CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

REPORT 81-9E

MINERAL WASTE RESOURCES OF CANADA REPORT NO. 5 - MINING WASTES IN THE PRAIRIE PROVINCES

R.K. COLLINGS

MINERALS RESEARCH PROGRAM

MINERAL SCIENCES LABORATORIES

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ERRATUM SHEET FOR CANMET REPORT 81-9E

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by

R.K. Collings

Page 7 - (Table 3) bottom right hand column should read:

"Coarse fraction from tailings is recovered and used as backfill, finer fraction (slimes) is pumped to ....."

Page 13 - (Table 5) bottom right hand column should read:

"...Brine from the solution mine at Belle Plaine is used for ..."

Page 14 - (Table 5) right hand column should read:

"...sodium chloride from the solution mine at Belle Plaine is transported in slurry..."

MINERAL WASTE RESOURCES OF CANADA
REPORT NO. 5 - MINING WASTES IN THE PRAIRIE PROVINCES*

by

R.K. Collings**

SYNOPSIS

Legislation restricting mining in many urban centres, exhaustion of ore deposits, and increased cost of locating and developing new orebodies have combined to focus attention on mineral waste accumulations as possible supplemental sources of mineral raw material. Current annual production of such wastes by the mining industry of Canada is about 650 x 10^6 t. Only a small portion of this is used because of the remote location and low quality of these wastes and a lack of detailed information on their nature and possible uses. Current applications include road construction and maintenance, railroad ballast, smelter flux, and mine backfill. Uses for selected wastes studied by CANMET researchers include the recovery of contained metals and minerals, the production of concrete and construction aggregates, the manufacture of bricks, building blocks and mineral wool insulation, and use as mineral filler and soil additive.

This report provides background information on waste rock and mill tailings in the Prairie Provinces where more than 90 x 10^6 t of such wastes are produced annually. Data on the occurrence, mineralogy, petrography, and physical and chemical characteristics of wastes from 21 operating mines are provided in tabular form for 4 principal types of mines - metal, uranium, non-metallic or industrial mineral, and coal. Potential uses for these wastes are noted along with relevant research.

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* Project MRP-3.3.0.0.07 - Identification, Characterization, Evaluation of Primary Mineral Wastes.

** Head, Non-Metallic and Waste Minerals Section, Mineral Sciences Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa.

RESSOURCES CANADIENNES EN REBUTS MINÉRAUX
RAPPORT NO. 5 - LES REBUTS MINÉRAUX DANS LES PROVINCES DES PRAIRIES*

par

R.K. Collings**

RÉSUMÉ

Les lois qui restreignent l'exploitation minière dans de nombreux centres urbains, l'épuisement des gisements de minerai, la hausse des coûts de la découverte et de la mise en valeur des nouveaux gisements de minerai ont tous contribué à attirer notre attention sur la possibilité d'utiliser les minéraux résiduels à titre de sources supplémentaires de minéraux bruts. La production annuelle courante de déchets dans l'industrie minière du Canada est de l'ordre de 650 x 10^6 t. Cependant, l'industrie n'en utilise qu'une petite quantité en raison de certains facteurs comme l'éloignement des dépôts, leur faible teneur en minerai pur ou à cause du manque d'information concernant leur nature ou leurs usages éventuels. On s'en sert présentement pour la construction et l'entretien des routes ou comme ballast, comme fondant dans les fonderies et comme matériau de remblayage dans les mines. Les chercheurs de CANMET ont étudié la possibilité d'utiliser certains déchets à des fins telles que la récupération du métal et des minéraux qu'ils contiennent, la production de béton et d'agrégats destinés au secteur de la construction, la fabrication de briques, de blocs et d'isolants en laine minérale, l'utilisation comme matériaux de charge ainsi que la préparation d'amendements ou de neutralisants pour les sols.

Ce rapport fournit des données de base sur les roches résiduelles et les résidus d'établissement de broyage dans les provinces des Prairies dont la production annuelle s'élève à environ 90 x 10^6 t. Les données concernant l'abondance, la minéralogie et les propriétés physique et chimiques des déchets de 21 mines en exploitation sont disposées en tableaux pour les 4 principaux types de mine: métaux, uranium, minéraux non-métalliques ou industriels et charbon. Les usages possibles de ces déchets et la recherche pertinente sont mentionnés.

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* Projet MRP-3.3.0.0.07 - Identification, caractérisation et évaluation des minéraux résiduels primaires.

** Chef, Section du traitement des minéraux non-métalliques et résiduels, Laboratoires des sciences minérales, CANMET, Energie, Mines et Ressources Canada, Ottawa.

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INTRODUCTION

Canada has large resources of most metallic and non-metallic minerals as well as of coal and uranium. These are non-renewable and many higher-grade deposits are steadily being depleted as the mining industry strives to satisfy an ever-increasing demand for metals and minerals. Exhaustion of favourably located ore reserves and environmental legislation restricting mining near urban centres are forcing operators to look for and to develop more distant deposits. The net result is increased costs at all stages, from initial exploration through to the shipment of processed ore or mineral concentrates to markets. These factors have stimulated research into the technical and economic feasibility of recovering metals and mineral material from lower-grade but often more accessible deposits, including mining wastes. This report is concerned with such wastes in the Prairie Provinces.

Mining wastes are being generated and accumulated at a rate in excess of 650 x 10^6 t/a in Canada. The Prairie Provinces account for about 90 x 10^6 t. Such wastes normally have been of little interest and, in fact, represent additional expense in that they are costly to treat and to maintain in dumps and tailing ponds. Some, however, are now being examined more closely. Environmentalists, on the one hand, are concerned with pollution hazards with respect to air and water, whereas mining companies and other resource-oriented groups are becoming increasingly interested in the possibility of recovering additional metals and minerals, e.g., copper, gold, silver, barite, from certain of these tailings, and of using wastes as raw material for manufacturing various products, e.g., bricks and building blocks, and in other applications such as soil additives and as mineral fillers in various products.

The current interest in mineral wastes has pointed to an increased need for information on their physical and chemical natures. The Canada Centre for Mineral and Energy Technology (CANMET) is engaged in a study of mineral wastes which has three major objectives:

- to identify mineral wastes and to determine their magnitude and nature,
- to publish information on their physical and chemical properties, and potential uses,
- to encourage further study and research by industry and government.

As part of this study, technical data on Canada's vast and growing mineral waste resources have been systematically documented. Reports on mining wastes have been published for Ontario, Quebec, British Columbia, and the Atlantic Provinces, (1,2,3,4). The Quebec report is also available in French (5). Others include a report on mineral wastes as potential fillers (6) and one on ferrous metallurgical wastes (7).

MINERAL WASTES

Mineral wastes are divided into four general groups in Table 1. Those in the first two are large-volume, low-grade mixtures of minerals and as such are usually unattractive for further economic exploitation. Overburden material can be used for roads or as landfill, and waste rock may be useful as railroad ballast and as concrete and construction aggregates. However, in most instances, the problem of disposal is best solved by long-term stabilization and landscaping. Rehabilitation may greatly increase the value of disposal areas as building sites or as recreational parks.

The last two groups include wastes which have been partially processed and are often uniform in character and grain size. These wastes may contain significant amounts of metals and minerals that may be recoverable or they could be potential sources of raw materials for use as construction materials, in ceramic products, and in various other applications. The mining wastes considered in this report, i.e., waste rock and mill tailings, belong to Groups 2 and 3, respectively, of Table 1.

Table 1 - Classification of solid mineral wastes

	Group and type			
	1. Overburden	2. Gangue or waste rock	3. Mine and mill tailings	4. Metallurgical and chemical slags, dusts, and residues
Description	Soil, sand, clay, shale, gravel, boulders, etc.	Rock which must be broken and removed to obtain ore; many types, e.g., limestone, granitic and volcanic rocks	Rock minerals, usually sand to slime sizes but sometimes larger; may include sulphides	Slags, fly ash, cinders, dust, slimes, sludges, etc.
Characteristics	Heterogeneous and unconsolidated	Broken rock, usually homogeneous, but varying widely in size	Usually uniform in character and size	Usually uniform in character and size; sometimes toxic
Examples	Cover removed from open pit coal, gypsum, and some iron mines	Broken rock from open pits, e.g., iron mines	Tailings from many diverse operations, e.g., base, ferrous and precious metal processing, and non-metallic mineral operations	Slags from iron and steel plants, fly ash from power plants, salt from potash recovery operations, gypsum from phosphate fertilizer plants
Nature of problem and potential use	Materials handling and storage; little intrinsic value but may be useful as fill and in landscaping; waste rock may have value as railroad ballast and as construction aggregate, e.g., in concrete and asphalt mixes		Materials handling and storage; may compete for valuable land space; unsightly and possible source of air and water pollutants; potential source of metals and minerals and raw material for the manufacture of bricks, blocks, soil fertilizers and additives, mineral fillers, chemicals, etc.	

MINING WASTES IN THE PRAIRIE PROVINCES

Information on mining wastes in the Prairie Provinces is presented in Tables 2 to 9. These list the main operating mines, provide brief descriptions of the types of operation, geology and ore mineralogy, and describe the mineral wastes produced. Tonnage estimates and current and potential uses are noted. In addition, chemical and mineralogical data are given for a number of samples of mill tailings. Sand and gravel pits, gypsum mines, and dimension stone and crushed stone quarries have not been included although waste fines and coarse material may be available for reuse at these operations. As a further aid to appraisal, wastes are separated

Table 2 - Company, location, and identification number*

Company and location	Identification number
Metal mining operations	
Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Man.	1
Hudson Bay Mining and Smelting Co. Ltd., Snow Lake, Man.	2
Inco Metals Company, Thompson mine, Thompson, Man.	3
Inco Metals Company, Pipe mine, Thompson, Man.	4
Sherritt Gordon Mines Ltd., Fox Lake, Man.	5
Sherritt Gordon Mines Ltd., Ruttan Lake, Man.	6
Tantalum Mining Corp. of Canada Ltd., Bernic Lake, Man.	7
Uranium mining operations	
Eldorado Nuclear Ltd., Uranium City, Sask.	8
Gulf Minerals Canada Ltd., Wollaston Lake, Sask.	9
Industrial mineral mining operations	
APM Operators Ltd., Allan, Sask.	10
Central Canada Potash Co. Ltd., Colonsay, Sask.	11
Cominco Ltd., Vanscoy, Sask.	12
International Minerals and Chemical Corp. (Canada) Ltd., Esterhazy, Sask.	13
Potash Company of America, Saskatoon, Sask.	14
Potash Corporation of Saskatchewan Mining Ltd., Cory, Sask.	15
Potash Corporation of Saskatchewan Mining Ltd., Lanigan, Sask.	16
Potash Corporation of Saskatchewan Mining Ltd., Rocanville, Sask.	17
PPG Industries Canada Ltd., Belle Plaine, Sask.	18
Coal mining operations	
Coleman Collieries Ltd., Coleman, Alta.	19
Cardinal River Coals Ltd., Luscar, Alta.	20
McIntyre Mines Ltd., Grande Cache, Alta.	21

*The location of operations and waste samples from these operations are identified by corresponding numbers on the map, Fig. 1, and in Tables 2 to 9.

into four general categories based on origin as follows:

Metal mining operations	(Table 3)
Uranium mining operations	(Table 4)
Industrial mineral mining operations	(Table 5)
Coal mining operations	(Table 6)

Data for Tables 3 to 6 were obtained from a variety of sources including mine and mill operators, laboratory studies of representative samples, a preliminary report, Mineral Wastes in the Prairie Provinces (8), Operators Lists 1 and 4 (9,10), Annual mineral reviews (11), and from the technical press. Data for tables 7 to 9 were developed by CANMET staff using representative samples from operating companies.

The 21 mining and milling operations studied are identified by corresponding numbers in Tables 2 to 9 and on the map, Fig. 1.

METAL MINING OPERATIONS

Metal mining operations in the Prairie Provinces are essentially restricted to the province of Manitoba where four companies operate 7 or 8 mines and 4 milling or processing plants. Minerals produced include copper, zinc, lead, nickel, gold and silver, tantalum, cesium and lithium. Production is largely from underground mines although Inco's Pipe mine, near Thompson, is a surface operation. Production of waste rock at most mines is small. A part may be used underground as backfill, or on surface for mine road and highway construction and as railroad ballast. Waste rock from Tantalum Mining Corporation's mine at Lac du Bonnet is crushed and used as decorative stone in landscaping and as a road surfacing material.

The combined production of tailings at the mills noted in the tables exceeds 3 M t/a. The coarser sizes are recovered and used as backfill at several mines and the slimes are pumped to tailings disposal areas. The principal constituents of these tailings are iron sulphide and silicate minerals. Metal values are low and not economically recoverable at present prices. Tailings from Tantalum Mining Corporation's mill are being reprocessed for the recovery of additional tantalum, and research is in progress on the recovery of gallium from mica concentrates (12). Metal mining operations are listed and more fully described in Table 3.

URANIUM MINING OPERATIONS

Uranium is produced at two mines, one underground and one surface, both in Saskatchewan. Waste rock production at the former is small and is used mostly as road-bed fill. Waste rock production at the latter is substantial at more than 2 M t/a, but no use is made of this material. Tailings from the two operations total about 900,000 t/a but again no use is made of this material apart from a small amount for backfill in underground stopes. Uranium mining operations are listed and more fully described in Table 4.

INDUSTRIAL MINERAL MINING OPERATIONS

Industrial minerals produced in the Prairie Provinces include clay, dimension and crushed stone, potash, salt, sand and gravel, silica sand, and sodium sulphate. Many are relatively small-scale surface operations which produce very little mineral waste material.

Potash is by far the most important industrial mineral in the Prairie Provinces. Production is restricted to Saskatchewan and is mostly from underground mines. The broken rock is treated on surface by flotation to recover potash. Large amounts of waste salt - about 1.5t/tK_2O equivalent - are produced; however, there is only a limited market for this material, as road salt. The bulk of the production is piped to large storage and containment areas. One company recovers potash by a unique solution mining, evaporation and crystallization process. Part of the waste salt from this operation is shipped to a nearby plant where high-purity salt is produced by vacuum-pan evaporation. Saskatchewan potash operations are covered in more detail in Table 5.

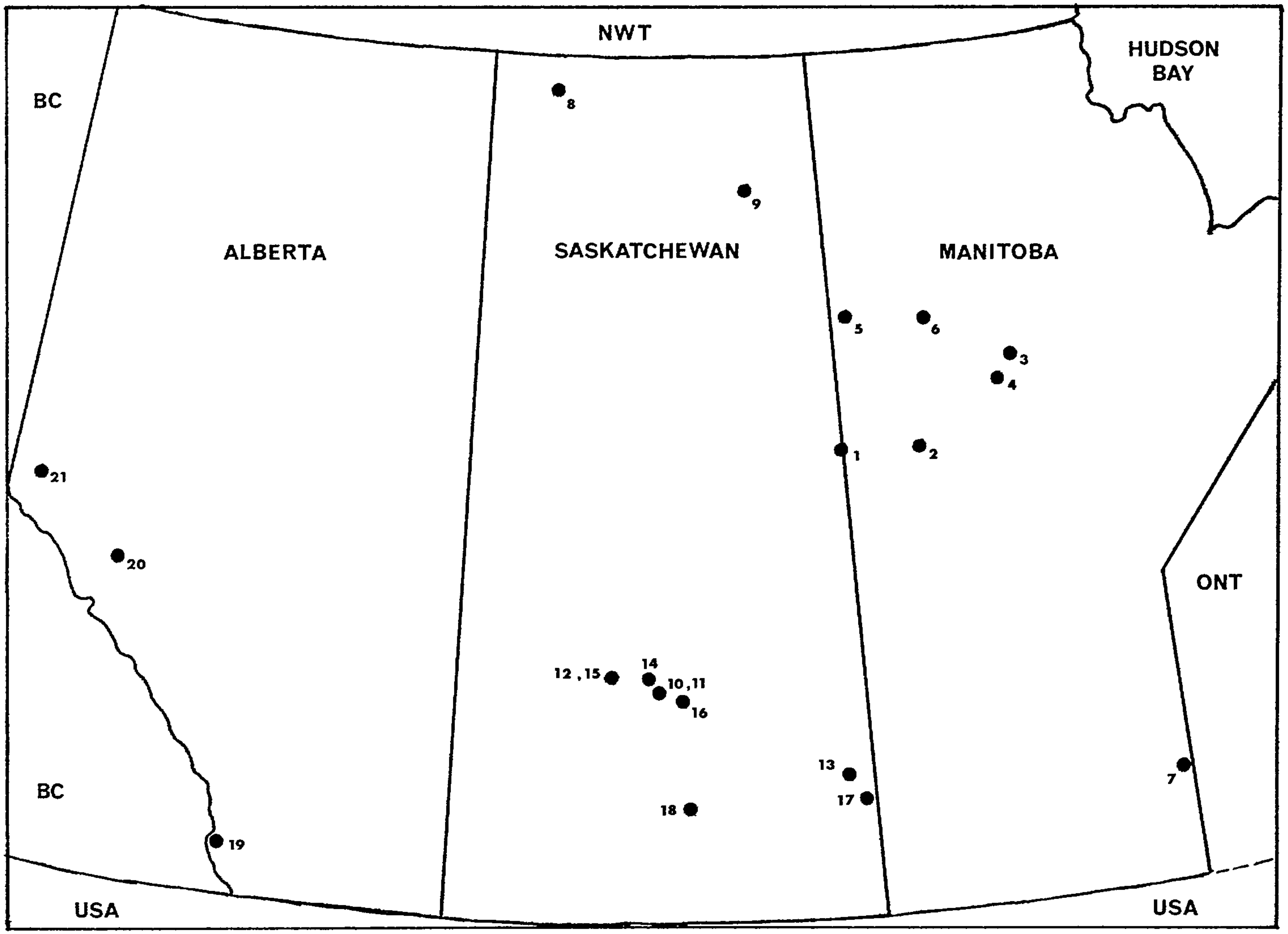

Fig. 1 - Mining/mineral processing operations listed in Table 2

Table 3 - Mineral wastes, metal mining operations

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes		
		Item	Rock	Mill tailings
1,2 Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Man. 1 - Flin Flon 2 - Snow Lake	Underground - copper, zinc, lead, gold, silver; seven mines in Flin Flon area - Snow, Anderson, Chisel, Ghost, Osborne, Stall and White Lakes	Amount**	250,000 t/a	50 to 60 Mt (1 Mt/a)
	Mill at Flin Flon; mill capacity - 7500 t/d; crushing, grinding, flotation, cyanidation	Size	Minus 0.5 m	100% minus 2 mm
		pH		7.6
		Relative density		3.3
	Sulphide ore zone in volcanics; minerals include sphalerite, pyrite, pyrrhotite, galena, chalcopyrite, arsenopyrite			
		Current or potential use	Used underground as backfill; may be used on surface for roads, dams, and as fill	Tailings pond disposal; potential source of iron and sulphur

3,4 Inco Metals Company Thompson, Man. 3 - Thompson 4 - Pipe Lake	Underground - nickel, copper, gold, silver; two mines in Thompson area - Thompson and Pipe	Amount**	500,000 t/a	25 Mt (1.5 to 2.0 t/a)
	Mill at Thompson; mill capacity 15,000 t/d; crushing, grinding, flotation	Size	Minus 0.5 m	Mine fill - 75% minus 150 μm Fines - 95% minus 150 μm
		pH		8.5
		Relative density		2.9
	Ore zone enclosed in metasediments and consists of sulphides (pyrrhotite, pentlandite, chalcopyrite and pyrite present as massive sulphide bands and disseminations in serpentinite) with minor amounts of nickel arsenides	Constituents***	Metasediments - quartzites and siliceous biotite schists	
		Current or potential use	Dressing for open pit roadway, railroad ballast, highway maintenance and new roadway construction projects	Coarse fraction from tailings is recovered and used as backfill, finer fraction (silicas) is pumped to tailings pond; slimes grade about 0.2% Ni; extensive study of the recovery of additional mineral values from tailings was made some years ago

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 3 (cont'd)

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes		
		Item	Rock	Mill tailings
5 Sherritt Gordon Mines Ltd., Fox Lake, Man.	Underground - copper, zinc	Amount**	150,000 t (15,000 t/a)	4 Mt (800,000 t/a)
	Mill capacity - 3000 t/d; crushing, grinding, sizing, flotation	Size pH Relative density	Minus 0.15 m	100% minus 500 μm 5.4 3.7
	Ore occurs in mixed volcanic and sedimentary sequence-rhyolitic tuffs, basalt flows, arkose, chert, dacitic tuffs, slaty sediments; minerals include pyrite, chalcopyrite, sphalerite, pyrrhotite	Constituents***	Andesite, feldspar porphyry, siliceous-basic hornblende gneiss, quartz biotite gneiss	P.C. - pyrite, pyrrhotite (25%) M.C. - copper, zinc, gold, silver (0.13% Cu, 0.29% Zn, 20 g/t Ag, 0.3 g/t Au)
		Current or potential use	Backfill, surface roadways and, crushed, for underground roads	Sized tailings are used for backfill underground (400,000 t/a)

6	Sherritt Gordon Mines Ltd., Ruttan Lake, Man.	Underground - copper, zinc (open pit depleted)	Amount**	10 Mt	16 Mt (2.3 Mt/a)
		Mill capacity - 10,000 t/d; crushing, grinding, sizing, flotation	Size	Minus 1 m	90% minus 200 μm, 50% minus 75 μm
		Ore occurs in metamorphosed intermediate volcanics and sediments; minerals include pyrite, chalcopyrite, sphalerite, pyrrhotite	Constituents***	Low sulphide, sedimentary and volcanics	P.C. - pyrite, pyrrhotite (21% Fe, 24% S) M.C. - copper, zinc (0.1% Cu, 0.3% Zn)
			Current or potential use	Dike construction, roadbed, mine backfill	Mine backfill; possible use in manufacture of sulphuric acid; recent research on the recovery of gold and silver was not encouraging

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 3 (cont'd)

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes: Item	Rock	Mill tailings
7 Tantalum Mining Corp. of Canada Ltd., Bernic Lake, Man.	Underground - tantalum, cesium, lithium	Amount**	15,000 t (1500 t/a)	1.45 Mt (160,000 t/a)
	Mill capacity - 1000 t/d; crushing, grinding, tabling and magnetic separation, flotation	Size	0.3 m and 30 mm	45 to 65% minus 150 µm
	Complex zoned pegmatite; minerals include quartz, mica, feldspar, spodumene, pollucite, beryl, amblygonite, stanniferous tantalite, tapiolite, microlite, albite, lithiophilite, apatite	Constituents***	Quartz, mica, feldspar	P.C. - feldspar, quartz, mica M.C. - spodumene, beryl, lithium phosphate, tantalum-bearing minerals, gallium and rubidium in mica
		Current or potential use	Crushed and used as decorative stone in landscaping or for road surfacing	Potentially of interest as feldspathic sands for glass manufacture; reprocessing being initiated for additional recovery of tantalum; research indicates good quality feldspathic sand may be produced; on-going flotation research to recover gallium-bearing mica concentrate and gallium

Table 4 - Mineral wastes, uranium mining operations

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes: Item	Rock	Mill tailings
8 Eldorado Nuclear Ltd., Uranium City, Sask.	Underground - uranium ($Na_2U_2O_7$)	Amount**	3.36 Mt (120,000 t/a)	8.0 Mt (280,000 t/a)
	Mill capacity - 1600 t/d; crushing, grinding, flotation, base and acid leaching	Size	Minus 0.15 m	Minus 75 µm
	Ore zone is in metamorphosed sediments and volcanics; uranium occurs mainly as pitchblende associated with hematite, chlorite and carbonate (13)	Constituents***	Gneiss, schist, argillite, granite	P.C. - quartz, feldspar, mica M.C. - sulphides, sulphates, uranium, chlorides
		Current or potential use	Roadbed fill for surface and underground but is not used for land fill	Backfill in stopes; an on-going study by company to isolate economic byproducts continues

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 4 (Cont'd)

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes		
		Item	Rock	Mill tailings
9 Gulf Minerals Canada Ltd., Wollaston Lake, Sask.	Open pit - uranium (U_3O_8)	Amount**	1 to 10 Mt (2.2 Mt/a)	1 to 10 Mt (650,000 t/a)
	Mill capacity - 1800 t/d; crushing, grinding, leaching	Size	Minus 1.0 m	50% minus 75 μm
		pH		10.8
		Relative density		2.7
	The uranium deposit is located in metamorphosed rocks; mineralization is confined to a brecciation zone which is characterized by intensive chloritic alteration	Constituents***		P.C. - chlorite, sericite, clay minerals, carbonate, silica (13) M.C. - tourmaline, sulphides (13)
		Current or potential use	None - AECB regulations prohibit reuse of wastes from uranium mining operations	None

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 5 - Mineral wastes, industrial mineral mining operations

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes: Item	Rock	Mill tailings
10 Allan Potash Mines Ltd., Allan, Sask.	Underground - potash (KCl), 9 mines, all in Saskatchewan, 1 solution mine (Belle Plaine)	Amount**	nil	Large quantities at each mine location; approximately 1.5 t of salt (NaCl) produced for each tonne of K_2O equivalent
11 Central Canada Potash Co. Ltd. Colonsay, Sask.	In underground mining, machines break the potash which is raised to surface, crushed, scrubbed with a brine solution and treated by flotation to separate potash from salt;	Size		Mostly minus 3 mm
12 Cominco Ltd., Vanscoy, Sask.	the potash (KCl) is dried, sized and packaged for shipment to markets;			
13 International Minerals and Chemical Corp. (Canada) Ltd., K-1, K-2, Esterhazy, Sask.	the salt (NaCl) is sent to large surface storage areas; about 1.5 t of salt are produced for every 1.0 t of K_2O equivalent.	Constituents		Essentially salt with some clay impurity
	In solution mining, a hot solution is injected under pressure into a cavity	Current or potential use		Waste salt is pumped to disposal areas; small quantities are used as road salt.
14 Potash Corporation of America, Saskatoon, Sask.	in the potash beds through boreholes; the cavity is washed and brine withdrawn from the bottom and pumped to surface for processing consisting			Brine from the solution mine at Allan is used for the recovery of fine evaporated salt.

* Locations shown in Fig. 1

** Amount accumulated

Table 5 (cont'd)

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes		
		Item	Rock	Mill tailings
15,16,17 Potash Corporation of Saskatchewan Mining Ltd. (PCS), 15- Cory Division, Saskatoon, Sask. 16- Lanigan Division, Lanigan, Sask. 17- Rocanville Div., Rocanville, Sask.	of evaporation, crystallization, and salt separation; a portion of the sodium chloride from the solution mine at Allan is transported in slurry form to a neighbouring plant for the recovery of fine crystallized salt; the remaining salt brine is pumped to a large disposal pond.			
18 PPG Industries Canada Ltd., Belle Plaine, Sask.	The potash of Saskatchewan is of Middle Devonian Age and occurs in beds near the top of the Prairie Evaporite formation; the three predominant minerals occurring in the potash-bearing zone are halite ($NaCl$), sylvite (KCl), and carnallite ($KCl.MgCl_2.6H_2O$); halite and sylvite occur together as a mechanical mixture known as sylvinite; a conservative estimate of the recoverable potash in Saskatchewan is 118×10^9 t KCl (70×10^9 t K_2O) of which 8×10^9 t may be extracted using conventional mining methods and the remainder by solution mining.			

* Locations shown in Fig. 1

Table 6 - Mineral wastes, coal mining operations

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes: Item	Rock	Mill tailings
19 Coleman Collieries Ltd., Coleman, Alta.	Open pit - coal; (ceased operations in 1980)	Amount**	5 Mm^3/a	6 Mt (600,000 t/a)
	Mill capacity - 385 t/h; crushing, tabling, cycloning	Size	Minus 1 m	Minus 50 mm
		pH		7.7
		Relative density		2.0
	Bituminous coal in sandstone/ shale formation	Constituents***	Sandstone, shale	P.C. - bituminous thermal coal, shale; M.C. - sandstone
	Rewash mill for plant refuse dump material; mill capacity - 300 t/h; crushing, jigging, tabling	Current or potential use	None	Rewashed to recovery thermal coal for Japanese market; refuse from rewashed material currently being studied for suitability as road fill in highway construction; may also be useful as land fill and in dam construction

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 6 (Cont'd)

Company mine/mill location*	Type of operation, geology and ore mineralogy	Mineral wastes		
		Item	Rock	Mill tailings
20 Cardinal River Coals Ltd., Luscar, Alta.	Open pit - coal	Amount**	10 Mt ($20\ Mm^3/a$)	10 Mt (750,000 t/a)
	Mill capacity 800 t/h; crushing, screening, flotation, cycloning, heavy media separation	Size pH Relative density	Minus 2 m	Minus 40 mm 7.7 1.8
	Bituminous coal seam, extensively folded	Constituents***	Sandstone, shale, siltstone	P.C. - rock fragments, moisture M.C. - coal fines, magnetite
		Current or potential use	None	None

21	McIntyre Mines Ltd., Coal Division, Grande Cache, Alta.	Surface and underground - coal	Amount**	85,000 t	400,000 t/a (minus 20 mm) 110,000 t/a (minus 600 μm)
		Mill capacity 650 tph; crushing, heavy media separation, froth flotation	Size		100% minus 20 mm, 25% minus 600 μm
			pH		8.7
			Relative density		2.0
		Bituminous coal seam	Constituents***	Sandstone, mudstone, shale	
			Current or potential use		All products are or may be used for electric power generation provided moisture content is below 7%

* Locations shown in Fig. 1

** Amount accumulated

*** P.C. - principal constituents, >10%

M.C. - minor constituents, <10%

Table 7 - Mineralogy of mill tailings

Sample No.*	Constituents >20%	10 to 20%	<10%
Metals			
1	quartz, pyrite	--	chlorite, dolomite, mica
3	quartz	pyrrhotite, plagioclase	mica, chlorite, amphibole
3a	serpentine	pyrrhotite	quartz, chlorite
5	pyrite, quartz	--	pyrrhotite, plagioclase, chlorite, amphibole
Uranium			
9	quartz	dolomite	chlorite, serpentine
9a	quartz	chlorite	gypsum, talc
Coal (ash)			
19	quartz, kaolin	--	dolomite, magnetite, calcite
20	quartz, magnetite	kaolin, clay minerals	plagioclase
20a	calcite, quartz	--	dolomite, chlorite, clay minerals
21	quartz, mica	kaolin, magnetite, calcite	dolomite
21a	quartz, mica	magnetite, kaolin	calcite

* 3, 3a; 9, 9a; etc., - two samples from the same company

Common salt is recovered from underground deposits at several locations by solution mining and evaporation of the saturated brine. Sodium sulphate, by contrast, is crystallized from natural brine lakes. Neither type of operation produces significant quantities of waste.

COAL MINING OPERATIONS

Coal production in the Prairie Provinces is restricted to Alberta and Saskatchewan which together account for 60% or more of Canada's output of bituminous, sub-bituminous, and lignite coal. Production of bituminous coal is confined to 6 or 7 locations in Alberta, all near the British Columbia border. Most of the production is shipped to Japan for coke-making, however, one operation supplies bituminous coal to Ontario Hydro and to West Germany. Bituminous coal is processed and upgraded by crushing, screening, flotation, cyclone and heavy-media separation.

Large quantities of waste are produced at most mines. This waste is trucked or otherwise conveyed to waste disposal dumps and tailing ponds. Some process tailings contain significant quantities of coal which is potentially recoverable for use in electrical power plants. Coal recovery from process tailings has, in fact, been started at one plant (12). Production of sub-bituminous and lignite coal for power generation is largely by open pit, the former being produced mostly in central Alberta, the latter in Saskatchewan near the international border. The ores are direct shipping with little processing apart from crushing and screening being required. Very little waste, apart from overburden, is generated. Overburden is returned to the pit as mining is advanced. Coal mining operations are listed and described in more detail in Table 6.

Table 8 - Chemical analyses - mill tailings samples (metals and uranium)

Sample No.*	Compound - %						
	SiO_2	Fe	Al_2O_3	CaO	MgO	S	LOI
Metals							
1	35.1	19.1	7.2	4.3	5.7	14.5	11.0
3	59.0	8.8	12.8	2.3	5.9	5.6	3.8
3a	36.1	11.8	1.3	0.6	36.9	2.9	13.4
5	25.3	22.1	5.6	2.0	4.0	26.6	16.8
Uranium							
9	49.9	0.9	12.0	7.1	21.1	0.1	10.1
9a	73.2	1.8	8.8	3.8	8.9	0.8	3.6

* 3, 3a; 9, 9a; - two samples from the same company

Table 9 - Chemical analysis - mill tailings samples (coal)

Sample No.*	H_2O	Ash	Volat Mat	Fixed C	S	Cal /g	B.T.U. /lb
19	1.2	46.8	20.9	32.3	0.3	3760	6765
20	1.3	28.6	18.2	53.2	0.2	5950	10700
20a	0.9	41.9	14.5	43.7	0.2	4895	8795
21	0.9	56.0	13.9	30.1	0.3	3335	6005
21a	1.2	50.1	14.3	35.6	0.4	4030	7250

Ash analysis	Compound - %							
	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	P_2O_5	TiO_2
19	52.1	3.5	28.2	6.4	2.1	1.1	0.2	1.3
20	55.4	8.8	26.3	1.9	-	0.8	0.2	0.9
20a	64.9	3.0	20.4	2.9	1.0	1.0	0.3	1.0
21	60.4	5.5	21.8	4.2	1.2	2.3	0.3	0.8
21a	57.1	9.8	22.8	2.3	1.0	2.4	0.2	0.8

* 20, 20a; 21, 21a; - two samples from the same company

CONCLUSION

This report presents available data on the physical, chemical and mineralogical nature of mining wastes in the Prairie Provinces. It shows that some wastes may be of interest for the recovery of contained metals and minerals and as raw material for various industrial uses. In some instances the physical nature of the material, e.g., particle size and size distribution, may have to be altered to meet requirements for a potential use; in others, chemical specifications of raw material for a particular use may be unnecessarily stringent. Thus the waste producer may be obliged to undertake further processing, or the consumer may have to lower specifications to permit use of a particular mineral waste. Cooperation at all stages is the key to wider utilisation.

The development of viable uses for mineral wastes is a complex problem. The successful application of mineral wastes to particular end uses cannot be accomplished without extensive laboratory research and process development. However, the quantity and variety of raw material and the diversity of possible end uses together present a challenge that should not go unheeded by industry and government, especially in view of developing shortages of energy and, under certain circumstances, of mineral raw materials.

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REFERENCES

1. Collings, R.K. "Mineral waste resources of Canada, Report No. 1 - Mining wastes in Ontario"; CANMET Report 76-2; CANMET, Energy, Mines and Resources Canada; 1976.

2. Collings, R.K. "Mineral waste resources of Canada, Report No. 2 - Mining wastes in Quebec"; CANMET Report 77-55; CANMET, Energy, Mines and Resources Canada; 1977.

3. Collings, R.K. "Mineral waste resources of Canada, Report No. 3 - Mining wastes in British Columbia"; CANMET Report 79-22; CANMET, Energy, Mines and Resources Canada; 1979.

4. Collings, R.K. "Mineral waste resources of Canada, Report No. 4 - Mining wastes in the Atlantic Provinces"; CANMET Report 80-12E; CANMET, Energy, Mines and Resources Canada; 1980.

5. Collings, R.K. "Ressources Canadiennes en rebuts mineraux, Rapport No. 2 - Les rebuts mineraux au Québec"; CANMET Report 77-55F; CANMET, Energie, Mines et Ressources Canada; 1977.

6. Collings, R.K. "Mineral waste resources of Canada, Report No. 6 - Mineral wastes as potential fillers"; CANMET Report 80-13E; CANMET, Energy, Mines and Resources Canada; 1980.

7. Collings, R.K., Wang, S.S.B. "Mineral waste resources of Canada, Report No. 7 - Ferrous metallurgical waste"; CANMET Report 80-19E; CANMET, Energy, Mines and Resources Canada; 1980.

8. Collings, R.K., Winer, A.A., Bartley, C.M. and Feasby, D.G. "A preliminary report of sources of mineral wastes in the Prairie Provinces"; Division Report MPI 72-76; Mines Branch, Canada, Energy, Mines and Resources; 1972.

9. "Metal and industrial mineral mines and processing plants in Canada"; Operators List 1; Energy, Mines and Resources Canada; 1977.

10. "Coal mines in Canada"; Operators List 4; Energy, Mines and Resources Canada; 1978.

11. Annual mineral reviews; Energy, Mines and Resources Canada; 1979.

12. Personal communication.

13. Campbell, M.C. "Production of uranium in Canada"; Division Report ERP/MSL 81-55(J); CANMET, Energy, Mines and Resources Canada; 1981.

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