The Dynamic Evolution of the Metallurgical Engineering Companies in Canada – 1961 to 2011

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Setting the Stage

The role of the engineering community in the metallurgical sector is to design and manage delivery of commercially successful projects based on metallurgical data and principles developed by test-work, theory or experience.

However the field is complex, with many actors taking multiple roles in the overall process.

Figure 1 illustrates, in a general way, the inputs at different stages of a project development by a range of key participants. This chapter focuses on the "Engineering", and "Engineering, Procurement and Construction Management (EPCM)" section, of the overall process, and in particular the development of the Metallurgical Engineering groups not owned by the mining and metals companies.

To understand the evolution of the sector, it is easiest to frame it with three different business models at work within different parts of the sector.

The first model is typical of the Iron and Steel industry from the 60s till now. Major process packages were bought from foreign suppliers, often on a turnkey basis. The owners' internal resources specified, contracted and managed the packages and the internal or local engineering groups filled in the gaps to complete the project. As an example, "in the 60s, Stelco did 95% of their own engineering with a large in- house group" to manage a wide range of projects and process and/or equipment vendors" (McLean, 2011).

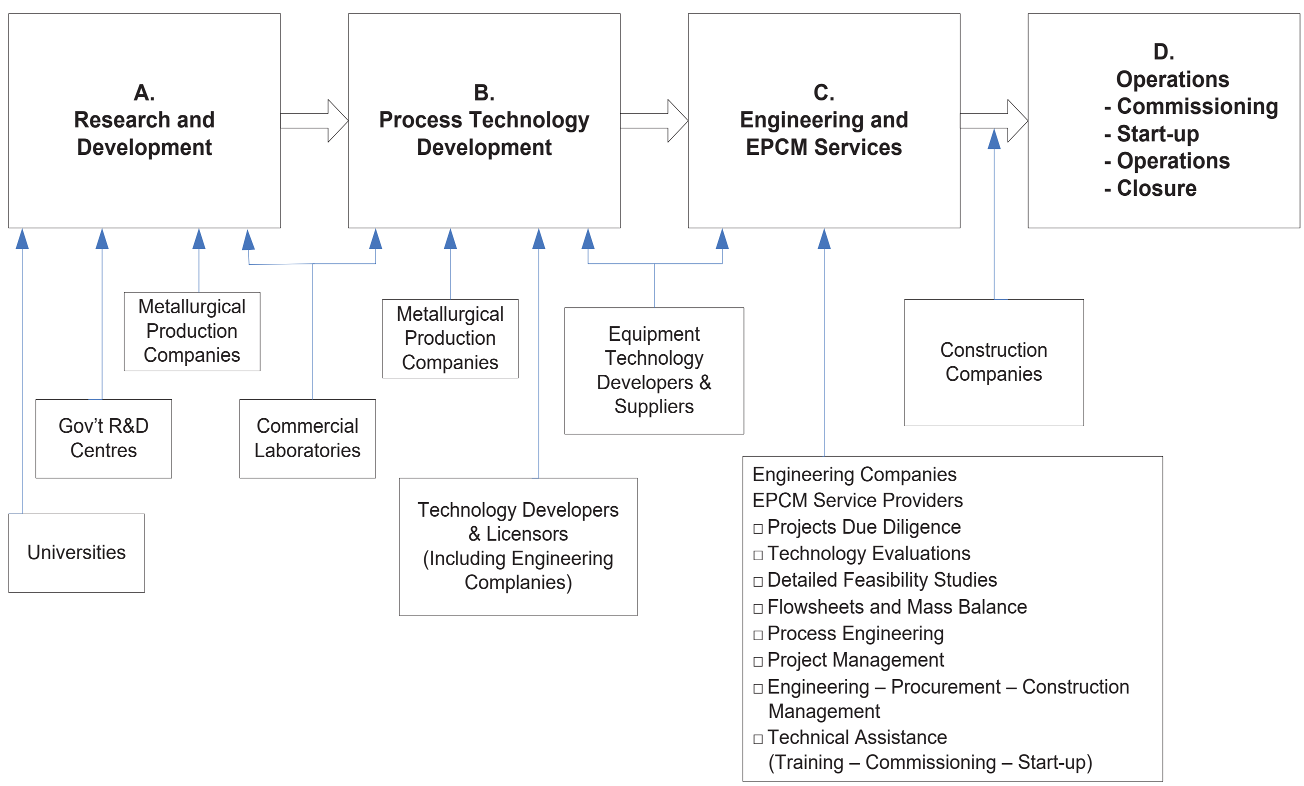

Figure 1. The roles in metallurgical plant projects

Figure 2 illustrates a project delivered under this model in the 60s, The Adams Mine Pelletizing Plant, with a major foreign-supplied "process plant". The project was managed by the owner with wrap-around services provided by local engineering companies, in this case including Fenco.

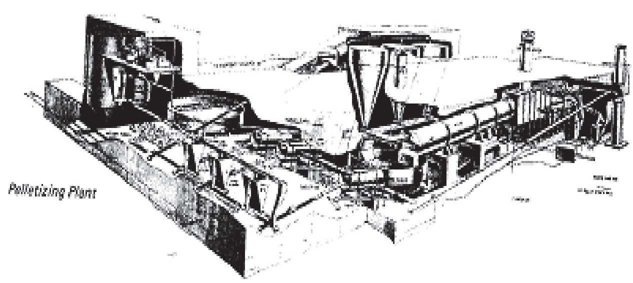

Figure 2. The Adams Mine pelletizing plant, Ontario. (Mining in Canada, 1965)

Referring back to Figure 1, in general, the process plant suppliers were responsible for items 'A' and 'B' and most of 'C' within their battery limits. This model largely continues to operate today.

The second business model, in general, applies to production of sulphide concentrates and non-refractory gold, a major part of the metallurgical engineering activity of the last 50 years. For these projects, a range of well established test-work programs are normally required to develop a flowsheet and to size major equipment prior to detailed engineering. There is little opportunity or need for a turnkey or proprietary plant beyond the supply of specific equipment. Test work, in the early days, was largely done in-house by the operating companies, with a few exceptions as described in the chapter on metallurgical laboratories. The engineering was mostly done by the owners, supported as required by multidisciplinary companies specializing in the sector such as Kilborn, Wright Engineers, Bechtel, Fluor and Geco. There were, however, a group of well-known individuals or small consulting groups that supported smaller mining companies. Typical of these were Doug Beaumont, John Mortimer, John Hemstock and David Livingston in the base metal concentrators and gold plants, Art McPherson for grinding, Al Ross and Clyde Lendrum for uranium processing, and Phil Wiser for asbestos.

By 2011 we have a large number of engineering companies in this sector. Each has their metallurgical group to guide and interpret the test work, normally still done by contract laboratories across the country. However, the owners generally no longer do the full feasibility studies or the detailed engineering and project management which are instead contracted out to specialist engineering groups or to EPCM providers.

The third business model corresponds to the third sector, which is the most complex and generally characterized by high temperature and/or high pressure processes in the non-ferrous and light metals sectors. Canada has been a world leader in this sector, taking laboratory and pilot plant work for new processes to commercial success. Many of these successes are described elsewhere in this book but they include pressure oxidation of gold and uranium, high pressure acid leaching of zinc and copper sulphides, electric furnace reduction of nickel laterites, the continuous smelting and converting of copper concentrates to matte and more recently to blister copper.

All of the processes were initially characterized as unique, high risk multidisciplinary developments where success was as much attributable to process vessel design and material systems, process control approaches or fundamental understanding of heat and mass transfer and fluid mechanics, as it was to the metallurgy. Owners typically had substantial engineering teams to define these unique projects and manage their implementation, often with a general engineering group or constructor.

In the 60s, in this more complex sector, there were again very few independent consultants. Prominent were Frank Forward in hydrometallurgy, and Jan Reimers and Hatch Associates in the pyrometallurgical sector. Canadian mining companies certainly benefited from the outstanding design and engineering skills provided by the local engineering companies of the era.

Examples of this are the Falconbridge (now Xstrata) smelter retrofit with the fluid bed reactor and electric furnace design which started up in 1978 and the Noranda Process reactor which started up in 1973 at the Horne smelter, now Xstrata. These plants remain in operation today, a testament to their robust design. Over subsequent years the in-house teams have been substantially reduced and very few engineering and EPCM groups have developed in this area.

Key External Drivers for the Metallurgical Sector

The three described sub-sectors have evolved differently over the 1961-2011 period as they have reacted to the external economic, market and political pressures of the period:

- Starting in the 60s the environmental movement drove legislation that changed attitudes to emissions and effluent discharges
- Major increases in energy costs happened in the 70s and 80s
- Workplace health and safety awareness and enforcement also gained momentum in the 70s and 80s
- Economic stresses were caused by increased taxation
- Competitive pressures were increased by the NAFTA agreement in the 80s and more recently the WTO agreement
- Over 80% of our metallurgical production capacity was sold to foreign interests in the last two decades

Every one of these trends in the operating environment, except the last, has led to extensive research and development needs and a wide array of new innovations. The implementation of the projects required a depth of engineering talent to ensure effective commercialization.

A key factor underpinning the significant surge of innovation was the result of profound developments in the understanding of metallurgy that had evolved in the 50s and 60s.

New instruments, such as the electron microscope and computers for process control, had become available. Further, serious effort had been put into understanding fundamental thermodynamics and the introduction of chemical engineering principles of unit operations and reaction kinetics.

It had also been recognized that the successful ramp-up to full capacity of new facilities required a multi-disciplinary approach to process vessel and facility engineering. These developments allowed the rapid evolution and successful implementation of a wide range of facilities covered elsewhere in the book.

Superimposed on these macro influences have been seven significant economic downturns or recessions in North America over the 50 years.

In retrospect, the recessions of the early 70s and early 80s caused the most profound structural changes to the Canadian metallurgical engineering sector and a strong growth of independent engineering and project management groups.

The Way It Was

For the formative period of the Canadian mining and metallurgical sector up until the 70s, the approach to projects was in general as follows:

- The owners did the research and development in their own research facilities,
- The owners did the metallurgical engineering,
- The owners did the management of the projects,
- Civil and structural design were done either by specialized consulting engineering groups or by in-house resources of the contractors, fabricators or owners,
- Major contractors or fabricators:
    - did most of the detailed design, and
    - the construction and construction management.

"During the boom times of the 60s the owners had large internal groups. Alcan had over 600 people in their engineering groups and redeveloped the Arvida smelter with four new pot lines over the decade, as well as developing and managing the Auganish refinery plus the green-field Kurri-Kurri smelter in Australia and the Lynemouth smelter in the UK." (Chamberland, 2011)

Stelco also had a strong internal group that delivered and managed packages for a wide range of projects at the Hamilton Works in this period.

Similarly, Inco built a large engineering team to develop the PT Inco facility in Indonesia and the Exmibal smelter in Guatemala. Placer developed a range of major overseas facilities including those at Porgera and Lihir in Papua New Guinea and Marcopper in the Philippines.

During this period the Mines Branch in Ottawa had a leadership role in process development as outlined in the earlier chapters.

Tables 1 and 2 summarize the consulting engineering companies, or companies whose business focus included a strong engineering component, active in Canada during the early 60s, with major involvement in the metallurgical plants sector. Table 1 is for the non-ferrous sector, Table 2 for the iron and steel sector.

Two things are immediately apparent. First is the overwhelming presence of major foreign groups at that time, and second is the relatively small number of Canadian engineering firms with a metallurgical process capability. Primarily these were Hatch Associates, Wright Engineers, Kilborn, Simon Carves with Ferrco and MacByrne Engineering in the steel sector.

The Transition

Over the next twenty years, which included four recessions, to contain costs as metal prices stagnated, the major metallurgical production companies steadily shed their in-house research, project development and delivery capability, relying more and more on contract research laboratories, consulting engineers and project management groups to provide services as required. A few retained strong core groups to manage the "outside" groups and some maintained a strong research and development capability.

As the owners internal resources contracted the consulting, engineering groups grew to fill the gap. During this same period, exacerbated in the 90s recession, major Canadian fabricators shed their engineering groups or shut down completely. Dominion Engineering and Dominion Bridge were two of the latter groups. Again, this presented an opportunity for the engineering companies to expand their scope.

The other key trend was the withdrawal from the Canadian market of many of the major steel mill package suppliers as they disappeared or consolidated.

Table 1. Companies active in the Canadian non-ferrous metallurgical engineering in the 60s

	Process Engineer	Discipline Engineer	Process Vendor	Constructor	Primary Sectors
Boliden*	✓		✓		NF
Bechtel*		✓		✓	MP + Al
Davy International*	✓	✓	✓	✓	MP (+ I&S)
Det Norsk*	✓		✓		NF
Dravo *	✓	✓	✓	✓	NF (+ I&S)
Giffels		✓			NF
Hatch Associates	✓	✓			NF (+ I&S)
Kaiser Engineers*	✓	✓	✓		MP
Kilborn	✓	✓			MP
Lurgi Chemie*	✓	✓	✓		NF (+ I&S)
Mechim*	✓	✓	✓		NF
Outokumpu*	✓	✓	✓		NF
Shawinigan Engineering		✓			Al
Simon Carves		✓	✓		NF + Acid Plants
Surveyor Nenniger and Chenevert		✓			NF
Wrights Engineering	✓	✓			MP

I&S = Iron and Steel **Foreign owned Companies*
MP = Mineral Processing
NF = Non Ferrous
Al = Aluminum

Table 2. Companies active in the Canadian iron and steel sector in the 60s

	Process Engineer	Discipline Engineer	Process Vendor	Constructor	Primary Sectors
Andco Technical Services* (Division of A E Anderson Construction)	✓	✓	✓	✓	I&S
Arthur G McKee*	✓	✓	✓	✓	I&S
CH2M (later, CH2M HILL)*	✓	✓		✓	various
Chemical Construction Corp	✓	✓	✓		I&S
Danieli*	✓	✓	✓		I&S
Dastur Engineering*	✓	✓		✓	I&S
Davy International*	✓	✓	✓	✓	I&S
Ferrco	✓	✓			I&S
Foundation Engineering/Fenco		✓			I&S
Hatch Associates	✓	✓			I&S
HERR-VOSS (later Herr-Voss Stamco)*	✓	✓	✓	✓	I&S, metals
Hoogovens *	✓	✓	✓		I&S
Keen Engineering		✓			civil
Koppers*	✓	✓	✓	✓	I&S
Kvaerner*	✓	✓		✓	various
Lockwood Greene*	✓	✓		✓	I&S, mining
Lurgi Chemie*	✓	✓	✓		I&S
Mac Byrne Engineering	✓	✓			various
MAN GHH*			✓		various
Mannesmann-Demag*	✓	✓	✓		I&S, metals
Mesta Machine Company*	✓	✓	✓	✓	I&S
Midrex Technologies*	✓	✓	✓		I&S
Morgan Engineering Systems*			✓	✓	I&S, metals
Outokumpu*	✓	✓	✓		metals
Pennsylvania Engineering Company*	✓	✓	✓	✓	I&S
Stone and Webster*		✓		✓	I&S
Taylor-Winfield Corp*		✓	✓		metals
VOEST-Alpine (VAI)*	✓	✓	✓		metals
Wean Equipment Corp*	✓	✓	✓		I&S, metals
Waterbury Farrel*	✓	✓	✓	✓	I&S

**Foreign owned Companies*
I&S = Iron and Steel
Note: As companies specific corporate names often change, each company is generally identified by a single clearly recognizable name throughout.

Figure 3. Falcondo Dominicana complex
(Photo courtesy of Xstrata Nickel)

During this same period, many Canadian mining companies were venturing further overseas. As they went, they often took their engineering and project management providers with them, introducing them to international work and sowing the seeds for the current Canadian global prominence in several sectors.

Early examples of this included the projects of Placer, Inco, and Alcan referenced above, as well as the following:

- Falconbridge developing Falcondo Dominicana in the Dominican Republic - Figure 3. This project only became commercially viable with the introduction of novel smelting furnace technologies.
- QIT building RBM/RBIT in South Africa and
- Barrick building Goldstrike in Nevada.

During the 60s, 70s and 80s there were many other examples around the world. However, each downturn in the economy stressed the engineering sector which responded with consolidations, reorganizations and bankruptcies. During this period other overseas groups established themselves, prospered for a while but eventually withdrew due to competitive pressure. Seltrust from the UK would fall into this category.

Nevertheless, during this period, the “export” oriented growth of the engineering service providers was actively supported by the Canadian Government’s Export Development Corporation (EDC). Over the years, EDC support has made a significant contribution to the success of the engineering and project management sector in the international market.

Consequently, by the early 90s there were several major Canadian companies designing, project managing and construction managing major metallurgical facilities globally.

Where Are We Now?

By 2010 the active companies in Canada were very different, as shown in Table 3.

Many of the leading companies of the 60s have disappeared in mergers, acquisitions or bankruptcies. Wright Engineers was acquired by Fluor, and Simons was bought by AMEC. Kilborn, Simon Carves, Geco, Fenco, Shawiningan Engineering and Lavalin had all been absorbed by SNC, now SNC Lavalin Inc.

Acres and Kaiser Engineers had been bought by Hatch. H.G. Engineering, started in the early 70s, was bought by Worley Parsons. Stone and Webster was bought out of bankruptcy in 2000 by the Shaw Group, and Davy disappeared first into Trafalgar House and subsequently into Kvaerner, (now Aker Solutions) along with parts of Chemetics. Aker’s process and construction business was subsequently purchased by Jacobs Engineering Group.

Table 3. Summary of the major active companies in 2010

	Process Engineer	Discipline Engineer	Process Vendor	Project Managers	Contractors	Primary Sectors
AMEC*	✓	✓	✓	✓	✓	NF + MP
BBA	✓	✓		✓		Iron Ore + MP + NF
Cegertec		✓				
Fluor*	✓	✓	✓	✓	✓	NF + Conc.
Genivar		✓				MP
Hatch	✓	✓	✓	✓		NF + Al + I&S +MP
March Consulting	✓	✓		✓		MP
Met-Chem*	✓	✓		✓		Iron Ore + MP + NF
Metso*	✓	✓	✓			MP + NF
Outotec*	✓	✓	✓			MP + NF
Quad Engineers	✓		✓			I&S
Roche	✓	✓		✓		Iron Ore + MP
SGS Lakefield*	✓					NF
SNC	✓	✓	✓	✓	✓	NF + Al + MP
Tecsult (AECOM)*		✓		✓	✓	
Wardrop Tetratech*		✓				NF + MP + Al
Worley Parsons*	✓	✓	✓	✓	✓	NF

NB This does not include oil sands activities
** Foreign controlled subsidiaries or joint ventures*

The engineering groups serving the steel sector have also consolidated or withdrawn from Canada. Due to the continued financial pressure on the Canadian steel companies, the key global groups serving the sector, such as Danielli, Siemens, Mannesman-Demag, Voest Alpine, NKK and others are no longer much in evidence locally. Ferrco has long gone but key steel processing staff have continued as Quad Engineering, which still continues to serve the steel sector.

The nature of the engineering input has also changed. EPCM was first introduced to metallurgical projects in Canada in the 70s by Hatch, for the SIDBEC Complex in Contrecoeur, Québec (see Figure 4). As Sidbec was a new entity at the time, this approach was a logical low-overhead way to start the steel making company. Over the years, within Canada, EPCM has become the standard approach.

Sidbec was also the first green-field direct reduced iron (DRI) based steelmaking complex globally.

Figure 4. The Sidbec Complex, Contrecoeur, Québec
(Photo courtesy of ArcelorMittal)

There are still circumstances where turnkey solutions are offered, but normally this is in a low risk environment and for well established proprietary technology packages such as acid and oxygen plants.

As experienced engineering resources have become very scarce over the last decade, it has become apparent that a substantial owner's team overseeing the EPCM contractor's team effectively duplicates the effort and adds cost. This has led to the development of integrated teams, a mature approach to risk management that will likely be a significant part of the engineering sector's future. The Dofasco CPCM cold mill complex in Hamilton (see Figure 5), built in the 80s, was a very successful example of this approach. A Dofasco-NKK-Hatch-Contractor team delivered the project on time, on budget and met the performance requirements.

The result of the decades of structural change has been very positive for Canadian "metallurgical" companies. Hatch and SNC compete successfully and globally on projects up to "mega-project" size. The Canadian subsidiaries of global groups such as AMEC, Tetratech and Worley Parsons have also prospered.

Figure 5. The Dofasco CPCM complex, Hamilton, Ontario
(Photo courtesy of ArcelorMittal)

Starting in about the 80s, a whole new group of mid-tier Québec-based groups such as BBA, Metchem, Genivar and Roche, has rapidly developed. Combined with strong engineering schools in Québec, both francophone (Laval, Polytechnique, ÉTS) and anglophone (McGill, Concordia), these Québec based companies have grown rapidly, and actively contribute beyond Québec to the development of metallurgical activities in many areas of the world.

The last major trend to develop in the boom period of 2004-2008 involved owners requesting EPCM service providers to join forces on large projects, addressing the chronic shortage of experienced project staff. A recent example of this was the Alouette Aluminum smelter in Sept-Îles (see Figure 6), delivered ahead of schedule and below budget by an SNC Lavalin-Hatch Joint venture. "The Alouette smelter is currently the most productive aluminum smelter in the world." (Lombard, 2011)

Taking a long view, the growth of the Canadian Metallurgical Engineering and project management groups has been a remarkable success.

Figure 6. The Alouette smelter complex, Sept-Îles, Québec
(Photo courtesy of Aluminerie Allouette)

The People

The development of this sector over the last 50 years can be attributed to the vision of many remarkable individuals. The four individuals from the consulting fraternity who have been recognized by their peers in the metallurgical and mining sectors by election to the Canadian Mining Hall of Fame are:

- Harold Wright (Wright Engineers)
- Roland Kenneth (Ken) Kilborn (Kilborn Engineers)
- Gerald Hatch (Hatch Associates)
- Bert Wasmund (Hatch Associates)

All four individuals made remarkable contributions to the growth of the engineering sector: Harold Wright and Ken Kilborn in the area of the mills and concentrators, Gerry Hatch to pyrometallurgy and development of EPCM methodologies, and Bert Wasmund primarily to pyrometallurgy. All four made major impact through the companies and teams they built or mentored over many decades.

Table 4 presents examples of individuals from the engineering fraternity who have been recognized by MetSoc, CIM, and CMP* for their outstanding contributions to Canadian metallurgy as recipients of major industry awards. It is noted that many other individuals from this fraternity have in fact been recognized by a number of professional bodies for outstanding work in their respective fields. Providing peer recognition and rewards continues to be a core part of the function of CIM and its constituent societies.

Engineering companies that have been honoured with the MetSoc Xstrata (Falconbridge) Innovation Award are:

- Hatch (Solid cooper cooling system for furnace refractory protection)
- Eco-Tec (Acid purification unit)

All these individuals and companies have shown leadership in translating and transferring the fine research of our universities and commercial and national laboratories into successful operating facilities through a multidiscipline approach to metallurgical plant design and project implementation.

The Future?

There are several trends emerging that may change the rules of the game.

The most prominent is outsourcing to low cost centers. Several major mining and metallurgical groups are demanding more and more work to be done in low cost centers, typically India, Malaysia, China or other centers in the emerging economies. The impacts are profound and focus around a key issue: When you balance the lower man-hour cost with lower productivity plus added supervision and checking, are the costs really less and is the quality compromised?

In many of the fast emerging economies EPCM is not the preferred delivery model. Will Canadian consulting groups be able to compete with other delivery approaches?

With most Canadian metallurgical groups owned by foreign companies, there will no longer be the same incentive for local metallurgical firms going overseas to use Canadian consultants. This will limit the international opportunities for growth for those companies that are not already international.

Equipment vendors such as FLSmidt, Metso and Outotec are offering engineering packages and thereby competing directly with the more traditional engineering companies. Will this confine the Canadian engineering company's role to "wrap around" activities as in the Iron and Steel sector?

China will play an increasingly important role in the development of mine and metallurgical projects around the world, initially as facility owner-operator, but also as an increasingly competitive source of process development and design.

The key question is whether Canadian engineering companies will maintain world-class metallurgical technology know-how to compete in the evolving world economy as engineers or businessman?

As so many have remarked, "It is very risky to make predictions, particularly about the future", but given a strong track record of quality, innovation and leadership, the Canadian metallurgical engineering companies will survive. However the next fifty years will follow a totally different trajectory from the last fifty.

Table 4. Major Awards received by MetSoc, CIM and CMP* metallurgists in the engineering companies

CIM Inco Medal	Mineral Processor of the Year**	MetSoc Airey Award	MetSoc Hydrometallurgy Award
Al Ross	Chuck Edwards	Gerry Hatch	Brian Krysa
Gerry Hatch	Michael Allan	Bert Wasmund	Kevin Fraser
	Ken Thomas	Pierre Duhaime	
		Ken Thomas	

*CMP is the CIM Canadian Mineral Processors

** Prior to 1997, this was known as the "Mill Man of the Year" Award

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Mining in Canada, 1965.

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