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CANMET'S ENVIRONMENTAL AND PROCESS RESEARCH ON URANIUM

D. Moffett, G. Zahary, M.C. Campbell and J.C. Ingles

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CANMET'S ENVIRONMENTAL AND PROCESS RESEARCH ON URANIUM[1]

by

D. Moffett*, G. Zahary**, M.C. Campbell+ and J.C. Ingles++

ABSTRACT

Environmental research related to uranium tailings is being carried out within the Mining Research Laboratories and Mineral Sciences Laboratories of CANMET, EMR. Field-related research on uranium tailings has been conducted at Elliot Lake for over five years. Much of the work has been focused on a program to rehabilitate pyritic tailings. This has resulted in developing a practicable technology for growing vegetation on such wastes. Limitations have been small size of the test-plots and the relatively short period during which experiments have been carried out.

A research program aimed at identifying and reducing acidic and radioactive effluents is also underway at Elliot Lake. These liquid effluents have been identified as the most serious threat to the environment.

Research at the Mineral Sciences Laboratories and its predecessor divisions relating to the processing of uranium and thorium ores is outlined. A process has been developed for recovering thorium which could reduce the overall radioactive load in the tailings. Much of the current work is related to developing new technology for recovering uranium from lower-grade ores which, however, is unlikely to be implemented within the next ten years. A significant effort is also being made in removing pyrite, preconcentrating radioactive minerals, and identifying and removing chemical compounds that carry radium in solid tailings. All of these investigations could have impact on near-term solutions to some environmental problems. Mineral Sciences Laboratories has the analytical capacity to identify and characterize both the mineralogical and most radiochemical constituents of the Elliot Lake ores.

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Key words: Elliot Lake, Uranium Ores, Tailings Disposal, Vegetation, Radioactive effluents.

[1] Originally prepared as a brief to the Ontario Environmental Assessment Board on the uranium mine expansion in the Elliot Lake area, July 1977 (Report MRP/ERP/MRL/MSL 77-84 (R)).

RECHERCHES RELATIVES A L'ENVIRONNEMENT ET AU TRAITEMENT DE L'URANIUM (CANMET)[1]

par

D. Moffett*, G. Zahary**, M.C. Campbell+ et J.C. Ingles++

RESUME

Les recherches environnementales relatives aux résidus d'uranium se poursuivent aux Laboratoires de recherche minière et à ceux des sciences minérales de CANMET (EMR). Des recherches pertinentes sur le terrain se poursuivent à Elliot Lake depuis plus de cinq ans. La majorité des travaux a porté sur un programme visant à reconditionner les résidus pyritiques, et ont abouti à la mise au point de techniques pratiques de culture de la végétation sur ces résidus. La portée des expériences est toutefois limitée, puisque ces cultures ont été effectuées sur des lots expérimentaux de petites dimensions et au cours de périodes de durée relativement courte.

Un programme de recherches destiné à identifier et à réduire les effluents acides et radioactifs se poursuit présentement à Elliot Lake. On a en effet reconnu que les effluents présentent une menace des plus sérieuses pour l'environnement.

On trouvera ici les recherches, effectuées aux Laboratoires des sciences minérales, et dans les divisions qui l'ont précédé, et qui portent sur le traitement des minerais d'uranium et de thorium. Un procédé de récupération du thorium vient d'être mis au point: il permettrait de réduire la charge globale de radioactivité dans les résidus. La majorité des travaux actuels portent sur l'élaboration de nouvelles techniques pour la récupération de l'uranium à partir des minerais de basse teneur qui, toutefois, ne pourront vraisemblement être appliquées avant les dix prochaines années. D'importants efforts sont également faits pour prélever la pyrite, préconcentrer les minéraux radioactifs, et identifier et retirer les composés chimiques qui véhiculent le radium dans les résidus solides. Toutes ces recherches pourraient avoir des répercussions sur les solutions, à court terme, de certains problèmes environnementaux. Les Laboratoires

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Mots-clés: Elliot Lake, Minerais d'uranium, Elimination des résidus, Végétation, Effluents radioactifs

[1] Original préparé, sous forme de mémoire, à l'intention de la Commission d'évaluation environnementale de l'Ontario, relativement à l'expansion des mines d'uranium de la région d'Elliot Lake, juillet 1977 (Rapport MRP/ERP/MSL 77-84 (R)).

des sciences minérales peuvent procéder à des analyses pour identifier et caractériser les composés minéralogiques et pour la plupart radioactifs des minerais d'Elliot Lake.

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INTRODUCTION

The Canada Centre for Mineral and Energy Technology (CANMET) of the Department of Energy, Mines and Resources (EMR) conducts research in the extraction, processing and use of minerals in Canada. An essential aspect of this work is investigating new technology to improve working conditions and productivity, and to reduce the impact of mineral production on the natural environment.

CANMET, which until recently was known as the Mines Branch, has been associated with the processing of uranium ores since 1930. Its initial involvement was the development, by the late R. J. Traill, of a process for recovering radium from pitchblende. When the Eldorado uranium mine at Great Bear Lake was reopened after World War II, CANMET was asked to develop a process for recovering uranium from the gravity plant tailings, and the Radioactivity Division was established in 1946-47 to handle the assignment. A successful process was developed, and as the industry expanded in the early 50's, modifications as well as new processes were developed for treating the newly-discovered low-grade ore bodies.

Operating staff for the new mills built during this period were trained by the Radioactivity Division in the new technology, participating in process development in the pilot plant at Ottawa and treating ore from their respective properties. As a result, there has always been close rapport between CANMET and industry personnel. This rapport which has been maintained and reinforced by semi-annual meetings of a CANMET-sponsored forum known as the Canadian Uranium Producers' Metallurgical Committee, initiated in 1960.

With the commissioning of the new mills, research on uranium processing was de-emphasized, and the Radioactivity Division was absorbed into the Mineral Sciences and Extraction Metallurgy Divisions. Some development work on the recovery of thorium from plant process solutions continued through this period, parallelling efforts of the mining companies.

Research on environmental impact in the mineral industry is currently organized under the Mineral Sciences Laboratories and Mining Research Laboratories of CANMET. The Elliot Lake Laboratory was established in 1965 as part of the division now known as Mining Research Laboratories to conduct mining research under field conditions, principally in underground mines. Environmental research has been under way at this laboratory since its establishment (1). The focus originally was on developing methods of monitoring health hazards in the underground environment. The scope was expanded in 1971 to include the reclamation of mining wastes on surface. Both research areas have been expanded as concern has grown for the effects of mineral production on worker health and the environment. Research has recently been increasingly focused on issues directly related to the uranium industry.

Tailings at Elliot Lake over the past twenty years have been discharged into surface impoundment basins. Although alternative disposal schemes such as the use of tailings as backfill, separate impoundment of pyritic material, and deep-lake disposal have been proposed, CANMET research at Elliot Lake has been directed towards rehabilitating surface impoundment basins by vegetation. Work has concentrated on this aspect of the problem because there are already over 80 million tonnes* of tailings in these surface basins, and because this mode of disposal is unlikely to be altered in the near future. The other major investigation is to identify and control the acidic and radioactive seepage from abondoned tailings areas.

Research in mineral processing by the Mineral Sciences Laboratories has developed in response to two main factors:

(1) Newly discovered ores are proving to be more complex than those from previous producing areas.

(2) Ore treatment procedures continue to provide environmental problems.

REHABILITATION BY VEGETATION

A survey in 1971 (4) revealed that tailings containing sulphides were a significant mining-waste problem and that establishing a vegetative cover was the most acceptable reclamation procedure, but was not always technically or economically practical. Environmental research was thus initiated. The Nordic tailings basin of Rio Algom Ltd. was chosen as a site for field experiments because of its proximity to the Elliot Lake Laboratory.

Research began with laboratory studies of the physical and chemical properties of the tailings (5), followed by vegetation growth tests in

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* metric units are used throughout this report.
1 tonne = 1.10 short tons.

environmental chambers (6) and finally by field trials (7). This led to the development of an effective and practical vegetation scheme (12),estimated to cost from $4, 000 to $6, 000 per hectare* or $1, 600 to $2, 500 per acre.

CANMET Vegetation Scheme

The procedure for establishing a vegetative cover on the Elliot Lake tailings is summarized in Table 1. It involves an initial treatment to neutralize acidity in the intended root zone and to provide a basic load of nutrients. This is followed by cultivation and seeding with a mixture of two grasses. Fertilizer is subsequently applied monthly during the growing season for a five-year period after which the vegetative cover is considered self-sustaining.

Two basic criteria for tailings rehabilitation are met by establishing a healthy grass cover:

(1) Erosion by wind or water is resisted by a physically stable surface.

(2) The appearance of the tailings basin is improved.

Research Review

Research leading to the development of the vegetation scheme is described in laboratory reports and publications listed in the bibliography (5-13). The final and critical experiment began in 1973 on a 0.40-hectare (1-acre) area. This area was prepared as outlined in Table 1 except that 26 species of plants, 14 of which were perennials, were sown.

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* 1 hectare = 2.48 acres.

Table 1 - Scheme for Vegetating Uranium Tailings

Year 1	Year 2	Years 3 to 5
Clear area of debris	Fertilize with 33-0-0 at 0.011 kg/m^2 (100 lb/acre)	Fertilize with 33-0-0 at 0.011 kg/m^2 (100 lb/acre)
Apply limestone at 2.24 to 6.72 kg/m^2 (10 to 30 tons/acre)*	Reseed bare patches	Fertilize with 5-20-20 at 0.022 kg/m^2 (200 lb/acre)+
Fertilize initially with 5-20-20 at 0.022 kg/m^2 (200 lb/acre)	Fertilize with 5-20-20 at 0.022 kg/m^2 (200 lb/acre)+	
Rototill top 15 to 20 cm		
Seed** and fertilize with 0-46-0 at 0.011 kg/m^2 (100 lb/acre)		
Fertilize with 5-20-20 at 0.022 kg/m^2 (200 lb/acre)		

* Rate of limestone application is specific to each tailings area.

** Seed recommended is a 40 : 60 mixture of Redtop and Creeping Red Fescue at 0.0055 kg/m^2 (50 lb/acre).

\+ Apply at monthly intervals during growing season.

It was concluded at the end of the first year that a wide variety of plants will survive on tailings although many do not grow well. At the beginning of the fourth growing season, in 1976, nine of the fourteen perennials were judged to have persisted with acceptable health and vigour. The measured plant yield and coverage of ground for each of the species is shown in Table 2. Ground coverage is a primary objective and on that basis Reed Canarygrass, Redtop, Kentucky Bluegrass, and Creeping Red Fescue have been recognized as the best species. Legumes performed poorly and

Table 2 - Yield and Ground Coverage for Plants Grown on Uranium Tailings

Species	Plant Yield* (kg/m^2)**	Coverage %
Alfalfa+	0.128	45
Reed Canarygrass	0.107	100
Redtop	0.066	100
Kentucky Bluegrass	0.059	92
Climax Timothy	0.056	81
Tall Fescue	0.046	88
Creeping Red Fescue	0.038	95
Birdsfoot Trefoil+	0.018	-
Ottawa Red Clover+	0.016	10

* Dry matter.
** To convert kg/m^2 to tons/acre multiply by 4.46.
\+ Legume.

are not considered essential to a basic seed mixture. Because of its superior sod-forming properties and aggressive nature, a 40 : 60 mix of Redtop and Creeping Red Fescue is used in the scheme although there is some loss in overall plant yield.

Soil Development

For a vegetative cover to be self-sustaining, material in the root zone must perform the basic functions of a soil. One of these functions is to degrade dead plant material and recycle nutrients. This is performed by a variety of living organisms, e.g., bacteria, fungi, insects, etc. The number and diversity of micro-organisms that exist in the vegetated tailings are a measure of the occurence of this process. Table 3 gives the observed mean values for vegetated and bare tailings and shows that sufficient numbers of micro-organisms exist beneath the grass to support the recycling process (15). A local forest soil is included for comparison.

Table 3 - Number of Micro-organisms in Vegetated and Bare Tailings

Soil Type	Treatment	Mean Number of Micro-organisms per Gram of Soil (dry mass)
Tailings	None	0.01×10^6
Tailings	Vegetated	49.0×10^6
Forest (control)	-	2.2×10^6

Role of Trees

It has been observed that deciduous trees such as birch, poplar and willow have rooted naturally or volunteered on parts of the vegetated areas of the tailings. This encroachment of the natural forest is very desirable in the restoration and rehabilitation. In an attempt to accelerate the reforestation process, some 500 two-year-old cedar, spruce and pine seedlings were planted in 1973. A formal assessment of the experiment is underway (16), but the initial impression is that coniferous trees are not easily established even though, on the basis of physical properties, the tailings would appear to support their growth.

Radioisotope Uptake

Although radioactivity in the tailings presents no obstacle to establishing a good grass-cover, the creation of pathways for the transport of this radioactivity to the biosphere is important. In the summer of 1976, a study was undertaken which sought to determine the uptake of radioisotopes by grasses growing on uranium tailings (14). The concentration of uranium, thorium, radium-226, lead-210 and polonium-210 in the four most productive grass species growing on the tailings at the Nordic tailings basinwere measured. The observed mean values for grass tissue from the tailings and from a control potting soil are shown in Table 4. Uranium, radium-226 and lead-210 contents were found to be significantly higher in the grasses grown on the tailings than in the control soil. No estimate of the potential uptake of radioactivity by animals grazing on the vegetated tailings has been made.

Table 4 - Radioisotope Concentration in Grasses Growing on Uranium Tailings

	μg/g		pCi/g		
	U	Th	^{226}Ra	^{210}Pb	^{210}Po
On tailings	.030*	.014	5.48*	2.32*	.090
Control	.010	.017	.24	.12	.018

* significant increase over control at 95% confidence level (t-test).

"Black Grass"

The black discolouration observed in some of the test plots has received publicity and a measure of notoriety. Largely for that reason it is discussed here. Limited field and laboratory studies were begun in 1975 (11) in an attempt to identify the cause of the problem. It was hoped that the black discolouration could be duplicated in the laboratory, but this has not been possible. Fungi, bacteria or metal toxicity have been ruled out as causes. The discolouration does not kill the grass, although it does inhibit growth. A similar discolouration has been observed in grasses grown on other tailings containing sulphides; the best solution appears to be to avoid Timothy since it is the species most susceptible to discolouration.

Some Limitations

In spite of general optimism about the program it would be misleading not to identify some of the limitations of our work. Soil development is a process that takes place on a geologic time scale. Biological life is subject to the principle of limiting factors, i.e., its existence and performance is determined by the most limiting of the essential environmental factors. Results would be more conclusive if the field plots were older and larger, and plans have been made to vegetate the 2.5-hectare Spanish-American tailings area in 1977.

All the field work done so far has been on the areas covered by coarse tailings representing about 70% of the total surface area. Very little work has been done in areas covered by slimes, largely because this material will not support mechanical equipment.

It would be inaccurate to describe the tailings as anything but a hostile environment for plant life. The success achieved has been possible only because of the large investment in improving the soil environment and in accepting a low level of productivity from the biological system, i.e., accepting a low rate of survival and reseeding. Thus, critical constraints are more likely to be of an economic rather than of a technical nature.

TAILINGS EFFLUENTS

A survey of waste disposal practices at Canadian uranium mines in 1975 (2) indicated that water pollution represents the major environmental impact of uranium tailings basins. A research program was defined with the following objectives:

(1) To identify and characterize the acid-producing mechanisms which operate within the tailings.

(2) To investigate the paths by which deleterious substances - acid, metals and radioisotopes - are leached from the tailings and reach the watercourses.

(3) To propose remedial action to reduce pollutant discharge to the watercourses.

Acid Production

The work so far has consisted of field investigations of 17-year-old tailings at the west arm section of the Nordic tailings basin (20) which have provided an opportunity to monitor the acid-producing reactions in typical sulphide material. The coarse tailings or sands show markedly greater evidence of pyrite removal by oxidation at shallow depth than does the fine material, or slimes. Figure 1 shows this for two typical samples. Once acid is produced near the surface, it permeates through the tailings, leaching metals and radioisotopes into the groundwater. The existence of bacteria capable of accelerating the breakdown of pyrite has been established; in most cases the oxidation takes place very close to surface.

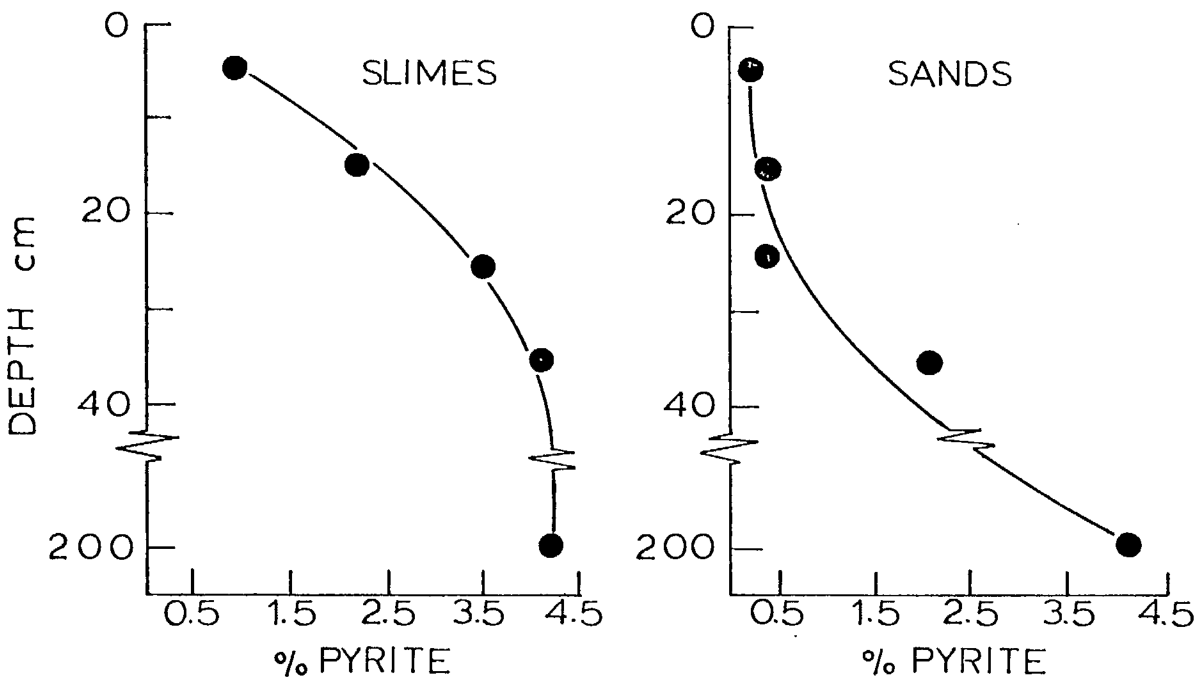

Figure 1: Pyrite content of tailings with depth.

Almost 20 years after the basin was abandoned, about 60% of the pyrite originally present in the top 20 cm of the tailings has been oxidized to sulphuric acid. This corresponds to a sulphuric acid production of 2000 tonnes for this 14-hectare tailings basin. There is evidence of less oxidation with increasing depth - the next 20 cm oxidizing only to the extent of producing a further 1000 tonnes of acid.

The parameter most often used to characterize acidity is pH. However, the pyrite oxidizing reactions that take place within the tailings often produce effluents that have an acceptable pH and yet may be extremely acidic. A better gauge of the inherent acidic nature of a liquid sample is a titration of total acidity with sodium hydroxide (21).

Pollutant Path

The depression of pH in a number of lakes in the Serpent River system is attributed to acidic seepage from tailings basins. A network of wells and weirs has been established on the west arm of the Nordic tailings and flow patterns within the tailings have been identified. Water from below the water table has been sampled each month from these wells for almost two years. Monitoring at the weirs has provided information on the quality and volume of seepage. Table 5 gives an example of the level of contaminants in seepage. From this data collection system, an understanding of the paths by which rain or snow falling on the tailings is translated into acidic seepage is being developed.

Because radioisotopes present in the tailings can be detected at very low concentrations, they provide a good means of following the leaching process and subsequent seepage into the surrounding watercourses. A detailed radiological investigation of the west arm tailings basin has been completed (24) and has shown the relationship between the zones of oxidation in the tailings and water pollution. Table 5 gives a summary of the water quality observed at various points in the tailings and also for seepage water. In particular, there are two distinctly different zones of oxidation within the tailings, which appear to be determined by the size classification of the tailings. The sands overlie highly acidic and radioactive water, whereas the water under slimes is much less contaminated. The quality of seepage through the dam is intermediate between these extremes. It would appear that careful disposal practice during the active life of the tailings basin to minimize the area covered by sands might reduce effluent pollution.

Table 5 - Water Quality in the Tailings Basin

	mg/L			pCi/L					μg/L
Sample location	Acidity	TDS**	Fe	^{226}Ra	^{210}Pb	^{232}Th	^{230}Th	^{228}Th	U
Beneath Sands	12,120	24,200	1,744	27	4,067	1,400	16,000	500	5,200
Beneath Slimes	< 50	4,840	68	137	42	-	-	< 15	198
Seepage	1,790	4,570	604	13	32	80	800	150	370
MPC_W*	0	1,500	0.3	10	100	2,000	2,000	7,000	40,000

* Maximum permissible concentration in water.
The given MPC_W's are compiled from a variety of regulatory agencies.

** Total Dissolved Solids.

An important anomaly in Table 5 is that the observed ^{226}Ra concentration in water beneath the slimes (137 pCi/L) is higher than in the acidic water under the sands (27 pCi/L). Since radium leaching from tailings is limited by the high sulphate concentration in the acidic water the observed water quality beneath the slimes may represent the effect of neutralization treatment undertaken to establish vegetation.

Radium Redissolution

The tailings contain a large reservoir of radium, and dissolution and leaching of this radium to the surrounding watercourses is potentially the most hazardous aspect of uranium tailings. One concern is the dissolution of the sludges and precipitates produced in the barium chloride treatment of effluents. A preliminary study to determine the stability of radium-barium sulphate precipitates was begun in the fall of 1976. This laboratory investigation examined the release of radium from a synthetic sludge into overlying solutions of differing pH and sulphate concentration. The results, summarized in Table 6, are erratic and raise more questions rather than provide answers. Only the sulphate concentration of the solution was found to influence radium release significantly, with an overall minimal release at 800 ppm.

Effect of Vegetation

The reclamation and vegetation of strip coal mines results in substantial reductions in acid loadings to the watercourses. Whether a vegetated tailings area would have a similar beneficial effect on water pollution from uranium tailings is unknown. A cooperative experiment

Table 6 - ^{226}Ra Activity (pCi/L) in Solutions Overlying Sludges

pH	Sulphate Concentration (ppm)			
	0	250	800	1500
2		3.0	1.2	8.2
4		5.2	1.2	6.2
6	56.8*	39.8	38.2	4.4
7		61.0	2.2	2.8
8		41.6	1.4	26.0
10		66.0	1.2	36.6

* mean of 3 values in distilled water (pH 6.5).

with Rio Algom Ltd. was begun in 1975 in an effort to assess the effects on water quality of various forms of surface treatment, including vegetation. Four model tailings pits were constructed on the Quirke mine site, each 9.14 m x 9.14 m by 1.52 m deep (30 ft x 30 ft by 5 ft deep). The loading of pollutants from each of these pits is monitored bi-weekly. One pit has been vegetated according to the CANMET scheme and a second remains untreated as a control. The others are covered with alluvial till, sawdust and 1.52 m (5 ft) of water. The experiment will run for three more years to allow sufficient time for the pyrite to oxidize.

Future Direction of Research

The necessary fragmentation in the work described in the foregoing sections of this report is currently being resolved as results are applied to the restoration of an entire tailings basin. Vegetation of the Spanish-American tailings basin represents the first attempt at rehabilitation of an entire uranium tailings basin by vegetation without top-soil cover. The consequences of a continuous vegetative cover on the acidic and radioactive seepage will be monitored.

A number of important milestones in the research program will take place in 1977-78: our test plots will cease to be fertilized as the 5-year management program closes; additional data will become available on the effects of vegetation on seepage from the cooperative experiment with Rio Algom Ltd.; and monitoring at the Nordic tailings basin over the past two years has provided a wealth of information which will be applied to the development of further control systems and procedures.

PROCESS RESEARCH

Thorium Recovery

The primary purpose of the work on thorium recovery was to improve the profitability of the Elliot Lake operations, but it also has an obvious application in eliminating an undesirable contaminant from effluents. In initial studies, only thorium was removed (35), but the work was later expanded to include the removal and recovery of rare earths which are in some demand for use in TV picture tubes and fluorescent lamps (36-39). While rare earths are not presently considered environmentally undesirable, their recovery and sale could help offset the additional cost of tailings treatment.

These treatment processes, even if they resulted in complete recovery of the thorium in solution, would not eliminate all thorium from the tailings.

Some is contained in monazite and in uranothorite grains locked in the monazite. These minerals are not attacked even by the most drastic treatment likely to be used on the ore, and hence the thorium retained is unlikely to present an environmental problem. Thus, answers to technical problems of thorium control in effluents are to be found both from the work at CANMET and that done by the companies themselves.

Water Treatment

An investigation was made in the early seventies of a proposed process for removing sulphate, nitrate, and ammonia from Elliot Lake effluents (33). This process employed ion-exchange to remove the sulphate and nitrate, followed by pH adjustment and air-stripping to remove ammonia. It was not found to be economically viable.

Recommendations for alternative treatment processes having a greater potential for success were also made. One was the separate treatment of mine water by liming and aeration to precipitate metals and strip the ammonia. Another was the elimination of nitrate and ammonia usage by substituting chloride elution and either magnesia or hydrogen peroxide for precipitation processes that have been investigated at CANMET in the past.

Ore Treatment

The principal cause of continuing acid seepage and subsequent leaching of heavy and radioactive metals from Elliot Lake tailings is the presence of pyrite. Bulk removal of pyrite from tailings could alleviate the seepage problem and also make the tailings more amenable to revegetation. Preliminary test work on old tailings from Elliot Lake indicated that up to 96% of the pyrite could be removed by flotation (34). Pyrite-free tailings would be more easily vegetated and preliminary results have indicated that a substantial concentration of radium-226 is achieved by flotation.

Work on tailings treatment will continue in fiscal year 1977-78 with more emphasis being placed on fresh tailings. In addition, work is planned on pyrite removal from raw ore, and on the effects of preconcentration on distribution of the various radioactive species in the separate fractions of beneficiated ore. The results from this work, which will require substantial analytical and mineralogical support, could provide a pyrite-free tailing.

Extraction: Radium distribution in the mill

Certain characteristics of radium-226 in tailings at Elliot Lake and some supportive evidence in laboratory leaching tests, indicate it is potentially soluble during sulphuric acid leaching, but is retained or precipitated out on carriers during the process and is discharged with the mill tailings. Such a carrier, a member of the jarosite family, with a radium content of 80,000 pCi/g, has been formed in the tailings and is believed to be amenable to removal by flotation. Mineral Sciences Laboratories has completed a sampling campaign of the Quirke mill of Rio Algom Ltd. to trace the distribution and disposition of radium-226. The samples are currently being analyzed and an assessment report prepared. Knowing that radium-226 is present, development work can be undertaken to better control the disposition of this and perhaps other radioisotopes and to minimize their discharge with the tailings. This concept must be considered somewhat speculative, of course; a more definitive assessment will depend on further work expected to be completed by the end of the calendar year 1978.

Extraction: Chloride leaching

The long term resolution of environmental problems related to uranium extraction may well lie in the development of an entirely new process. The conventional sulphuric acid process has pyrite, sulphate, radium and heavy metal problems. Nitric acid leaching has been investigated, but poses even greater anion disposal problems. Carbonate leaching is limited to alkaline ores. It appears that chloride chemistry provides the most promising avenue for developing new technology. In 1976, a comprehensive literature search was conducted (41-46), and laboratory work on chloride chemistry was begun along two routes: hydrochloric acid leaching (47) and dry chlorination.

Hydrochloric acid leaching would use conventional unit operations for uranium ore processing in that it would involve leaching, solution purification by solvent extraction or ion-exchange, and precipitation. Some initial test work has been done, but an effective process system has yet to be developed. The second route being investigated involves the high temperature chlorination of radioactive ores with the potential of recycling chlorine and minimizing the problem of anion disposal. To date, one report has been completed on dry chlorination with results of only a very few tests (50). Both processes have advantages, but major process design problems remain to be overcome. A high recovery of uranium, thorium, radium and rare earths would be effective in meeting environmental requirements. Objectives have been set to recover at least 95% of the uranium, 80% of the thorium, 80% of the rare earths and to produce tailings with less than 20 pCi/g of radium-226. The schematic flowsheet of the dry chlorination process (40), shown in Figure 2, gives some concept of the complexity of development work required prior to even an initial economic assessment of such new technology.

It should be noted that a new generation of processes, even with highly successful test work, must be considered to be a decade away, and could well meet with difficulties such as unavailability of suitable construction materials in that time frame. Nevertheless, initial test work has been encouraging.

ANALYTICAL RESEARCH

The requirements for analytical methods to determine radioelements for process research differ from those employed in environmental surveillance. For the former, speed in turn-around time is essential, whereas this requirement is usually much less stringent in environmental work. Environmentally-oriented radioelement analyses can thus rely on existing methods based on chemical and physical separations followed by measurement of more easily counted daughter elements, while for process research, direct methods are preferred. Such direct methods generally require more sophisticated and expensive equipment.

Mineral Sciences Laboratories already has much of the needed equipment as well as staff trained in its use, and has developed a rapid method for radium-226 analysis (58) which has greatly advanced current process research on this radioelement. Progress towards development of similar methods for other radioelements, adaptable to existing resources within MSL, is handicapped by manpower limitations.

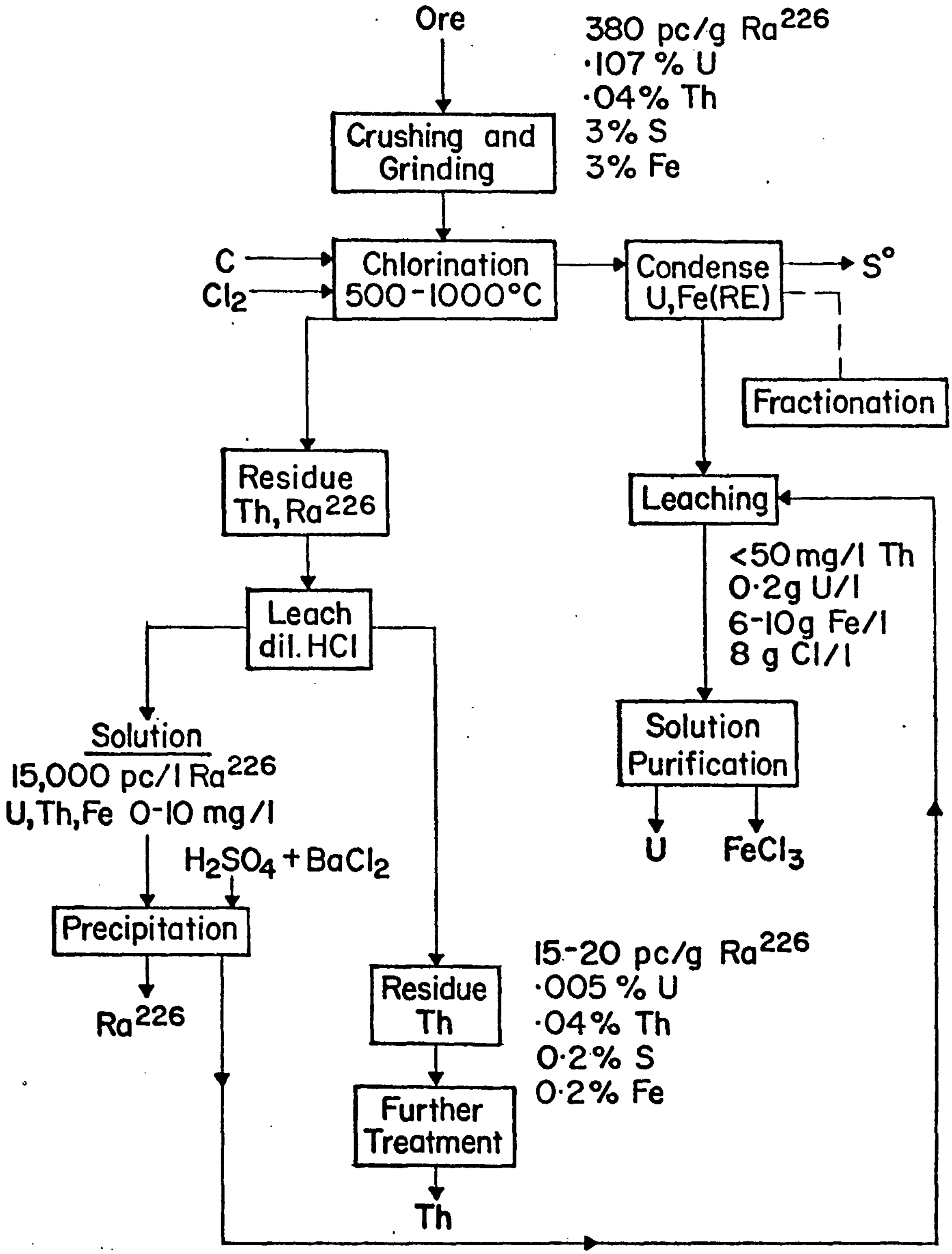

Figure 2: Schematic flowsheet for dry chlorination process.

COORDINATING COMMITTEES

CANMET has played a leading rôle in establishing technical committees or forums for the exchange of research information. The Canadian Uranium Producers' Metallurgical Committee has already been mentioned and reference need only be made to a sub-committee recently established by this group to coordinate research on radiological analysis.

A second organization is the Joint Panel for Occupational and Environmental Research for Uranium Production. It was established in late 1976, and seeks to compile an inventory of research and to encourage the development of a comprehensive program of research. Presently some ten organizations from industry, government and labour are contributing information to this panel.

CONCLUSION

This report has reviewed the contributions made by CANMET scientists in developing technology to further reduce the environmental impact of uranium mining and milling at Elliot Lake. An attempt has been made to place this work in perspective. Much of the basic information is drawn from research reports of other scientists, and where fine technical distinctions are to be made, the original reports should be consulted. Furthermore, much of the work is in the development stage and has to be tested in actual tailings basins and in pilot plants before results can be transferred to production operations. Results will be publicized through scientific publications and by field demonstrations to aid in the transfer of technology to industry and regulatory bodies.

In the short term CANMET research will continue more or less as described. The present distribution of manpower within the two relevant CANMET laboratories is shown in the appendix. In the longer term, conclusions reached by the Environmental Assessment Board will undoubtedly have an impact on future research.

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APPENDIX

Distribution of Manpower Within CANMET

	Man-Year	
	Mining Research Laboratories	Mineral Sciences Laboratories
Rehabilitation by vegetation	1.20	-
Tailings effluents	2.90	2.00
Process research	0.10	7.72
Analytical research and services	-	8.13
Support	0.80	3.85
TOTAL	4.70	21.70
	26.40	

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