Canadian Mineral Exploration and Discovery Analysis

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CANADA'S STANDING AS A WORLD EXPLORATION TARGET

In 1995, exploration expenditures in Canada totalled $717.6 million. Canada remained one of the world's top targets (second after Australia) for mineral exploration that year. In both 1996, with exploration expenditures (preliminary) of $872.6 million, and probably again in 1997, with company spending intentions of $876.0 million, Canada ranked second after Australia, continuing the close contest of the past three or more decades between these two countries. The United States, which from the limited and poor-quality exploration statistics that have been available for that country appears to have been a strong contender for first place as a destination for exploration capital from worldwide sources up until about 1980, has been consistently in third position beginning in 1980.

Based on official Canadian and Australian government surveys of company exploration expenditures, Canada ranked first every year from 1981 through 1990, and probably also in 1991. Canada ranked second after Australia from 1992 through 1996 (Figure 1). No single country other than Australia has come close to challenging Canada in 1996 or will do so in 1997.

Figure 1
Top Three Country Destinations of Mineral Exploration Capital from Worldwide Sources, 1971-96

Year	Rank		
	First	Second	Third
1996	Australia	**Canada**	United States
1995	Australia	**Canada**	United States
1994	Australia	**Canada**	United States
1993	Australia	**Canada**	United States
1992	Australia	**Canada**	United States
1991	**Canada**	Australia	United States
1990	**Canada**	Australia	United States
1989	**Canada**	Australia	United States
1988	**Canada**	Australia	United States
1987	**Canada**	Australia	United States
1986	**Canada**	Australia	United States
1985	**Canada**	Australia	United States
1984	**Canada**	Australia	United States
1983	**Canada**	Australia	United States
1982	**Canada**	Australia	United States
1981	**Canada**	Australia	United States
1980	Australia	**Canada**	United States
1979	Australia	United States	**Canada**
1978	Australia	United States	**Canada**
1977	United States	**Canada**	Australia
1976	**Canada**	United States	Australia
1975	United States	**Canada**	Australia
1974	**Canada**	United States	Australia
1973	Australia	United States	**Canada**
1972	United States	Australia	**Canada**
1971	United States	**Canada**	Australia

Source: Natural Resources Canada, based on official Canadian and Australian statistics and the best available data for the United States. Australian expenditures were 6.5% higher than those for Canada in 1983 and 3.3% higher in 1991; however, correcting the reported Australian totals for substantial mine development expenditures, which are not included in Canadian statistics, ranks Canada first in 1983 and 1991. No data are available for the former Soviet Union.

DISCREPANCIES BETWEEN EXPLORATION SURVEY RESULTS

In recent years, there has been considerable confusion concerning Canada's relative share of worldwide non-petroleum mineral exploration activity. Discussion has centred around the results of the proprietary annual survey of worldwide mineral exploration budgets prepared by the Metals Economics Group (MEG) of Halifax, Nova Scotia. Data from this partial survey have generally ranked Canada considerably lower than do the much more comprehensive official Canadian exploration statistics. MEG ranked Canada first in 1991, third in 1992, fourth in 1993, fifth in 1994, third in 1995 and third again in 1996 after Latin America and Australia, whereas Canada's actual position was first in 1991 and second in all subsequent years.

The MEG exploration survey of exploration budgets for 1996 covers almost all countries. The survey is invaluable because Canada and Australia are the only two countries in the world that have official, comprehensive government-run surveys of non-petroleum mineral exploration expenditures; therefore, despite being incomplete, the MEG survey provides the only source of information, for all other countries, of the worldwide activities of the world's larger companies.

The only exploration expenditure statistics available in the public domain for the United States for the years 1970 through 1979 are only rough estimates (from a paper by Schreiber and Emerson, 1984[1]) and, as a result, the relative position of the United States among the top three contenders for global exploration investment (Figure 1) is especially uncertain for the years 1970-79. U.S. exploration statistics for the 1980-91 period are from incomplete annual surveys carried out by the American Bureau of Metal Statistics Inc. (ABMS) on behalf of the Society of Economic Geologists. However, the ABMS survey no longer provides useful exploration statistics; therefore, since 1992, the MEG survey, with its limitations, has been the only source of aggregate exploration statistics for the United States.

Statistics provided by Canada's annual federal-provincial survey of mining and exploration companies provide a much more complete source of information for ranking Canadian exploration activity than does the MEG survey, as do similar statistics gathered and published by the Australian Bureau of Statistics for ranking Australian activity. More than 98% of the companies that are sent Canadian exploration survey questionnaires return those questionnaires completed. The majority of the companies that fail to respond do not appear to have substantial exploration programs, so it is likely that considerably more than 99% of total exploration expenditures of all the companies surveyed are gathered by this federal-provincial exploration survey. But some companies that did explore in Canada may not be surveyed because neither federal nor provincial governments were aware that these companies were engaged in mineral exploration in Canada that year.

Differences between Canadian and Australian Exploration Statistics

Official Canadian and Australian exploration expenditure statistics are not completely comparable because Australian exploration statistics include some costs that are excluded from Canadian statistics. Canadian exploration statistics exclude all expenditures at producing mines directed at the search for extensions, to depth and laterally, of the orebodies being mined. Such expenditures are included in development expenditures. However, in Canada, exploration for a new mine on the property of an existing mine is counted as exploration expenditures. In Australia, all expenditures involved in the search for additional ore on production leases, including expenditures on such work in producing mines, are included in exploration expenditures, whereas in Canada at least some of this work would be counted as "development."

This means that Australian exploration expenditure statistics are somewhat inflated relative to Canadian exploration expenditure statistics. This is demonstrated by the fact that, over the most recent six years for which Australian exploration statistics are currently available (fiscal year 1990/91 to fiscal year 1995/96 inclusive), exploration expenditures on production leases averaged 22.1% of total exploration expenditures in Australia. In Canada, over the eight calendar years from 1990 to 1997 inclusive (including "preliminary" 1996 and "company spending intentions" 1997), on-property or mine-site exploration averaged only 12.9% of total exploration expenditures. In Canada, such expenditures can be anywhere on a company's property surrounding its mine, and not only on ground equivalent to the more restricted Australian production leases. If reported and compiled in Australia, some of these Canadian expenditures would not be included as production lease expenditures, thus the percentage differences would actually be greater than between the 22.1% in Australia and the 12.9% in Canada.

While there are many reasons for differences in these percentages, it is evident that the same mineral exploration expenditures reported for Australia would be higher by an unknown but significant amount relative to Canadian exploration expenditures because of structural reporting differences. Therefore, exploration expenditures in Australia are not as much higher than exploration expenditures in Canada as they may first appear to be.

The value of Australian production of non-petroleum minerals is roughly one third greater than that of Canadian production; therefore, it is to be expected that exploration expenditures in Australia will normally exceed those in Canada.

Differences between Official Canadian Exploration Statistics and Metals Economics Group Exploration Statistics for Canada

The exploration statistics produced by MEG substantially understate Canada's share of worldwide exploration activity. There are several reasons for this. First, MEG results account for only two thirds or less of total exploration expenditures in Canada because, in 1996, this survey covered only 76 companies

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[1] Schreiber, Hans, and Mark Emerson, 1984: "North American Hardrock Gold Deposits: An Analysis of Discovery Costs and the Cash Flow Potential," *Engineering and Mining Journal*, October 1984, pp. 50-57.

exploring in Canada, a number that is substantially fewer than the 647 companies that were actually engaged in mineral exploration in Canada that year. Second, for the 1993-95 survey years, MEG used ever-increasing exploration budget cutoffs to limit the universe of companies it surveyed. There was a slight decrease to US$2.9 million in 1996 from US$3 million in 1995. For 1994, the cutoff was US$2 million and, in prior years, was US$1 million.

Because of these survey cutoff values, the MEG survey has consistently substantially underestimated exploration activity in both Canada and Australia. This is because, at least until recently, the contribution made by junior exploration companies was so much greater in Canada and Australia than in all other countries. Both Canada and Australia have hundreds of producing or non-producing (junior) companies that individually have spent less than the MEG cutoff amount on exploration annually, but that as a group have accounted for, and still account for, a substantial amount of exploration activity.

In 1996, MEG reported aggregate exploration budgets for Canada of US$460.8 million on the basis of 76 company returns. A company-by-company comparison of the companies surveyed by MEG for 1996 with individual company spending intentions for Canada from the 1996 federal-provincial survey of mining and exploration companies shows that some 571 companies with exploration expenditures in Canada were not covered by the MEG survey. According to Canadian federal-provincial statistics, these companies had planned to spend US$241.5 million exploring for the commodities covered by the MEG survey. The resulting underestimation of total exploration activity is most likely greater in the case of Canada (with US$460.8 million of exploration expenditures in 1996 according to MEG) than in the case of Australia (with US$665.9 million of exploration expenditures in 1996 according to MEG) because there are more junior companies engaged in exploration in Canada than there are juniors engaged in exploration in Australia.

Of the US$241.5 million of exploration expenditures in Canada not picked up by MEG, some US$63 million was to be spent by 13 companies, each of which provided data to the federal-provincial exploration survey of planned 1996 exploration expenditures in excess of the 1996 MEG survey cutoff amount of US$2.9 million. None of these 13 companies appear to have been surveyed by MEG. This means that MEG presumably should have reported Canadian exploration expenditures of about US$524 million for companies with exploration expenditures of US$2.9 million or more, and not the $460.8 million actually reported. Furthermore, the MEG survey does not cover exploration for all of the mineral commodities sought by companies. For example, uranium is not covered, but company spending intentions for uranium exploration in Canada during 1996 amounted to about 25% of total world uranium exploration expenditures for 1996 (as compiled by the International Atomic Energy Agency), a larger world share compared to the 13.1% that Canadian exploration expenditures (for the commodities covered by the MEG survey) constitute of world exploration expenditures reported by MEG. Therefore, Canadian exploration budgets reported by MEG are under-rating Canadian exploration efforts by excluding uranium from the commodity groups surveyed. However, exploration expenditures for all of the other commodities not covered by the MEG survey (industrial minerals other than diamonds, iron ore, bauxite and coal) would also have to be taken into account in a more comprehensive commodity analysis in addition to uranium exploration expenditures.

Another difficulty with the MEG survey is that worldwide exploration expenditures compiled by that survey are not comparable across all companies. In addition to including surface exploration expenditures, some companies include the search for extensions to orebodies in producing mines in the budgets that they report to MEG. Other companies include the costs of feasibility and engineering studies, but most do not. Because of these inconsistencies in what is included, it is difficult to assess the validity of comparisons by MEG of exploration expenditures across countries, or the validity of comparing MEG totals for exploration in Canada to exploration expenditure totals from the federal-provincial exploration survey (which clearly excludes the search for new ore in producing mines and deposits committed for production, and expenditures on feasibility studies and engineering studies at such properties).

Some MEG rankings compare total exploration budgets in individual countries such as Australia, Canada and the United States with those in vast geographical regions such as Latin America, Africa, Pacific/Southeast Asia and "Rest of World." Some of these comparisons are arbitrary and therefore constitute misleading comparisons. Latin America, for example, consists of more than 20 separate countries that jointly have an area on two continents that is more than double the area of Canada, the United States, or Australia. Latin America has a mineral industry with an annual value of non-petroleum mineral production almost double that of Canada and, therefore, it would not be unexpected for total Latin American exploration expenditures to be double those of Canada, yet when all companies are taken into account, including companies with worldwide exploration expenditures lower than US$2.9 million, this is probably not the case.

The relative positions of countries in world exploration as reported by MEG have shifted from one year to the next, in part because of changing methodology used by MEG, not only because of changing exploration expenditure cutoffs used by MEG, but also because of MEG's separation (in 1995) of Africa from "Rest of World." Until 1995, "Rest of World" had an area about ten times that of Canada, ten

times that of the United States, and about twelve times that of Australia.

The separation of Africa from "Rest of World" in 1995 resulted in a 30% decrease in the area of "Rest of World" and, consequently, a substantial decrease in exploration expenditures for "Rest of World" as follows: in 1994, the MEG exploration survey reported that "Rest of World" accounted for 15% of total world exploration expenditures of US$2.050 billion, that is, for US$308 million; in 1995, a redefined "Rest of World" accounted for only 6.7% of total world expenditures of $2.690 billion, or US$180 million. This change helped shift Canada's world position in terms of exploration activity (according to MEG) from fifth in 1994 to third in 1995. However, if Canada, the United States and Mexico, as well as the Central American portion of Latin America had, for example, been combined by MEG into a region called North America, then North America would have been consistently first in terms of worldwide exploration activity for the past few decades. This indicates some of the problems of comparing exploration expenditures for individual countries with expenditures combined by geographical region.

Changing Exploration Expenditures – Canada Versus the World

Exploration expenditures have been increasing annually since 1992, both in Canada and in the world as a whole. Table 1 compares percentage increases in exploration expenditures or budgets in Canada (from the federal-provincial exploration survey) to that for the remainder of the world (from MEG) since 1992. Although the percentage comparisons are not exact because of the changing annual budget cutoffs used in successive MEG surveys, and because MEG does not include exploration budgets for all commodities, Canada would appear, from this table, to have increased its proportionate share of mineral exploration expenditures somewhat since 1992. However, the MEG survey is probably not picking up an increasing portion of exploration expenditures by junior companies worldwide, both because of the increase in the MEG survey cutoff from US$1 million to US$2.9 million and because there has been a major increase in worldwide exploration expenditures by junior companies in the past three or four years. Therefore, it is no longer chiefly in Canada and Australia that the MEG survey is not reporting substantial exploration expenditures by junior companies, and it may even be that the proportion of total world exploration expenditures being directed at Canada (and also at Australia) is actually diminishing as a percentage of total worldwide mineral exploration expenditures. But because exploration expenditures have been increasing rapidly, and because such expenditures in Canada, in both 1996 and 1997, have been exceeded in only three previous years of 1987, 1988 and 1989 (possibly also in 1980 and 1981 but we are uncertain of this because the exploration survey methodology used in those years tended to overinflate exploration totals), there seems to be little or no reason to be concerned, even if the proportion of worldwide exploration expenditures directed at Canada may have been declining somewhat. This is especially the case when one takes into account the fact that Canadian companies account in total for more exploration spending worldwide than do companies from any other country; Canadian companies can therefore be expected to benefit from mineral discoveries and new mines in other countries that can be expected to result from their exploration in other parts of the world.

CANADA'S RECENT MINERAL EXPLORATION SUCCESS AND DISCOVERY POTENTIAL

Natural Resources Canada's most recent analysis of Canadian mineral exploration success covers the period 1946-90 inclusive. The results of that analysis (by Donald Cranstone, André Lemieux and Marcel Vallée) were summarized on pages 5.14-5.16 of the "Canadian Mineral Exploration" chapter of the 1994 *Canadian Minerals Yearbook*. The analysis demonstrated that the quantities of metal discovered in Canada were relatively low (compared to earlier periods) during the three-year periods 1982-84 and 1985-87, but were considerably improved in 1988-90. The analysis covered all metal deposits discovered in Canada, not only the economically mineable ones. As time has passed since 1990 and production decisions have been made, an increasing portion of the deposits discovered in the most recent three-year periods has been developed for production in comparison to what was shown in the 1994 analysis. Since the time that this discovery analysis was finalized (early in 1994), production decisions have been made for more than 60 Canadian metal deposits that were discovered between 1963 and 1990 and included in the discovery analysis. These 60 or more additional mines represent a considerable increase compared to the approximately 450 Canadian metal mines that had been developed as of 1993 from metal deposits discovered in Canada between 1946 and 1990 inclusive.

Canada's mineral exploration success of recent years and discovery potential in the near future appear to be promising on the basis of the many new mines currently under development or likely to be developed soon from recently discovered deposits. Some of the more significant discoveries and developments are summarized below.

Nickel

The Voisey's Bay nickel-copper-cobalt deposit, discovered in 1994 and currently thought to contain some 150 Mt of ore, represents the largest Canadian nickel discovery since the Thompson Nickel Belt with its 19 or more nickel deposits, which was discovered in

Manitoba during the 1950s and early 1960s. Voisey's Bay was not the only Canadian nickel deposit discovered in Canada in 1994. The Pipe Deep and Williams Lake deposits, both located in Manitoba's Thompson Nickel Belt, were also discovered that year. (See subsequent section of this chapter entitled "Nickel and the Archean-Proterozoic Boundary in Canada").

Canada is poised to regain, within the next few years, its former position as the world's leading producer of nickel.

Diamonds

In the past five years, 14 or 15, and probably more, diamond deposits that appear likely to be mined have been discovered in Canada. In addition to the BHP/Dia Met diamond project at Lac de Gras, which is being developed for production in 1998 (with at least eight deposits), as many as three other diamond projects seem likely to be in production within only a few more years. The current high level of diamond exploration activity in Canada makes it highly likely that still more diamond discoveries will be made. Canada appears likely to become one of the world's foremost producers of diamonds in the foreseeable future.

Uranium

Three major new uranium mining projects are awaiting development in Saskatchewan, but all need final environmental approvals before production development can formally begin. These are the McArthur River, Cigar Lake and Midwest projects, which will produce from a total of eight separate uranium deposits discovered in northern Saskatchewan's Athabasca Basin over the past two decades. The large, exceptionally high-grade world-class Cigar Lake and McArthur River deposits are considered to be the world's two greatest uranium discoveries ever.

Despite increasing uranium production that is scheduled or likely to be scheduled for Australia, Canada is likely to remain the world's foremost producer of uranium for at least the coming decade and probably beyond.

Copper

New nickel, diamond and uranium mines are not the only expected new Canadian mines. In British Columbia, three porphyry gold-copper mines (Huckleberry, Kemess South and Mt. Polley) are currently being developed. Other new copper mines seem likely, both in British Columbia and the Yukon. Two of these deposits (Huckleberry and Mt. Polley) were originally discovered in the 1960s, but it was additional exploration in more recent years that found the gold-rich zones that turned known deposits into viable orebodies. The copper from these new and anticipated B.C. mines, together with the copper that will come from the Voisey's Bay and Victor nickel-copper mines, as well as from various other new copper mines, should enable Canada to maintain its position as the world's third largest producer of copper for the foreseeable future.

Gold

Canada achieved an all-time record gold production of 175.3 t in 1991. Although production had declined to 146.4 t by 1994, it reached 150.9 t in 1995 and rose again to 164.1 t (preliminary) in 1996. If the gold price holds at the levels of early 1997 or higher, new gold mines under development seem likely to result in the achievement of new all-time Canadian gold production records in the near future.

Other Mineral Commodities

Canada's recent success in mineral exploration, discovery and production has not been restricted to metals and diamonds. Production from new coal mines, combined with production from existing mines, has resulted in record levels of Canadian coal output in recent years. Still other coal deposits have been outlined that should result in an even higher level of Canadian coal production as new marketing opportunities develop. The production of potash, salt and other minerals is at near-record levels.

Recent discoveries have also led to the opening of new graphite and garnet mines in Ontario, a wollastonite mine in Quebec (two other promising deposits of wollastonite have been found, one in Ontario and a much larger one in British Columbia), and a new pumice mine in British Columbia. Still other recently discovered industrial mineral and construction mineral deposits at various Canadian localities offer additional development opportunities.

DIAMOND EXPLORATION HIGHLIGHTS

The discovery in late 1991 of a diamond deposit (in kimberlite) of potential economic value at Point Lake near Lac de Gras in the Northwest Territories initiated a Canadian claim-staking rush of unprecedented magnitude in the Northwest Territories, Alberta and, to a lesser extent, Saskatchewan. Within a short period of time, a large number of companies were exploring for diamonds in many parts of Canada. The diamondiferous kimberlite at Point Lake does not represent the first diamond discovery in Canada. A loose 33-carat (ct) diamond was found, sometime before 1920, during excavation of a railway cut near Peterborough, Ontario, but it was rough, broken and of little value as a gem. In 1971, the Jarvi diamond, a loose one-quarter-carat gem-quality diamond, was found in glacial gravels in an esker near Timmins, Ontario.

During the 1960s, two separate groups of small diamonds were reported to have been found to the east

of Prince Albert, Saskatchewan, in glacial gravels. These reports had been thought by many people to have been a hoax but, since 1988, more than 40 kimberlite pipes have been found in that area near Fort à la Corne. These small diamonds may well have been indicator minerals for the Fort à la Corne kimberlite pipes. Of the more than 40 pipes found near Fort à la Corne, Saskatchewan, many of which contain diamonds, so far none have proven to be economically mineable because their diamond contents are low.

Serious exploration for diamonds in Canada began in 1960. The South African company De Beers has been continuously exploring for diamonds in Canada since then. Kimberlite pipes were discovered by De Beers during the 1970s and 1980s in other parts of Canada, chiefly in Ontario and Quebec, but also on Somerset Island in the Canadian Arctic and at a few other localities, but none of these pipes appear to have diamond contents that are anywhere close to ore grade.

In Alberta, 15 or 20 very small diamonds have been found in glacial and stream gravels in recent years, but their original sources are not known. They could have been carried south for many hundreds of miles by glaciers, but they also could have come from more local kimberlite intrusions. Eleven kimberlite pipes have recently been discovered near Hinton, Alberta, but it is not yet known whether any of them are diamondiferous.

In 1996, final federal government approval was granted for production from five diamondiferous kimberlite deposits at Lac de Gras. Although BHP currently plans to mine these five deposits, several more apparently attractive diamondiferous kimberlites have also been found, at least three of which, and perhaps more, are likely to be mined in the future.

In addition to what appear to be eight or more diamond orebodies discovered on the BHP-Blackwater Group property, another six promising diamond deposits have been discovered on three other separate properties with differing ownership, although it is too early to be certain that all of them will attain production. These consist of the Diavik project of Aber Resources Ltd. and Kennecott Canada Inc., also at Lac de Gras, with four promising deposits (A-154 South, A-154 North, A-418 and A-21); the Jericho project of Lytton Minerals Limited and New Indigo Resources Inc., some 150 km north of Lac de Gras, with one promising deposit (the JD/OD-1 deposit); and the AK property of Mountain Province Mining Inc., Glenmore Highlands Inc. and Camphor Ventures Inc., also with one promising deposit (the AK-5034 deposit), some 150 km southeast of Lac de Gras.

BHP-Blackwater Group

In 1996, exploration continued on the Lac de Gras property of BHP and its associates in the Northwest Territories. A total of 77 kimberlite intrusions have been found on this property, up from 66 intrusions a year earlier, at least 42 of which are known to contain diamonds. Twenty of these intrusions have been bulk-sampled. Exploration for additional kimberlites continues. By the time mine development began in late 1996, BHP had spent $200 million on the property. Much of this was on exploration, on bulk sampling using large-diameter diamond drilling and/or underground workings, and on feasibility and environmental studies.

At the time of writing, the project operator, BHP, had not yet published ore reserves data for the five diamond pipes it currently plans to mine. Table 2 lists the available bulk sample results for combined bulk sample data from each pipe for the Panda, Misery, Koala, Fox and Sable pipes, and for the Jay, Leslie and Pigeon pipes, which are not yet scheduled for mining but are likely to be mined after the initial five pipes.

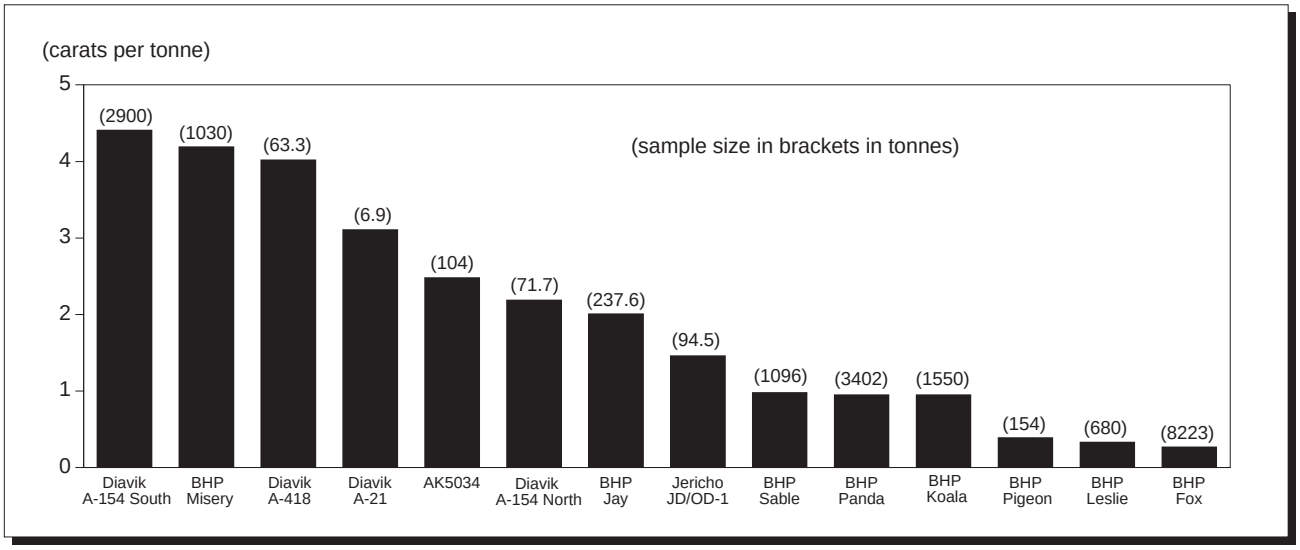
During 1995, bulk samples were also taken and tested from four other pipes on the same property (Cub, Grizzly, Arnie and Mark), but the diamond contents and initial quality assessment of the diamonds recovered indicated that these four pipes were of insufficient economic value to warrant additional work at that time. This is also the case for several other pipes from which small bulk samples were taken in earlier years. It would be surprising if at least some of these less attractive pipes were not further evaluated as mining proceeds and the need for additional ore becomes apparent.

The BHP diamond project will process 9000 t/d of ore for the first nine years of production, increasing to 18 000 t/d in subsequent years. The average value per tonne of each of the Panda, Misery and Koala deposits is in excess of US$100 (Table 2), which indicates that these three deposits appear to be among the world's highest-grade diamond deposits in terms of per-tonne values (Figure 2). The Sable deposit contains US$63/t of diamonds and the Fox deposit, US$34/t. The Leslie deposit, which has now been replaced by the higher-grade Sable deposit, will probably be mined later. The projected annual revenue from this project appears to be in the range of C$400 million-$500 million.

Diavik Project

The Diavik project is operated by Diavik Diamonds Mines Inc. of Yellowknife, Northwest Territories, which has a 60% interest in the project. Diavik Diamonds Mines Inc. is a wholly owned subsidiary of the large multinational mining company RTZ-CRA of London, England, as is Kennicott Canada Inc., which previously held the 60% RTZ-CRA interest in the property. The remaining 40% of the project is owned by Aber Resources Ltd. of Vancouver, British Columbia. Aber has put up 40% of the costs of exploring the property and retains the right to market its 40% share of diamond production.

Figure 2
Grades of Selected Canadian Diamond Deposits



Source: Natural Resources Canada, based on published data.

A total of 45 kimberlite pipes have been discovered on the combined Diavik property, of which at least 13 are known to contain diamonds. Four pipes, A-154 South, A-154 North, A-418 and A-21, currently appear to be the most promising.

Pipe A-154 South

Notable results were obtained by drilling the A-154 South kimberlite, including the recovery of a 1.76-ct diamond. A one-kilometre-long decline was driven to a depth of 155 m below the ground surface and a 2900-t bulk sample was taken during the winter of 1995/96; a total of 12 800 ct of diamonds were recovered for valuation. A sample representing roughly one half of the 12 800 ct, valued on the basis of early 1997 market conditions by experts in Antwerp, yielded a value of US$67/ct, which suggests a value of US$63/ct for the entire bulk sample. These data indicate that the A-154 South kimberlite has an average diamond content of 4.4 ct/t and a value of US$278/t. The estimated resource is 12 Mt to a depth of 400 m with as much as 20 Mt to a depth of 650 m. The A-154 South deposit is one of the world's highest per-tonne valued diamond deposits.

Pipe A-418

A 3000-t underground bulk sample was taken from the A-418 kimberlite using the same decline for access. The proximity of the A-154 North and A-418 kimberlites to the A-154 South kimberlite has facilitated underground sampling of these two kimberlites from the original A-154 decline. At the time of writing, the processing of the A-418 bulk sample was in progress at the pilot plant in Yellowknife. The rough diamonds are to be sent to Perth, Australia, for cleaning and sorting for initial valuation, and then on to Antwerp for valuation by Aber's consulting diamantaire. The results of these valuations are expected in June 1997. A 62.3-t sample from the A-418 kimberlite yielded 247.5 ct of diamonds (4.02 ct/t) valued at US$64.10/ct, or US$258/t. A-418 is estimated to contain 5.8 Mt to a depth of 250 m and a potential 15-20 Mt to a depth of 650 m.

Pipe A-154 North

A mini-bulk sample of 71.72 t from the A-154 North kimberlite yielded 156.8 ct of diamonds (2.19 ct/t) valued at US$35.10/ct, for a value of US$77/t. The A-154 North and A-418 kimberlite pipes are within 750 m of the A-154 South pipe. A-154 North has a preliminary resource of 5.3 Mt to a depth of 250 m, with a potential of 15 Mt to a depth of 650 m. Recent drilling results have increased the defined kimberlite tonnage to 10 Mt to a depth of 400 m. No additional testing of this pipe is planned because the upper one third of the pipe would be mined from the same open pit as A-154 South at minimal additional mining cost.

Pipe A-21

A mini-bulk sample from one large-diameter drill core sample yielded 3.1 ct of diamonds per tonne. The pipe contains an estimated 5 Mt to a depth of 400 m. Five additional large-diameter core holes have recently been drilled. The core was to be processed at the Yellowknife plant in April 1997 and the diamonds were to be sent to Perth, Australia, for cleaning, sorting and initial valuation.

AK Project

On the AK property, 150 km southeast of Lac de Gras, Mountain Province Mining Inc. (50%), together with its partners Glenmore Highlands Inc. (40%) and Camphor Ventures Inc. (10%), has drilled the AK-5034 kimberlite pipe. Drilling done to date has indicated an estimate of 18.3 Mt of diamondiferous kimberlite to a depth of 300 m. A mini-bulk sample of 104 t of this kimberlite, taken during the early winter of 1995/96 using a large-diameter diamond drill, yielded 2.48 ct of recovered diamonds per tonne.

Mountain Province Mining is of the opinion that a single diamond pipe of such size and grade in this remote locality is unlikely to be viable alone, and that two or three pipes, totalling perhaps 50 Mt of ore, may be needed. For this reason, the current exploration program in the vicinity is being aimed at the discovery of additional diamondiferous kimberlite pipes so that bulk sampling and feasibility studies can be carried out more economically on several pipes at the same time. Mountain Province Mining has recently raised $13 million to finance its diamond exploration work in the Northwest Territories and Glenmore Highlands has raised $4.65 million. The wholly owned Canadian exploration subsidiary of De Beers, Monopros Limited, has recently become a joint-venture exploration partner on this property.

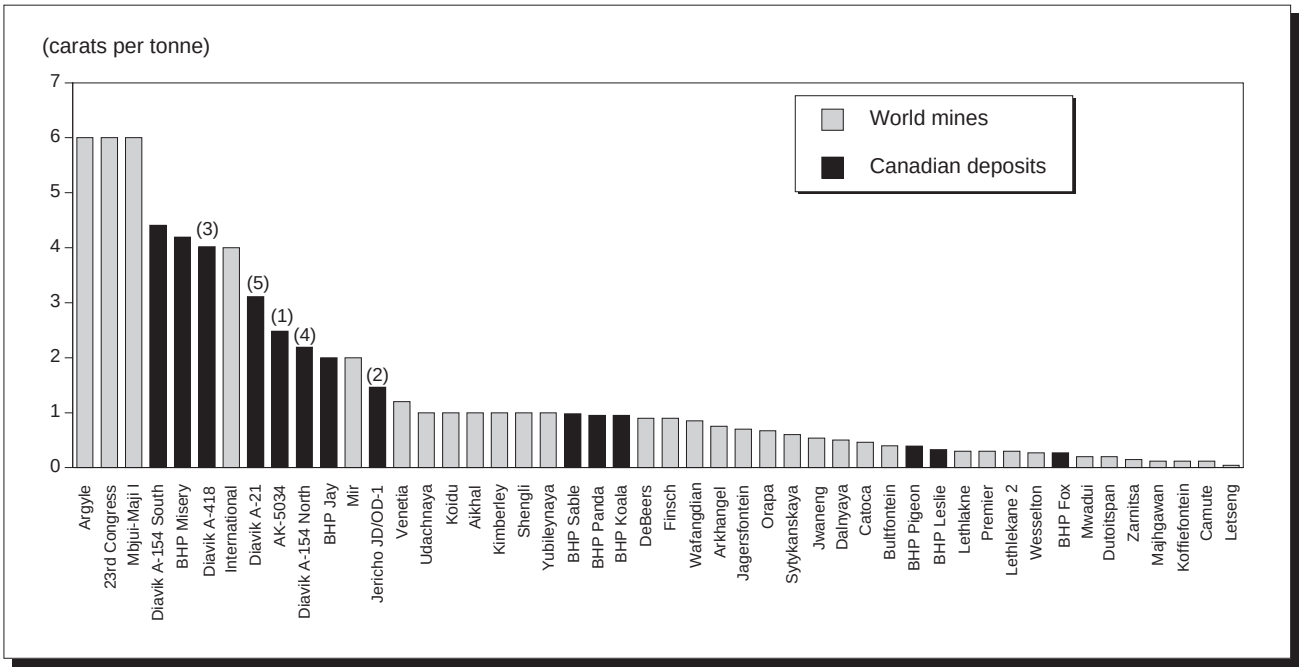
Jericho Project

Lytton Minerals Limited and its various partner companies have discovered at least six diamond-bearing kimberlite pipes on their various properties in the Northwest Territories.

A 94.5-t mini-bulk sample of kimberlite core from six delineation holes drilled into the JD/OD-1 kimberlite, owned by Lytton and New Indigo Resources Inc., yielded 138 ct of diamonds (1.46 ct/t). Early valuations averaged US$95/ct (US$139/t). The pipe is estimated to contain a resource of 15 Mt to a depth of 750 m.

A 15 000-t bulk sample was extracted in late 1996/early 1997 from a 257-metre-long decline driven at a depth of 75 m into the JD/OD-1 pipe. The sample was transported by winter road to the diamond sampling plant at the Lupin gold mine. Lytton plans to process an average of 4000 t per month there, with full results of the bulk sample test expected to become available by mid-1997 and to form the basis of a feasibility study for the Jericho project. Lytton has 12.5 million acres of mineral claims, approximately 30% of the area of the entire Slave Craton, which is the area of very old rocks that hosts all of Canada's significant diamond discoveries to date. The company recently signed a joint-venture exploration agreement on this property with Kennecott

Figure 3
Recoverable Diamond Grades From World Diamond Mines and Canadian Diamond Deposits



Source: Natural Resources Canada, based on published data.
(1) AK-5034 grade based on a sample of only 104 t of drill core. (2) JD/OD-1 grade based on a sample of only 94.5 t of drill core. (3) Diavik A-418 grade based on a sample of only 63.3 t of drill core. A 3000-t underground bulk sample is currently being processed. (4) Diavik A-154 North grade based on a sample of only 71.7 t of drill core. (5) Diavik A-21 grade based on a sample of only 6.9 t of drill core.

Canada Exploration Inc. (wholly owned by RTZ-CRA) and Ashton Mining of Canada Inc. (RTZ-CRA and Ashton also jointly own the large Argyle diamond mine in Western Australia).

COMPARISON OF RECOVERABLE GRADES AND VALUES OF CANADIAN DIAMOND DEPOSITS TO WORLD DIAMOND MINES

Available information concerning per-tonne recoverable diamond grades and values indicates that grades and values of the best 14 of the known Canadian diamond deposits compare favourably to those of world diamond mines (Figures 3 and 4). Figure 5 shows, for each province and territory, the number of properties that were undergoing diamond exploration in Canada in April 1993, August 1994, November 1995 and April 1997.

Diamond exploration continues on many properties at various Canadian locations. Extensive areas of Canada, chiefly in Manitoba, Ontario and Quebec, that are underlain by rocks of Archean age and therefore highly favourable for diamond exploration (Figure 6) have yet to be subject to serious exploration for diamonds.

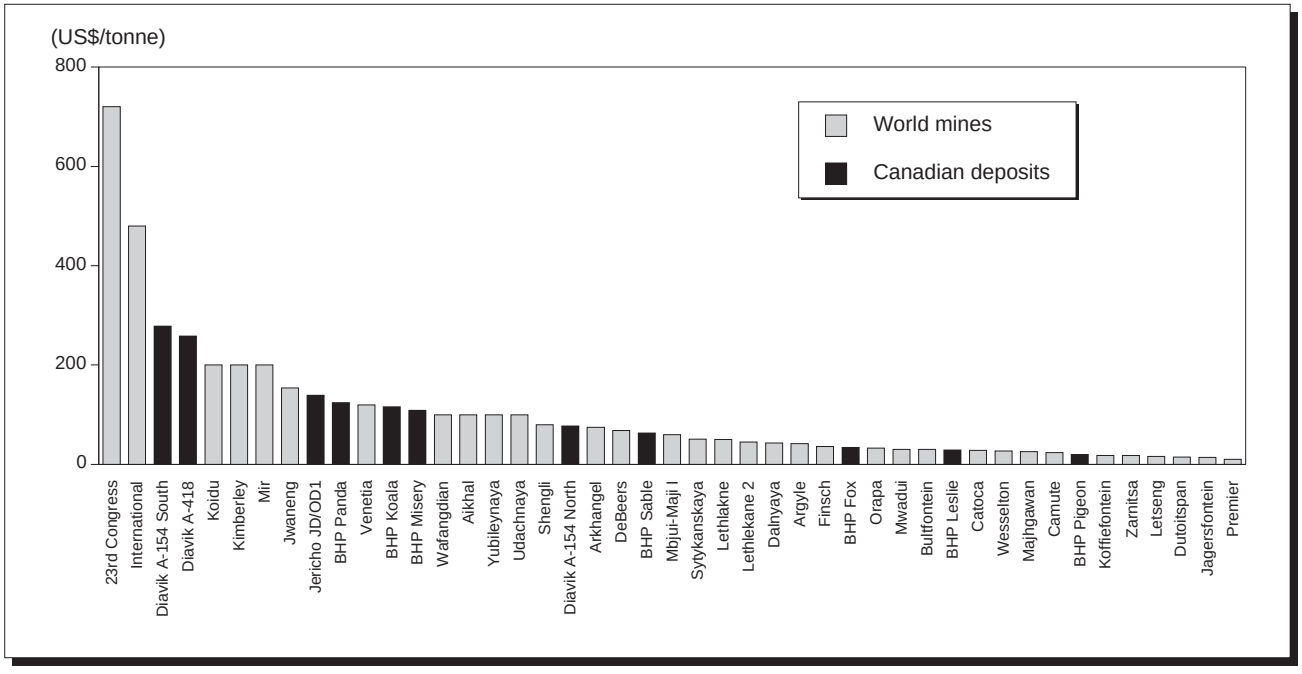
Canada appears destined to become one of the world's major diamond-producing nations within a few years. With 14 attractive diamond deposits discovered in Canada in only five years, many more diamond orebodies seem likely to be discovered in the coming years. Canada can therefore look forward to a long future as a major world diamond producer.

URANIUM DISCOVERY IN CANADA

Substantial quantities of uranium were discovered in Canada during the late 1970s and 1980s (Figure 7), some of it in exceptionally high-grade deposits. The Cigar Lake deposit (902 000 t averaging 12.2% uranium, plus an inferred 950 000 t averaging 4% uranium, for a total of 148 000 t of contained uranium), discovered in 1981, and the McArthur River (P2 North) deposit (457 000 t averaging 18.8% uranium, or 160 000 t of contained uranium), discovered in 1989, are Canada's most outstanding uranium discoveries ever. Either of these two deposits is outstanding compared to any uranium deposit previously discovered anywhere in the world. Deposits containing larger amounts of uranium have been discovered in the past, but none of these large deposits have such exceptionally high grades.

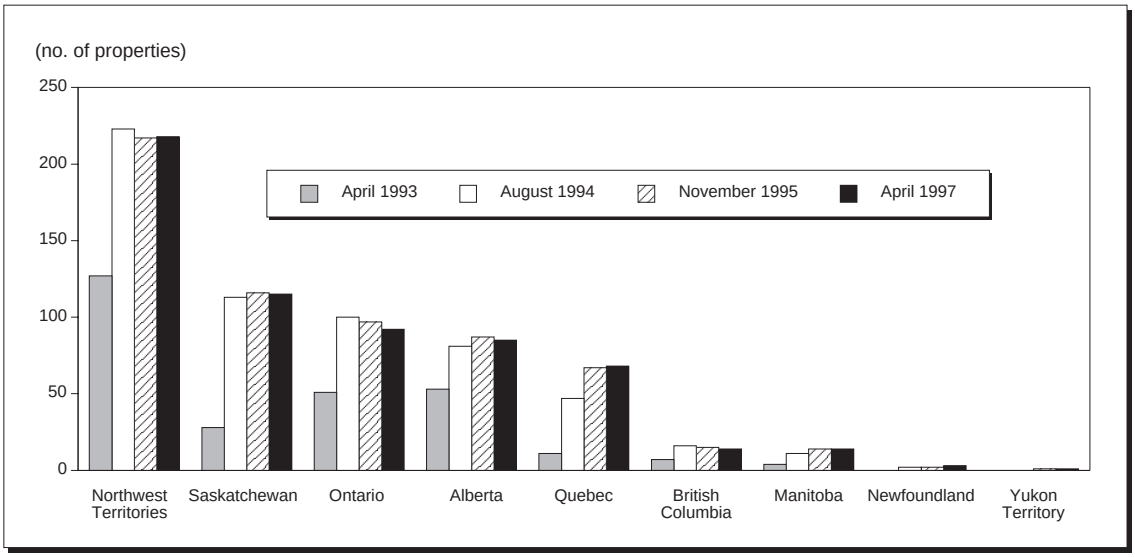
Nearly all of the uranium discovered in Canada during the 1970s and 1980s is in unconformity-related deposits (Figure 8). Most of them are in the Athabasca Basin region of northern Saskatchewan, but about half a dozen are in the Thelon Basin located to the west of Baker Lake, Northwest Territories.

Figure 4
Recoverable Diamond Values for World Diamond Mines and Canadian Diamond Deposits



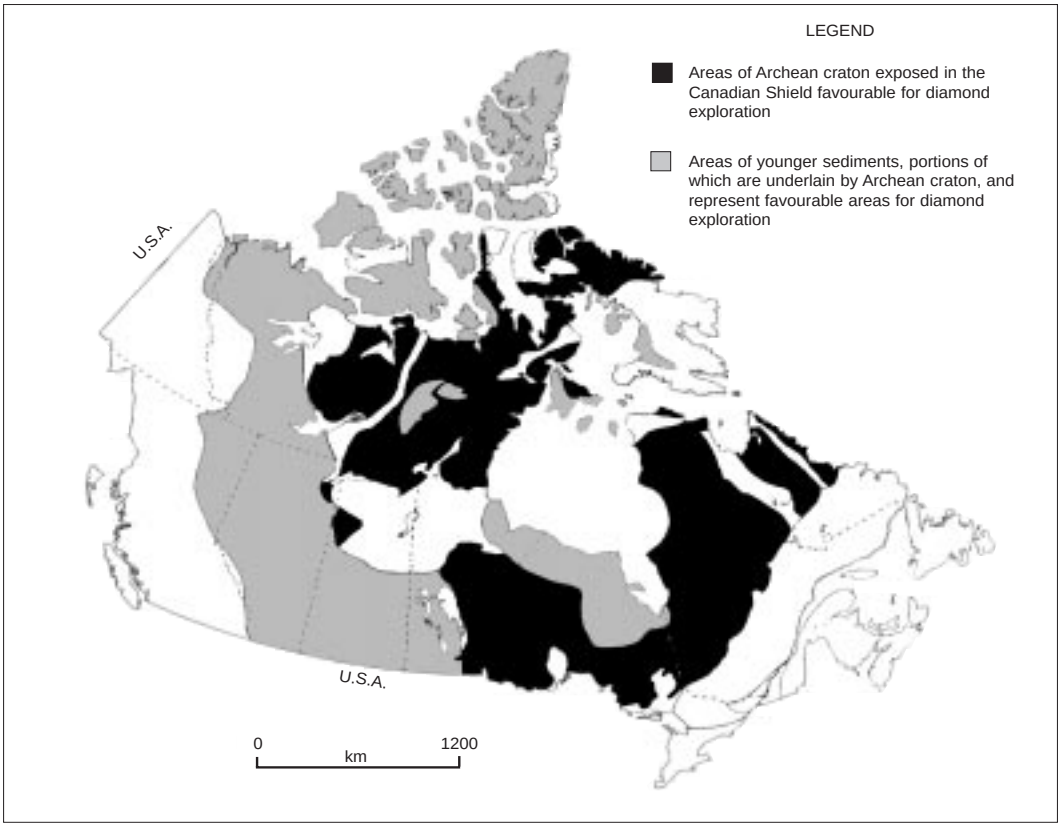
Source: Natural Resources Canada, based on published data.

Figure 5
Exploration for Diamonds in Canada
Regional Distribution of Properties



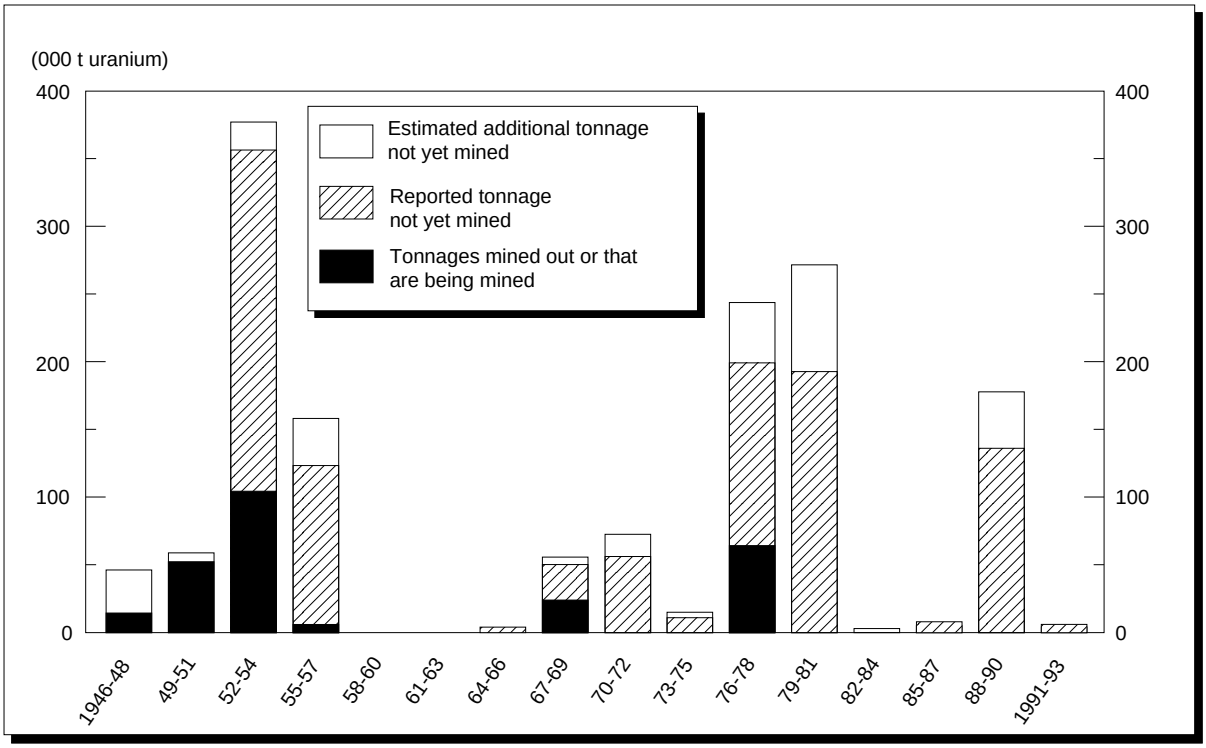
Source: Natural Resources Canada, based on MIN-MET CANADA database, and used under licence.

Figure 6
Areas of Canada Most Favourable for the Discovery of Economic Diamond Deposits Because They are Archean Craton



Source: Natural Resources Canada.

Figure 7
Uranium Discovered in Canada Per Three-Year Period, 1946-93



Source: Natural Resources Canada.

Relatively little uranium appears to have been discovered in Canada during the 1990s. This appears to be more the result of a cutback in exploration for new uranium deposits due to depressed uranium prices and concentration of exploration expenditures on further exploration of already known deposits (such as McArthur River, where substantial additional quantities of uranium were added by recent underground exploration) rather than to any anticipated difficulty in finding new uranium deposits in Canada. Underground exploration of the McArthur River deposit over the last few years has resulted in a major increase in both the known size and grade of the deposit. Only about 20% of the favourable zone there has been drilled from underground, so there still appears to be considerable potential to further increase reserves.

Recent uranium discovery experience in Canada suggests that when market conditions improve and exploration for new uranium deposits picks up, additional uranium discoveries seem almost certain.

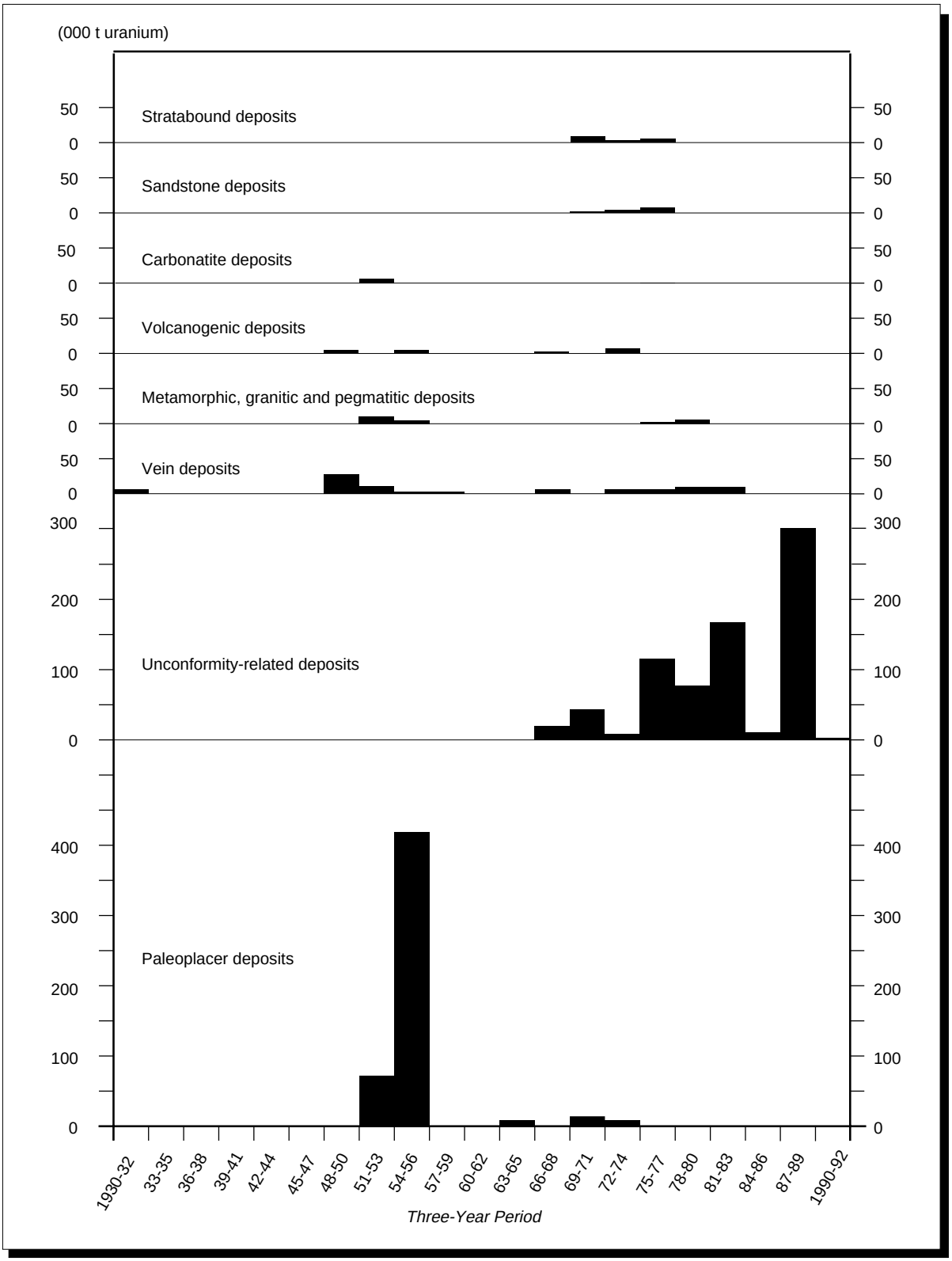
Somewhat higher uranium prices during the past two years, together with world uranium consumption substantially in excess of current uranium production, could result in an increase in Canadian uranium exploration directed at the search for new discoveries.

In recent years, grassroots uranium exploration expenditures have been quite low in Canada. Taking into account the outstanding uranium discoveries of the 1980s, it would be surprising indeed if additional new uranium discoveries were not made before too long. New discoveries, together with the important Andrew Lake, Kiggavik and several other attractive uranium deposits in the Thelon Basin of the Northwest Territories, as well as still other known but undeveloped uranium deposits in northern Saskatchewan, can be expected to yield a further generation of Canadian uranium mines.

NICKEL AND THE ARCHEAN-PROTEROZOIC BOUNDARY IN CANADA

The Thompson district, along with some 10 nickel deposits in the Cape Smith Nickel Belt of northern Quebec (some of which are being developed by Falconbridge Limited for production beginning later in 1997), and the important Voisey's Bay deposit all lie along or immediately adjacent to the Archean-Proterozoic boundary zone in the Canadian Shield (Figure 9). In Canada this zone extends some 3000 or more kilometres from southwestern Manitoba through northern Ontario, eastern James Bay and

Figure 8
Uranium Discovered in Canada Per Three-Year Period By Geological Deposit Type, 1930-93

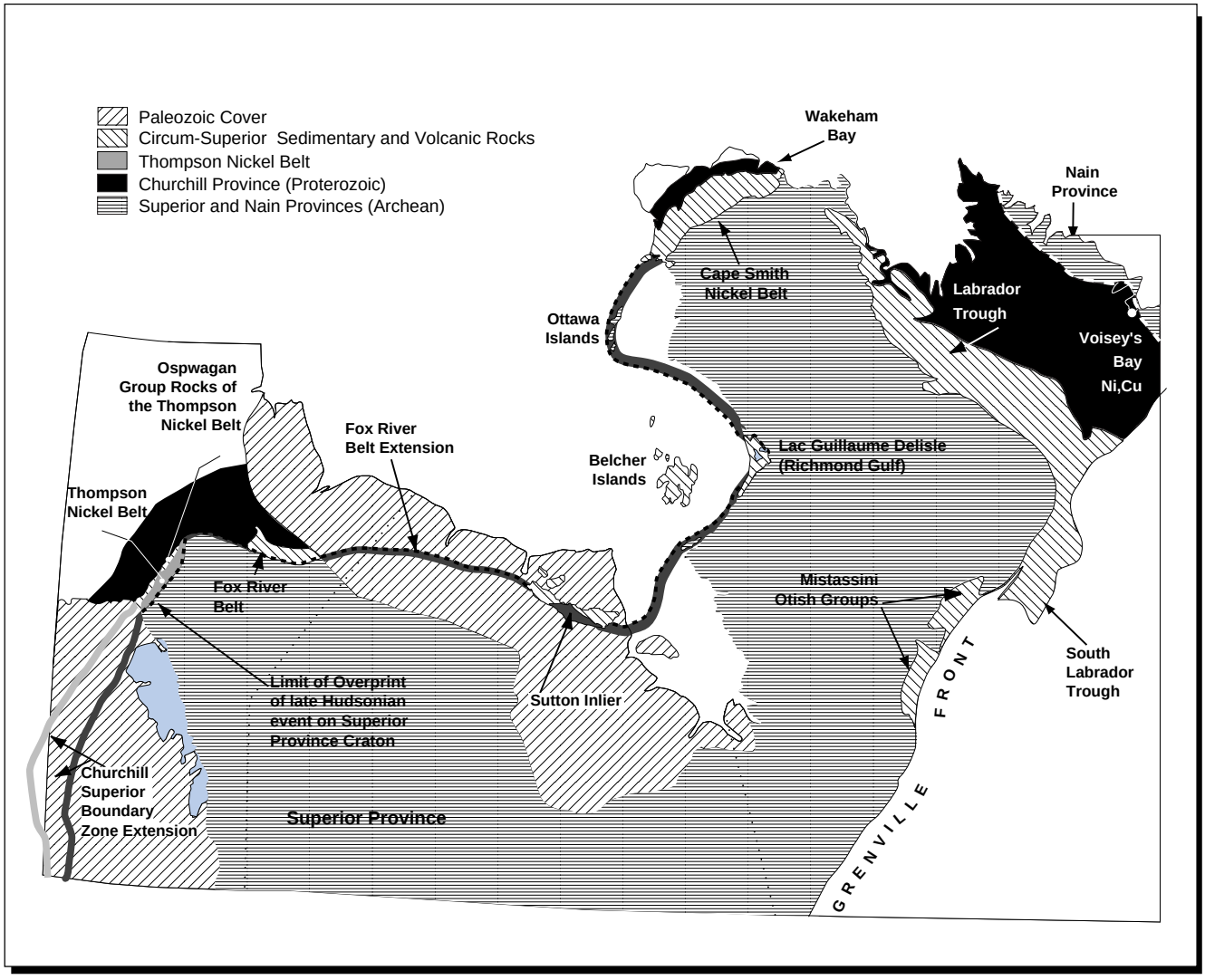


Source: Natural Resources Canada.

Hudson Bay, and the Ungava region of northern Quebec. Archean-Proterozoic boundary is also found in eastern Labrador, although whether it is a continuation of the same Archean-Proterozoic boundary that extends from the northern United States through Thompson and Ungava is not clear. The discovery of three promising nickel deposits (Voisey's Bay, Pipe Deep and Williams Lake) along the Archean-Proterozoic boundary zone over a period of no more than a year or two clearly demonstrates the high potential for discovery of still more nickel orebodies along that boundary. These discoveries, together with the deep, high-grade Victor-Nickel Rim copper-nickel deposit that was discovered at Sudbury in 1990 (nickel deposits are still being discovered at Sudbury even though the first nickel mines there were discovered more than 100 years earlier), the development of nickel-copper mines on the Raglan property in Quebec's Cape Smith Nickel Belt, and a major new underground exploration program of the Montcalm nickel deposit at Timmins, Ontario (discovered in 1976), make it clear that Canada still has an important future as a nickel producer and will soon regain its position as the world's largest nickel producer.

Note: Information in this review was current as of February 28, 1997.

Figure 9
Nickel Deposits and the Archean – Proterozoic Boundary



Source: Natural Resources Canada.

TABLE 1. RATE OF GROWTH OF EXPLORATION EXPENDITURES: CANADA COMPARED TO THE WORLD, 1991-97

Year	Exploration Expenditures in Canada[1]		Exploration Budgets in the Remainder of the World[2]	
	Growth Compared to Low Year 1992[2]			
	(C$ millions)	(%)	(US$ millions)	(%)
1991	531.8	n.a.	1 846	n.a.
1992	385.3	n.a.	1 610	n.a.
1993	477.3	+24	1 900	+18
1994	628.1	+63	2 130	+32
1995	717.6	+86	2 690	+67
1996	872.6[p]	+126	3 520	+119
1997	876.0[i]	+127	..	..

Source: Natural Resources Canada.
.. Not available; [i] Company spending intentions; n.a. Not applicable; [p] Preliminary.
[1] Federal-provincial survey of mining and exploration companies. [2] Metals Economics Group survey.

TABLE 2. AVAILABLE DATA CONCERNING CANADA'S MOST PROMISING DIAMOND DEPOSITS

Pipe	Total Tonnes Sampled	Total Carats Recovered	Average Grade	Average Value	Average Value
			(carats/tonne)	(US$/carat)	(US$/tonne)
BHP/BLACKWATER GROUP/ LAC DE GRAS PROPERTIES					
Panda	3 402	3 244	0.95	130	124
Misery	1 030	4 313	4.19	26	109
Koala	1 550	1 465	0.95	122	116
Fox	8 223	2 199	0.27	125	34
Leslie[1]	680	223	0.33	89	29
Pigeon[1]	154	60	0.39	51	20
Jay[1]	237.6	476.8	2.01	..	..
Sable	1 096	1 070	0.98	64[a]	63
DIAVIK PROPERTY					
A154 South	2 900	12 800	4.41	63.00	278
A154 North	71.72	156.81	2.19	35.10	77
A-418	63.3	247.5	4.02	64.10	258
A-21	6.9	21.49	3.11	..	..
JERICHO PROPERTY					
JD/OD1[2]	94.5	138	1.46	95	139
AK PROPERTY					
5034	104	257	2.48	..	..

Source: Natural Resources Canada, from company reports.
.. Not available.
[a] The $64/ct value includes a gem-quality diamond weighing 9 ct. If this stone is excluded, the average value is $48/ct and the average value per tonne is $47.
[1] The Leslie, Pigeon and Jay deposits are not currently scheduled for mining.
[2] A 15 000-t bulk sample has been mined and is being processed.