfast in New Liskeard
8:00 AM  - Depart for Cobalt
8:20 AM  - Cobalt Welcome Centre
9:20 AM  - Cobalt Lion’s Club Park
10:30 AM - Right-of-Way Mine
11:15 AM - Nipissing Low Grade Mill
12:30 PM - Lunch (Cobalt Town Hall)
1:30 PM  - Townsite Mine
2:00 PM  - Cobalt Mining Museum, underground tour.
4:00 PM  - Depart for Sudbury (snacks and beverages en route).

Estimated time of arrival in Sudbury is 7:00 p.m. Friday evening flights from Sudbury are NOT recommended.

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4 Breakfast is at participants’ expense. Breakfast is not served in the hotel restaurant, but participants may go to a couple of nearby restaurants.
5 Lunch is included in the field trip registration fee.
Northern Ontario Mining Tour - Field Trip Guide

Timmins - October 25

Introduction

Timmins is a city in northeastern Ontario, about 290 km north of Sudbury, with a population of about 43,000. Prospectors first discovered gold in the area, then known as “the Porcupine” and there has been mining continuously in the area since that time.

The field trip to Timmins will include both operating and closed sites, specifically, the Kam Kotia Mine (closed), the Coniaurum Mine (closed) and the Kidd Creek Mine (operating).

History of Timmins

The first person to set out for the Porcupine area was a prospector named Reuben D’Aigle. D’Aigle had previously been in the Yukon for the Klondike gold rush, and then, while studying at Queen’s University in Kingston Ontario, had seen some maps of northeastern Ontario prepared by the Geological Survey of Canada. The maps led him to the Porcupine for the first time in the summer of 1906. But while he found some gold in rock outcrops, it was disappointing compared to the nuggets he had seen in the Klondike. He returned in 1907 with a small team, staked a few claims, and then abandoned his efforts, not knowing how close he was to one of the richest discoveries in the world.

In 1909 several prospecting teams, moving north from the Cobalt camp, arrived in the Porcupine. Some promising discoveries were made, and word quickly spread south to Cobalt and beyond. In early June a team led by Jack Wilson arrived in the area, and on June 9 they came across a dome of quartz sticking out of the ground and decided to trench around it. Wilson later recalled,

“As I was examining the seams in the quartz, about twelve feet ahead of me I saw a piece of yellow glisten as the sun struck it. It proved to be a very spectacular piece of gold in a thin seam of schist... when the boys came back we got out the drills and hammers, and that night had about 132 pounds of very spectacular specimens.”
Following the vein they found it to be several hundred feet long and about 150 feet wide, running down the side of the hill. The dome of rock gave its name to the Dome Mine, which would become one of the "Big Three" mines in the area, and the longest operating in the camp.

Soon after Wilson’s team arrived in the area, another team lead by Benny Hollinger from Haileybury, and his partner, Alex Gillies, arrived in the Porcupine. After meeting up with Wilson, they moved further west and came across tools abandoned by D’Aigle. Just a few feet from one of D’Aigle’s test pits, they came across an outcrop that “looked as though someone had dripped a candle along it, but instead of wax it was gold.” They did not make the same mistake as D’Aigle – their claims lead to the Hollinger Mine, one of the greatest gold-producers in the western hemisphere.

A third major discovery was made that summer by Sandy McIntyre and his partner Hans Buttner, who staked four claims north of the Hollinger claims – the McIntyre Mine was born, though it would be several years before it entered production.

In 1910 the Dome Mine was the first to enter production. That spring, the gold rush began in earnest. Thousands of fortune seekers poured into the area, either in an attempt to stake their own claims, or more and more commonly, looking for work in high paying mining jobs. Towns sprang up overnight, and exploration and staking continued in an area about three miles (5 km) wide and five miles long. Mines all along the area started production over the next few years, buying plots staked during 1910 and 1911.

While a major fire in 1911 killed many people and destroyed much of the town and the operating mines, recovery was swift, and the mines were soon back in production. Indeed, at Hollinger, soil erosion following the loss of trees during the fire led to the discovery of several new gold veins.

The initial rush resulted in scores of small mines, but the hard rock mining demanded a high level of investment to be profitable, and many of the smaller sites with less valuable claims failed. Many of the surviving properties were consolidated by the larger holdings to produce a single mine that was much more profitable. Although the "big three" were the most successful at this, there were a number of other success stories as well. The Coniaurum Mine was founded in 1924; backed by Cobalt money, they amalgamated several older claims north of the McIntyre area. The mine proved highly profitable due to the nature of the veins, which tended to run
vertically. This allowed shafts to be sunk directly over the veins, without requiring the massive amounts of lumber needed to shore up horizontal drifts. The Coniaurum was successful into the 1950s, when the gold ran out. Another success was the Vipond, which had veins similar to the Coniaurum, and used their profits to build up a larger set of holdings.

Starting in the late 1920s and early 1930s a second wave of new mines opened across the area. Low labour costs due to the great depression changed the economics of running a mine, and an increased demand due to a lack of faith in paper money led to higher gold prices on the market. A number of sites formerly ignored due to low production were suddenly rendered profitable.

By the 1950s many of the original plots had been mined out, and only the richer veins remained profitable. By the mid-1960s most of the mines in the area had closed. Even the main Hollinger eventually closed in 1968.

However, a rise in gold prices beginning in the late 1960s, combined with improved mining and milling methods, led to renewed activity in the area. These efforts included reprocessing of some of the tailing piles left by the previous mining efforts.

Most recently many of the remaining claims were combined into the Porcupine Joint Venture.

**Timmins area Mines**

**The “Big Three”**
- Dome Mine, 1910-present, 14,537,595 ounces of gold produced
- Hollinger Mines, 1910-68, 19,327,691 ounces of gold produced
- McIntyre Mines, 1912-88, 10,751,941 ounces of gold produced

**Other early mines**
- Broulan Reef Mine, 1915-1965
- Buffalo Ankerite Mine, 1926-1953, 1978
- Cincinnati, 1914, 1922-24
- Coniaurum Mine, 1913-1918, 1928-1961
- Crown Mines, 1913-1921
- Kam-Kotia Mines
- Miracle Mining
- Paymaster Mine, 1915-19, 1922-1966
• Porcupine Pet Gold Mines, 1914-15
• Vipond Consolidated Mines, 1911-1941

The second wave
• Aunor Mine, 1940-1984
• Banner, 1927-28, 1933, 1935
• Broulan Porcupine, 1939-1953
• Concordia, 1935
• Delnite Mine, 1937-1964, reopened as a pit 1987-88
• DeSantis Porcupine Mines, 1933, 1939-42, 1961-64
• Faymar, 1940-42
• Halcrow-Swayze, 1935
• Hallnor Mine, 1938-1968, 1981
• McLaren Mine, 1933-37
• Moneta Mines, 1938-1943
• Naybob Gold Mines, 1932-1964
• Pamour Mine, 1936-1999, also operated the Hallnor and Aunor Mine

Newer ventures
• Aquarius, 1984, 1988-89
• Bell Creek Mine, 1987-91, 1992-94
• Hoyle Pond Mine, 1985-present
• Kidd Creek Mine, 1966-present
• Owl Creek Mine, 1981-89

Field Trip Sites

Kam Kotia Mine

The Kam Kotia Mine is located just west of Timmins, and is considered to be the worst abandoned mine site in the Province of Ontario. The site was mined for base metals from the early 1940’s until 1972. During that time 6 million tonnes of sulphide rich tailings were deposited into three tailings areas, two of which were unimpounded. The site had been the focus of considerable remediation efforts funded by the Province, through the Ontario Ministry of Northern Development and Mines. At the outset of this work, the tailings were located on more than 500 hectares of land and produced acid mine drainage that had severely impacted one river, impacted another and threatened the ground water in the area. More information on the Kam Kotia Mine is presented in Appendix 2, a paper presented at Sudbury 2003 by Chris Hamblin of the Ontario Ministry of Northern Development and
Mines, and Marz Kord of B.H. Martin Consultants. Additional information on Kam Kotia is available at: http://www.mndm.gov.on.ca/mndm/mines/mg/abanmin/kamkotia_e.asp

The visit to Kam Kotia will focus on efforts by the Ontario Ministry of Northern Development and Mines to remediate the site.

**Subsidence Sites**

Historically, the mines in Timmins, nearly all underground mines, were very close to the town. As the town has continued to grow, significant development has occurred over mined out areas. This has led to ongoing challenges related to the subsidence of underground mine workings, dating back to the 1920s. Most of the underground workings were not backfilled as part of the mining operations. Where backfill was used, it was mostly loose sand. This, combined with often thin and weak crown pillars in workings close to the surface, have resulting in numerous cases of subsidence. This problem has become worse as the water levels have increased in the underground workings, washing out what little sand backfill was used.

Since 1999, when water levels began approaching the ground surface, a number of areas of active subsidence became evident. Subsidence events affected commercial, institutional and residential properties outside of mine property boundaries, as well as some roads. Extensive subsidence also occurred on the Hollinger Golf Course. Another area that has experienced significant subsidence is McKane Motors, a local car dealership.

In the 1980s, geotechnical investigations to establish an inventory map of abandoned mines at risk of subsidence, known as "Areas of Caution" were started. Since 1999, work has been underway to prioritize subsidence areas of concern, and extensive remediation efforts have been carried out. In addition, areas at risk have been fenced for safety. Work has also been carried out to determine the stability of other stopes where subsidence has not yet occurred. In some cases, underground stopes may require backfilling to reduce the future risk of subsidence.
Aerial view of Kam Kotia Mine in 1989
Google Earth view of the Kam Kotia Mine
Cave-in at the Moneta Mine site as a result of subsidence, 1963

Aerial view of subsidence on the Hollinger Golf Course. Plenty of extra hazards for the golfers!
Another site in Timmins that was at risk of subsidence was a major intersection on Highway 101, the main highway through Timmins. Geotechnical testing showed that a crown pillar below the intersection was unstable and the area was identified as an area of caution. As a result, the road was closed and a reinforced concrete cap was put on top of the crown pillar. This intersection is illustrated in the inventory map below, prepared for the municipality, as well as in the photos below. In addition, an image from Google Earth illustrates the larger area, including the subsidence on the golf course.
Inventory map of mine openings and areas of subsidence, prepared for the municipality of Timmins in 1989.

Remediation work following the identification of a subsidence risk at the major intersection in the above map.
Google Earth image of areas of subsidence in Timmins, including the highway intersection (1) and the golf course (2).
Coniaurum Mine

As described previously, the Coniaurum Mine first opened in 1913, and after shutting down from 1918 until 1928, remained in operation until 1961 when it was flooded during a severe storm. Further re-processing of the tailings was conducted for about a year in 1988. The property is currently held by the Porcupine Joint Venture, or PJV.

The PJV was formed in 2002 with the joining of the Timmins operations of Placer Dome Limited and Kinross Gold Corporation. The PJV holds about 37,590 hectares in the Timmins area. Except for the Dome Mine and the Hoyle Pond Mine, which continued to operate, the majority of the properties were in a state of partial or complete abandonment at the time of formation of the PJV. The PJV owns over twenty-five tailings deposits located throughout the Timmins area, including the Coniaurum tailings, as well as several waste rock dumps located on the Dome, Pamour and Hoyle Pond properties.

Until the property was acquired by the PJV, little reclamation work had been conducted on the site. As a result of weathering and storm events, severe erosion of the tailings surfaces as well as breaching of the internal and external dykes had resulted in seasonal release of tailings solids to the nearby Porcupine River.

Prior to the site being acquired by the PJV, some rehabilitation had been conducted in 2000, including capping of a shaft, and demolition and disposal of buildings and foundations.

In 2003 and 2004, an evaluation of the Coniaurum Tailings impoundment was undertaken that led to the development of a closure plan for the property and was submitted to the Ministry of Northern Development and Mines in December 2004. As a result of the tailings assessment and the Coniaurum Mine Closure Plan, Placer Dome undertook the closure design and started reclamation of the tailings facility in 2005.

The objective of the tailings reclamation was to physically stabilize the facility to prevent further release of tailings solids to the environment. The project was divided into three phases, and included the contouring of the entire facility as well as the installation of a ditching network to collect and convey runoff away from the facility while substantially reducing tailings surface erosion.
All rehabilitated areas were covered with a wood pulp by-product. By October 2005, about 40 percent of Phase 1 of the project had been seeded and inspections of the site indicated a high level of success in the early re-vegetation efforts.

In 2006, PJV completed the majority of the work on Phase 2 of the project, in the eastern portions of the Upper Tailings Dam. Earthworks included the construction of a network of ditches and swales required to safely convey melt and rain water off the facility while eliminating erosion that had actively affected the tailings since the early 1960’s, as well as the re-sloping of perimeter dams. Large volumes of tailings were moved around the facility in order to promote surface sheet flows while restricting concentrated flows to the constructed ditches.

Pulp and paper mill by-products, which had been used with success in Phase 1 of the project as a growth media for revegetation, were placed in various areas of Phase 2 and were seeded in the spring of 2007.

Also as part of the 2006 works, a discharge channel was constructed at the north end of the Lower Tailings Dam which was designed to safely remove water from the facility and discharge to the Porcupine River. Work on the Lower Tailings Dam continued in 2007 with the construction of a ditch network as well as contouring of the exterior perimeter dams.

Information on reclamation efforts at the Aunor, Broulan, Pamour and Bell Creek tailings, also held by the PJV, is included in Appendix 3.
Coniaurum tailings before reclamation

Coniaurum tailings during reclamation work. The wood pulp by-product (dark brown) is being applied

Coniaurum in 2006. This photo is taken from the same location as the 2 photos above
Kidd Creek Mine

The Kidd Creek Mine is located about 22 km from Timmins, and has been in operation since 1966. The mine produces copper, zinc, and other base metals, and is one of the largest and richest deposits of its type in the world.

The operation consists of the mine site, and a metallurgical site located just east of Timmins. The metallurgical site includes a mill producing copper and zinc concentrates, a copper smelter and refinery, a zinc plant, a cadmium plant, an indium plant and a sulfuric acid plant. Tailings from the mill are deposited in a facility to the north of the metallurgical site. The facility contains over 100 million tonnes of tailings, and by the time the site closes in 2023 it is expected that there will be more than 130 million tonnes of tailings. The tailings are conical in shape, with a radius of about 1.2 km.

Since 1973, tailings have been thickened prior to disposal. Kidd Creek was the first site in Canada to employ this method of tailings disposal. Tailings are thickened by reducing their water content prior to disposal. This in turn eliminates the need for dams, dikes or other containment structures for the tailings. Thickened, rather than conventional tailings disposal is used at Kidd Creek due to the topography, hydrology and soil conditions of the area. In particular:

- The area is not suitable for the construction of tailings dikes, and the risk of instability would be increased due to the extremely poor soil conditions.
- The tailings are finely ground and could not be used for dike construction, thus increasing costs.
- The site is situated on high ground surrounded on three sides by Porcupine River tributaries.
Google Earth view of the Kidd Creek Metallurgical Facility
Cobalt – October 26

Introduction

In 1902 the Ontario government decided to build a railway from North Bay to the small farming communities of Haileybury and New Liskeard on the shores of Lake Temiskaming. By the summer of 1903, the railway was reaching a point 103 miles from North Bay. Legend has it that one evening that summer, Fred LaRose, a blacksmith working on the construction of the railway, was in his tent when he saw a fox outside. LaRose grabbed his hammer and threw it at the fox. He missed, and the hammer clanged against a rock face. In the morning LaRose picked up his hammer, and discovered that when he had thrown it, it had chipped away some of the rock and exposed a silver vein. The Cobalt silver camp had been born.

The true stories of the discovery of silver around the Mile 103 section of the railway are not as romantic as the legend, but by the time of the first snow in November of 1903 word of the discovery had spread. By 1905 there were sixteen mines in the area, and in 1911 production exceeded 30,000,000 ounces. Cobalt was the biggest silver mining camp in the world and was known by everyone in North America who ever picked up a newspaper. Mining continued until the 1930's, then slowed to a trickle. Activity renewed in the 1950's then slowly dropped off, and there are no longer any operating mines in the area.

The silver mines of Cobalt, and the prospectors and miners that discovered them and worked the mines, have left an indelible mark on Canadian history. The discoveries at Cobalt led the way to further exploration, mining and settlement in northern Ontario and Quebec.

Cobalt was a training ground, the birthplace of hardrock mining in Canada. The ore was close to surface, which meant that men with limited experience could prospect and begin mining, and then hone their skills as the mines went deeper. Those who learned their trade in Cobalt moved north, discovering gold in Kirkland Lake and Timmins and further afield in Canada and around the world.

The historical importance of Cobalt is recognized and kept alive in many ways. In 2001, Cobalt was named “Ontario’s Most Historic Town” by TVOntario, and in 2002 the area was declared a National Historic Site.
Visitors can go to the Cobalt Mining Museum, which boasts one of the largest collections of silver in the world, and follow the Heritage Silver Trail to several mine sites in the area.

In addition to this important historical legacy, the mining activities in Cobalt have also left an environmental legacy. Millions of tons of mine waste rock and mill tailings were dumped on the land and in local lakes. In Cobalt ores, silver was associated with arsenic minerals. Little of this arsenic was ever recovered - most of it ended up in the tailings and waste rock. Today this arsenic contaminates surface water in the area and poses risks to the environment and human health.

The Cobalt area is also laced with many miles of underground mine workings, as well as surface trenches, pits and shaft openings. As a result, there are risks of subsidence of underground mine workings, and many areas that have been fenced off to prevent people from entering mine workings. These mine hazards are another aspect of the legacy of mining in Cobalt.

About the Field Trip

The field trip to Cobalt will explore several themes:
- the historic legacy of mining in Cobalt, and some of the challenges this legacy presents from the perspective of reclamation.
- the environmental legacy of mining in Cobalt, including the scope of mine waste disposal in the area, the extent of water pollution, and factors contributing to water quality in the area.
- reclamation efforts in the area to date and some of the ongoing challenges regarding reclamation, particularly the reclamation of mine wastes that are geochemically unique in Canada.
- geochemistry of tailings and other wastes in the area, and some of the uncertainties regarding geochemical processes in these wastes.
- potential risks to human health and the work being done to better understand and manage these risks.
- public safety hazards posed by open holes and subsidence of underground mine workings.

The field trip will inform participants while at the same time facilitating discussion about the unique technical challenges associated with addressing environmental problems in the Cobalt area. Hopefully, some fruitful
discussions will come from this, together with greater interest in continuing some of the much needed research and development in the Cobalt area.

For more information about the historic and environmental legacy of mining in Cobalt, participants can visit the website written and maintained by one of the field trip leaders:  [www.cobaltmininglegacy.ca](http://www.cobaltmininglegacy.ca)

### History of Cobalt

The Ontario Government decided in 1902 to build a railway from North Bay to New Liskeard and Haileybury. This area of rich farmland was seen as a prime starting point for further settlement. At that time, no one dreamt that silver mining in Cobalt, and gold mining further north in Kirkland Lake and Timmins, would become the driving force for settlement, rather than farming.

By the summer of 1903 the line, the “Temiskaming and Northern Ontario,” was getting close to Haileybury. That summer, contractors working for the railway made a series of spectacular discoveries around the shores of a boot shaped lake called Long Lake, about 5 miles south of Haileybury. Spectacular, but for one problem – none of the amateur prospectors had a clue what they had found – but all knew it was something of value.

Word of the discovery reached the Ontario Bureau of Mines, and Willet Green Miller, a professor at Queen’s University and Ontario's first Provincial Geologist, was sent to Cobalt in late fall. Millar quickly realized that the veins were rich in silver. Blackened samples rich in tarnished silver had been overlooked by the early prospectors in favour of the samples containing shinier but less valuable minerals such as niccolite. At the base of one vein, Millar reported that there were “pieces of native silver as big as stove lids and cannon balls”. Four samples collected by Miller contained over 23% silver. From his visit Miller concluded that “The ore is undoubtedly very rich, containing values of nickel, cobalt, silver and arsenic, and a comparatively small vein could be worked at a handsome profit.”

Despite these discoveries, there was no great staking rush in the spring of 1904. Many were convinced that this discovery would fizzle and fade. However, some prospectors did come to the area, and by the end of 1904, much of the best ground had already been staked. It was in that year too, that Miller named the camp “Cobalt.” The stage was set for a rush in the spring of 1905.
Word began to spread that the discovery at Cobalt was no hoax, and prospectors and developers began flooding into the area in 1905. By late 1905 there were sixteen mines in the area employing 438 men and shipping $1,366,000 worth of ore.

The mines at that time were very small and most were simple operations. Ore was mined with picks, hammers and drilling bars and hoisted to the surface by hand. Profits were huge; in 1906 $2,000,000 worth of ore was shipped. As the richest surface veins were exhausted, the exploration for new veins intensified and existing mines started to go deeper.

In 1908, Cobalt supplied nearly 9% of the world's total silver production, an incredible growth in production in just a few years.

Mining in Cobalt reached its peak in 1911. By this time the town was thriving and had a population of between 10,000 and 15,000. In 1911 production reached 31,507,791 oz of silver, an all time high for the area.

The first two years of World War I were hard times in Cobalt. Many of the men were overseas in the war, leaving a smaller labour force to work the mines. By 1917, labour shortages forced many mines to stop their mining operations. However, improvements in methods to recover silver from the mined rock meant that rock in many of the older waste rock piles could be processed to recover silver. As a result, miners were put to work recovering waste rock for processing.

By the end of the war Cobalt had reached a milestone with the shipment of 10,000 tons of pure silver. However, the camp was entering its twilight. The postwar population was only about 7,000 and 1919 was marked by a long bitter strike.

The 1920's were hard times, with few mines surviving the decade. By 1932 only one of the large mines, the Nipissing Mine, and a few minor producers were left in operation.

World War II and the period following saw a revitalization of mining in Cobalt. Until then, there had been little use for the cobalt contained in the ores, and most of it ended up in the tailings, but during and after the war new medical and metallurgical uses were developed for cobalt. In addition, the discovery of new high grade veins led to renewed exploration and mining for silver.
For a while in the 1950s, the glory days of Cobalt returned. Several mines reopened, new veins were discovered, and old waste rock and tailings were re-processed for their silver and cobalt content.

Inevitably, the ore was depleted, and by the 1970's most of the mines had again shut down. By the mid 1980s, mining had come to an end. A couple of short lived ventures kept hopes alive through the 1990s, but today the mines of Cobalt are silent. Today, only one operation remains, recovering metals from recycled materials. But Cobalt has closed before only to be revitalized later, and many in the area still hope that mining will again drive the town’s economy. Rising commodity prices and increasing exploration for silver, base metals and even diamonds may lead to mining again in the future.

**Environmental Legacy**

Decades of mining activity have forever scarred the landscape around Cobalt. This activity has left a significant environmental legacy. There are two aspects to this legacy – mine hazards, and pollution.

At the Canadian National Vimy Memorial Site in France, it is important to stay on the trails. Venture off the trails, and danger may lurk. Unexploded bombs and shells lie just beneath the surface, still powerful enough to maim and kill decades after the battle. So too in Cobalt, dangers may lurk. Because the silver veins were often right at the surface, the landscape is dotted with pits and trenches. Step into one and you could break an ankle, or fall to your death. Many of these mine hazards are now fenced off. Others are not.

A further hazard, more hidden, is mine subsidence – the collapse of underground mine workings, leading to problems on the surface. Subsidence is a particular concern in Cobalt because the veins were very close to the surface – few of the mines went down more than 300 feet. The problem is made more complicated in Cobalt by the fact that the town was built around the mines, and there are many miles of mine tunnels under the town, some very close the surface.

One morning in 1987, a small hole appeared in Highway 11B in town. By the end of the day, there was a large hole in the road, and the road was closed. The road caved in as a result of the collapse of the underground mine workings, leaving a 60 foot gap in the road. People jokingly referred to
it as the world’s biggest pothole, but it was a graphic demonstration of the risks of mine subsidence in Cobalt. The Ontario government spent several millions of dollars in the 1980's and 1990's, testing to identify areas at risk for subsidence, and then doing remedial work to reduce those risks.

Visitors to Cobalt may note with some surprise the almost barren hill on the east side of Cobalt Lake, sometimes referred to as “Nip Hill” since this was the property of the Nipissing Mining Company. The area around Cobalt is also littered with the leftovers of decades of mining – waste rock and tailings. And the lakes and streams around Cobalt are laden with arsenic and other contaminants.
Cobalt stands as a testament to just how much mining has changed in the last century. The prospecting and mining methods used in Cobalt would be completely unacceptable today. In many ways Cobalt is an excellent classroom to learn how NOT to protect the environment from mining activity.

Silver was found in narrow veins in the rock, and there were hundreds of these veins, many very close to the surface or right at the surface. The preferred method of finding these veins was to cut all the trees and systematically dig trenches down to the bedrock. The Nipissing Mining Company, which held one of the largest areas of claims in Cobalt, took this method one step further. Lake water was pumped up the side of Nip Hill, and then sprayed under high pressure, removing all of the soil. Nip Hill was laid completely bare. Today, almost 100 years later, much of the hill remains barren, and while it is a great place for geology students to explore, trees are struggling to retake the hill, and make it green again.

The soil from Nip Hill ended up in the nearby lakes – Cobalt Lake and Peterson Lake. By 1910, Cobalt Lake was dirty and murky, full of debris from the prospecting, as well as mine tailings from the nearby mills.

Waste rock and tailings were disposed of with no regard for the environment. Waste rock was frequently disposed of in dumps that extended outwards from mine headframes. Similarly, tailings were normally disposed of in the closest convenient depression in the land, sometimes even right beside the mill. Since some mills were built on lakes, including Cobalt Lake, many tailings were also disposed of in the lakes.

The waste rock and tailings contained minerals composed in part of arsenic, and were also high in nickel and cobalt. This is because the silver ore in Cobalt was a mixture of silver with a number of different arsenic-bearing minerals known as arsenides and sulfarsenides. Little of the arsenic was ever recovered, and most ended up in the waste rock and tailings.

Arsenic continues to leach from these mining wastes, and most of the lakes and streams around Cobalt are laden with arsenic – some of the highest concentrations of arsenic in water anywhere in Canada. Despite remediation projects, Cobalt remains one the largest sources in Canada of releases of arsenic. Estimates of the amount of arsenic discharged each year into Lake Temiskaming range from 10,000 to 18,000 kilograms – more than all operating mines in Canada, combined.
Field Trip Sites

Cobalt Train Station and Welcome Centre

The Cobalt Welcome Centre is located in the historic Cobalt train station, on the shores of Cobalt Lake. The Welcome Centre has information on area attractions and there is also a gift shop. The Welcome Centre features a movie made by the Canadian Government to showcase mining in Cobalt.

The train station itself is an attraction. The station, completed in 1910, is the second Cobalt train station, the first one having burnt down. Built at the height of the silver boom in Cobalt, the present station, which is a heritage building, is an excellent example of train station architecture, designed by the same architect who designed Union Station in Toronto. This station
marked the beginning of their new lives in Cobalt for those who came to Cobalt seeking their fortune, and is a fitting starting point for the field trip.

Cobalt Train Station and Welcome Centre

Cobalt Lake – Lion’s Club Park

Several mills deposited their tailings in Cobalt Lake: the Cobalt Lake Mill, Cobalt Reduction Company, McKinley-Darragh Concentrator, McKinley-Darragh tailings mill, the Hellens Mill and the Agnico tailings mill.

In 1914, the lake was drained, and tailings were removed for reprocessing. New tailings were returned to the lake. Operations continued until 1920 and again from 1922 to 1932, when a cave-in occurred in a mine under the lake, allowing tailings to flood into the workings.

Cobalt Lake in 1932, after the cave-in. This is the portion of the lake south of the park.
In 1951 the Hellens Mill was built on the site of the Cobalt Lake Mill to reprocess tailings. The lake was again drained, and operations continued until 1955. Initially, the new tailings were deposited in the north end of the lake, but because of their high cyanide content, it was decided to deposit them in Cart Lake instead.

In 1966, Agnico Mines drained the lake for the third time and reprocessed tailings until 1969, with the new tailings being deposited in the north end of the lake.

It is estimated that well in excess of 300,000 tons of tailings remain in the lake.

Some of these tailings now form the foundation of the Cobalt Lion's Club Park, which divides the lake. During the cleanup following a major fire in 1977, mine waste rock from around the town and rubble from buildings destroyed in the fire were dumped in the lake to increase the size of the park from one baseball diamond to two.
Right-of-Way Mine Site

The headframe of the Right-of-Way Mine is one of the oldest, and best preserved in Cobalt. The structure dates from about 1906. The Right-of-Way is perhaps the most improbable mining property anywhere. With mining rights only along the railway line, the property was 4 miles long and 99 feet wide, and followed the curve of the rail line south along the lake shore. Despite this, the property was very profitable.

This site, part of the Heritage Silver Trail in Cobalt, highlights some of the challenges faced in Cobalt - how to complete mine closure in the area and address the environmental concerns, thereby reducing the risks to the environment and human health, while respecting the heritage and historical legacy of Cobalt.

Abandoned mine sites are seen by most as eyesores at best, serious hazards at worst. Many do not realize the essential role that abandoned mining structures, particularly headframes, play in the collective memory of mining communities like Cobalt. Mine headframes are simple structures, essentially serving as the top of an elevator shaft. Yet headframes are often the only visible sign of the work that goes on deep beneath them. And that is the key to their importance in mining towns. For these communities the mining landscape and structures that remain after the mines close become a powerful component of their identity as mining towns and a memorial of a proud past. Thus, in these communities structures such as headframes are not eyesores, but part of their identity.

In the book “Industrial Cathedrals of the North”, Cobalt author and now Member of Parliament, Charlie Angus, wrote that “Miners talk of specific mines the way sailors talk about individual ships, the way veterans invoke particular battles.” Acknowledging that mining is dangerous and that, sadly, many have lost their lives working underground, Angus added that “When a mine shuts down, the headframe remains as a cenotaph. Tear down this cenotaph and you attack a common memory.”

In Ontario, mine closure is regulated under the Mining Act, which requires all mines in the province to submit closure plans. The Act specifies information to be included in a closure plan and also includes the “Mine Rehabilitation Code of Ontario” which details requirements with respect to mine openings, tailings dams and other containment structures, surface water and groundwater monitoring, metal leaching and acid rock drainage, physical stability of sites, and revegetation. The Ontario Mining Act requires that
headframes and other structures be removed to an extent that is consistent with the specified future use of the land. Tourism is an acceptable future land use if there is someone to take over the maintenance of the structures, but the removal of such structures is a common part of mine closure in Ontario and elsewhere.

Clearly, the challenge of completing mine closure in the Cobalt area and addressing the environmental concerns, while respecting the heritage and historical legacy of Cobalt is not an easy one. The challenge is both technical and social.

The technical challenges are related to the need to preserve the integrity of heritage resources such as the Right-of-Way Mine, while remediating sites to reduce risks to the environment and human health. In many cases it is easier and less costly to remove structures and to haul away contaminated soils and building materials for safe disposal, rather than to remediate sites in such a way that heritage structures are preserved. The methods of remediating a site by this approach are well understood, but undertaking remediation that preserves heritage structures is less well understood.

The social challenge can be even greater. In some mining communities, efforts to remediate can be greeted with suspicion, for they can be seen as a threat to the community. This is further complicated in communities when the scope of environment concerns are either not understood, or are ignored or denied. In his book, Charlie Angus highlights how sensitive such issues can be in describing the demolition of the headframe of the O’Brien Mine in Cobalt in 1995. There were concerns that the headframe was structurally unsound, and presented a safety hazard. The company owning the headframe bulldozed the site and burned the debris. “The day the company burnt the O’Brien, the old men were gathered outside the post office, all eyes on the black smudge hanging over the timber line. Bill McKnight stood with his hawk face defiant under unruly, white hair barely tamed by a baseball cap. ‘They’re stealing who we are,’ he said, ‘Soon there’ll be nothing left at all.’” The other old ones, as if seeing bits of themselves in the funeral pyre, nodded grimly, ‘They shoulda left the damned thing alone,’ said one of them shaking his head.”

There has been progress in meeting this challenge in Cobalt. Despite the loss of the O’Brien Mine headframe and several others, others, including the Right-of-Way, have been preserved. However, significant challenges remain. Mill foundations pose a significant challenge, particularly those that are contaminated with arsenic and other metals.
Right-of-Way Mine, probably in about 1907

Right-of-Way Mine in 2006
Nipissing Low Grade Mill Site and Tailings

The Nipissing Mine and Mill complex was one of the largest and longest operating sites in Cobalt. The complex was located on the hill on the east side of Cobalt Lake, opposite the town, known as Nip Hill. The first mill built by Nipissing was completed in 1907 on the southeast shore of the lake, and it operated until 1912.

In 1911 the Nipissing high grade mill was built, using mercury amalgamation. A small amount of tailings were deposited in a depression down the hill from the mill, close to Cobalt Lake. Tailings were contained by a concrete wall, but there is a culvert in the wall and most of the tailings have been washed down to the lake. The Nipissing high grade mill ceased milling in 1918, though the refinery on site continued to operate, producing silver bullion. Remaining tailings contain some of the highest concentrations of arsenic and other contaminants of any tailings in the area.

In 1912 the Nipissing low grade mill was built further north on the hill. This mill operated until 1932, using cyanide. The foundation of the Nipissing low grade mill is a prominent feature in town, and is part of the Heritage Silver Trail. The lookout built on top of the foundation affords one of the best views of the area.

Nipissing Low Grade Mill in 1925
The mill burnt down in 1934, and over the years, debris has gradually been cleared from the site. However, there has not been any concerted effort to remediate the site. Data from a screening level health risk assessment completed by the Ontario Ministry of the Environment (2005) show that the soils around the foundation, as well as parts of the foundation itself, are high in arsenic, mercury and other metals.

The tailings from the Nipissing low grade mill were deposited in a depression north of the mill. These tailings are one of the largest on land deposits of tailings in the Cobalt area. Comparison of a photo taken shortly after the mill burned down with recent views of the tailings suggest that as much as 50% of the tailings present in 1934 have been removed by erosion, and likely re-deposited in Mill Creek.

By the early 1990s the tailings were a wasteland. Erosion of tailings into Mill Creek was continuing, and the tailings were a significant source of arsenic into Mill Creek. Extensive surface crusts formed in the dry summer months as a result of chemical reactions in the tailings. These crusts were water soluble and very high in arsenic. Heavy rains would dissolve these crusts, resulting in high concentrations of arsenic flushing into Mill Creek. In addition, dust laden with arsenic and other metals from the tailings was a potential hazard to those living near the tailings.
In the late 1990s, the tailings were covered with about 30 cm of clay and revegetated. The vegetation has taken hold across the tailings, and the difference is striking. The grey, dusty wasteland has been replaced by lush vegetation.

Significantly, the successful revegetation of these tailings has largely eliminated the problem of dust from the tailings. This has helped reduce the potential risks to those living near these tailings. The revegetation has also reduced the recreational use of these tailings, particularly by youths on dirt bikes. Before revegetation, this recreational use contributed to the dust problems with these tailings, and may have put those riding on the tailings at significant risk from the dust due to the degree of exposure.

The visit to the tailings will provide an opportunity to assess the degree to which the reclamation efforts have been effective, and to discuss some of the challenges that remain.
Dust on Nipissing Low Grade Mill Tailings in 1991

Townsite Mine

Like the Right-of Way Mine, the Townsite Mine has one of the oldest headframes still standing in the Cobalt area. This headframe is one of the most unique in town – right beside the road, the road actually curves around the headframe. This reflects reality in Cobalt – the mines came first, and everything else like houses, schools, road and sidewalks was secondary. Adjacent to the Townsite Mine is a gloryhole – underground workings that were mined through to the surface, giving a unique glimpse into the subterranean world of the mine.

Sadly, the condition of the Townsite headframe is poorer than that of the Right-of-Way, and subsidence of underground workings may one day take the headframe. Just in front of the headframe, between the headframe and the road, is a slowly growing sinkhole – evidence of the potential hazards associated with subsidence in Cobalt.
These hazards were driven home graphically one day in the summer of 1987. What appeared one morning to be a small hole in the road just south of the Townsite Mine grew as the day went one, until the road, then closed to traffic, completely collapsed. It was jokingly called the “world’s biggest pot hole”. But it was no joke.

The main road through town remained closed for several weeks while the road was repaired. Backfilling the hole was not an option – the exposed underground working would have taken an untold number of dump truck loads of rock to fill. In the end, a unique solution was found - a bridge. The open workings visible in the picture above were first capped, and then bridge foundations were established in structurally sound bedrock adjacent to the mine workings. The void was then filled, and capped with a concrete slab. Today, only a slight rise in the road belies the fact that the bridge structure lies below the pavement.
Road collapse as a result of underground subsidence in Cobalt, 1987

Remediation work in progress following the road collapse
This incident led to an extensive investigation of subsidence hazards in Cobalt, beginning in 1989. Extensive drilling was carried out, and in high risk areas, innovative technologies were used to assess underground mine openings, including cameras, ultrasonic equipment, sonar profilers, and even a remotely operated submersible vehicle. One of the high risk areas identified in this work was a senior citizens’ residence, just north of the Townsite Mine. The location and nature of the structure limited the options for addressing the problem.

In the end it was decided to drill a series of vertical and angled holes around the building, use them to insert sand fill using gravity. Once the void had been largely filled with sand, the final backfilling was completed using concrete pumped in through an old mine shaft. Finally, grouting was used to fill the last of the voids. Similarly innovative solutions were used to stabilize other areas in Cobalt, including the elementary school. The multi-million dollar program did much to reduce the risks to Cobalt and its residence due to mine subsidence. But as evidenced by the sinkhole in front of the Townsite headframe, some hazards remain.

Schematic drawing to illustrate work done to stabilize underground mine openings under the senior citizens’ residence in Cobalt (from T.G. Carter et al., presented at Sudbury ‘95).
Cobalt Mining Museum

The Cobalt Mining Museum, just a short walk up the hill from the train station, looks small from the outside. However, its galleries contain many artefacts and photos that tell the history of Cobalt, from mining, to fires, to the unique people and events that help make the town special. The main gallery contains many spectacular samples of ore from the Cobalt silver mines, and the museum boasts the world’s largest display of silver.

The building itself is historic. Built in 1909, the building was originally the home of the Cobalt Nugget, the first newspaper in town. The Nugget is still published today, though in 1921, once the boom days in Cobalt were over, it moved south to North Bay. In 1915, the brothers that established the Nugget established a second newspaper that is also still in print, the Northern Miner. Back then, “the Miner” covered the growing mining camps of northern Ontario, but from those humble beginnings back in Cobalt the Northern Miner now has a global reach.
Colonial Mine

The underground tour at the Colonial Mine, guided by staff from the Cobalt Mining Museum, provides a unique underground experience. The narrow damp tunnels of the mine give a real appreciation for the conditions under which miners worked, and tour guides sprinkle the tour with many stories to help bring the past to life. It is a very different experience from other underground tours, such as the Dynamic Earth tour in Sudbury.

As you walk along the tunnel, notice the many holes that have been drilled in the tunnel walls – holes drilled by students from the Haileybury School of Mines.

The Colonial Mine is also the site of one of the largest remaining waste rock piles in the Cobalt area. In addition, the site provides an excellent vantage point to view the Crosswise Lake tailings deposit. Crosswise Lake is the largest lake in the area, and hosts the largest accumulation of tailings. Tailings were deposited in the north end of the lake by at least five different mills. This tailings deposit is very large, although estimated tonnage is not known. Crosswise Lake is significantly shorter than it used to be. A dam was built across Farr Creek to limit the migration of tailings along the creek, but this dam failed in the 1970s and has not been rebuilt. North of this dam the tailings are vegetated and the area is a wetland. At the north end of this wetland, which is the northern limit of tailings migration, there is a small water level control dam.
Crosswise Lake Tailings from the Colonial Mine in 2006. The Colonial Mine waste rock is in the foreground.
Appendix 1: Field Trip Leaders

**Bryan Tisch, M.Sc.**

Bryan completed both his undergraduate and Masters Degrees in Biology at Laurentian University. He is currently a Senior Environmental Scientist with the CANMET - Mining and Mineral Science Laboratories (CANMET-MMSL) of Natural Resources Canada, and is Co-President of the Ontario Chapter of the Canadian Land Reclamation Association.

Prior to joining Natural Resources Canada, Bryan was Manager of Environmental Services for Laurentian University’s Elliot Lake Research Field Station. During his time in Elliot Lake, Bryan worked on a variety of reclamation projects in Elliot Lake, Sudbury and Timmins, encompassing flooded tailings (water covers), dry covers and the direct establishment of vegetation in tailings. Bryan was the driving force behind the research leading up to the full-scale rehabilitation of the Pronto mine tailings (near Elliot Lake) through the use of papermill biosolids. This was the first full-scale application of this sort of material to a mine site in Ontario, and the success at Pronto was largely responsible for further long-term utilization of papermill biosolids at mine sites in the Timmins (Ont.) area.

Bryan is continuing to develop opportunities to utilize organic “waste” materials for the rehabilitation of mine sites, through his current initiative entitled “Green Mines Green Energy”. This initiative aims to rehabilitate mine tailings to the extent that energy crops such as corn, canola, soy and others can be grown and utilized as feedstock for the production of biofuels.

**W.O. (Bill) Mackasey, M.Sc., P. Geo.**

Bill’s career spans over 40 years working for government agencies and mining companies, that started with exploration and mining geology, and progressed from site-specific earth science projects, to broader studies of land-use issues at the regional, provincial and national level. Close to 30 years were spent with the Ontario government in the field of mining geology, abandoned mines, mine reclamation, land-use planning and policy development. He served as a mine environment advisor for the Assistant Deputy Minister of Mines, Ontario, and to the Brazilian Government. Bill also represented the Ontario Mining Association on the Great Lakes St. Lawrence Round Table of the Ontario government’s Lands for Life land-use planning...
exercise. He has produced over 40 technical papers on geology, mineral potential, abandoned mines and land-use planning.

Mr. Mackasey established his own company eleven years ago in Sudbury and serves as a consultant on mineral potential assessment, policy development, restoration of land values, and for solving land use problems in regions affected by mining.

Dawn Spires, B.Sc.

Dawn Spires graduated with a B.Sc. Agriculture from the University of Guelph with a major in Soils Science. Her early work experience includes forming her own environmental consulting firm with 3 colleagues and establishing a Geotechnical Watershed study area for the Ministry of the Environment in Sudbury as part of the cross-provincial Acid Precipitation in Ontario Study (A.P.I.O.S.).

Currently Dawn is a Rehabilitation, Inspection & Compliance Officer with the Ministry of Northern Development and Mines, and assigned to inspect mine sites throughout the province of Ontario. Her area of responsibility includes the seven closure plans for the Cobalt area mines, which were in “Temporary Suspension” in 1991 when the Rehabilitation of Mines legislation was proclaimed.

Charles Dumaresq, M.Sc.

Charles is a geologist who first visited Cobalt in 1986 for a Carleton University Geology Department field camp. In 1991 and 1992 he carried out environmental research in the area as part of his graduate work at Carleton. From 1993 to 1997, Charles continued working in the Cobalt area, with colleagues from Natural Resources Canada. In January 2006, Charles began participating, as a scientific advisor, on the Cobalt Soils Study Steering Committee.

In the summer of 2006 he launched a website about Cobalt – [www.cobaltmininglegacy.ca](http://www.cobaltmininglegacy.ca). The goal of this website is to help foster further research and monitoring in the area and, ultimately, an environmental clean-up in the area that reduces the risks to the environment and human health, while respecting the heritage and historical legacy of Cobalt.
Charles works for Environment Canada, and while Cobalt is a personal interest and not part of his responsibilities with Environment Canada, he has spent 15 years working on issues related to mining and the environment. He participates in the Mine Environment Neutral Drainage (MEND) program and the National Orphaned and Abandoned Mines Initiative (NOAMI), and is involved in the preparation of an Environmental Code of Practice for Metal Mining. His group is also responsible for Canada’s *Metal Mining Effluent Regulations*, which regulate the quality of waste water discharged from Canadian metal mines.
Appendix 2: The Rehabilitation of Ontario’s Kam Kotia Mine: An Abandoned Acid Generating Tailings Site
THE REHABILITATION OF ONTARIO’S KAM KOTIA MINE: AN ABANDONED ACID GENERATING TAILINGS SITE

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Abstract

The Ontario Ministry of Northern Development and Mines (MNDM) has begun the rehabilitation of the Kam Kotia Mine site. This site is located within the municipality of Timmins, in northeastern Ontario, Canada, and is considered to be the worst abandoned mine site within the Province.

The site was originally mined for base metals in the early 1940’s and eventually ceased production in 1972. During that time 6 million tonnes of sulphide rich tailings were deposited into three tailings areas, two of which were unimpounded. The tailings are currently located on more than 500 hectares of land and produce acid mine drainage that has severely impacted one river, is impacting on another and could potentially be threatening the ground water in the area. Currently the projected rehabilitation costs for the site are approximately C$40 million, but it is expected that the final amount could be higher.

Under a four year, $27 million fund for rehabilitating Crown owned abandoned mine sites throughout Ontario, a rehabilitation plan for the Kam Kotia Mine site has been developed. The plan provides a five-phased approach, with each phase being of a distinct and unique benefit to the site and taking approximately one year to complete.

To date, MNDM has committed $14 million in order to conduct the first two phases of the five-phased rehabilitation plan. Phase “A”, which involved the construction of a lime treatment plant and a new engineered impoundment structure, was completed in July 2002. The Phase “B” work, which saw the relocation of the unimpounded south tailings to within the new impoundment structure constructed during Phase “A”, was conducted during the winter of 2002/03.

The remaining three phases of rehabilitation will be completed as funds are available.

Introduction

The Kam Kotia Mine, which is located within Robb Township in the northwest part of the City of Timmins, Ontario, Canada, was mined for copper, zinc and secondary silver and gold. The mine was originally developed in the 1940’s under the Federal Government’s War Minerals program. Subsequent to the ending of that program, the mine was operated by a commercial operator intermittently, finally ceasing operations in 1972. Since then, the mining and surface rights of most of the site have reverted to the Crown, leaving the responsibility of rehabilitation in the public realm.
In addition to physical hazards located on the site, there were about 6 million tonnes of high sulphide tailings located within three distinct tailings areas – much of which was unimpounded and covered more than 500 hectares. Acid Mine Drainage (AMD), and leached heavy metals, produced from all three of the tailings areas has had a large impact on the surrounding lands and waters. In addition, there have also been issues with dusting, aesthetics and physical mine hazards, such as the main shaft, an open pit and a thin crown pillar.

The three tailings areas located on the Kam Kotia Mine site are referred to as follows: a) the “North Unimpounded Tailings” or “NUT” located in the northeast area of the site, b) the “North Impounded Tailings” or “NIT” located in the northwest area of the site, and, c) the “South Unimpounded Tailings” or “SUT” located in the southern area of the site. (See Figure 1 for a site plan.)

For many years the area to the south of the mine site has been known as the “south kill zone”. This is an area in which virtually all vegetation has been destroyed by the site’s AMD. Acidic drainage from the SUT area into the Little Kamiskotia River, which is to the south of the site, has resulted in the severe impacts on the biota of that river, with its waters at a pH of 3 or lower.

The areas to the north and northeast have been similarly impacted by contaminated drainage from the NUT area and the Kamiskotia River to the north of the mine site has been heavily impacted. (See Figure 2 for a view of the NUT tails and one of the acidic seeps.)

In response to rising concern over impacts to the local environment from the contaminated drainage from the site, and the possibility of the contamination of groundwater in the area, MNDM contracted a consortium of firms, headed by SENES Consultants Limited, in the year 2000. The SENES Consortium was to develop a plan to rehabilitate each of the environmental and health and safety hazards on the site.

The Five Phases of Rehabilitation

After considering various options to rehabilitate the site, SENES developed a five-phased approach of rehabilitation for the Kam Kotia Mine site – each of which is of a distinct and unique improvement to the site and each of which will take about one year to conduct. (See Figure 3 for a site plan showing the five phases of rehabilitation for the site.) The SENES plan predicts that the total cost to completely rehabilitate the site will total approximately $40 million. However, the Ministry has now completed the first two phases of rehabilitation and, based on the costs experienced to date, it is now expected that the total cost to rehabilitate the site could be higher.

During Phase “A”, the first phase of rehabilitation on the site, a Lime Addition Treatment Plant, and its required infrastructure, was constructed on the site. That plant has now been operated for about a year by one of the firms that was partially responsible for the construction of the plant. This period has effectively been the plant’s commissioning period. The Lime Plant is expected to operate for at least fifty years, and much longer if the entire five-phased rehabilitation plan is not fully completed.

The other component of the Phase “A” work dealt with the construction of an impoundment dam structure within the NUT area, including the stabilization and reinforcement of the existing “North-South” dam. This newly impounded area has been designed to hold all of the remaining unimpounded tailings, which will be physically re-located to within the dam area during the subsequent phases of rehabilitation, neutralized with lime and then the impounded area will be developed as a wetland.

Phase “B” dealt with the re-location of the SUT tailings, estimated at 330,000 m³, to within the new NUT impoundment area where they were to be mixed with lime and neutralized. The completion of this work meant that there should shortly be very little new effect to areas to the south and southwest of the mine site – the areas where there is human habitation.
A large cost saving was created by using an acid-neutralizing product called “Envirolime” to neutralize the relocated tailings, instead of the more common Hydrated lime. Although a slightly greater amount of the Envirolime was required to get the same results as the hydrated lime, the cost for the Envirolime per unit volume was less than half of that of hydrated lime. The Envirolime was also an easier product to apply to the relocated tailings than hydrated lime as it can be applied in a dry state and doesn’t tend to be as windblown due to its coarser granular form. The constituents of Envirolime are as follows: CaO 63 to 75%
MgO 1 to 8%
SiO₂ 1 to 2%

The Phase “C” work will involve the relocation of the unimpounded NUT tailings that remain outside of the new NUT impoundment dam to within the NUT impoundment area.

The Phase “D” work will deal with the rehabilitation of the north and east seeps and creeks in the northeast area of the site.

Lastly, Phase “E”, the final phase of rehabilitation for the site and also probably the most costly, will be conducted. Phase “E” will involve a number of different rehabilitation components, including: a) the reinforcement of the remaining NIT impoundment structures, b) the construction of an engineered cover over the NIT tailings, c) the development of a wetlands over the NUT impoundment area, and d) the rehabilitation of the physical hazards on the site including the open pit, the crown pillar and the main shaft.

Based on the recommendations and cost projections provided by the SENES report, the Ontario government committed to complete the Phases “A” and “B”. In January of 2001, a contract was awarded to Wardrop Engineering Inc. to conduct the engineering and prepare a design plan for these two phases. Although some modifications did occur during the construction work, the Wardrop design became the basis for the work that was conducted during the first two phases.

### Table 1: Projected costs for each phase of rehabilitation at the Kam Kotia Mine site

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<th>Phase</th>
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<td>E</td>
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<td><strong>Total Cost to Rehabilitate the Kam Kotia Mine Site</strong></td>
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* Costs include 30% contingacy.

### Phase “A” Rehabilitation

The Phase “A” work was tendered as three contracts in July 2001, and in September 2001, three firms were selected to conduct the work. The project management contract was awarded via tender to B.H. Martin Consultants Ltd., of Timmins, Ontario. The construction of this phase was divided into two projects.

Project 1 included the construction of the NIT interception ditch, the pump house and forebay as well as the Lime Treatment Plant. This contract was awarded to North America Construction (1993) Ltd., of Morriston, Ontario.

Project 2 included the preparation of rock, granular, and clay pits as well as the construction of the new NUT dam and reinforcing the north dam. This contract was awarded to M.J. Labelle Co. Ltd., of Cochrane, Ontario.

The combined bids for the Phase “A” projects were more than $9.8 million. This amount was more than 65% higher than the original cost projections even after the projected cost was adjusted to include the additional costs for the reinforcement of the North-South dam and the construction of a high-density sludge plant.
during Phase “A”, rather than waiting to convert it during a later Phase of rehabilitation. These additional costs caused MNDM to put a cap on Phase “A” and “B” expenditures. It became the project manager’s and the Ministry staff’s responsibility to ensure that any extra cost was offset by savings found elsewhere during the construction work.

The Phase “A” work started in October 2001, with the intention of it being completing by March 31st, 2002. Project 2 had difficulty developing the granular and clay pits due to warmer than usual winter weather, so the Project 2 completion date was extended until the summer of 2002.

Once the construction of the dam started, it was realized that the information provided during the tender was not adequate and that approximately $400,000 was required for the extra material in the NUT dam due to lower than expected original ground. Since there was no cost overrun allowed, it was decided to forego the topsoil and seeding of the NUT and the North-South dam to offset the extra costs. Project 2 was completed by July 18, 2003 with no cost overruns.

Project 1 had its own difficulties. Problems were encountered, both during the Phase “A” construction and later during the Lime Plant operation, with the selection of pumps for Project 1. Changes also had to be made to the sludge outfall piping resulting in costs for this component escalating to about three times that originally bid. To cover these additional costs, some of the tailings north of the SUT interception ditch were left in place, to be removed during the Phase “B” work. Project 1 was completed on March 30, 2002 with no cost overruns.

Phase “B” Rehabilitation

The Phase “B” work was tendered as two contracts during September 2002, and in October two firms were selected to conduct the work.

A local Timmins firm, Leo Alarie and Sons Ltd., was the successful bidder for the Phase “B” construction work. The Project Management contract was awarded to D.F. Elliott Consulting Engineers of New Liskeard. However, due to the price cap that had been placed on the combined Phase “A” and “B” work, the two firms’ bids for the Phase “B” work exceeded the total amount of money available for the project by $142,991.26. As a result, before the project even started both of the firms and the Ministry were looking for ways that the cost of the Phase “B” work could be pared down. It had been expected that the only possible way to do this would be to limit the actual amount of tailings to be re-located by leaving the thinner areas around the perimeter of the SUT in the expectation that their acid generating potential would have already been exhausted.

The Phase “B” work started slowly. Alarie had indicated that they would need good frost conditions to be able to move their equipment onto the tailings. Unfortunately, both heavy snow and milder than usual temperatures in the early part of the winter contributed to very poor frost conditions. As a result, excavation and transport of the first loads of tailings did not occur until the second week of January, and much of the early work was sporadic. To further complicate matters, although the contracts called for a project completion by March 31st, 2003, Alarie had indicated in their schedule that they intended to complete the project by the end of February so that they would be able to remove their equipment from the site before the spring “reduced load” requirements were to take effect.

Fortunately for the project, Northern Ontario was hit with a period of deep freeze starting in mid-January and lasting right through February. In order to relocate all of the estimated 330,000 m³ of tailings in the SUT to the NUT impoundment area, Alarie’s original plans had called for the relocation of 6,000 m³ of tailings daily. However, due to the delays experienced, Alarie began to operate two 12-hour shifts, seven days a week, and brought substantially more equipment onto the site. This resulted in them being able to relocate 9,000 m³ of tailings
per day and complete the project by early March.

In the end Alarie relocated a total of about 340,000 m$^3$ of tailings to the NUT impoundment area, with the only tails left in place being around hydro-electric poles in the SUT and those that were over the pipeline from the pumphouse to the Lime Plant. All other SUT tailings were relocated to the NUT impoundment area.

The savings that were expected to be obtained from a reduction in the tailings removed were actually realized by Alarie managing to reduce the clearing and grubbing required to conduct the tailings relocation, and by canceling the seeding of the SUT area. The reduction of the seeding had been considered as a possible cost cutting measure since before the project had begun – one that was discussed with the local residents of Kamiskotia Lake. However, Alarie indicated that, due to the severe frost conditions in the ground by the latter part of February, the seed could not be harrowed into the peat soil as deeply as needed to ensure the seeds survival.

It was determined that if the seed could not be sufficiently harrowed in, it would probably be killed by the Agricultural (Ag) Lime’s alkalinity. So the seed was cancelled, and the total cost reductions resulted in enough savings that the final combined costs of Phases “A” and “B” were $4,111.88 less than the expenditure cap placed on these phases of the project. However, Ag Lime was still spread over the peat/soil surface after the removal of the tailings to provide increased buffering capacity in the pore water in the ground, and the area should be able to revegetate naturally.

**Future Phases of Rehabilitation**

As funds become available, further phases of rehabilitation at the Kam Kotia Mine site will be conducted. Plans are already under way to begin Phase “C” during the winter of 2003/04, contingent on funding.

Phase “C” removal of the unimpounded NUT tailings within the northeast of the site will also have to be conducted as a winter project. However, it is projected that the volume of the NUT tailings to be relocated will be 2.5 times greater than the volume of the SUT tails that were moved during Phase “B”, so it is possible that Phase “C” may have to be conducted over a two-year period.

**References**

**Figures**

*Figure 1:* An aerial view of the Kam Kotia Mine site prior to rehabilitation commencing.

*Figure 2:* A view of the NUT area, and the northeast seep with a pH of 2 to 3, prior to rehabilitation.
Figure 3: A map of Kam Kotia showing the five phases of rehabilitation (SENES, 2000)
Appendix 3: Reclamtion and Dust Control on Decommissioned Tailings Facilities and Waste Rock Dumps – Making the Best of an Industrial Waste By-Product: Biosolids Timmins, Ontario, Canada
Reclamation and Dust Control on Decommissioned Tailings Facilities and Waste Rock Dumps – Making the Best of an Industrial Waste By-Product: Biosolids
Timmins, Ontario, Canada

General Overview
On July 1, 2002 the Porcupine Joint Venture was formed by the joining of the Timmins operations of Placer Dome (CLA) Limited and Kinross Gold Corporation. As such, the newly combined operation holds the largest land base within Cochrane District and the City of Timmins with a combined area of about 37,590 hectares. Except for the Dome Mine and the Hoyle Pond Mine, which continued to operate, the majority of the properties were in a state of partial or complete abandonment and progressive rehabilitation work was required as part of active closure plans or agreements with the Ontario Ministry of Northern Development and Mines.

The Porcupine Joint Venture owns over twenty-five tailings deposits located throughout Deloro, Tisdale, Hoyle and Whitney Townships in the City of Timmins, as well as several waste rock dumps located on the Dome, Pamour and Hoyle Pond properties. While vegetation has managed to re-establish itself on some of the tailings, either naturally or as part of seeding and fertilization programs, the majority of the tailings deposits and waste rock dumps present nutrient deficient environments that require innovative methods of reclamation. Some of the tailings deposits are almost entirely vegetated or are covered by a relatively hard shell of oxidized tailings, preventing dust generation. However, several of the remaining deposits had very little vegetative cover and consist of well-drained sand-sized tailings that generate substantial amounts of dust after extended dry and windy periods. Furthermore, some of the tailings facilities are continually subject to erosion.

Dust generation from tailings facilities and waste rock dumps has resulted in complaints from nearby residents and business owners.

Experimental Trials
In 2000-2001, the Timmins Operations of Kinross Gold Corporation had initiated a dust abatement program at the Aunor, Broulan and Pamour facilities. Initially, sand fencing was installed on Aunor Dam B in order to prevent horizontal transport of dust. This method succeeded at reducing dust emissions by about 30 to 40 percent with low to moderate winds. However, dust resulting from high winds and dry, warm weather could not be controlled adequately using sand fencing. The dam was eventually seeded using the chain harrow method, which also involved turning over the top few inches of the tailings so that material less prone to wind transport was exposed. The seeding mixture used consisted of a variety of grasses and other plants such as clover with a fertilizer mix consisting of sufficient amounts of nitrogen, potassium and phosphorus to support plant growth during its first season. Within two weeks of seeding, the entire top portion of the dam was green. However, by the following year, fertilizer nutrients had washed away and vast areas of new grass began to die off.

About 100 acres of Pamour Dam No. 3 were similarly prepared and seeded around the top and inside periphery of the upper dykes, away from the central pond, in areas highly subjected to wind erosion. The north and west downstream slopes, also prone to erosion by the dominant winds, were covered with a thin layer of readily available overburden and seeded. Within two to three weeks of seeding, with the help of rain and cool temperatures, grass and clover had taken hold of the tailings, creating an attractive stopover site for migrating geese. As an added windfall, goose droppings will help improve and
maintain the nutrient content of the tailings. As was the case for the Aunor revegetation project, the grass rapidly died off during the following summer.

Short of importing enormous quantities of topsoil or peat from remote sites, which would result in vast areas of newly disturbed and/or deforested land, innovative methods of soil enhancement had to be investigated.

In 2001, our personnel began investigating the use of biosolid waste by-products in cooperation with local waste management, mining and forestry companies. The use of such materials to enrich nutrient poor mine tailings had already been proven to encourage rapid growth of vegetation by providing excellent moisture retention properties and nutrient supplement. Furthermore, rapid revegetation of tailings areas and waste rock storage will prohibit surface runoff and erosion and help protect nearby surface water bodies.

By 2002, an understanding was reached with Abitibi Consolidated in nearby Iroquois Falls to develop synergies between the two operations that would benefit both companies. As part of the pulp and paper manufacturing process used at the Iroquois Falls mill, about 300 to 400 cubic metres per day of biosolids are generated from the process wastewater treatment plant located at their mill. Traditionally, the peat-like substance, which consists of decomposing microorganisms and wood fibres, was being landfilled at costs that became uneconomical to the pulp and paper mill. The material being landfilled was a proven soil amendment material. In an effort to encourage the development and implementation of innovative waste management methods, and building on experience with the experimental use of pulp and paper biosolids on copper and uranium mine tailings in Elliot Lake, the Ontario Ministry of the Environment (MOE) provided exceptional support in the creation of a partnership between the pulp & paper and mining industries. As such, the MOE was willing to permit the use of biosolids in order to promote rapid revegetation on surfaces previously disturbed by mining activities. Added benefits to the usage of pulp and paper biosolids include the capture of atmospheric carbon, making such projects compliant with the recently ratified Kyoto Protocol.

By July 2002, the MOE had permitted the use of biosolids on the Pamour Mine tailings as well as on the Bell Creek Tailings Facility, west of the Hoyle Pond Mine. The initial placement of biosolids upon the Pamour Dam No. 3 tailings consisted of a 10 to 15 centimetre thick layer of biosolids in the northwest quadrant of the dam where the majority of the dust was generated. In late September 2002 after a rest, or aeration, period of about two months, the biosolids were seeded with a grass mixture similar to that used within highway right-of-ways by the Ontario Ministry of Transportation. Within two weeks of seeding, grass was observed to have reached a height of about 5 centimetres.
Placement of fresh biosolids on Pamour Dam No. 3 continued throughout winter 2002-2003 and until the end of 2003 with areas receiving as much as 45 centimetres of the soil amendment. Seeding of the biosolids generally took place during the warmer months following an average aeration rest period of one to two months to allow dissipation of nitrogen compounds that can harm young seedlings. In order to create a dense root mat and ground cover that would provide long term protection against wind and runoff erosion of the soil amendment, a seed mixture containing a large proportion of oats and barley was initially used. The same mixture was also used on biosolids placed on internal slopes within Dam 3 to investigate the efficiency of the early ground cover as a temporary and biodegradable geogrid that would allow the establishment of more durable grass, legume and shrub species. Within two and a half to three months of seeding, a healthy cereal crop existed on Pamour Dam No. 3 that provided nourishment for migrating bird species.

Porcupine Joint Venture’s long-term plan for the use of biosolids is to continue placement of the material wherever on all available disturbed surfaces. Monitoring of biosolids will continue to include annual or semi-annual evaluations of plant health and root mass growth.