

# Canadian Mineral Exploration and Discovery Analysis

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## CANADA'S STANDING AS A WORLD EXPLORATION TARGET

In 1996, exploration expenditures in Canada totalled \$895 million. Canada remained one of the world's top targets (second after Australia) for mineral exploration that year. In both 1997, with exploration expenditures (preliminary) of \$804 million, and probably again in 1998, with company spending intentions of \$771 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 since 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 1997 (Figure 1). No other single country, other than Australia, has come close to challenging Canada in 1997 or will do so in 1998.

## DISCREPANCY BETWEEN EXPLORATION SURVEY RESULTS

The confusion concerning Canada's relative share of worldwide non-petroleum mineral exploration activity continues. The results of the proprietary annual survey of worldwide mineral exploration expenditures prepared by the Metals Economics Group (MEG) of Halifax, Nova Scotia, which represents a

**Figure 1**  
**Top Three Country Destinations of Mineral Exploration Capital from Worldwide Sources, 1972-97**

Year	Rank		
	First	Second	Third
1997	Australia	<b>Canada</b>	United States
1996	Australia	<b>Canada</b>	United States
1995	Australia	<b>Canada</b>	United States
1994	Australia	<b>Canada</b>	United States
1993	Australia	<b>Canada</b>	United States
1992	Australia	<b>Canada</b>	United States
1991	<b>Canada</b>	Australia	United States
1990	<b>Canada</b>	Australia	United States
1989	<b>Canada</b>	Australia	United States
1988	<b>Canada</b>	Australia	United States
1987	<b>Canada</b>	Australia	United States
1986	<b>Canada</b>	Australia	United States
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1982	<b>Canada</b>	Australia	United States
1981	<b>Canada</b>	Australia	United States
1980	Australia	<b>Canada</b>	United States
1979	Australia	United States	<b>Canada</b>
1978	Australia	United States	<b>Canada</b>
1977	United States	<b>Canada</b>	Australia
1976	<b>Canada</b>	United States	Australia
1975	United States	<b>Canada</b>	Australia
1974	<b>Canada</b>	United States	Australia
1973	Australia	United States	<b>Canada</b>
1972	United States	Australia	<b>Canada</b>

Source: Natural Resources Canada, based on official Canadian and Australian statistics and the best available data for the United States.

Notes: 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.

partial survey, has generally ranked Canada considerably lower than does the more comprehensive official Canadian exploration survey. MEG ranked Canada first in 1991, third in 1993, fifth in 1994, third in 1996 and fifth again in 1997 (after Latin

America, Australia, Africa, and the Pacific-Southeast Asia). This relatively low ranking is partly because Canada, a single country of 10 million km<sup>2</sup>, is being compared with multi-country continental areas such as Latin America (20.5 million km<sup>2</sup>) and Africa (30.3 million km<sup>2</sup>). Also, Latin America and Africa each have total values of mineral production that are considerably higher than that of Canada.

Canada's actual position in terms of exploration expenditures, compared to single countries rather than geographic areas, was first in 1991 and second after Australia in the subsequent years from 1992 to 1997 inclusive. No other single country comes close to matching Canada's position, especially when all exploration expenditures, including those of the smaller junior companies that are not included in the MEG survey, are taken into account.

The MEG survey of exploration budgets for 1997 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 exploration 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<sup>1</sup>) 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 that were carried out by the American Bureau of Metal Statistics (ABMS) on behalf of the Society of Economic Geologists. However, the ABMS survey no longer provides useful exploration expenditure statistics; therefore, since 1992, the MEG survey, with its limitations, has been the only source of aggregate exploration statistics for the United States as well.

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. It is unlikely that any of the companies that fail to respond have significant mineral

exploration programs; it is therefore likely that significantly more than 99% of total exploration expenditures of all the companies surveyed are gathered by this federal-provincial survey. But there are almost undoubtedly other companies that did explore in Canada that were not surveyed because neither the federal nor provincial governments were aware that these companies were involved in mineral exploration in Canada that year.

## Differences Between Canadian and Australian 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 have excluded all expenditures at producing mines directed at the search for extensions, to depth and laterally, of the orebodies being mined. Such expenditures have been included in "development expenditures." On the property of an existing mine, only exploration for a "new mine" (additional deposit) has been counted as exploration expenditures in Canada. In Australia, on the other hand, 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."

As a result, Australian exploration expenditure statistics are somewhat inflated relative to Canadian exploration expenditure statistics. This is demonstrated by the fact that, over the six fiscal years 1990/91 to 1995/96 inclusive, exploration expenditures on production leases averaged 22.1% of total exploration expenditures in Australia, while 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. Also in Canada, such expenditures can be anywhere on a company's entire property surrounding its mines, and not only on ground equivalent to the more restricted Australian "production leases." If Canadian "on-property" exploration expenditures were reported and compiled using the Australian system, some of these Canadian expenditures would not be included as "production lease" expenditures but, rather, as exploration expenditures not on production leases; the Canadian percentage would therefore be significantly lower than 12.9% and the percentage difference would be greater than 22.1% in Australia minus the 12.9% in Canada.

These percentages differ for many reasons. What is clear is that, because of structural reporting differences, aggregate mineral exploration expenditures reported for Australia are higher, by an unknown but significant amount, relative to how the same exploration expenditures would be reported in Canada.

<sup>1</sup> Schreiber, Hans and Emerson, Mark, 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.

Therefore, in recent years, exploration expenditures in Australia have not actually exceeded exploration expenditures in Canada by as much as a simple comparison of each country's respective statistics would suggest.

The value of Australian production of non-petroleum minerals is roughly one third greater than that of Canadian production. For this reason alone, it would be expected that annual exploration expenditures in Australia would normally exceed annual exploration expenditures in Canada.

### **Differences Between Official Canadian Exploration Statistics and Metals Economics Group Exploration Statistics for Canada**

The annual exploration statistics produced by MEG substantially understate both annual exploration expenditures in Canada and the share of worldwide exploration activity directed at Canada. There are several reasons for this. First, MEG's 1997 exploration expenditure totals account for about only two thirds of total exploration expenditures in Canada. In 1997, this survey covered only 84 companies exploring in Canada, a number that is substantially less than the 617 companies that were actually engaged in mineral exploration in Canada that year.

For the survey years 1993 to 1995, MEG used increasing exploration budget cut-offs to limit the universe of companies it had to survey. The exploration budget cut-off was US\$1 million for 1993 and prior years. This was raised to US\$2 million in 1994 and then to US\$3 million in 1995. It decreased to US\$2.9 million in 1996 and stayed at US\$2.9 million in 1997.

Because of the relatively high cut-offs (US\$2.9 million, equivalent to C\$4 million in 1997), the MEG survey has consistently and substantially underestimated exploration activity in both Canada and Australia. This has been because, at least until recently (and probably again because of the difficulties in raising exploration capital in the aftermath of the Bre-X incident), the contribution made by junior exploration companies has been so much greater in Canada and Australia than it has been in all other countries. Canada and Australia both have hundreds of smaller producing companies and non-producing (junior) companies that individually have spent less on exploration annually than the MEG cut-off but that as a group have accounted for, and still account for, a substantial amount of domestic exploration activity in Canada and Australia.

In 1997, MEG reported aggregate exploration budgets for Canada of US\$435.9 million on the basis of 84 company returns. In addition to the 84 larger companies surveyed by MEG, MEG surveyed another 71 companies that expected to explore in Canada in

1997, but that expected to spend less than US\$2.9 million on exploration worldwide that year. These smaller company exploration totals were reported by MEG in a table of companies with individual exploration expenditures of less than US\$2.9 million worldwide (the MEG cut-off value), so they were not included in MEG's worldwide exploration totals. These 71 companies reported exploration spending intentions for Canada of US\$61.7 million (C\$84.5 million) in addition to the US\$435.9 million for the 84 companies counted by MEG. A company-by-company comparison of the companies surveyed by MEG for 1997 with individual company spending intentions for Canada from the 1997 federal-provincial survey of mining and exploration companies shows that in addition to the 84 companies plus 71 companies surveyed by MEG, another 462 companies with exploration expenditures in Canada were not covered by the MEG survey. According to Canadian federal-provincial statistics, the 462 companies covered by the federal-provincial exploration survey, but not by MEG, planned to spend US\$199.4 million exploring for the commodities included in the MEG survey. This amount plus the US\$61.7 million picked up by MEG for the 71 smaller companies surveyed by MEG, but not included in the MEG totals because they spent less than US\$2.9 million worldwide, totals an additional US\$261 million, relative to the MEG total of US\$435.9 million for exploration in Canada. Of the US\$199.4 million of exploration dollars in Canada not picked up by MEG, some US\$47.1 million was to be spent by 12 companies, each of which had reported to the federal-provincial survey planned 1997 exploration expenditures in Canada that are in excess of the 1997 MEG survey cut-off of US\$2.9 million. None of these 12 companies appear to have been surveyed by MEG. This means that MEG should probably have reported exploration expenditures in Canada of roughly US\$483 million for companies with exploration expenditures of US\$2.9 million or more, instead of only US\$435.9 million. Furthermore, the MEG survey does not cover exploration for all of the mineral commodities actually being sought by companies. For example, the most recent worldwide exploration statistics for uranium, compiled by the International Atomic Energy Agency, indicate that uranium exploration in Canada accounted for roughly 30% of the US\$107 million of uranium exploration expenditures worldwide. The 1997 MEG survey has Canada accounting for only 10.8% of worldwide exploration spending of US\$4.03 billion for the commodities covered by the MEG survey, which is much less than the 30% for uranium. For a comprehensive exploration comparison for all mineral commodities worldwide, exploration expenditures for all the other mineral commodities not covered by the MEG survey, chiefly the industrial minerals (other than diamonds, which are included by MEG), iron ore, bauxite and coal would have to be included in addition to those for uranium.

Another difficulty with the MEG survey is that exploration expenditures compiled by that survey are not

comparable across all companies. In addition to including surface exploration expenditures, some companies are including the search for extensions to orebodies in producing mines in the budgets that they report to MEG, but others are not. Other companies are including the cost of feasibility and engineering studies, but most companies are not. Because of the 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 has clearly excluded both the search for new ore in producing mines and in deposits committed for production, as well as expenditures on feasibility studies and engineering studies at such properties).

As already discussed, 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. The area of Africa is triple or more the areas of these three important mining countries. Both Latin America and Africa have mineral industries with annual values of non-petroleum mineral production approximately 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 the changing methodology used by MEG, not only because of the changing exploration expenditure cut-offs 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 10 times that of Canada, 10 times that of the United States, and about 12 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 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 with comparing exploration expenditures for individual countries with expenditures combined by geographical region.

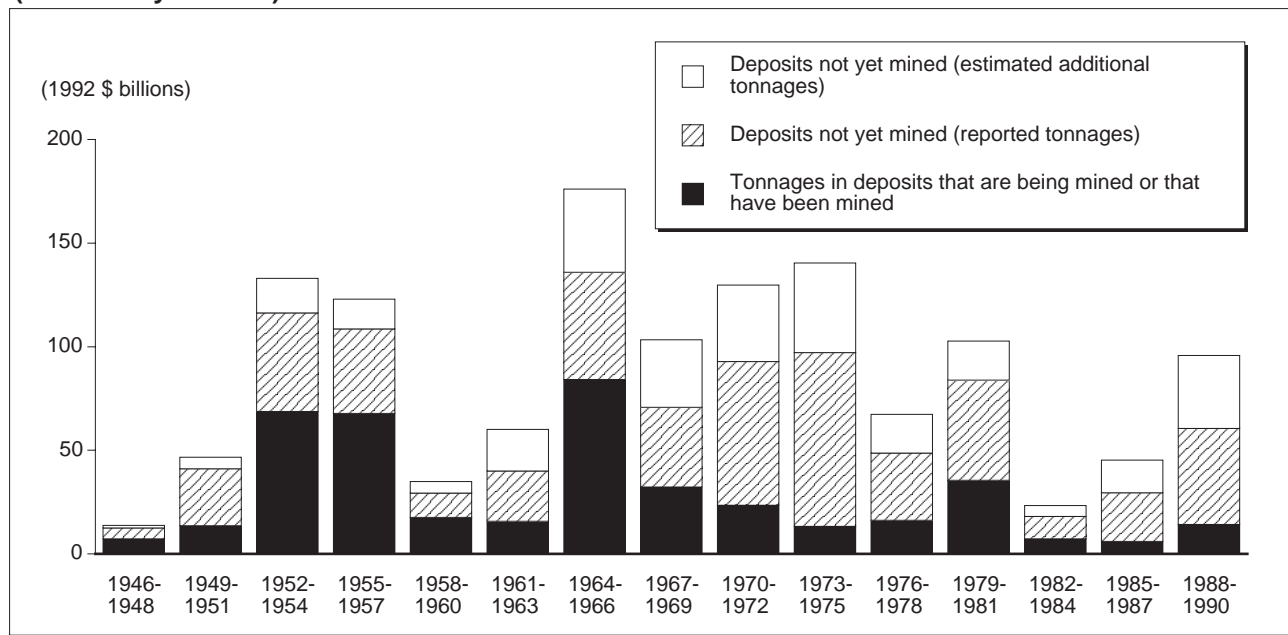
## ARE DISCOVERY RATES SUFFICIENT TO MAINTAIN CANADA'S MINERAL INDUSTRY FOR THE FORESEEABLE FUTURE?

Beginning about 1950, Canada's non-petroleum mineral industry grew rapidly. This happened not only because of marketing opportunities that resulted from a growing world economy, but also because of a remarkable period of metals exploration and discovery in Canada over a 30-year period that began in the early 1950s. Subsequently, the discovery rate in Canada dropped off considerably over a period of approximately six years from 1981 to 1987 (Figure 2) and the discovery costs per dollar of metal discovered became very high during these six years. There was notable improvement in the three-year period 1988-90, but the cost of discovering this metal far exceeded the costs of the 1950s, 1960s and 1970s, even after adjustment for inflation. Natural Resources Canada's discovery analysis has not been updated since 1990 but, on the basis of incomplete information, indications are that the discovery record in Canada was, at best, only mediocre in the subsequent three-year period 1991-93. However, the next three-year period, 1994-96, appears to have been the most successful three-year discovery period in Canada since the 1970s. Discovery success in Canada subsequent to 1996 also looks good.

## RECENT MINERAL EXPLORATION AND DISCOVERY ACTIVITY AND RESULTS

The notable Canadian discovery success of the mid-1990s appears to be continuing. While it is impossible to list here all the discoveries made in Canada in recent years, the following text will yield a rough idea of recent successes. In the case of nickel, in addition to the nickel-copper-cobalt deposit at Voisey's Bay where 116 Mt of attractive mineralization had been identified by the end of 1997, and where Inco Limited has indicated that the company expects to establish 150 Mt or more, another four nickel-copper deposits have recently been discovered at Sudbury, Ontario, and all four of them are fairly deep. Falconbridge Limited has found the relatively high-grade Onaping Deep deposit that was initially intersected by drilling

**Figure 2**  
**Value of Metals Discovered in Canada from 1946 to 1990, at 1987-91 Average Prices**  
**(Preliminary Results)**



Source: Natural Resources Canada.

in 1994, a deposit that is distinct from that currently being mined at the company's Onaping mine on the northwestern rim of the Sudbury intrusion. A second Falconbridge discovery at Sudbury is the Norman West deposit, a deep deposit on the northeast rim that Falconbridge initially intersected by drilling in 1996. In addition, Inco has announced the discovery of two new nickel deposits in the vicinity of the Copper Cliff South mine. These are the Kelly Lake deposit, south of the mine, at a depth of 1370 m, and an as-yet-unnamed high-grade deposit located to the north of Copper Cliff South at a depth of 900 m.

Also in Ontario, underground exploration is in progress at Inco's deep Victor No. 2 copper-nickel deposit on the eastern rim of the Sudbury intrusion (discovered in 1990), and on the Montcalm nickel-copper deposit near Timmins where Outokumpu Mines Ltd. has undertaken underground exploration and a feasibility study is in progress on a deposit that was initially discovered in 1976.

In Manitoba, Falconbridge continues to drill the recently discovered promising Williams Lake nickel deposit along the southwestern extension of the Thompson Nickel Belt. In southeastern Manitoba, Canmine Resources Corporation has discovered the Maskwa nickel-copper deposit in the Bird River region near the site of the former Dumbarton mine. In Quebec, an aggressive exploration program on Falconbridge's Raglan property in the Ungava Nickel Belt, where production began in 1997, is discovering additional nickel-copper ore.

Also in Quebec, Noranda Inc. discovered the deep Porphyry Mountain copper-molybdenum deposit at its Gaspé Copper operation. This deposit contains some 200 Mt that average 0.73% copper and 0.08% molybdenum (with the copper and molybdenum values together corresponding to a 1% copper-equivalent grade), at depths of between 1000 m and 1700 m below surface.

In Ontario, the recently discovered Separation Rapids pegmatite deposit, some 60 km north of Kenora and 60 km east of and along strike from the Tanco mine at Bernic Lake, Manitoba, which is being explored by Avalon Ventures Limited, is yielding attractive results. The "Big Whopper" pegmatite on the property has been traced over a strike length of 1.2 km and ranges from 15 to 80 m in thickness. The deposit contains at least 7 Mt containing 30-60% of the mineral petalite ( $\text{LiAlSi}_4\text{O}_{10}$ ) and 25-30% of a rubidium-rich potassium feldspar. The deposit has lithium grades in the range of 1.3-1.7%  $\text{Li}_2\text{O}$  and rubidium grades in the range of 0.25-0.35%  $\text{Rb}_2\text{O}$ . Petalite is used in ceramics.

In Saskatchewan's Athabasca Basin, exploration continues for high-grade uranium orebodies such as the world-class Cigar Lake and McArthur River deposits discovered there in 1981 and 1989, respectively. Nine or more new uranium mines in the Athabasca Basin, including Cigar Lake and McArthur River, are currently either being developed for production or are in the final approval process.

Diamond exploration in Canada continues to locate new kimberlite pipes, some of them diamondiferous, in the vicinity of the Ekati mine, the Diavik project, the Jericho project and the AK-5034 deposit. At Fort à la Corne, Saskatchewan, 80 kimberlites have been discovered, about half of them diamondiferous, including several diamond deposits that are very large but low in grade. Exploration of the Fort à la Corne area for diamonds continues. In Alberta's Buffalo Hills, a joint exploration venture of Ashton Mining Canada Inc. (42.5%), Alberta Energy Corporation (42.5%) and Pure Gold Resources Inc. (15%) has discovered 23 kimberlite intrusions since early 1997, with a number of other geophysical targets yet to be tested by drilling. Although relatively low in grade, several of the kimberlites have potentially economic diamond values.

In the Yukon, work continues on the Kudz Ze Kayah, Wolverine and Wolf copper-zinc-lead-silver-gold deposits and the Fyre Lake copper-cobalt-gold deposit. In the Northwest Territories (N.W.T.), more than 15 attractive diamond deposits have been discovered to date, with additional discoveries highly likely. Also in the N.W.T., WMC International Ltd. continues to drill the large Meliadine West gold deposit. Other attractive gold deposits are being further explored in various parts of Canada. These include the Boston gold project (BHP Minerals Canada Ltd.), the George Lake project (Kit Resources Ltd.), and the Meadowbrook project (Cumberland Resources Ltd.), all three of them in the N.W.T.

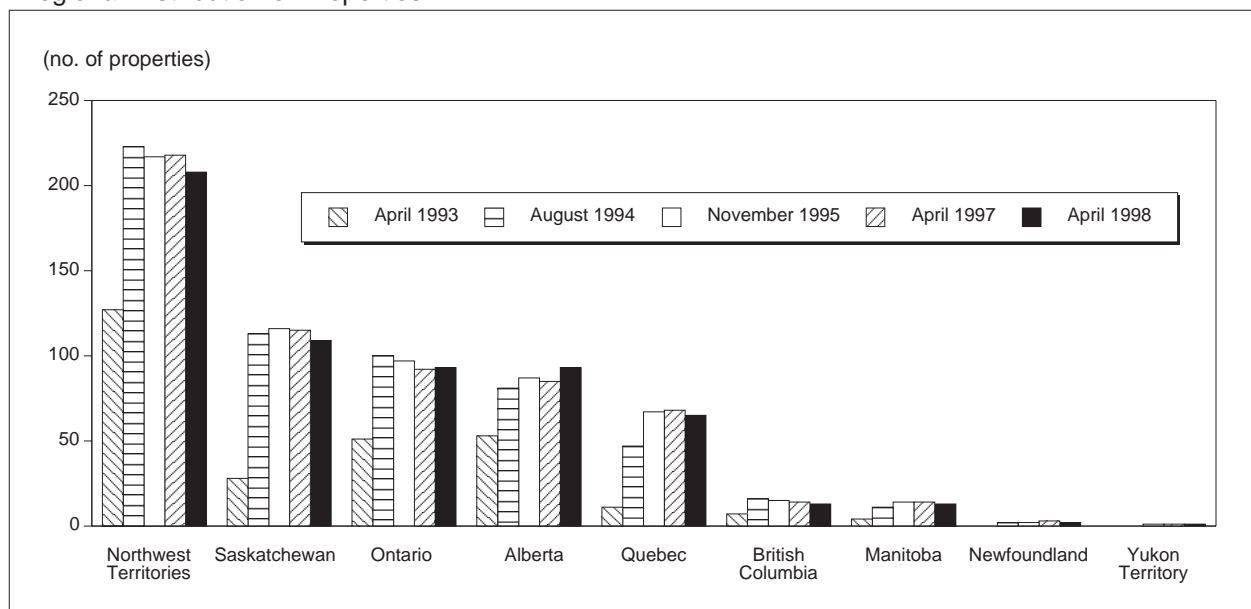
## DIAMOND EXPLORATION HIGHLIGHTS

### Introduction

In April 1998, there were some 600 diamond exploration properties in Canada, about the same number as in 1994, 1995 and 1997. The provincial/territorial distribution of those properties is depicted in Figure 3. The most notable diamond exploration event of 1997 was the discovery of diamondiferous kimberlites in the Buffalo Hills of northwestern Alberta where 23 separate kimberlites had been discovered by the end of March 1998. A considerable number of promising geophysical targets remain to be tested. The diamond contents of the most attractive of the Alberta kimberlites appear to be considerably lower than those of the N.W.T. deposits, but gem-sized, gem-quality diamonds are present. The available grades (based on nothing more than very small-sized samples) do fall within the range of grades of the world's diamond mines. The potential economic significance of these Alberta discoveries will not be clear until larger bulk samples are taken from them and a sufficient quantity of diamonds are recovered to permit diamond valuation.

Exploration continues in the Fort à la Corne region of Saskatchewan, to the east of Prince Albert, where the first kimberlite discovery was made in 1988. Several companies that are active there have discovered more than 80 kimberlite intrusions, and some of them are exceptionally large and about half are diamondiferous. The best available information on diamond

**Figure 3**  
**Exploration for Diamonds in Canada, 1993-98**  
Regional Distribution of Properties



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

contents indicates that their diamond contents are low, but they are close to the diamond contents of the world's lowest-grade diamond mines. Diamond exploration continues in various other parts of Canada, but what is somewhat surprising is that there is so little of this exploration going on in the extensive areas of Saskatchewan, Manitoba, Ontario and Quebec that would appear to offer discovery potential that is just as favourable as that for the Northwest Territories prior to the initial diamond discoveries there.

In March 1998, Diavik Diamond Mines Inc. filed a project description with the Government of Canada for its proposed \$875 million Diavik diamond mine at Lac de Gras. In 2002, when the Ekati diamond mine and the Diavik mine are both in full operation, these two mines together are expected to have a combined annual revenue of about \$1.3 billion. This will place Canada in fourth or fifth position in the world in terms of annual diamond production value. Still other mines from already-known diamond deposits and from likely future diamond discoveries in Canada seem almost certain, so Canada can be expected to become an even more important diamond producer.

### Ekati Diamond Mine

BHP and its associates are developing the Ekati diamond mine for production to begin in October 1998. A total of 100 kimberlite intrusions have now been found on this property, including 23 discovered in 1997. The most interesting of the 1996 discoveries are the comparatively small Koala North and Beartooth kimberlites. The diamond contents for these kimberlites are listed in Tables 1 and 2. Bulk samples of 200 t were taken from each of these 1996 kimberlites in 1998, but their diamond contents are not yet available. Of the twenty-three 1997 discoveries, the 97-A, 97-B, 97-C and 97-D kimberlites are the most promising (Table 2). The grades for the above six kimberlites, with recovered diamond contents that range from 1.12 to 5.52 ct/t, are based on core samples that weigh only 57 to 668 kg. Larger mini-bulk or bulk samples will be required to provide meaningful grades. Exploration continues on the large BHP-Dia Met property where the potential for the discovery of additional diamond orebodies is excellent. Current mining plans, based on production from the Panda, Misery, Koala, Fox and Sable deposits (Table 3), should support an initial mine life of some 17 years. An operation lasting 25 or more years seems probable based on the other orebodies that have already been discovered.

### Diavik Project

The Diavik project is operated by Diavik Diamond Mines Inc., with a 60% interest in the project. The company is a wholly owned subsidiary of the large multinational mining company Rio Tinto Zinc PLC of London, England, as is Kennecott Canada Inc., which previously held Rio Tinto's 60% interest in the prop-

erty. The remaining 40% of the project is owned by Aber Resources Limited of Vancouver, British Columbia. Aber has put up 40% of the costs and retains the right to market its 40% share of diamond production.

To the end of 1997, a total of 50 kimberlite pipes had been discovered on the Diavik property, of which 20 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. In March 1998, Diavik Diamond Mines Inc. filed the project description for a Diavik mine with the federal government, thus commencing the government's environmental assessment process for this proposed \$875 million (+25%) project. Diavik is located 300 km northeast of Yellowknife and 35 km southeast of the BHP Ekati diamond mining operation. The company hopes to have the necessary approvals in place by the fall of 1999 with construction to start soon thereafter, and production planned for 2001 or 2002. This schedule is to be refined during the feasibility study that is now in progress. An ore production rate of 2 Mt/y is planned in the prefeasibility study using a conventional diamond recovery plant with heavy medium separation followed by X-ray diamond recovery. Diamond production will increase to the range of 6 million to 8 million ct/y. Annual production will decline to 3 million to 4 million ct/y beyond year 15, and the life of the operation is expected to be 16-22 years. Mining and production figures and timetables are subject to revision upon completion of the feasibility study, which is expected in the fourth quarter of 1998. When production is achieved, direct employment on the project will be between 300 and 400.

The resource base at Diavik comprises an estimated 123 million ct of diamonds, of which 104 million ct, or 83% of the total resource, have been included in the current estimated mineable reserve. The kimberlite pipes at Diavik are under shallow water adjacent to a 20-km<sup>2</sup> island in Lac de Gras. Temporary dikes will be required to isolate the pipes from the lake for mining. While exact sequencing of the dike construction is not yet final, the prefeasibility mining plan contemplates the initial construction of a dike around the A-418 pipe, and then using the granite waste that will be produced from the mining of this orebody to construct another dike around the A-154 South and A-154 North pipes.

Exploration of the Diavik property continues. In 1998, up to \$9 million will be spent on exploration, including up to \$4.3 million for drilling on previously identified pipes other than the four main pipes. A mini-bulk sample will be taken on the recently discovered A-11 kimberlite.

### Jericho Project

Lytton Minerals Limited and the company's various partner companies have discovered at least seven diamond-bearing kimberlites on their properties in the Northwest Territories.

On the Jericho property of Lytton Minerals and New Indigo Resources Inc., a 14 500-t bulk sample was extracted during the winter of 1996/97 from underground workings in the JD/OD-1 kimberlite and hauled 30 km by truck to Lytton's bulk sampling plant located at the Lupin gold mine. A representative 9400-t sample of this material, covering all phases within the pipe, was processed to yield 10 539 ct of diamonds (1.12 ct/t) having an average value of US\$60/ct. The remaining 5100 t were not processed because of the predictability of the diamond grades that were obtained from the 9400 t that were processed. The largest diamond recovered weighed just over 40 ct; the largest gem-quality diamond weighed 23.99 ct. An unusual number of larger diamonds were recovered. The JD/OD-1 pipe has a surface area of 1.2 ha. Its resources, to a depth of 300 m, are as follows:

- Indicated resource, 5.0 Mt, (0.93 ct/t);
- Inferred resource, 1.1 Mt, (1.0 ct/t); and
- Total resource, 6.1 Mt, (0.94 ct/t).

An open pit to a depth of 180 m would recover a mineable resource of 3.8 Mt averaging 1.01 ct/t, with a stripping ratio of 4.2:1. Preliminary scoping studies, based on mining the higher-grade phases first, suggest that the mining rate should be about 1650 t/d at a capital cost of approximately \$50 million.

The 1.8-ha JD/OD-3 kimberlite, which is located under a small lake some 7 km west of JD/OD-1, has resources of 10.5 Mt, to a depth of 350 m, averaging 0.7 ct/t. This estimate is based on the 7.34 ct of diamonds recovered from a 10.53-t large-diameter core sample (0.697 ct/t). A 30-t mini-bulk sample that was taken in early 1998 is to be treated at Lytton Minerals' plant in North Vancouver, British Columbia. A bulk sampling program, along with further delineation drilling, is planned for the JD/OD-3 pipe in early 1999. Exploration continues for additional kimberlites on the AK/CJ property.

### Ice Claims LI-201 Kimberlite

Kennecott Canada Inc. has the right to earn a 50% interest in certain claims jointly owned by Lytton Minerals Limited and New Indigo Resources Inc. This agreement excludes the Jericho property. Kennecott has discovered the LI-201 diamondiferous kimberlite (which is entirely land-based) on the Ice claims. A 281.1-kg sample from this kimberlite has returned 60 diamonds that each weigh more than 0.15 ct.

### AK Property

On the AK property, located 150 km southeast of Lac de Gras, Mountain Province Mining Inc. (90%) and its partner Camphor Ventures Inc. (10%) have drilled the AK-5034 kimberlite pipe that was discovered in 1995. This drilling has indicated some 20 Mt of diamondiferous kimberlite to a depth of 350 m. A 104-t

mini-bulk sample of this kimberlite, which was taken with a large-diameter drill, yielded 2.48 ct/t of diamonds. De Beers has valued the diamonds that are 7 points (0.07 ct) or larger in size from this mini-bulk sample, which yielded a grade of 1.5 ct/t valued at US\$55/ct, or US\$82.50/t.

The Canadian subsidiary of De Beers, Monopros Limited, has entered into a joint exploration venture with the two partners, and can earn a 60% interest in the AK/CJ property by funding exploration and a bulk sampling program on one or more kimberlites, completing a feasibility study, and funding the development of a mine.

In 1997, De Beers discovered an additional three diamondiferous kimberlite pipes on the Telsa, Hearne and Tuzo properties, all of them within 1.1 km of the AK-5034 kimberlite and all under a lake, but close to shore. Mini-bulk samples of about 50 t were taken from each of the AK-5034, Hearne, Tesla and Tuzo pipes during the winter of 1997/98. Monopros anticipates that additional ore tonnages that might result from the three new discoveries could significantly improve the economics of production from the property.

### Buffalo Hills, Alberta

Ashton Mining of Canada Inc. (42.5% interest) is the operator of a diamond exploration project in the Buffalo Hills of northwestern Alberta. The other partners are Alberta Energy Company (42.5%) and Pure Gold Resources Inc. (15%). Since early 1997, a total of 23 kimberlite intrusions have been discovered on this property, and several of them are diamondiferous. The best results obtained to date are those for the K-6, K-14 and K-91 kimberlites (Table 1). Although average diamond contents for these kimberlites are considerably lower than those for the 16 most interesting deposits currently known in the Northwest Territories, they are within the grade range of the world's diamond mines. Diamond values from such small samples are not available. A bulk sample in excess of 500 t is to be taken from the K-14 complex. Between 70 and 80 additional drilling targets are currently recognized on the Buffalo Hills property where exploration is still in its early stages.

### Fort à la Corne, Saskatchewan

The first kimberlite discovery at Fort à la Corne (65 km east of Prince Albert) was made in 1988. Several companies have been exploring the region since that time and approximately 90-100 kimberlites have now been discovered; some of them are exceptionally large in size, and the largest of them is 1.6 km in diameter.

A diamond exploration joint venture between Cameco Corporation (30%), Monopros Limited (a subsidiary of De Beers, 30%), Kensington Resources Limited (30%) and Uranerz Exploration and Mining Limited (10%



carried interest) includes 71 of these kimberlites, roughly half of which are diamondiferous. The highest reported diamond contents are lower than those for most of the kimberlites in the Northwest Territories and are lower than those for all but one of the three best diamondiferous kimberlites discovered to date in Alberta. Any diamond contents for the Fort à la Corne kimberlites that are available to the writer are not equivocal and so are not quoted here.

## COMPARISON OF DIAMOND CONTENTS OF CANADIAN DIAMOND DEPOSITS WITH WORLD MINES

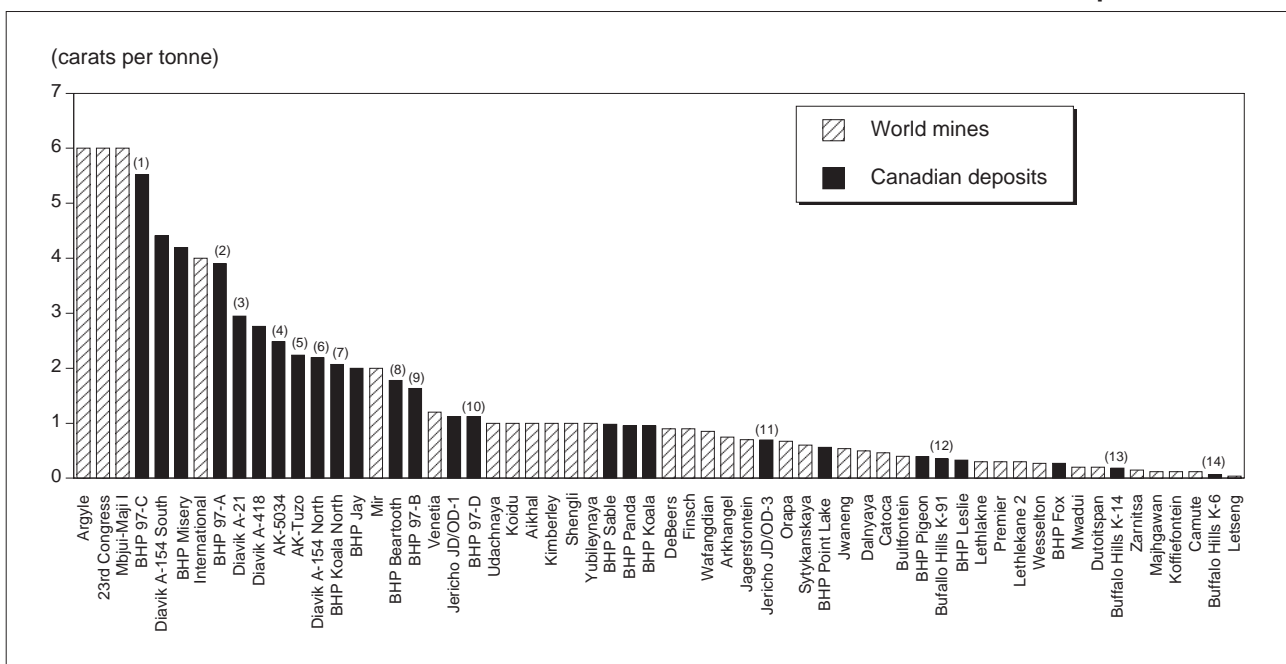
Recoverable diamond grades for the 25 Canadian diamond-bearing kimberlites for which unequivocal recoverable diamond content is publicly available appears to fall toward the higher-grade range of world diamond mines (Figure 4). On the other hand,

most, if not all, of the currently known Canadian diamond deposits are on the small side relative to the orebodies of the world's largest diamond mines. Recoverable diamond values for currently known Canadian diamond deposits also appear to fall towards the higher value range for world diamond mines (Figure 5).

However, it is important to recognize that the sample sizes used for determination of diamond contents are small, especially in the case of the six deposits for which the sample size is less than one tonne (BHP 97-C, BHP 97-A, BHP Koala North, BHP Beartooth, BHP 97-B and BHP 97-D, refer to Figure 6); consequently, the actual recoverable diamond contents and values for some deposits are likely to turn out to be considerably different once more appropriately sized bulk samples are eventually taken.

*Note: Information in this review was current as of May 15, 1998.*

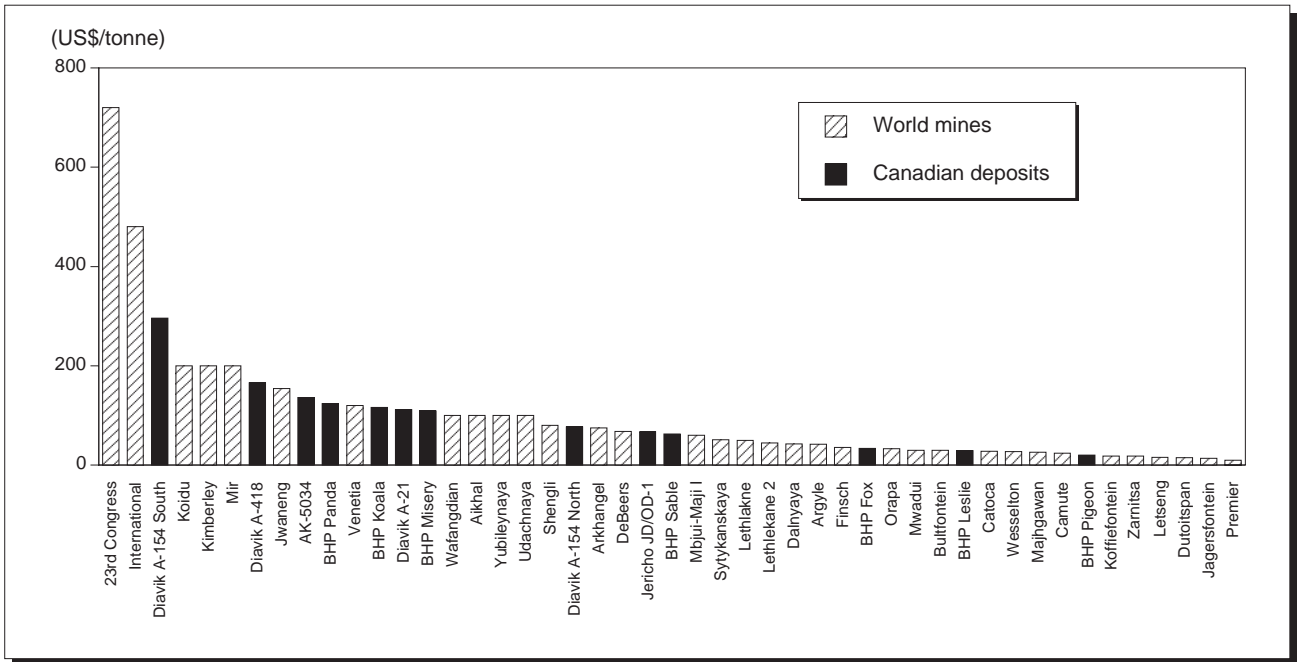
**Figure 4**  
Recoverable Diamond Grades From World Diamond Mines and Canadian Diamond Deposits



Source: Natural Resources Canada, based on published data.

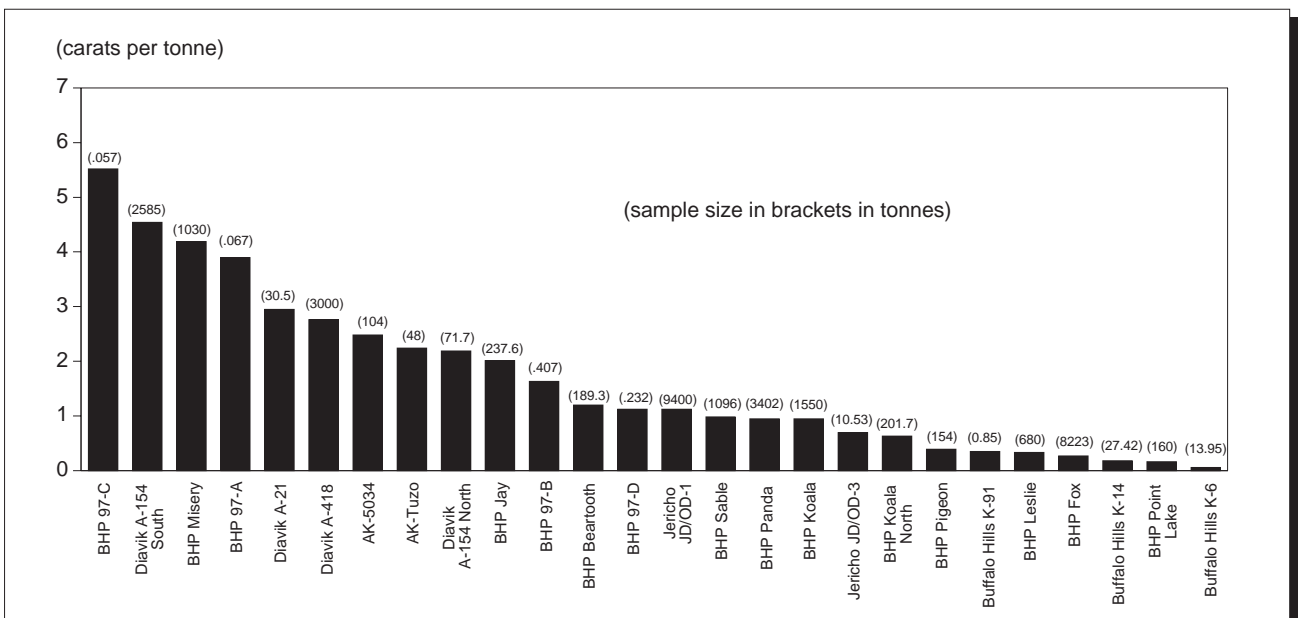
(1) BHP 97-C based on a sample of only 0.057 t of drill core. (2) BHP 97-A based on a sample of only 0.067 t of drill core. (3) Diavik A-21 grade based on a sample of only 30.5 t of drill core. (4) AK-5034 grade based on a sample of only 104 t of drill core. (5) AK-Tuzo based on a sample of only 48 t of drill core. (6) Diavik A-154 North grade based on a sample of only 71.7 t of drill core. (7) BHP Koala North based on a sample of only 0.269 t of drill core. (8) BHP Beartooth based on a sample of only 0.376 t of drill core. (9) BHP 97-B based on a sample of only 0.407 t of drill core. (10) BHP 97-D based on a sample of only 0.232 t of drill core. (11) Jericho JD/OD-3 based on a sample of only 10.53 t of drill core. (12) Buffalo Hills K-91 based on a sample of only 0.85 t of drill core. (13) Buffalo Hills K-14 based on a sample of only 27.42 t of drill core. (14) Buffalo Hills K-6 based on a sample of only 13.95 t of drill core.

**Figure 5**  
**Recoverable Diamond Values for World Diamond Mines and Canadian Diamond Deposits**



Source: Natural Resources Canada, based on published data.

**Figure 6**  
**Grades of Selected Canadian Diamond Deposits**



Source: Natural Resources Canada, based on published data.

**TABLE 1. SELECTED DATA ON CANADA'S MOST PROMISING DIAMOND DEPOSITS**

Pipe	Total Tonnes Sampled	Total Carats Recovered	Average Grade  (carats/tonne)	Average Value  (US\$/carat)	Average Value  (US\$/tonne)
<b>BHP/BLACKWATER GROUP<sup>1</sup>/ LAC DE GRAS PROPERTIES</b>					
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 <sup>2</sup>	680	233	0.33	89	29
Pigeon <sup>2</sup>	154	60	0.39	51	20
Jay <sup>2</sup>	237.6	476.8	2.01	..	..
Sable	1 096	1 070	0.98	64 <sup>a</sup>	63
Point Lake	160	90+	0.56	..	..
<b>DIAMIK PROPERTY</b>					
A-154 South	2 900	12 800	4.41	67	296
A-154 North	71.72	156.81	2.19	35	77
A-418	3 000	8 275	2.76	56	166
A-21	30.5	90	2.95	38	112
<b>JERICHO PROPERTY</b>					
JD/OD-1	9 400 <sup>b</sup>	10 539	1.12	60	67
JD/OD-3	10.53	7.34	0.697	..	..
<b>AK PROPERTY</b>					
5034	104	257	2.48	55	136
Tuzo	48	108	2.24	..	..
<b>BUFFALO HILLS PROPERTY</b>					
K-6	13.95	0.876 <sup>c</sup>	0.06	..	..
K-14	27.42	4.86 <sup>d</sup>	0.18	..	..
K-91	0.85	.301	0.35	..	..

Source: Natural Resources Canada, from company reports.

.. Not available.

<sup>a</sup> 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. <sup>b</sup> A 15 000-t bulk sample was mined, but only 9400 tonnes of it was processed. <sup>c</sup> Probably not a representative sample. Includes a clear yellow diamond weighing 0.76 ct. <sup>d</sup> Includes a 0.6-ct diamond and more than five other diamonds larger than 0.18 ct.

<sup>1</sup> The Blackwater Group's 49% interest in this project can be broken down as follows: Dia Met Minerals Ltd., 29%; C. Fipke, 10%; and S. Blusson, 10%. <sup>2</sup> The Leslie, Pigeon and Jay deposits are not currently scheduled for mining.

**TABLE 2. MOST PROMISING RECENT DISCOVERIES ON THE EKATI DIAMOND MINE PROPERTY AND RELATED BHP PROPERTIES IN 1996 AND 1997**

Pipe	Tonnes Sampled	Total Carats Recovered	Average Grade
			(carats/tonnes)
<b>1996 DISCOVERIES</b>			
Koala North	0.2684	0.555	2.07
Beartooth	0.3760	0.668	1.78
<b>1997 DISCOVERIES</b>			
97-A	0.0669	0.261	3.90
97-B	0.4070	0.662	1.63
97-C	0.0572	0.316	5.52
97-D	0.232	0.260	1.12

Source: Dia Met Minerals Ltd. news release dated November 4, 1997.

**TABLE 3. PRE-PRODUCTION MINING RESERVES**

Reserves Classification	Panda Pit	Misery Pit	Koala Pit	Fox Pit	Sable Pit	Panda Pit	Koala Pit	Total
Proven (Mt)	8.6	4.8	10.0	8.1	11.0	–	1.0	43.5
Probable (Mt)	4.0	0.7	4.6	8.6	1.9	0.8	1.8	22.4
Total (Mt)	12.6	5.5	14.6	16.7	12.9	0.8	2.8	65.9
Grade (ct/t) (diluted basis)	1.09	4.26	0.76	0.40	0.93	0.97	1.63	1.09
Average value (US\$/ct)	130	26	122	125	64	130	122	84

Source: Dia Met Minerals Ltd. Annual Report 1996-1997.  
– Nil.