OVERVIEW OF TAILINGS RECLAMATION IN EASTERN CANADA

by

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Abstract An overview of the climate, topography, and the various factors associated with the production of minerals in Eastern Canada as they impact on mine tailings reclamation.

Additional key words: Eastern Canada, mine tailings, reclamation.

Introduction

The wide and diversified range of metals mined in the mineral producing provinces of Ontario, Quebec, New Brunswick Nova Scotia and Newfoundland represented 35% Of the total value of mineral production in Canada in 1986. The production which accounted for the other 65% of the total value was mainly attributable to the hydrocarbon production of the Prairie Provinces (Manitoba, Saskatchewan and Alberta) and British Columbia.

The production by provinces in Eastern Canada and the number of producing mines/ mills is shown in table 1. It is of interest to note that 1 province, Prince Edward Island is the only non-mineral producing province in Canada and it is located in Eastern Canada.

Mine tailings in Eastern Canada include a wide range of waste types and conditions. Mining of lead, copper, zinc, nickel, gold, uranium, silver, iron, and other minerals have produced a variety of tailings wastes with unique characteristics. Table 2 shows the distribution of these areas in Eastern Canada. The area of tailings from both active and closed mining operations is included as well as the extent of the area which has been vegetated or reclaimed as of 1975. This survey of mine wastes made in 1975 by CANMET indicated that there were 10,372 hectares (25,629 acres) of tailings in Eastern Canada of which 919 ha (2,271 acres) had been stabilized with some form of vegetative cover. It is of interest to note that this area of tailings occupies approximately 0.036% of the total area ofthe 6 eastern proivinces. At the time of the survey, mine waste stabilization was just beginning to be generally accepted. A large part of the stabilized tailings could be attributed to natural vegetation encroachment and the reclamation efforts of a few

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progressive mining firms.

The earliest reclamation work in the east was in 1932 in Timmins, Ontario, when the McIntyre-Porcupine Company converted their first tailings disposal site into a park. The next major development in vegetating tailings was the work started in the mid 1950's by Inco Limited in the Sudbury area with their successful establishment of grass and legumes on sulphide tailings.

By the mid 1970's an increasing number of test plots began to appear on different tailings areas in Eastern Canada and plant growth trials were initiated in various laboratories and green - houses. These experiments,carried out by a few part-time and full-time reclamationists, began to provide input into the literature on the ways and means of addressing tailings vegetation in the Canadian situation. The foresight of the various companies in underwriting the costs associated with this research at a time when there was little or no public pressure reflected then and continues to reflect to their credit.

Gold, silver and iron tailingsappeared to present little chemical difficulty to vegetation establishment. Local climatic conditions, such as the growing season, precipitation distribution, and wind direction were the predominant problems facing the reclamation of these wastes. Stabilization of the tailings surface and the addition of plant nutrients provided the neccessary conditions for the establishment of the early grasses and legumes. With the sulphide containing wastes of the copper, nickel, zinc, lead and uranium mines, attention was also directed towards alleviating the harmful chemical conditions inherenlty present. The addition of lime, other alkaline tailings, topsoil, rock barriers, and chemical sealants were used to nullify the impact of the reactive nature of these tailings.

Research continued to find the answers to the many problems confronting the people actively involved in the reclamation of these wastes. In the late 1970's, both the federal and the provincial goverments became increasingly involved in developing legislation regarding the stabilization and the revegetation of areas covered with mine tailings to minimize their impact on the environment.

Ecological Situation

With the exception of the coal mining operations in the Maritime Provinces of Eastern Canada, the major mining operations are located in the Precambrian Shield.

The major portion pf the topography can be classified as undulating with valleys between rounded hill tops. Glaciation in the late Pleistocene era was responsible for many of the geomorphic formations and soil types in the Shield area. The land was heavily scoured and much of the soil removed with the result that numerous rock outcrops were and remain exposed.

The generally harsh climate in the mining areas of Eastern Canada with the short number of frost free days and long cold winters has inhibited the rate of soil development. Soil flora and fauna are active in most areas less than half of the year. The physical forces brought into play by the alternate cycles of freezing and thawing with the associated expansion and contraction of the mineral material, has been a major factor in breaking down the rock to particle size.

Compared to the rest of the world, the formation period of the present soils in Canada has been short. Most of the material was transported by ice or water as recently (in geological time) as the Wisconsin period of the Pleistocene era to its present site.

In general the ecological factors have combined to develop a podsol type soil with glacial surface deposits of water modified tills, lacustrine silts and sands located in the valleys.

Reclamation

The developing of a park on their first tailins disposal site by McIntyre Porcupine in 1932 initiated tailings reclamation in Canada. Their method was to cover the tailings with soil and establish an appropiate planting of grass, trees and shrubs. Other gold mines in the Tim- mins, Ontario, area subse- quently started reclaiming their tailings dumps in the 1960's. Herman Keller pioneer- ed in developing low mainten- ance vegetation covers involv- ing legumes in this same area. Since the tailings were mainly silica from the waste quartz in the ore, he was able to develop a program for direct seeding into the tailings.

The base metal mines and uranium mines in New Brunswick Quebec and Ontario were faced with the problems of mining sulphide ores and the consequent acid generating potential and low pH levels of their tailings. Negative results from early attempts at establishing vegetation on their tailings in the 19940's at Inco Limited in Sudbury directed the Company's research efforts to other methods of dust control such as sealants and water sprays. These proved ineffective and costly. Small scale investigations into methods to establish vegetation on the tailings were resumed in the early 1950's. The procedures developed from this start will be discussed later in the paper.

In the late 1960's Drs. E.Watkin and Jack Winch of the Crop Science Department, Ontario Agricultural College of the University of Guelph were involved in a project sponsored by the Ontario Cover Crop Committee to improve low grade rough pastures for livestock production. Their interest in the research to improve the vegetative cover on rough pasture land in Northern Ontario soon broadened to include the problems associated with establishing a vegetative cover on tailings. Before long, they initiated a field test plot program on the uranium tailings at Elliot Lake.

In the early 1970's, the first major research program into developing the requirements and methods to establish vegetation on sulphide tailings was started in the Crop Science Department at the University of Guelph. This five year program was funded and sponsored by Noranda Mines Limited and was under the full time direction of Dr. Edward Watkin. Amongst other things, this research proved the necessity of including legumes in tailings revegetation programs. The superiority of Birdsfoot Trefoil (Lotus corniculatus L.) as the legume for this purpose was established.

Other than Inco Limited, the mining companies in Eastern canada did not have the in house capabilities or equipment for undertaking reclamation revegetation. These companies had to turn to outside contractors to carry out this work. Erocon Limited of Timmins, Ontario, founded by Herman Keller and Dol Brothers of Cookstown, Ontario, founded by J.Dol developed and contributed, through their interest in this work, their ingenuity, and their understanding of the special factors involved in seeding tailings, much of the knowledge along with many of the practices currently in use.

Case Studies

The original approach to revegetation on the 3 sites reviewed is similar. However, somewhat different approaches to handling the problems associated with acid generation in tailings are evolving at the different sites.

The history and practices followed in the current Inco Limited tailings reclamation program since its inception in the early 1950's have been the subject of numerous papers in recent years (Peters, 1985).

The experience gained over the past 35 years, both positive and negative, has resulted in the formulation of the following guidelines. These, in general, are applicable to most sites in Eastern Canada.

1. The first seeding in the tailings area should be located in the portion closest to the prevailing winds during the growing season to minimize damage

to or covering of the young plants by drifting wind borne tailings.

2. Agricultural limestone, as required, should be applied and worked into the surface prior to seeding. The major portion should be applied at least 6 weeks before seeding. This permits sufficient time for the reaction to raise the pH of the tailings to 4.0-5.0. The balance should be applied immediately prior to seeding.

3. In the Sudbury area, the late summer is the best time to seed grasses. After July 21, the rate of success of seed germination and seedling establishment is enhanced due to more favourable temperatures and increased availability of moisture from precipitation.

4. Although the late summer is the optimum time for seeding grasses, the short period remaining in the growing season, is insufficient for legume seedlings to establish a sufficiently deep and strong root system to withstand the heaving effects of the repeated freezing and thawing of the tailings surface the following spring.

5. The use of a companion crop to provide shade and reduce the velocity of the surface winds is essential.

6. Nitrogenous fertilizer should be applied, at low but sufficient rates, several times as required, during the establishment period to ensure maximum uptake.

7. The surfacing of the slopes with south and southwesterly exposure with 15 cm. (6") of clay to ensure an adequate supply of moisture for growth is worthwhile.

8. The use of a mulch on the slopes, preferably one containing straw, to provide shade for the seedlings and to reduce the evaporation of soil moisture during the critical period of seedling establishment is worthwhile.

9. When clay is used to surface rhe outside slope of a tailings dam, the whole slope should be covered from top to bottom. The addition of a clay topdressing on a tailings slope will physically reduce the porosity of the slope's surface. In all cases, it is essential to maintain the structural integrity of the dam and no treatment which will change a dam's structural strength should be employed in revegetation. If required, adequate diversion ditches for the safe drainage of the slopes should be included as part of the surfacing program.

The presence of tree seedlings which were voluntarily establishing themselves in the newly grassed areas became very apparent in 1964. This indicated that the first step had been taken in establishing a climax vegetative cover similar to the original cover.

Several tree plots to assess the adadaptability of different species were set out. Based on the information gained from these plots a full scale program was developed for the planting of coniferous species. Currently many of the tree seedlings used in this program are grown 4600 feet underground at the Creighton Mine. Field experiments to assess the potential of mixed plantings with species that possess the capability to fix atmospheric nitrogen are underway in coopération with the federal government.

In 1974 a plan to develop a Wildlife Management Area on the tailings as a possible end use was initiated. Various testing programs to assess any impact on the food cycle and life cycle of species which might inhabit this eventual forest cover and ponds were carried out. Many were undertaken by students in graduate courses at Laurentian and other Ontario universities. Results indicated that this was a worthwhile program and the first steps to introduce a flock of Canada Geese (Branta canadensis) were taken in 1985 with the introduction of 70 fledglings. Many of these, and subsequent annual introductions, have returned each year during the spring migration and several have brought back mates with whom they have raised families.

Falconbridge Limited, like many other Canadian mining companies, has successfully established grass and legume vegetative covers on tailings areas (Michelutti, 1975). Unlike most companies, Falconbridge has utilized overburden material as a reclamation technique to prevent the upward migration of metallic salts, and minimize water infiltration (Spires, 1975; Michelutti, 1978). It is evident that in some instances these vegetative covers have not completely eliminated acidic, metal contaminated seepages.

Falconbridge's overall objective is to establish a methodology that will allow companies to walk away upon abandonment of a tailings area, with no further treatment required. One method to do this is to prevent the oxidation of the pyrrhotite and sulphur wastes that ultimately generate sulphuric acid. To minimize or prevent this oxidation, various covers are currently being investigated.

The types of covers being investigated are firstly dry covers and secondly wet covers.

Two different dry covers are under test at their Fecunis Tailings Area. The first consists of a 2 m. thick layer of waste rock with individual pieces ranging in size from 1 cm. to 15 cm. Digested sewage sludge from the Regional Municipality of Sudbury is mixed with the rock layer to fill the interstices. This sludge ,not only blocks the oxygen transfer to the tailings but also will be a partial source of nutrients for the ultimate vegetative cover. Another test made possible by the reasonable proximity of a source of a fine waste alkaline material,is the use of this material to block the rock interstices.

The second method consists of a 2 m. thick layer of domestic garbage from the Regional Municipality of Sudbury which is covered with a 30 cm to 60 cm (1-2 feet) stabilization layer. It is anticipated that the methane generated by the decomposition of the garbage will act to block the oxygen.

Various organic materials are being tested in developing wet covers on tailings as an oxygen barrier by Falconbridge (Griffiths, !988). The idea is to construct a swamp with water to act as the oxygen barrier along with the growth of swamp plants.

The preliminary results from the tests with both types of covers, wet and dry, indicate some improvement in the quality of the seepage water. However, more research in this area is needed.

The reclamation of uranium tailings in the Elliot Lake area poses many of the same , but also a few different, problems to thoise encountered in the more traditional tailings materials from sulphide ores. The extraction of uranium uses a sulphuric acid leaching system. The mil;ling of thore produces a material with no particle bigger than 0.5mm (0.02 in.). Following the extraction of the uranium, the resulting waste material (tailings) is discharged to the disposal area. Upon settling, the its texture ranges from a fine sand to a very fine silt. The principal mineral is quartz (85%) with smaller amounts of pyrite (2-5%), mica, thorium, radium 226, and calcium sulphate (5%).

The difference between laboratory determination of limestone requirement and the field experience graphically shows the diference in working under completely controlled conditions and in the field where control of the various factors impacting is minimal. In the laboratory, itwas found that applications of limestone above 22 tonnes/ha. (10 tons per acre) gave the optimum benefit when it was completely mixed through the tailings. On the other hand, under field conditions it was found necessary to apply up to 65 tonnes/ha.(30 tons/acre).

The major treatment of the tailings surface and revegetation at Rio Algom took place between 1971 and 1978. Current observations (1988) of the areas, some ten plus years later, provide some rather interesting information. Where maintenance fertilization was carried for at least 2 years, the vegetation developed into a viable stabilizing ground cover. In areas where fertilization was limited, the herbaceous ground cover is sparse. However, if this same surface is protected from water and wind erosion, native trees and shrubs have colonized the area. In areas of high fertilization, the competition from the grasses has not permitted this colonization. The areas susceptible to erosion soon returned to the barren state. This also has occurred in some slimes areas where a high acidic water table had restricted access and plant establishment. These observations illustrate how critical it is to get the vegetation established as soon as possible after the surface preparation and the neutralization of the area to be seeded.

As can be seen from the foregoing, the emphasis in the resarch area of tailings stabilization is switching to developing walk away scenarios when a tailings area is ready for abandonment from the revegetation alone. In the case of sulphide tailings, the acid generation potential must be handled to reduce the metal content of seepage waters. Vegetaive covers in their roll of precipitation interceptors, transpiration agents and as providers of organic matter for decomposition will continue to have a roll in the improvement of seepage water quality. Their proven rolls as surface stabilizers and aesthetic aids to the environment are now just part of the overall tailings stabilization scheme.

Regulations

Although specific regulations concerning tailings revegetation are often not spelt out in the various provincial acts and guidelines, nearly all are open to the interpretation that it can be required. This requirement is becoming more and more the practice.

The provincial requirements must be as strict as the federal ones and they can be stricter.

The requirements are subject to change and it is advisable that these be reviewed with the local coontrol personnel before a new project is commenced or a major alteration made to an existing operation.

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TABLE 1 METAL AND INDUSTRIAL MINERAL MINES/MILLS IN EASTERN CANADA

PROVINCE	MINERAL	COMMODITY	NUMBER OF (1) FACILITIES	1986 (2) PRODUCTION (x10)
Ontario	Metals:	Gold	18	46700 g
		Silver	3	437 KG*
		Base Metal	3	599400 Kg
		Nickel	16	137000 Kg
		Iron Ore	3	13200 T
		Uranium	4	4445 Kg
		Magnesium	1	N/A
		Calcium &		
		Strontium		
	Non Metals:	Gypsum	3	1309 T
	(not including:	Nepheline Syenite	2	485 T
	lime, dolomite,	Talc	2	N/A
	calcium and	Salt	5	6708 T
	cement)	Silica		832 T
Quebec	Metals:	Gold	18	29464 g*
		Silver	0	50 Kg*
		Iron Ore &		
		Titanium	3	13200 T
		Columbium	1	N/A
		Base Metal	11	109045 Kg
	Non Metals:	Asbestos	4	515 T
	(not includung:	Silica	4	821 T
	lime, calcite,	Talc	1	40 T
	cement and	Salt	1	N/A
	chromite)	Graphite	1	N/A
New Brunswick				
	Metals:	Gold	1	107 g*
		Base Metal	1	249570 Kg
		Antimony	1	N/A
	Non Metals:	Potash	2	191 T
	(not including:	Silica	2	N/A
	lime, cement,	Coal	1	600 T(est)
	calcium and	Silica	2	N/A
	dolomite)			

* Includes by-product silver from gold and base metal mines.

** Includes by-product silver from gold and base metal mines.

TABLE 1 METAL AND INDUSTRIAL MINERAL MINES/MILLS IN EASTERN CANADA (Continued)

PROVINCE	MINERAL COMMODITY		NUMBER OF (1) FACILITIES	1986 PRODUCTION (x10)(2)
Nova Scotia	Metals:	Tin	1	N/A
		Gold	1	N/A
	Non Metals:	Gypsum	6	6164 T
	(not including:	Salt	2	N/A
	lime, cement,	Silica	1	N/A
	calcium and	Barite	1	1211 T
	dolomite)	Coal		2900 T (est)
Newfoundland	Metals:	Iron Ore	2	19465 T
		Base Metal	1	6686 Kg
	Non Metals:	Gypsum	3	449 T
	(not including:	Asbestos	1	45 T
	cement)	Pyrophilite	1	N/A
		Silica	1	N/A

Source: 1) Canada, Energy, Mines and Resources, 1987 (a)

2) Canada, Energy, Mines and Resources, 1987 (b)

TABLE 2 DISTRIBUTION OF TAILINGS IN EASTERN CANADA.*

Mine Type Province	Cu,Pb,Zn,Ni. Open	Closed	Veg	Au,Ag. Open	Closed	Veg	Fe. Open	Closed	Veg
Newfoundland	57	45	0				460	0	0
Nova Scotia	0	39	26						
New Brunswick	307	24	18						
Quebec	1093	242	39	785	624	257	370	0	0
Ontario	1711	171	278	1175	1372	265	1033	12	3
Totals	3168	521	361	1960	1996	522	1863	12	3

	Uranium Open	Closed	Veg
Newfoundland			
Nova Scotia			
New Brunswick			
Quebec			
Ontario	172	340	33
Totals	172	340	33

* Area in hectares.

Canada, Energy, Mines and Resources, 1975.

AREA OF PROVINCES

Newfoundland	37,163,735	hectares
Prince Edward Island	566,171	"
Nova Scotia	5,284,093	"
New Brunswick	7,156,913	"
Quebec	135,780,889	"
Ontario	91,743,326	"