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MINERAL WASTE RESOURCES OF CANADA REPORT

NO. 6 — MINERAL WASTES AS POTENTIAL FILLERS

R.K. COLLINGS

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MINERAL WASTE RESOURCES OF CANADA
REPORT NO. 6 - MINERAL WASTES AS POTENTIAL FILLERS*

by

R.K. Collings**

SYNOPSIS

The rate of generation of mineral wastes by Canada's mining, metallurgical and chemical process industries currently is about 800 x 10^6 t/a. Significant and increasing amounts of the coarser sizes, e.g., rock and slags, are being utilized for such purposes as road, dam and breakwater construction, and as railroad ballast, but use of the finer sizes, e.g., mill tailings, flue dusts and chemical sludges, is limited. Possible applications include their use as fillers in a wide variety of products. Their acceptance would depend on proximity to markets, suitability, an acceptable selling price, and an assured supply at specified grade over an established contract period. Samples of fine-sized wastes from locations within 250-km radii of Montreal and Toronto were examined to identify potential filler applications. Most would not qualify as high-quality, top-of-the-line mineral fillers but would only be suitable for lower-grade applications such as in asphalt mixes, caulking and sealing compounds, and jointing cements.

The current rate of consumption of mineral fillers in Canada is estimated to be 500 000 t/a. Half of this amount is produced domestically, the remainder is imported. Use of mineral wastes as fillers conceivably could reduce imports. Additional benefits would include conservation of mineral resources and a limited beneficial effect on the environment. More published information on mineral wastes and their potential applications is required, along with cooperative studies between producer and potential consumer and industry and government, to stimulate interest and a greater research and development effort.

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RESSOURCES DE REBUTS MINERAUX AU CANADA

RAPPORT NO. 6 - REDUTS MINERAUX EMPLOYES COMME REMPLISSEURS*

par

R.K. Collings**

SYNOPSIS

La quantité de rebuts minéraux produite par les industries canadiennes de l'exploitation minière et de transformation métallurgique et chimique est actuellement estimée à environ 800 x 10^6 tonnes/année. Des quantités importantes et croissantes de rebuts plus grossiers tels que les roches et les scories sont utilisées à des fins de construction des routes, des barrages et des éperons et comme empierrement des chemins de fer tandis que les rebuts plus fins tels que les stériles d'usine, les poussières de carneau et les boues chimiques sont en quantité très limitée. On pourrait aussi les employer comme remplissage dans une infinie variété de produits. Leur admissibilité dépendra de la proximité des marchés, de la convenance, d'un prix de vente avantageux et d'un approvisionnement assuré et à une teneur désignée pendant une période contractuelle définie. Des échantillons de rebuts de fine granulométrie provenant d'un rayon de 250 km de Montréal et de Toronto ont été étudiés pour en identifier les applications possibles comme remplisseurs. La plupart de ces matériaux ne pourraient être employés comme remplisseurs minéraux de haute qualité mais sont néanmoins convenables dans les applications à basse teneur telles que les mélanges pour asphalte, les composés de calfeutrage et de scellage et les pâtes à joints.

Le taux actuel de consommation des remplisseurs minéraux au Canada est évalué à 500 000 tonnes/année; la moitié provient de source domestique et le reste est importé. L'usage des rebuts minéraux comme remplissage pourrait réduire ces importations. D'autres avantages incluent la conservation des ressources minérales avec un effet bénéfique quoique limité sur l'environnement. Afin de stimuler l'intérêt et un essor de la recherche et du développement, il devrait y avoir plus d'information publiée sur les rebuts minéraux et leurs applications et des études devraient être effectuées en collaboration entre les producteurs et les usagers et l'industrie et le gouvernement.

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INTRODUCTION

The term mineral filler denotes a group of minerals, principally silicates and carbonates, that are used in the manufacture of various products to reduce consumption of other, more expensive materials and, secondly, to modify and improve physical properties. In some applications, and especially in paints, mineral fillers are classed as extenders or extender-pigments, their prime function being to reduce consumption of more costly pigment material. Although many minerals can be employed as fillers, those commonly used include asbestos, barite, bentonite, calcium carbonate, clays, diatomite, feldspar, mica, nepheline syenite, pyrophyllite, silica and talc. They are used either individually or in combination in the manufacture of a wide range of consumer products, e.g., asphalt mixes, cleansers and detergents, concrete products, fertilizers, insecticides, linoleum and floor tile, paints and varnishes, paper, plastics, roofing products and rubber.

Although most mineral fillers must meet fairly rigid specifications, e.g., nepheline syenite in paint formulations and kaolin in paper, other applications, e.g., asphalt mixes and concrete products, essentially require only that the filler be relatively fine, available in adequate quantities, and inexpensive. Wastes from many mining, metallurgical and chemical processing operations could satisfy these latter requirements.

Mineral wastes are available in large quantities throughout Canada. Most are of no interest as mineral fillers because of their remote location or impurity, but some are uniform in composition and close to filler markets. Their use as fillers may be beneficial not only in reducing overall costs but also for other reasons e.g., conserving mineral resources, improving the environment, and reducing imports of filler minerals.

This report provides information on mineral fillers, examines a specific segment of that industry, and identifies a number of wastes that may have potential as alternative or supplemental material for use in specific products or applications.

PROPERTIES AND USES OF MINERAL FILLERS

The most important filler minerals, their principal properties and main uses, are listed in Table 1. Table 2 lists filler applications and notes their function. An examination of these tables reveals the many types and applications of filler minerals, and the distinguishing properties that make them particularly suitable. For example, ground calcium carbonate is the most universally employed mineral filler-extender because of its ready availability, high purity, good white colour, and relatively low cost. By contrast, asbestos is a speciality filler because of its fibrous nature and is used primarily as a reinforcing agent in asphalt mixes, floor tile, drywall joint cement, and in caulking and sealing compounds.

As noted in the introduction, mineral fillers are primarily used to reduce consumption of more costly materials in specific products, e.g., to substitute for titanium dioxide in paints, resins in plastics, and bitumen in asphalt mixes. They additionally serve to modify and improve physical properties, e.g., flow, colour, and tint retention of paints, and hardness, strength, and resistance to tear of rubber. Some products are heavily loaded with fillers. Asphalt mixes, for example, may contain 50% or more of filler by weight.

Some products, e.g., paint, paper and rubber, require high-purity, high-performance fillers. Those used in such applications must meet rigid specifications for purity, colour, particle size, degree of softness or hardness, etc. Other applications, such as asphalt mixes, mortars and cements, have less demanding specifications and therefore can utilize a wider variety of lower grade, and consequently lower cost fillers. Mineral wastes, the main subject of this report, are of interest for some of the latter applications as noted by asterisks in Table 2. These uses are not so dependent on high purity and whiteness of the filler but rather on other characteristics such as durability, particle size, density, etc. A good example is the use of waste limestone fines from aggregate preparation plants as filler in asphalt paving. Such wastes and potential applications are discussed more fully in a later section of this report.

THE MINERAL FILLER INDUSTRY OF CANADA

The mineral filler industry of Canada is diverse and complex. One paint company, for example, reported purchase of no fewer than 55 types of 10 different filler-extenders in 1978. A further indication of the complexity is illustrated in the 1979 Rubber Blue Book which, under "Extenders, Fillers and Reinforcing Materials, Non-Black Materials", lists no fewer than 20 different mineral fillers-extenders used in rubber formulations and over 200 mineral trade names of required grades. Production of fillers is largely confined to the non-metallic sector of the mineral industry where many companies produce fillers as coproducts of a larger output of industrial minerals for specific applications, e.g., the production of nepheline syenite for the paint industry is small compared with that for glass and ceramics. The total production of mineral fillers in Canada cannot be accurately ascertained from published Statistics Canada data because production is not reported separately. Similarly, data concerning imports are not available separately and often are included in general or basket categories. The total consumption also is difficult to determine because fillers are consumed in hundreds of products. Table 3 lists available data for 1977 for the production, trade, and consumption of 16 selected non-metallic minerals. Shown also is their estimated consumption as fillers-extenders in various products. These latter data were derived from a non-metallic mineral consumption survey by Statistics Canada. Although incomplete, these data indicate a consumption of about 500 000 t of fillers in 1977, if the 100 000 t of fly ash used in portland cement is included. Imports are estimated at 250 000 t and include: part of the barite, bentonite, limestone and marble, mica, silica and talc used; most of the diatomite; and all of the fuller's earth and kaolin. Canadian production, by difference, would be 250 000 t.

Mineral fillers vary widely in value. Delivered prices may range from $5 to $10/t for lower grades such as those used in asphalt mixes, to $100 to $150/t for the finer grades of extender pigments used in paint and plastics, to $500/t and more for speciality fillers such as precipitated and fumed silicas for rubber formulations. Assuming an average value of $50/t, consumption of mineral fillers in Canada in 1977 would have been valued at about $25 million. A recent study in the United States, by the Charles H. Kline organization, placed the 1977 value of fillers in that country at $380 million (1).

Owing to time constraints, the present study was restricted essentially to southern Quebec and Ontario, both areas of relatively high density population and together accounting for perhaps 75% of the Canadian production and consumption of fillers. This study includes a review of mineral waste dumps in these areas which conceivably could provide acceptable filler material.

Producers of mineral fillers, extenders, and pigments in Quebec and Ontario are listed in Tables 4 and 5, respectively. Although the bulk of the production is used domestically, small but significant amounts are exported to the United States. Some companies market their own products whereas others prefer to use marketing agents such as St. Lawrence Chemicals in Montreal and L.V. Lomas Chemical Co. Ltd. at Malton. These agents may act also for producers in the U.S.A. who export fillers to Canada. Consumption in the area under study consists of production by the companies noted plus imports. Available data do not allow a simple breakdown of consumption on the basis of individual products or applications; however, assuming that mineral wastes could be utilized in 20% of the applications, there could be a market for perhaps 100 000 t as fillers. At $10/t, this market would have a value of $1 x 10^6$. Potentially useable mineral wastes that could be considered as fillers are discussed in the next section.

Table 1 - Properties and uses of principal mineral fillers

Fillers	Properties	Uses		Remarks
		principal	other	
Asbestos	fibrous, inert, heat resistant, moderate oil absorption	asbestos-cement products, vinyl-asbestos floor tile, joint cement, caulking and sealing compounds	plastic, paper, rubber, paint	shorter varieties (Grade 7) are used as fillers and extenders, principally as reinforcing and flow-control agents; possible health hazard and, as a result, asbestos gradually is being replaced by other fillers in some applications, e.g., by mica in joint cement for dry-wall construction
Barite	heavy, inert, low oil absorption	paint, foamed plastics	caulking and sealing compounds, rubber	principally used as extender pigment and filler when weight and high density are criteria; used in metal primer paints and in gloss and semi-gloss paints and floor enamels
Bentonite	colloidal, may be dispersed in water, low oil absorption	adhesives, paints, insecticides, oil-well drilling mud, iron ore pelletizing	detergents	acts as a thickening agent in adhesives and paints, aids pigment/adhesive sus-pension and increases viscosity; use in insecticides is principally as a diluent of dry powders; major use as pelletizing agent for iron ore concen-trates; widely used in oil-well drill-ing muds
Diatomite	porous, large surface area, low specific gravity, high oil absorption	paint, paper	plastics, caulking and sealing compounds, insecticides	principal use is in formulations for flat paint and varnishes to reduce gloss and as a pitch control, absorp-tive agent, in paper manufacture
Kaolin	plate-like particle shape, low brightness, low to moderate oil	paper, rubber, caulking and sealing compounds, plastics, carpet backing	paint, adhesives, oil cloth, ink, insecticides	several varieties used including air-floated, water-washed, calcined; ideal as filler for many grades of paper where

Table 1 (cont'd)

Fillers	Properties	Uses		Remarks
		principal	other	
	absorption, easily dispersed in water			brightness is not important; improves workability (slip) of caulking and sealing compounds; used in latex paints; in rubber improves tensile strength and resistance to tear and abrasion
Limestone and dolomite (calcium, magnesium carbonates)	soft, soluble in acids, white, high brightness, low oil absorption	paint, caulking and sealing compounds, plastics, floor tile, rubber, carpet backing, asphalt products	paper, adhesives, fertilizers, insecticides	abundant, low cost, widely used filler-extender; quality grades are used in paints, paper, plastics and rubber, lower quality material used in asphalt mixes, caulking and sealing compounds, and in fertilizers and insecticides
Mica	flat, plate-like particle shape, flexible, inert, low- to moderate-oil absorption	joint cement, plastics, paint, asphalt roofing, drilling muds	paper, rubber	principal use is in dry-wall joint cement where it gradually is replacing asbestos fibre, provides good workability; expanding use as a reinforcing agent in moulded plastic bodies; used primarily as mould release agent by the rubber industry; expanding use in oil-well drilling muds
Nepheline syenite	white, high brightness, inert, low oil absorption	paints, plastics		nepheline syenite is finding increased acceptance and use in high-quality paint formulations because of good brightness, high bulking capacity, good resistance to staining and chalking, and excellent tint retention
Portland cement	readily available, low- to moderate-oil absorption, chemically reactive, may have some bonding action	asphalt mixes, asbestos-cement products		increasing cost of portland cement may limit its use as filler-extender; cement kiln dust, a waste product, may be acacceptable substitute in some applications, e.g., in asphalt mixes

Table 1 (cont'd)

Fillers	Properties	Uses		Remarks
		principal	other	
Pyrophyllite	soft, plate-like particles, inert, low- to moderate-oil absorption	paint, asphalt roofing, joint cement	insecticides, battery boxes	similar applications as talc
Rock dusts	abundant, inexpensive, variable in physical and chemical composition	asphalt mixes, mortars, concrete products		useful as low-grade filler
Silica	harsh, inert, high brightness, low- to moderate-oil absorption	paint, plastics, rubber	caulking and sealing compounds	available as ground silica, precipitated silica, silica gel, fumed silica; ground silica, because of abrasiveness, has limited applications and is chiefly used in exterior paints and in floor and traffic paints and enamels; precipitated silica finds its greatest application as a filler in rubber products, including footwear, and heels and soles for boots and shoes; silica gels are used in many products including adhesives, paints, plastics and rubber - silica gel is of particular value as a flattening agent in clear varnishes; fumed silica is used as a reinforcing agent in silicone rubber, in adhesives, and in caulking and sealing compounds
Talc	soft, white, low brightness, low- to moderate-oil absorption	paint, plastics, cosmetics, caulking and sealing compounds, rubber, paper	adhesives, printing ink, insecticides	greatest consumption in paint where talc acts as a film reinforcing and flattening agent; use in plastics includes vinyl tile and floor covering; use in rubber products is primarily as a dusting agent; some talcs contain tremolite fibre which may constitute a health hazard in certain applications

Table 2 - Applications and functions of mineral fillers

Applications	Minerals used	Function
Adhesives	kaolin, calcium carbonate, talc, bentonite precipitated silicas	to lower cost, control viscosity and flow, reinforce, improve adhesion
*Asbestos-cement products	calcium carbonate, fly ash, mica, mineral wool	to lower cost by partially replacing portland cement and to reduce requirement for asbestos fibre
*Asphalt products, including shingles, roll roofing, liquid asphalts and asphaltic concrete	calcium carbonate, talc, pyrophyllite, mica, abestos, rock dusts, portland cement	to lower cost, control viscosity and flow, reinforce and, as dusting agent, to prevent sticking, e.g., of shingles and roll roofing
*Building products, including mortars and cement, bricks and blocks, concrete products and stuccos	calcium carbonate, rock dusts, fly ash, diatomite, pumicite	to lower cost, improve physical properties
Carpet backing, including resin, jute, latex and polyvinylchloride types	calcium carbonate, alumina hydrate, feldspar, nepheline syenite, kaolin	to lower cost, improve physical properties, increase fire resistance, e.g., alumina hydrate
*Caulking and sealing compounds, including putty	calcium carbonate, kaolin, talc, asbestos, silica	to lower cost, improve workability and as bulking and reinforcing agents
Cosmetics	talc	to provide required physical properties
*Drilling muds	bentonite, barite, mica, perlite	to improve physical properties, control density, viscosity and flow
Detergents, dry, soaps and cleansers	bentonite, silica	to lower cost, improve physical properties

*Some mineral wastes may be useful as fillers in these products.

Table 2 (cont'd)

Applications	Minerals used	Function
*Fertilizers	kaolin, diatomite, bentonite	as diluent to control strength and aid application and as coating on granules to inhibit caking
*Floor tile and linoleum	calcium carbonate, asbestos, talc, kaolin	to lower cost, improve physicl properties, reinforce
*Insecticides and pesticides	fuller's earth, calcium carbonate, talc, pyrophyllite, bentonite, kaolin, diatomite	as carrier and diluent to control strength
Paints and varnishes	calcium carbonate, nepheline syenite, talc, kaolin, silica, barite, diatomite, mica, bentonite, pyrophyllite	to lower cost and improve physical properties, e.g., flow, colour, tint, retention, stability, durability and weatherability
Paper, including wallpaper	kaolin, fuller's earth, calcium carbonate, talc, pyrophyllite, diatomite, mica	to lower cost and to improve quality, surface finish, and printing properties (ink retention); talc may be used for pitch control
*Plastics	calcium carbonate, asbestos, mica, kaolin, barite, talc, pyrophyllite, nepheline syenite, diatomite, silica	to lower cost, reinforce, improve physical properties
*Rubber	Calcium carbonate, kaolin, precipitated silica, talc, mica, barite	to lower cost, improve workability and physical properties, e.g., hardness, strength, and resistance to tear

Table 3 - Canadian production, trade and consumption of selected minerals (1977)[1]

Mineral	Producing provinces	Production tonnes	Imports tonnes	Exports tonnes	Consumption[2] tonnes - all uses	Consumption as filler or extender-pigment[3] tonnes	use
Asbestos	Que., B.C., Yukon, Nfld.	1 517 360	4 112	1 415 244	106 228	n.a.	floor tile, plastics, in caulking and sealing compounds, and in asphalt products
Barite	Ont., B.C.	116 950	5 979	69 421	19 031	5 000	principally in paint and varnish, and in rubber and plastic formulations
Bentonite	Man., Sask., Alta.	n.a.	358 724	n.a.	343 123	6 500	fertilizer, stock and poultry feed, rubber and paper products; does not include use in pelletizing iron ore, in foundry castings or in oil-well drilling muds
Diatomite	B.C. - no current production	1 239	27 179	nil	23 277	16 000	rubber and paper products, and in fertilizer dusting
Fuller's earth	no production	nil	6 307[4]	nil	6 307	6 000	soaps and detergents, paint and varnish, insecticides and pesticides
Kaolin (china clay)	no production	nil	175 051[4]	nil	175 051	150 000	principally in paper and paper products, also in paints, varish, rubber and linoleum products
Limestone	all except P.E.I.	60 161 000	2 922 684	1 502 492	907 127[5]	150 000	ground limestone or marble used as filler in paper, paint, plastics, rubber, and in asphalt products, caulking and sealing compounds, fertilizers and insecticides
Marble	Que., Ont.	397 000	7 655	nil			

Table 3 (cont'd)

Mineral	Producing provinces	Production tonnes	Imports tonnes	Exports tonnes	Consumption(2) tonnes - all uses	Consumption as filler or extender-pigment(3) tonnes	use
Mica	Que.	n.a.	6 309	n.a.	4 222	4 000	principally in dry-wall joint cement, and in paint and varnish, rubber, plastics, and paper
Nepheline syenite	Ont.	574 558	nil	443 763	75 525	6 000	principally in paint, rubber and plastics
Silica	all except P.E.I.	2 316 680	1 101 186	56 297	2 728 851	20 000	gypsum products, fertilizer, paint and varnish, paper, roofing and rubber products
Talc, soapstone and pyrophyllite	Ont., Que. Nfld.	74 400(6)	33 769 nil	small 30 000(7)	41 884	34 000	principally in paint and joint cement, gypsum, roofing, and pulp and paper products, also in rubber, plastics, insecticides and adhesives
Fly ash	N.S., N.B., Ont. Man., Sask., Alta.	2 000 000	nil	nil	100 000	100 000	principally in concrete products as partial replacement for portland cement; because fly ashes have pozzolanic (cementing) properties they are, in effect, more than inert fillers
Portland cement	all except P.E.I.	9 639 679	257 812	1 274 652	8 622 839	n.a.	used in asphalt mixes and in roofing products
Rock dusts	all except P.E.I.	600 x 10(6)	nil	nil	n.a.	n.a.	used in asphalt mixes, mortars and concrete products

(1) Statistics Canada

(2) Apparent consumption - production, plus imports, less exports, or consumption reported by Statistics Canada

(3) Estimated on basis of consumption data reported by Statistics Canada

(4) Imports assumed to equal reported consumption

(5) Whiting or whiting substitute - ground chalk, precipitated calcium carbonate, ground limestone and marble

(6) Not separately available

(7) Estimated

Table 4 - Mineral filler, pigment, and extender-pigment producers, province of Quebec

Producer	Plant location	Product(s)	Principal filler/pigment application
Baker Talc Limited, Montreal	South Boulton	talc	filler in paper, paint, joint cements, plastics
Broughton Soapstone & Quarry Company Limited, St. Pierre de Broughton	St. Pierre de Broughton	talc	filler in asphalt mixes and products, e.g., shingles and roofing
Canadian Titanium Pigments Limited, Varennes	Varennes	titanium dioxide	pigment in paints and paper
Gulf Canada Limited, Montreal	Bedford	limestone - coarse to fine sizes	finer sizes used as filler in asphalt and as soil additive
Indusmin Limited, St. Canut	St. Canut, St. Donat de Montcalm	silica sand and flour (ground silica)	silica flour used in asbestos cement products and in concrete block
Industrial Fillers Limited, Montreal	Phillipsburg	limestone	filler in joint cements, carpet backing, putty
Marietta Resources International Ltd., Boucherville	Boucherville	mica	filler in plastics, joint cement, oil-well drilling mud
Tioxide of Canada, Tracy	Tracy	titanium dioxide	pigment in paints and paper

Table 5 - Mineral filler and extender-pigment producers, province of Ontario

Producer	Plant location	Product(s)	Principal filler/pigment application
Canada Talc Industries Limited, Madoc	Madoc	talc, dolomite	talc used as a filler in paint, and plastics; dolomite used as diluent in insecticides and pesticides and in dry-wall joint cement
Extender Minerals of Canada Limited, Mississauga	Matachewan	barite	pigment and filler in paint and plastics
Indusmin Limited, Toronto	Midland	silica sand and flour (ground silica)	flour is used in autoclaved concrete block
Indusmin Limited, Toronto	Nephton	nepheline syenite (coarse to fine sizes)	fines are used in paints and plastics
Steetley Industries Limited, Hamilton	Timmins area	talc	filler in paint, plastics, and cosmetics
3M Canada Limited, Havelock	Havelock	traprock - roofing granules, aggregates, fines	fines are used as filler in asphalt products
Wm. R. Barnes Ltd., Waterdown	Perth	limestone - crushed stone, aggregate, fines	fines used as filler in paint, cosmetics, ceramics, rubber and plastics

MINERAL WASTES AS MINERAL FILLERS

During the past several years the writer has been systematically documenting technical data on Canada's vast and growing mineral waste resources. The current rate of generation of solid wastes is about 800 x 10^6/a. Reports have been published on mining and mineral processing wastes in Ontario, Quebec, and British Columbia and compilation of data for the Atlantic and Prairie Provinces is well advanced (2,3,4). Reports on metallurgical and chemical process wastes also are in preparation in CANMET.

Although significant amounts of the coarser sizes of mineral wastes are being used in road and dam construction, as railroad ballast, and as construction aggregate, utilization of the finer sizes, e.g., mill tailings, metallurgical dusts, and chemical sludges, is relatively minor. Such wastes may have potential as mineral fillers.

The applications for which the finer sizes could be considered are indicated in Table 2. These, as previously noted, are not so dependent on purity and colour but rather require that the filler be readily available, inexpensive, uniform in composition and relatively inert. This report deals only with selected wastes in southern Quebec and Ontario, and particularly those in the highly industrialized sections within 250-km (150-mile) radii of Montreal and Toronto.

These wastes are identified on the map, Fig. 1, by numbers 1 to 13, and are described separately below. Additional information is presented in Tables 6 to 9. This information was obtained largely from field studies made in October and November, 1979, from the laboratory investigation of selected samples, and from the previously noted reports on Ontario and Quebec (2,3).

1. FLY ASH

Ontario Hydro uses imported bituminous coal for its six electrical power generating stations. The ash content of this coal is 10%, of which 80% reports as fly, or coal ash and the remainder as bottom ash. Production of fly ash is about 1 x 10^6 t, about half of the Canadian total, and of bottom ash 250 000 t/a. About 30% of the Ontario fly ash is utilized as a pozzolanic additive in concrete, in road construction, and in land reclamation, the remainder is stockpiled in lagoons or used as landfill. Applications or products in which fly ash could be used as a filler or additive material include asphalt mixes and compounds, and portland cement. It could also be utilized in the manufacture of mineral wool, lightweight aggregates, and clay brick. Bottom ash is finding ready acceptance in road construction. Other potential applications are as a sandblast grit, as a roofing granule, and as a traction grit for ice conditions on roads and highways (7).

2. SILICA FUME

Silica fume is finely divided silica powder that is generated during the electric furnace production of silicon metal and ferrosilicon alloys. It is produced by Union Carbide Canada Ltd. and Chromasco Ltd. at Beauharnois, Quebec and by SKW Metallurgical Industries at Becancoeur, Quebec. Total production is about 30 000 t/a, part of which is recovered as a dry powder from electrostatic precipitators and part as sludge from wet scrubbers. This material is of particular interest as a potential filler or additive for refractory grouting mixes and caulking compounds, and as a source of silica in portland cement, asbestos cement and concrete products. It may also be useful as a filler in rubber, plastics, and in certain paints.

3. CALCITE TAILINGS

Approximately 4 x 10^6t of calcite tailings were produced by St. Lawrence Columbium and Metals Corp. during columbium oxide recovery operations near Oka, Quebec. Although the plant is closed, there is a continuing interest in the possible recovery and use of these tailings as a soil amendment and neutralizer. With moderate benefication, e.g., sizing, magnetic separation, and grinding, these tailings possibly could be of interest as filler or additive material in asphalt mixes, grouting and caulking compounds, in brick and block manufacture, and for other purposes.

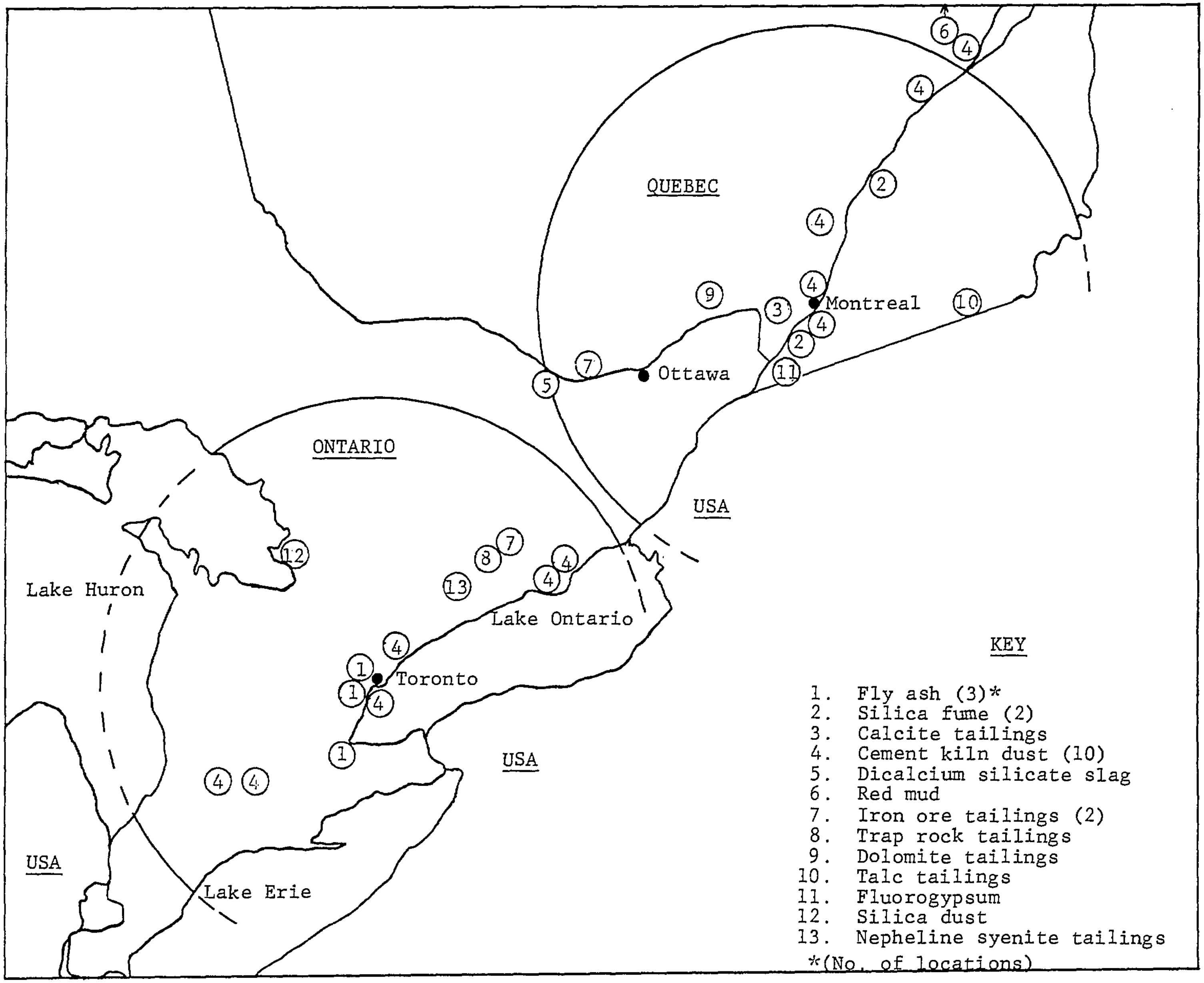

Fig. 1 - Location and identification of selected mineral wastes within 250-km radii of Montreal, Que., and Toronto, Ont.

Table 6 - Mineral waste occurrences, current and potential uses, provinces of Quebec and Ontario(1)

Identification No.	waste	Location	Amount-tonnes (t/a or total)	Description	Uses: current(2)	Uses: potential(3)
1.	Fly ash	Toronto, Mississauga, Hamilton, Ont.	750×10^3 (from 3 plants)	dark gray, mean diameter 10 µm but may range up to 150 µm, glassy, spherical particles, composed of compounds of silicon, aluminum, iron, calcium and carbon with minor magnesium, titanium, potassium, sulphur and alkali compounds	road construction, land reclamation, additive to concrete	asphalt mixes and in brick and block manufacture
2.	Silica fume	Beauharnois, Becancoeur, Que.	30×10^3 (from 3 plants)	gray, finely divided (85% minus 10 µm), principally consists of amorphous silica (SiO_2 varies from 85 to 99% depending on source), bulk density $0.25 g/cm^3$	high temperature insulation and in refractory cement mfg	portland cement mfg, concrete and asbestos-cement products, in paint, plastics and rubber products
3.	Calcite tailings	Oka, Que.	4×10^6 (total)	gray, 50% minus 150 µm, principally calcite (75%), with silicates (18 to 20%), minor apatite	soil neutralizer and fertilizer (limited use)	asphalt mixes, brick and concrete block mfg
4a.	Cement kiln dust	St. Constat, St. Basile, Joliette, St. Michael, Villeneuve, Que.	100×10^3 (from 5 plants)	gray-brown to white, minus 45 µm, principally calcium oxide (45% to 50%), with silicates (15 to 20%), and alkalies (5 to 20%); K_2O may range up to 40% in "by-pass" dust	asphalt mixes	bitumen extender in asphalt mixes, as a coater for fertilizers and insecticides, soil additive, feed supplement for cattle, neutralizer for acid soils and effluents, in SO_2 abatement systems and in sewage treatment

(1) Wastes with potential as mineral filler within 250-km radii of Montreal and Toronto.

(2) In Canada.

(3) Principally as filler but other uses also noted.

Table 6 (cont'd)

Identification		Location	Amount-tonnes	Description	Uses	
No.	waste		(t/a or total)		current[2]	Potential[3]
4b.	Cement kiln dust	Woodstock, Bath, Picton, Clarkson, Bowmanville, St. Mary's, Ont.	120×10^3 (from 6 plants)	gray-brown to white, minus 45 µm, principally calcium oxide (45% to 50%), with silicates (15 to 20%), and alkalies (5 to 20%); K_2O may range up to 40% in "by-pass" dust	asphalt mixes	bitumen extender in asphalt mixes, as a coater for fertilizers and insecticides, soil additive, feed supplement for cattle, neutralizer for acid soils and effluents, in SO_2 abatement systems and in sewage treatment
5.	Dicalcium-silicate slag	Haleys Station, Ont.	40×10^3	gray, minus 2 mm, principally calcium orthosilicate, $CaSiO_4$, with minor magnesia, alumina and calcium fluoride	none	in portland cement mfg., and in brick and block products
6.	Red mud	Arvida, Que.	1.5×10^6	brownish-red, minus 100 µm, consists principally of oxides of silicon, aluminum, iron, sodium and titanium	none	filler/pigment in paints and plastics, brick and concrete products, fluorspar substitute in steel mfg., pelletizing agent for iron ore, recovery of contained minerals and metals
7a.	Iron ore tailings	Shawville, Que.	18×10^6 (total)	gray, 35% minus 150 µm, principally amphibole and quartz, with serpentine, talc, mica, feldspar	none	bitumen extender and filler in asphalt mixes, brick and block mfg
7b.	Iron ore tailings	Mamora, Ont.	10×10^6 (total)	gray, 90% minus 250 µm, limestone, syenite, trap rock (40% SiO_2, 20% CaO, with alumina, magnesia), minor pyrite and pyrrhotite	none	bitumen extender and filler in asphalt mixes, brick and block mfg

Table 6 (cont'd)

Identification No.	Identification waste	Location	Amount-tonnes (t/a or total)	Description	Uses: current(2)	Uses: Potential(3)
8.	Trap rock tailings	Havelock, Ont.	50×10^3	gray, 100% minus 850 µm, 35% minus 100 µm, trap rock, plagioclase, amphibole, quartz, chlorite (45% SiO_2, 22% Al_2O_3)	asphalt mixes	bitumen extender and filler in asphalt mixes, in brick and block mfg., in mineral wool manufacture
9.	Dolomite tailings	Kilmar, Que.	3×10^3	off-white, 100% minus 150 µm, principally dolomite magnesite and calcite, some serpentine	none	bitumen extender and filler in asphalt mixes, in plastic pipe, in brick and block mfg
10.	Talc tailings	Highwater, Que.	4×10^3	off-white, 85% minus 45 µm, principally dolomite and magnesite with up to 20% talc	thermal insulation (experimental use)	in joint cements, in concrete paints, plastics and cleansers
11.	Fluoro-gypsum	Valleyfield, Que.	30×10^3	gray-white, 75% minus 150 µm, principally fluorogypsum (75%) with anhydrite (25%) and minor quartz and fluorite, slightly acidic	none	filler in plastics?, as set control agent in portland cement, in gypsum products mfg
12.	Silica dust	Midland, Ont.	variable, up to 300/t week	white, 85% minus 75 µm, principally quartz (99% SiO_2) with minor metallic (mill) iron	autoclave concrete block mfg	bitumen extender in asphalt mixes, brick and block mfg, in asbestos-cement products, in concrete paints
13a.	Nepheline syenite tailings	Peterborough area, Ont.	50×10^3 (from 2 plants)	gray-white, 50% minus 150 µm, principally nepheline syenite with feldspar, mica, hornblende and magnetite (5%)	additive in portland cement	in asphalt and concrete mixes, for recovery of higher-grade nepheline syenite
13b.	Nepheline syenite dust	Peterborough area	5×10^3	off-white, 60% minus 45 µm, principally nepheline syenite, plagioclase, K-feldspar and mica, with minor magnetite and calcite	none	bitumen extender in asphalt mixes, in plastic pipe, joint cement, and brick and block mfg

Table 7 - Physical properties of mineral wastes[1]

Identification No.	Identification waste	Colour	Reflectance[2]	Refractive index	Particle shape	Particle size % minus µm	Surface area cm^2/g[3]	Relative density	Bulk density g/cm^3	Oil absorb. ml/100 g	pH[4]
1	Fly ash	gray to dark gray	0.16	1.55	spherical	75% - 45	3 475	2.5	0.94	38.4	11.0
2	Silica fume	gray	0.38	1.50	rounded to sub-angular	60% - 150	8 850	2.4	0.46	66.7	8.5
3	Calcite tailings	gray to white	0.37	1.57	sub-rounded to angular	50% - 150	(7)	2.8	1.45	20.0	8.5
4a	Cement kiln dust[5]	white	0.82	1.57	angular	90% - 45	8 260	2.1	0.46	60.3	12.0
4b	Cement kiln dust[5]	gray	0.35	1.57	angular	67% - 45	5 400	2.8	0.79	37.1	12.0
5	Dicalcium-silicate slag	gray	0.34	1.60	angular	50% - 45	1 380	3.1	1.11	31.0	11.6
6	Red mud	reddish brown	0.25	(6)	not determined	75% - 75	12 400	3.0	0.61	85.3	10.4
7a	Iron ore tailings	dark gray	0.24	1.60	angular	90% - 212	1 545	3.3	1.60	17.0	8.8
7b	Iron ore tailings	gray	0.32	1.60	angular	35% - 150	(7)	2.9	1.08	35.8	12.0

(1) Mineral wastes identified and described in Table 6.

(2) As determined by Hunter colour difference meter and based on reflectance of 0.78 for standard white plaque.

(3) Blaine air permeability apparatus.

(4) Suspension of 10 g of waste sample in 100 ml of distilled water.

(5) By-pass dust, 4a; normal dust, 4b.

(6) Index could not be determined.

(7) Samples were too coarse for Blaine apparatus.

Table 7 (cont'd)

Identification No.	Identification waste	Colour	Reflectance[2]	Refractive index	Particle shape	Particle size % minus µm	Surface area cm^2/g [3]	Relative density	Bulk density g/cm^3	Oil absorb. ml/100 g	pH[4]
8	Trap rock tailings	gray	0.27	1.60	sub-angular	100% -850	(7)	2.9	1.50	19.3	9.6
9	Dolomite tailings	off-white	0.57	1.60	angular	100% - 106	(7)	2.2	1.58	18.2	9.2
10	Talc tailings	off-white	0.68	1.60	sub-angular to platy	85% - 45	3 315	3.0	0.96	29.3	8.5
11	Fluorogypsum	off-white	0.69	1.52	crystals	50% - 75	3 129	2.5	0.80	22.4	5.4
12	Silica dust	off-white	0.73	1.54	sharply angular	85% - 75	(7)	2.7	1.34	20.7	6.5
13a	Nepheline syenite tailings	grey-black	0.32	1.58	sub-angular to platy	60% - 150	(7)	2.8	1.40	14.3	8.9
13b	Nepheline syenite dust	off-white	0.65	1.54	angular	60% - 45	4 022	2.6	0.93	27.7	9.3

Table 8 - Chemical analyses of mineral wastes[1,2]

Identification No.	Identification waste	Compound or element - % SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	Cl	F	S	C	LOI
1	Fly ash[3]	43.6	17.0	21.0	3.4	0.9	2.4	1.4	n.d.	n.d.	n.d.	1.4	n.d.	8.0
2	Silica fume	93.8	0.6	0.5	0.8	0.5	0.5	0.1	n.d.	n.d.	n.d.	n.d.	0.5	1.8
3	Calcite tailings	4.0	2.7	0.6	50.0	1.7	n.d.	n.d.	n.d.	n.d.	n.d.	0.5	n.d.	36.2
4	Cement kiln dust[4]	13.0	2.9	2.7	41.5	2.0	14.4	0.8	n.d.	3.5	n.d.	7.5 (SO_3)	n.d.	n.d.
5	Dicalcium silicate slag	33.4	2.7	0.8	61.4	1.6	n.d.	n.d.	n.d.	n.d.	0.6	n.d.	n.d.	n.d.
6	Red mud	17.0	27.0	17.8	5.0	n.d.	n.d.	10.2	12.7	n.d.	n.d.	n.d.	n.d.	11.4
7a	Iron ore tailings	42.1	15.8	11.7	20.3	7.7	n.d.	0.5	n.d.	n.d.	n.d.	1.1	n.d.	1.9
7b	Iron ore tailings	50.0	12.9	5.9	5.4	19.0	n.d.	n.d.	n.d.	n.d.	n.d.	2.8	n.d.	5.2
8	Trap rock tailings	48.0	15.2	13.0	9.8	4.9	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	3.3
9	Dolomite tailings	8.0	0.7	0.5	11.9	36.3	n.d.	n.d.	n.d.	n.d.	n.d.	0.1	n.d.	41.0
10	Talc tailings	22.3	9.0	4.6	3.0	32.8	n.d.	n.d.	n.d.	n.d.	n.d.	0.4	n.d.	26.1
11	Fluorogypsum	1.2	n.d.	n.d.	35.7	n.d.	n.d.	n.d.	n.d.	n.d.	1.1	47.6 (SO_3)	n.d.	15.3
12	Silica dust	99.0	0.2	0.3	0.03	0.01	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.2
13a	Nepheline syenite tailings	59.5	1.3	24.2	0.5	0.1	5.1	10.2	n.d.	n.d.	n.d.	0.03	n.d.	1.2
13b	Nepheline syenite dust	56.1	1.1	26.4	1.3	0.03	5.1	9.7	n.d.	n.d.	n.d.	n.d.	n.d.	0.8

(1) Mineral wastes identified and described in Tables 6 and 7.

(2) Chemical analyses by Chemical Laboratory, CANMET, except where noted.

(3) Chemical analysis by Ontario Hydro.

(4) Chemical analysis by St. Lawrence Cement.

n.d. not determined

Table 9 - Mineralogy of mineral wastes[1,2]

Identification No.	waste	Constituents greater than 20%	10 to 20%	less than 10%
1	Fly ash	glass	--	quartz, magnetite, hematite, mullite
2	Silica fume	amorphous material	--	quartz (minor)
3	Calcite tailings	calcite	--	apatite, dolomite, quartz, mica
4	Cement kiln dust	amorphous material(?)	--	calcite, quartz, anatase
5	Dicalcium silicate slag	dicalcium silicate	--	tricalcium silicate (alite)
6	Red mud	hematite	anatase, calcite	quartz
7a	Iron ore tailings	pyroxene, amphibole	--	K-feldspar, plagioclase
7b	Iron ore tailings	amphibole, quartz	serpentine, talc, mica	K-feldspar, plagioclase
8	Trap rock tailings	plagioclase, amphibole, quartz, chlorite	--	K-feldspar, dolomite
9	Dolomite tailings	dolomite, magnesite	serpentine	calcite, quartz
10	Talc tailings	magnesite, dolomite	talc	chlorite
11	Fluorogypsum	gypsum, anhydrite	--	quartz, fluorite
12	Silica dust	quartz	--	--
13a	Nepheline syenite tailings	plagioclase, K-feldspar, mica	calcite, pyroxene	hornblende, magnesite
13b	Nepheline syenite dust	plagioclase, K-feldspar	--	--

(1) Mineral wastes identified and described in Tables 6, 7, 8.

(2) Mineralogical analyses by Ore Mineralogy Laboratory, CANMET.

4. CEMENT KILN DUST

Cement kiln dust (CKD) is produced at every cement plant in Canada. Total production is about 500 000 t/a, 45% of which comes from Ontario and Quebec. CKD has been used as a filler in asphalt paving mixes with good results. Use in this area is expected to increase with the increased cost of bitumen. N-Viro Energy Systems Inc., of Toledo, Ohio, reported that "replacement of the 10 x 10^6t/a of bituminous roadbase consumed in the U.S.A. with a bitumin mix containing 10% CKD and 10% fly ash would utilize by-products, conserve a billion gallons of oil and save purchasers an estimated $350 million per year" (5). Other potential applications for CKD include its use as an absorbent for SO_2, as a coater of fertilizers and insecticides, as cattle feed supplement, and in neutralizing acid lakes and mine waters. High alkali CKD has been used experimentally as a soil neutralizer and fertilizer, particularly for acid soils.

5. DICALCIUM SILICATE SLAG

An estimated 40 000 t of dicalcium silicate slag is generated annually by Chromasco Ltd. during the production of magnesium metal at Haleys Station, Ontario. This material is similar in composition to portland cement and may have some application in cement manufacture, possibly as a filler or extender. Good quality building brick has been produced experimentally with this slag by an autoclave process developed at CANMET (6).

6. RED MUD

Red mud is produced by ALCAN Ltd. at Arvida, Quebec, in the Bayer process for the manufacture of aluminum metal. This material has been the subject of much research in Canada and in other countries. Production is about 1.5 x 10^6t/a. Red mud is potentially of interest as a mineral pigment, as an additive in clay brick during manufacture, and as a pelletizing agent for iron ore. Other non-filler/pigment applications include use in water purification, as a substitute for fluorspar in steel manufacture, and for the recovery of contained alumina, iron oxide, titanium dioxide and soda (10).

7. IRON ORE TAILINGS

Two former iron ore operations, one at Shawville, Quebec, the other at Marmora, Ontario, generated millions of tonnes of mill tailings at these locations. These are of potential interest as fillers or as sand in asphalt mixes. They may also be used as fine sand in concrete and in brick and block manufacture. Dry-pressed facebricks have been produced experimentally from the Shawville tailings at CANMET (9).

8. TRAP ROCK TAILINGS

Trap rock fines from 3 M Company's roofing granule plant at Havelock, Ontario, have been used as a filler in asphalt paving mixes. These fines also may be useful as filler in certain types of plastics, e.g., plastic pipe. Tailings from Havelock currently are being studied at CANMET as raw material for mineral wool manufacture.

9. DOLOMITE TAILINGS

Canadian Refractories Division of Dresser Industries Ltd., operates a magnesite-dolomite mine at Kilmar, Quebec, for the production of refractory brick. Production of mill tailings averages about 3000 t/a. These tailings have potential as a filler or sand in asphalt mixes, in plastics, and may also be satisfactory for brick and block manufacturing.

10. TALC TAILINGS

Talc is produced at two locations in Quebec - at Highwater by Baker Talc Limited and at St. Pierre de Broughton by Broughton Soapstone and Quarry Company Limited and, in Ontario - at Madoc by Canada Talc Limited and, 80 km west of Timmins, by Steetley Industries Limited. Wastes from these operations, although of small volume, may be useful as fillers in dry-wall joint cement, in concrete paints, and in plastics. Wastes from Highwater have been used experimentally in the production of thermal insulation (11).

11. FLUOROGYPSUM

Fluorogypsum waste is produced by Allied Chemical Limited at hydrofluoric acid manufacturing facilities at Valleyfield, Quebec, and Amherstburg, Ontario. Although not now utilized, this material might be useful as filler in caulking and sealing compounds and in certain plastics. It currently is being studied as a set-control agent for portland cement concrete (8).

12. SILICA DUST

Indusmin Limited operates a milling and beneficiation plant for the production of glass sand at Midland, Ontario. Fines from this operation are sold for use in the manufacture of autoclaved concrete block. Excess fines are generated during periods of peak production of glass sand. This material probably would be satisfactory as a filler in caulking and sealing compounds. It also could be used in the manufacture of asbestos-cement pipe provided adequate and continuing supplies could be maintained.

13. NEPHELINE SYENITE TAILINGS

Nepheline syenite operations in the Peterborough, Ontario, area, - Indusmin Limited at Nephton and IMC Chemical Limited north of Havelock - produce two grades of wastes - fines from dust collectors and tailings from beneficiation processes. Total production is about 50 000 t/a. The fines could be utilized as a filler-extender in a number of products, e.g., paints, plastics, caulking and grouting compounds. The coarser material could be used in cement and concrete, and as aggregate or extender in asphalt mixes.

OBSERVATIONS AND RECOMMENDATIONS

Although the bulk of the mineral wastes produced by Canadian industry is of limited value for use as filler, some, including those listed in Table 6 and discussed in the previous section, are deserving of further study. A number of consumers of mineral fillers in the Montreal and Toronto areas have expressed interest in several of these as possible substitutes or partial substitutes for higher cost fillers that in some instances must be imported. Of particular interest are silica fume from silica/ferrosilicon production at Beauharnois and Becancoeur, Quebec, silica dust from glass sand processing at Midland, Ontario, trap rock fines from Havelock, Ontario, cement kiln dust, and fly ash. Producers of these wastes, in turn, are keenly interested in marketing part or all of their production to reduce disposal costs. Producers and potential consumers are often unaware of each other's requirements. There is thus a distinct need for more published information on mineral wastes and their possible used on the one hand, and on potential markets and market specifications on the other. The Waste Exchange Service operated by the Ontario Research Foundation, Mississauga, serves as an excellent vehicle for the transfer of information relating to wastes and potential markets between producers and potential consumers.

The need for information is basic. However, acquiring information is only the beginning. Following identification of a potential use for a particular waste, a detailed, cooperative program of research and development is required to evaluate the technical and economic feasibility of utilizing it. If successful, a mutually satisfactory price must be agreed upon. The producer will want to cover possible extra handling and processing costs whereas, the consumer will want a price significantly lower than that being paid for current supplies. He additionally will require assurance of the ability of the producer to supply adequate quantities of specified material over an agreed contract period.

Developing uses for mineral wastes, particularly in the complex filler market, is not a simple task but the quantity and variety of raw materials available and the diversity of possible applications, together present a challenge that should not go unheeded by industry and government. In a paper presented at the 1977 Mining and Industrial Waste Conference, Toronto, J.J. Emery noted "there is still much potential for the utilization of waste and byproducts as resources to be developed", and suggested that "an integrated approach by government, industry, and private research organizations is needed to foster the new technology required for waste and byproduct management and utilization" (12).

A special need exists to achieve this aim in that detailed information is not available in published form. The Charles H. Kline organization of Fairfield, New Jersey, has undertaken periodic studies of extender and filler pigments in the United States. The latest being in 1977. A comparable study in Canada would be invaluable in more precisely identifying resources, possible applications, and markets.

Optimum utilization of Canada's mineral resources is a goal that will be achieved only through the cooperative efforts of industry and government. The utilization of wastes is an integral part of this objective.

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