

GSCHIS-A009.pdf**Author:** Geoffrey B. Leech**Title:** Operation September 1972**Date of this version:** 2007**Number of pages in document:** 16 pages**Author Biography:**

Geoffrey B. Leech (B.A.Sc. UBC 1942, M.Sc. Queen's, Ph.D. Princeton 1949, F.R.S.C. 1960) grew up on a farm near Salmon Arm, south-central British Columbia. During the Depression of the 1930s, he learned to mine placer gold along the Fraser River and later he mucked in a hard rock gold mine in B.C. Mineral exploration for International Nickel Company of Canada Ltd. for 3½ years took him to northern Ontario, Yukon, Alaska and Venezuela, as well as underground mine geology at Sudbury. He mapped and studied the geology of the Shulaps Range along with the ultramafic complex for the British Columbia Department of Mines, and joined the Geological Survey of Canada in 1949. From 1950 to 1965, he mapped several areas in the Purcell and Rocky mountains for GSC, during which he discovered two mineral deposits (gypsum, magnesite) that became mines. From 1966 to 1971, he was assigned to the Mineral Deposits Section, and then during 1972-79 was Head of Economic Geology Subdivision followed during 1979-82 as Director of Economic Division. He retired in 1982. He was a member of the Committee for the Metallogenic Map of North America from 1967 to 1981 and Associate Secretary General of the International Association on Genesis of Ore Deposits from 1978 to 1986.

Operation September 1972

G. B. Leech
2007

The Challenge

On a pleasant afternoon in late March 1972, Dr S.C. “Binks” Robinson returned to his office, obviously distraught. As the only full-time member of a Task Force he headed, I was working in it. He had come from a meeting at the Department of Energy, Mines and Resources (EMR) headquarters at which members of the Department of Industry, Trade and Commerce (ITC) had met with EMR Assistant Deputy Ministers (ADMs) Charles H. Smith and Michael Butler and others. ITC’s message was that at the next General Agreement on Tariffs and Trade (GATT) meeting, they wished to “negotiate from strength” on mineral matters. They wanted to be armed with, as I remember Dr Robinson’s repetition, “order of magnitude figures on Canada’s endowment of nickel, copper, zinc and – what are the other main minerals? – by autumn”. They wanted numbers on not just the presently known deposits and mining districts but also on economically exploitable material awaiting discovery by 2000 AD. Thus was born what ADM Smith dubbed “Operation September”¹

We were not told what, if any, arguments or cautions were advanced, then or later, to ITC. Apparently, EMR endorsed the idea of a Canada-wide appraisal of metal resources for its own reasons and the Geological Survey of Canada (G.S.C.) had (reluctantly?) agreed.

We were given to understand that the Operation was confidential. G.S.C. had lead responsibility, supported by Mineral Resources and Mines Branches. Dr. Fortier stressed to me that G.S.C.’s lead was to be well guarded.

The expectation of quantitative estimates of Canadian metals was undoubtedly sparked by the recently acclaimed quantitative estimates of Canada’s oil and gas. It in no way downplays that achievement to point to contrasts between estimation of fossil fuels and estimation of most metals. Most oil and gas deposits are relatively large targets in layered sedimentary rocks and technologies for procuring information have deep penetration. Most metals are much smaller targets in complex settings – needles in jumbled haystacks rather than apples in well ordered ones. Methods of detection have only shallow penetration. Furthermore, metals occur in a wide range of geological environments, sedimentary, volcanic and plutonic. Individual metals occur in more than one environment. Copper runs the gamut, in numerous types of deposits with various co- and by-product partners that influence their exploitability. Appraisal of a region’s metal endowment requires appraisal of every geological environment for each deposit type appropriate to it.

¹ This paper has been written for a non-technical reader, in the hopes that it will be of assistance in the future development of a history of the Geological Survey.

The Response

The unexpected and unprecedented demand caught G.S.C. unprepared in some respects that had immediate impact. Economic geologists were few and their work had not been oriented toward quantitative regional appraisals. No policy had encouraged the development and maintenance of data banks directed to that purpose, so the in-house information needed immediately was difficult to assemble quickly.

We were asked (told) to report, in style unstated, on Ni, Cu, Mo, Pb, Zn, U and Fe. Now!! The estimates would be truly pioneer for the first five of these seven metals. For uranium, previous estimates existed that were more restricted in scope than the new demand but could be used as a base. For iron, the estimate could be built on a previous national one.

Responsibility for the estimations of Canadian metal abundances and for overall coordination of the Operation fell on the newly formed Economic Geology Subdivision. While almost every member contributed in some way, the main load was carried by a handful of 'standard bearers'. They carried full responsibility for estimates of metal abundances and partial responsibility for rating metal exploitabilities and preparation of the Report. Mineral Resources and Mines Branches had lead responsibility for rating of exploitabilities. Mineral Resources also contributed in other ways, as did members of G.S.C.

Some of the support for estimation of abundances was 'organized'. Mineral Resources made a timely input of information on Canadian past production and present reserves and additional resources plus information on other occurrences and 'showings'². In G.S.C., the Regional and Economic Geology Division arranged meetings in Vancouver, Calgary and Ottawa at which Cordilleran and Canadian Shield geologists described their regions in styles tailored to their audience of economic geologists, who in turn initiated discussion and raised questions that might not normally have seemed significant in the regional work.

An important part of the G.S.C. support came later in the Operation through ad hoc discussions between individuals when questions about certain areas arose.

The early Mineral Resources Branch input was led by Don Cranstone, under direction of Jan Zwartendyk. Don made many later contributions to the Operation. Jan coordinated Mineral Resources and Mines Branch inputs and contributed to the Report.

Main responsibilities fell on the Subdivision's five 'standard bearers': Gordon Gross, with his assistant Roy McLeod, was responsible for iron, and Heward Little, with support from Dick Williams of Mineral Resources, was responsible for uranium. The remaining five metals, for which no prior regional estimates much less Canada-wide ones had ever

² Reserves are a category of resources. They are well-measured ore, i.e. material economically exploitable at present. Additional resources are, usually, less well measured to unmeasured and less assuredly to assuredly not exploitable at present. (These are non-technical definitions).

been attempted, fell on the Mineral Deposits Section headed by Don Sangster: lead and zinc – Don Sangster; copper and molybdenum – Rod Kirkham with office support from Janet Carrière; and nickel – Roger Eckstrand.

These responsibilities overlapped because of the polymetallic nature of various deposit types, but far from causing confusion, this was a strength. Don Sangster, one of whose specialties was the deposit type “volcanogenic massive sulphides”, contributed to the copper portfolio regarding the copper linked to zinc. Roger Eckstrand provided the amount of copper linked to nickel, and Gordon Gross the amount linked to iron in deposits of skarn type. This information on linkages was more than ITC had asked for, but surely metal couplings have significance in “negotiating from strength”.

The circumstances of the previous estimates for iron and uranium did not provide a model for the kind of work required in the pioneer estimates of the other five metals. The deadline left no time for experimenting or backtracking. In earlier day mining parlance, it was “grab the shovel and start mucking”. And that is apt – the job was done essentially ‘by hand’, there being neither time nor people to computerize, even if feasible, much of the material handled.

Don Sangster soon became a tower of strength in the Operation, his initiatives felt well beyond his Section.

The first step was obvious, to improve the database on Canadian deposits provided by Mineral Resources, who were aware of its shortcomings. These core Mineral Deposits Section scientists had earned the respect of the mining industry, which brought confidential information, provided informally on the mutual understanding that it was for useful scientific work. Gathered as it was, this information mostly didn’t fill the current need but even so, there could be room for ethical concern, especially if a source might be compromised. They quietly proceeded to ask in industry for specific information, explaining why and promising confidentiality. They apparently got useful response. No-one but they know what they got and whence it came and nothing related to Operation September will provide answers.

“Look for rocks and patterns like where the mine is” the prospectors will tell you. This was basically the root of the system developed to proceed with Operation September – judge target regions against known productive areas.

The ‘standard bearers’ had experience in the study of deposit types. Briefly, this involves recognition that metals occur in reasonably distinct types of deposits, some polymetallic and some not, and that there are relationships between deposit types and their geological environments. Furthermore, in given environments there may be clues of various scales and subtleties that suggest the existence of deposits of a certain type. Thus, using as wide as possible databases on the geology of productive regions and the characteristics of deposit types, other regions may be appraised qualitatively and quantitatively by a series of comparisons.

In qualitative appraisal, a region is first classified in terms of major types of geological terrain, and then is subdivided into regions of more specific types of terrain. If one of these is a type known from the database of types of mineral deposits and their environments to contain mineral deposits elsewhere, it becomes a target area. Information on target areas is searched first for the larger scale indicators of the possible presence of deposits of appropriate types, and then for more specific clues. How far the processes proceed towards detail depends on the quality of available information. Regions are further evaluated as to the types, amounts and results of prior exploration and, if possible, concepts that guided it.

Subsequent quantitative appraisals apply databases on amounts of metal in well-explored mineral districts containing the same type of deposits as those 'flagged' in the qualitative appraisal.

No better system is known. It works well in Lotus Land. Elsewhere it involves leaps from shaky springboards into morasses of soft information.

Databases on types of mineral deposits and their environments are difficult to develop. This was especially so in 1972, particularly for deposits known only from literature. The data bank had to include deposit types not yet discovered or only poorly represented in Canada, but members of the Mineral Deposit Section had had virtually no opportunity to see foreign deposits.

Relationships between deposit types and their environments are often hard nuts to crack, but important. The better the 'hows and whys' of relationships can be understood, the better their values as indicators in mineral discovery can be rated. There is much more to be learned about many types.

In Lotus Land, databases on amounts of metals in productive areas include past production and, with various degrees of certainty, the amounts still in the ground, information on the size-ranges of deposits and relative amounts of various grades of ore, and information on exploration in the area, as an indicator of the likelihood of further discoveries. In fact, records of past production are commonly missing or are incomplete. They almost never include information on proportions of ore grades. Figures on reserves and additional resources are rarely records of what is actually there, if only because detailed measurements are costly, so only enough is expended to maintain a working inventory that depends on the type of ore body and company policy. Furthermore, release of information on deposits and on exploration beyond the mines may depend on company policy.

In 1972, the geology of huge parts of Canada was known only at reconnaissance level, far below that needed for guidance on mineral potentials. (Much still is.)

During their struggle to assemble databases and scrutinize the myriad maps and reports used in appraisals, the 'standard bearers' participated in the design of the framework on which the numerical results of the Operation would be reported (Figure 1).

Figure 1

Resource Estimates

EXPLOITABILITY ↑ Decreasing feasibility C B A	Additionally <u>exploitable</u> before 2000 AD (on discovery) with more than 50% probability with 10% to 50% probability	1C	2C	3BC Additionally possibly exploitable before 2000 AD 4BC	
	Presently exploitable on discovery	Category 1A	2A	3A	4A
	Already discovered	Additional expectable in mining areas and around other identified sites	Additional prospective in areas where occurrences are known	Additional speculative in virgin areas	
	1	2	3	4	
→ Decreasing assurance EXISTENCE					

The last step in the appraisal process (but not the end of Operation September) was to rate the exploitabilities by 2000 AD of the metals estimated to exist. This was a tri-Branch effort.

First, guidelines had to be established. Assumptions had to be reached concerning, for example, world metal prices, costs (all steps through development, mining, treatment and marketing) in the light of possible technological advances by 2000 AD in mining, metallurgy and transportation infrastructure. As well, decisions had to be made on which matters were to be disregarded, e.g. availability of capital and people, changing markets and exchange rates, foreign ownership, taxes. The guidelines were established mainly by Mineral Resources (economics) and Mines (technology) in consultation with G.S.C. The guidelines and reasoning that led to assumptions were set out in Appendix 1 of the Report.

The ratings were carried out in a series of round-table discussions by teams of, commonly, about eight people, e.g. four Mines Branch, two Mineral Resources and two G.S.C.

G.S.C. had important input because of the mineral deposit type approach to estimation of the existence of deposits. Prediction of the presence of a particular type of deposit carries with it predictions about its gross physical nature and mineralogical characteristics that affect costs of mining and treatment and perhaps about accessory elements that add value or trouble, e.g. precious metals or arsenic.

The estimates of abundance in tons and ratings of exploitability of Ni, Cu, Mo, Pb and Zn were presented in Figure 1; the horizontal axis of the grid presented four categories of assurance of existence and the vertical axis presented three levels of probability of exploitability on discovery by 2000 AD.

Uranium and iron were reported and rated on different grids to accord with internationally standard and/or industrial terminology.

- Uranium was reported in short tons of U_3O_8 . Its exploitability was rated in terms of two price ranges.
- Iron had special categories of assurance of existence and levels of exploitability. Iron differs from the rest in that deposits are typically extensive (the deposit type skarn is the exception) and relatively easily detected during regional geophysical and other surveys. Thus the category of 'speculative in virgin areas' used for the other six elements is less appropriate. The rating of exploitabilities is also different. The market commodity is a bulk product, iron ore, of relatively vast abundance. Therefore, the type of ore, its location and the transportation infrastructure are dominant influences on exploitability. Estimates were presented in pairs – crude ore and the metal – expressed in units of millions of long tons.

Upon completion of the exploitabilities rating, the task of building the Report commenced. The Report contained more than 160 Tables, each consisting of 'boxes' of numbers. Nearly 1,300 boxes were filled, checked, and rechecked. For each metal, a short text and special map(s) were developed. The maps, mostly the 'fold-in' type, were important. All outlined Canada's geological provinces, but beyond that, the map style varied with the metal. The maps were developed as appraisals progressed and decisions were made regarding areas requiring special attention. The final maps were drawn by hand, checked in detail, and then coloured by hand. Some were enhanced by pie-diagrams conveying information on quantities by size and further information by colour.

Fortunately, none of the major contributors was forced to pause because of illness. Personal difficulties were over-ridden. No-one involved in the Operation had leave. The Report was submitted on time.

The Report

The Report was entirely anonymous. Appendix 8 listed eighteen participants in the Operation, among whom six were noted as having prime responsibilities for quantitative estimation of undiscovered metals.

Introduction (Geoff. Leech)

An objective of the Introduction was to lessen the danger that number-happy users might not fully appreciate or might choose to ignore the caveats, letting numbers divorced from texts become 'facts'. It was therefore short and avoided jargon, to encourage reading, and included caveats that were also stated elsewhere.

The opening statement was that the Report contained a rough appraisal of Canada's resources of seven metals, developed through a crash program to obtain order of magnitude estimates. This was followed by the scheme (layout) of the Report and the Figure 1 grid on which estimates were presented, i.e. degrees of assurance of existence vs. feasibilities of exploitability (not possibilities of exploitation).

The main part of the Introduction provided an explanation of how the estimates were derived, including databases, qualitative and quantitative estimates and exploitability ratings (about half of the text devoted to the latter, including a synopsis of the guidelines).

A short section "Nature of the Estimates" noted some difficulties in estimating metals not faced in estimation of oil and gas. Another, "The Question of Which Resources will be Converted into Reserves" reinforced the point that estimates of metals in the ground are not estimates of what will be recovered in any particular scheme of events. Even most tonnages in Level A 'exploitable on discovery' are far from being on the shelf and available on demand. Only those in Category 1A are ready "reserves". Beyond the geological challenges to discovery lie various political and economic factors that influence the incentive to explore; these were explicitly excluded from the exploitability ratings. Assuming incentive to explore, there is usually a considerable interval between commencement of search and discovery of an important exploitable deposit, and a further interval between discovery and production. Depending on deposit type, there may be physical and economic restrictions on the rate of production.

A further section, "Consequences of the Natural Associations of Various Metals", noted that changes in the rate and/or locale of production of a metal may result in unavoidable changes for one or more other metals. Consider zinc. Most of the zinc deposits in the Canadian Shield contain copper, so increasing zinc production increases copper production. In the Cordilleran region on the other hand, increasing zinc production increases lead production. In the Sudbury area, nickel is linked to copper, whereas in the

Thompson area of Manitoba, independent changes in nickel production are possible. These tonnage ties are detailed in the Appendices on copper, lead-zinc and nickel.

The final section of the Introduction noted factors that could have contributed a conservative bias to the estimates. Records of measured and partly measured deposits (Category 1) were incomplete, especially in 1B and 1C. They were a factor in appraisal of less well-known regions. This was noted in the copper Appendix. The metals rated as discovered (Category 1) and additionally expectable in mining areas and other identified sites (Category 2) were those within reach of current detection methods, so essentially this limiting factor was built into estimates for the less well-explored areas, which were conservative to the extent that new technology increased depth of detection. The potentials of certain vein-type deposits in virgin areas were excluded as impossible to estimate quantitatively. This may have affected some uranium estimates. National parks and some provincial parks were excluded, though some have definite mineral potential. Weaknesses in geological databases depress estimates. The important Sudbury nickel-copper area was a special case. It was excluded. Two operators virtually controlled the area. They maintained a conservative attitude on reporting reserves and controlled other information closely enough to prevent valid estimates by others. The lack of Sudbury did not affect the database used to appraise other areas, but Sudbury policies applied to reporting some exploration elsewhere in Canada did. This was explained in the nickel Appendix

Summary of the Results of the Operation.

Following the 10 page Introduction, a series of 18 Tables summarized the results of Operation September. Tables 1 – 13 presented, on the Figure 1 grid, the tonnages of each of the five metals Ni, Cu, Mo, Pb and Zn, in Canada as a whole (Table 1) and in each of its geological provinces (Tables 2 – 13). Succeeding Tables presented U and Fe on grid frameworks whose categories and units were international standards and/or used by industry: uranium in Canada (Table 14) and in each of the geological provinces (Table 15) and iron in Canada and in each geological province (Table 16). Table 17 presented, for each of the seven metals, the Canadian resources additional to reserves expressed in terms of multiples of reserves (Category 1A), (Sudbury excluded). Table 18 presented, for each of the seven metals, Canadian reserves (Category 1A) in terms of multiples of 1970 outputs, and presented resources additional to these reserves in terms of multiples of reserves and the degree of expectation of them being made available. The geological provinces were shown on an accompanying map.

Appendix 1 – Guidelines for Rating Exploitability of Base Metal Deposits
(Jan Zwartendyk)

The opening words of Appendix 1 were *“The purpose in Operation September was to rate the degree of certainty of exploitability of the mineral deposits estimated to be present. This is distinct from a rating of the likelihood that they will in fact be exploited. For Operation September, the question was: could they be exploited in an economic base, if discovered, given certain specific assumptions set out in the Report. The answer, for Operation September, hinged on Canadian costs relative to world prices.”*

“We considered only direct costs, which include all steps between discovery and marketing.... These were considered in the light of the characteristics of the deposits, their locations and the estimated technological advances by 2000 AD. Thus, given certain commodity prices, how much would profitably be exploited?”

“Certain possible constraints were disregarded, e.g. inadequate demands, capital and manpower availability, foreign ownership, regional development, changes in exchange rates, balance of payments and taxation. The presently exploitable category is straightforward. For the groups listed as exploitable later but by 2000 AD, assumptions about future prices and costs were necessary. Most technological capabilities are cost-dependent, i.e. we can or cannot do something at a certain acceptable cost level.”

The Assumptions about world prices of Pb, Zn, Cu, Ni and Mo were that

- “a) prices are set in world markets and are not significantly influenced by Canadian production (i.e. we are price takers, not price setters).*
- b) prices in constant dollars of Pb, Zn, Cu, Ni and Mo will remain roughly constant to 2,000 AD.*

This was an operational simplification based on the expectation that there are enough factors in sight that will act as price maintainers (such as ‘unconventional sources’, recycling, more efficient use, substitution, technological advances) that we can assume that prices will not go significantly up or down as a general trend”.

“Additional future costs related to pollution abatement were thought to add perhaps 10% to total base metal costs, but these would be reflected world-wide in the future and thus result in a slight price increase; hence although Canada’s costs for abatement might be higher than those in less developed countries, overall differential relative to world prices would not change significantly enough to be taken into account in Operation September”.

The Assumptions about cost effects of technological advances were that

- “a) some mining and ore treatment methods would be applied that were already physically possible but not economic.*
- b) some new economically practical mining and ore treatment methods would be developed”.*

“Such technological advances may make new kinds of deposits economic and may lead to lower cut-off grades in some ‘traditional’ types. Such improvements are implicit in forecasts that prices will remain steady in terms of constant dollars”.

“Metals in addition to those reported in this operation but which occur in the deposits can be advantageous, e.g. gold, or disadvantageous, e.g. arsenic, and were considered in the ratings.”

“Costs of open-pit mining were regarded as likely to decrease but those of underground mining were not. Exploitability was deemed more likely to be influenced, in general, by technological advances in metallurgy than in mining.”

The assumptions on transportation cost were that, *in addition to present transportation facilities and methods, there would be pre-2000 AD*

- a) a Mackenzie Valley highway;*
- b) a northern B.C. railway to the Yukon;*
- c) increased access southeast of Hudson’s Bay; and*
- d) ‘routine’ navigation routes to the Eastern Arctic.*

Appendices 2 – 7

The succeeding six Appendices were the meat of the Report, and might better have been dignified as ‘Chapter’:

- Appendix 2: Copper and Appendix 3: Molybdenum by Rod Kirkham
- Appendix 4: Nickel by Roger Eckstrand
- Appendix 5: Lead and Zinc by Don Sangster
- Appendix 6: Uranium by Heward Little
- Appendix 7: Iron by Gordon Gross.

Each consisted of a Table of Contents (1 or 2 pages), text on styles of occurrence and other matters that affect estimations (3 – 5 pages), tables, mostly Figure 1 type (3 – 44 pages), and fold-out map(s) except Appendices 6 and 7, illustrated differently. The following notes, extracted inconsistently, show some of the range of information the Appendices contained.

Appendix 2: Copper

Text – 3 pages, Tables – 23, Map

No large area (more than a few thousand square miles) should be considered totally without potential for copper until it has been explored reasonably well. This is because of the diversity of deposit types and geological settings in which it occurs and the number of metals, base and precious, with which it may be associated.

Gold and silver with the Cu Zn Pb association and platinum group elements with the Ni Cu association can be significant factors of exploitability.

Much information is lacking on low grade deposits and on currently sub-economic deposits of Cu and/or Mo in which the disseminated content of metallic minerals decreases gradually outward with no distinct boundary. Part of the lack is due to lack of incentive to measure beyond current mineable limits. This affects estimates in Category 1, so can affect estimates elsewhere. Part of the lack is due to explorers' preference to remain silent about discovery of localities they might wish to return to if economic conditions change. This affects estimates in certain regions.

The map 'Copper Potential of Canada' delineated the geological provinces, the segments into which they were divided for estimation purposes and outlines areas of moderate to high potential (possible high potential in the Yukon). The map was augmented by 17 pie diagrams that portrayed, by sizes, total tonnages of copper and, by colours, amounts already discovered and exploitable and amounts discovered by not yet exploitable.

Appendix 3: Molybdenum

Text – 3 pages, Tables – 16, Map

The map 'Molybdenum Potential of Canada' was similar in design to the map in Appendix 2. Twenty-one important deposits were distinguished as to whether they were 'stand alone', co-product with copper or copper deposits with by-product molybdenum.

Appendix 4: Nickel

Text – 4 pages, Tables – 44, Map

Canadian nickel deposits can, for resource estimation, be divided into three types, nickel, nickel-copper (ultramafic) and nickel-copper (gabbroic)

	Type	Associated Rock	Ni:Cu Ratios	Examples
1.	'Ni'	ultramafic	100:1 to 10:1	Thompson, Manitoba Western Australia
2.	Ni-Cu	ultramafic	5:1 to 1:1	Raglan, Katiniq, Quebec Shebandowan, Ontario
3.	Ni-Cu	gabbroic	2:1 to 1:2	Sudbury, Ontario Lynn Lake, Manitoba

The distinction between ultramafic and gabbroic rock association is especially important in evaluating low-grade deposits. A significant proportion of the nickel in ultramafic rocks is locked into silicates and unrecoverable, whereas in gabbroic rocks the proportion locked in is insignificant.

Among ultramafic rocks, Phanerozoic ophiolites seem to be without potential whereas ultramafics in Proterozoic tectonic belts appear to have high potential. Among gabbroic rocks, no distinctions have been recognized to aid in qualitative regional appraisals.

Appendix 4 outlined three major problems of nickel estimation:

1. Sudbury, Canada's leading area, had to be omitted. Virtually all the Ni-Cu resources there are controlled by two companies that maintain a conservative attitude in reporting reserves and other resources and hold information closely enough to prevent valid independent estimates by others. Sudbury is apparently geologically unique, so its lack did not affect the data-base used in estimations of other regions. The extension of Sudbury policy to exploration elsewhere did. An area in NWT and another in Quebec in which INCO conducted major programs for several years had to be excluded, with loss of data-base information and estimates.
2. The highly concentrated nature of Canada's nickel deposits at Sudbury and Thompson. Another Sudbury is doubtful but there could be another Thompson somewhere. Is there?
3. Exploitability of low grade nickel deposits.

Appendix 5 – Lead and Zinc

Text – 4 pages, Tables – 41, Map

Generalities concerning major geological types of occurrence

<u>Region</u>	<u>Deposit type</u>	<u>By-Product</u>	<u>Iron Sulphide content</u>
Appalachian	Zn-Pb-Cu	Cd, Ag	High
Canadian Shield	Zn-Cu	Cd, Ag	High
Interior Platform	Zn-Pb	Cd	Moderate
Eastern Cordillera	Zn-Pb	Cd	Low
Yukon	Zn-Pb	Cd, Ag	High to moderate
Arctic Islands	Zn-Pb	Cd	Low to moderate

Appendix 7 – Iron

Text – 5 pages, Tables – 20, Figures – 4

One of the ways in which iron differs from the other metals in Operation September is that the market commodity is a bulk product, iron ore, of relatively vast abundance. Therefore the type of ore, its location and the transportation infrastructure are dominant influences on exploitability.

The Aftermath

We never learned whether Operation September was used in a GATT meeting.

Operation September sparked a G.S.C. recognition of economic geologists and their work that, if not new, was certainly heightened. One early result of this better understanding was recognition of the usefulness of work outside Canada – boots on selected foreign mineral districts and face-to-face discussions with people who know the ground. Another effect was recognition of a place for regional economic geologists in some areas. The consequence was a gradual judicious increase in staff and scope.

Some years earlier, Dr. S.C. Robinson had initiated geomathematical work in G.S.C. and that unit became part of the new Economic Geology Subdivision. It was not utilized in Operation September, as there was no time for experimentation. After things calmed down and work thrust aside by the Operation received overdue attention, memories of the ‘by hand’ job prompted Project Appalachia. This was an effort to develop and apply methods of combining information and concepts on regional geology, mineral deposits and mathematics in a computer-aided regional mineral resource appraisal. The Canadian Appalachian region was selected as the experimental base because its geology was relatively well known and peppered with a variety of mineral deposits. Bill Poole and Don Sangster contributed major thought and effort in addition to carrying on their ‘ordinary’ work. Despite the enthusiastic cooperation of Frits Agterberg and his associates on the mathematics side, the geological staff was too few to provide the continued input needed to go farther.

Just a few years after Operation September there began a flow of requests for mineral resource appraisals of areas proposed for parks, followed by requests for appraisals for larger regions in connection with land claims negotiations. The experience of the Operation was a good foundation for the work styles needed.

In the Department of Energy, Mines and Resources, the Mineral Resources Branch almost immediately capitalized on Operation September. The first use was in MACS – Mineral Area Classification Study – an unpublished work aimed at presenting “an overall view of Canada’s mineral industry and its relationship to Canada’s economic development”. MACS was followed by MAPS – Mineral Area Planning Study – completed by April 1975. This was a physically large report (many maps) that made full use of Operation September’s maps and numbers. The preface states “MAPS was intended to be a discussion document designed to elicit comment, criticism and elaboration from all parties interested in the future mineral development of Canada”. MAPS was not published but a report adapted from it entitled “Metal Mining in Canada 1976 – 2000” was released in 1976. A summary of conclusions reached in MAPS was published by *The Northern Miner* on December 9, 1976.

Four of the five G.S.C. standard bearers in Operation September are alive in 2007. Each is known internationally for publications on types of mineral deposits and other work.

Participants in Resource Estimations³

The estimates are based on the judgments of the following participants in “Operation September”, who were supported by advice and assistance of their colleagues. Asterisks indicate those with prime responsibilities in quantitative estimation of undiscovered metals.

R.W. Bruce	Mines Branch
D. Cranstone*	Mineral Resources Branch
A. Dubnie	Mines Branch
O.R. Eckstrand*	Geological Survey of Canada
W.A. Gow	Mines Branch
G.A. Gross*	Geological Survey of Canada
G.O. Hayslip	Mines Branch
W.R. Honeywell	Mines Branch
R.V. Kirkham*	Geological Survey of Canada
P.P. Lafleur	Mineral Resources Branch
G.B. Leech	Geological Survey of Canada (coordinator)
H.W. Little*	Geological Survey of Canada
C.R. McLeod	Geological Survey of Canada
D.E. Pickett	Mines Branch
D.F. Sangster*	Geological Survey of Canada
A. Stemerowicz	Mines Branch
R.M. Williams	Mineral Resources Branch
J. Zwartendyk	Mineral Resources Branch (coordinator)

³ This information was included as “Appendix 8” in the Operation September Report.