The Victor Diamond Project

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Abstract

De Beers Canada is presently conducting a feasibility study to determine whether it is both financially and environmentally feasible to construct and operate an open pit diamond mine at Victor site near Attawapiskat.

The project has numerous challenges relating to access, logistics, dewatering and water management. The pre feasibility study has identified the need for additional hydrogeological, geotechnical, civil geotechnical and geological drilling programmes to be conducted to provide the information necessary to complete the feasibility study during 2003.

This presentation will include the technical and environmental challenges and how these are being addressed to satisfy the First Nations, the federal and provincial regulatory processes and the De Beers Canada Corporate and Environmental Policy.

1. Introduction

The Victor Diamond Project is centred on two kimberlite pipes, some 100 kilometres west of the First Nation village of Attawapiskat in the James Bay Lowlands of Ontario (Figure 1). Access is by temporary winter trail in the winter, or by helicopter. Float-equipped aircraft can land on the Attawapiskat River some five kilometres from the project site, and in cold years, there is a temporary ice airstrip for the winter months.

Exploration and evaluation work has proved the presence of 22 kimberlite pipes in the area, and work by De Beers has proved 21 of these to contain diamonds (kimberlite is one of the primary source rocks for diamond: diamonds are not formed in kimberlite, but transported from deep within the earth to the surface by kimberlite, Mitchell 1986, 1995, e.g. Haggerty, 1999). However, while only one kimberlite appears currently to be of economic interest, two or three other smaller bodies warrant some additional work to better define their potential.

A Pre-feasibility study was undertaken on the Victor deposit during 2002, and, although the results did not demonstrate the deposit to have reached the internal financial hurdle rate for the project, the upside potential was sufficient to justify a full Feasibility Study during 2003. This Feasibility Study is now in progress, and should be complete by the end of 2003. The study will essentially be finished by the end of September, with the remainder of the year being devoted to writing up the report.

1.1 Geology

Kimberlite is a volcanic rock, and at Victor, it is present as two irregularly cone-shaped bodies. These are emplaced through the Palaeozoic carbonate sediments overlying the Archaean basement. The pipes are concealed beneath glacial till, glacio-marine clays and present day peat and muskeg. This sequence varies from a few metres up ton 40 metres thick over the pipes. The entire region forms part of the extensive wetlands comprising the James Bay Lowlands, with alternating fen and bog landforms. Forest is preserved along many river and creek margins as narrow strips of vegetation. Intermittent vestigial ice lenses are preserved as Palsa. Extensive water, ponds and small lakes typify the landscape. The water table is usually within 50 cm of the surface. Present day drainage is incised into the bedrock or into the surficial sediments.

Evaluation studies have a probable resource of just over 25 million tonnes. The Feasibility study

will move this from a probable to an indicated category. Grade is variable, with an average of 25 carats per hundred tonnes, with considerable variation between the different geological kimberlite facies (Figures 2 and 3). This is a far cry from the diamond mines in the Northwest Territories, which are reporting grades in excess of 140 carats per hundred tonnes up to several hundred carats per hundred tonnes.

Unlike metal mines, the value of a diamond is controlled by a number of factors: carat weight (size), colour, Crystal shape and the clarity of the individual stone. These are essentially the same "4 C's" referred to by our colleagues in the jewellery trade. Each of these factors contributes to the value of a diamond. There can be two diamonds, each the size of a cranberry or blue berry side by side on a table and one could have a value of about 50cents, while the other could have a value of $50,000. It is therefore important to have a large parcel of diamonds from a deposit so that an accurate estimate of the value can be made.

The viability of a kimberlite deposit hinges not upon the grade of the rock or the value of the diamonds, but upon the revenue per tonne. Miners mine tonnes: thus it is important to know with some degree of accuracy the average value of each tonne of rock extracted. Estimates indicate that the revenue per tonne for Victor will be around Cdn$100 per tonne. This is in contrast to Ekati, which is estimated at around $140.00 per tonne or Diavik, which is estimated at around $260.00 per tonne. For comparison, Snap Lake is predicted to be around $180 per tonne.

The Victor deposit is thus a low-grade deposit, and will not be a prolific producer in the same league as Ekati or Diavik. Current planning is for an open pit mine to a depth of just over 220 metres, with a mining rate of about 2.5 million tonnes a year. This gives a mining life of around 15 years, two for construction, 11 for mining and two for closure of the mine Current estimates for construction capital are around $730 million. Current Internal rates of return estimates are just over 8%, which is below the company's hurdle rate of 12%. There are a number of up-side potentials that could enable the project to meet this target, and a Feasibility Study which will be completed by the end of 2003 will define these in some detail.

For the project to move forward, four things are needed. These are (i) a positive Feasibility Study; (ii) a negotiated Impact Benefit Agreement with the Attawapiskat First Nation, (iii) a completed Environmental Assessment and the issue of the various permits and licences, and (iv) De Beers' Board approval for the funding for construction.

2. Technical issues

Water is the main technical challenge facing the project. Surface water level is close to the land surface. This is separated from the underlying bedrock by a low permeability glacial sequence. The underlying country rock is a carbonate sequence that is waterlogged. The carbonates contain various other minerals that contribute to mildly saline waters. About 225 metres below surface, the bedrock changes from a dominantly carbonate sequence to mudstones, and then to a carbonate and evaporite sequence, before reaching the Archaean basement granites and gneisses around 280 metres. The deeper ground waters are saline (Figure 4).

Access to the area is poor because of the muskeg environment. Road and site construction are therefore important and expensive.

Preliminary hydrological and mining studies have shown that while underground mining might be feasible, it is not practical because of the safety problems associated with the groundwater, and the related expense. If the feasibility study is positive and a mine goes ahead, this would be for an open pit operation.

Studies have shown that between the site and the village of Attawapiskat, construction of an all season road is impractical. There is no aggregate or rock available for the western half of the road. Construction costs thus sore, and the estimate for a 110-Km road is in excess of $150 million, a cost that the project cannot support.

Because the site is entirely with in the muskeg of the James Bay Lowlands, access and foundations are problematic. There are no roads, and it is difficult to move when the ground is not frozen as everything is one huge swamp. Gravel and sand deposits are few and far between: there are however, a number of limestone bioherms that come close to surface, and inn places outcrop. It is planned to use these to provide aggregate.

3. Environmental issues

The majority of the environmental issues revolve around water in one way or another. An environmental baseline study was started in 1999 as part of the Advanced Exploration Programme. This has been continued and expanded to provide the current baseline for the project site. Element considered have included water (both ground and surface, aquatic life (fish and benthos), vegetation studies, raptors, mammals (fur bearing mammals, moose, caribou, and the like), meteorology (there has been a weather station at site since 2000), migratory birds in the coastal flyway, traditional ecological knowledge, and archaeology. Socio-economic impacts – both negative and positive – from the project area being considered. Attention has been given to looking for endangered and threatened species.

No studies have been done on the coastal areas of James Bay as many others have discussed these areas. These areas are peripheral to the project and would only be affected by the movements of materials to Attawapiskat.

3.1 Wildlife

Wildlife surveys have been undertaken within the project area and have been augmented by studies of particular animals such as winter moose and caribou studies to provide information on wildlife migration patterns. This information will be integrated with traditional ecological knowledge obtained from the Attawapiskat First Nation to give a balanced picture.

3.2 Vegetation

Similarly, vegetation studies show the area dominated by broad expanses of muskeg (peatland) terrain. Higher areas, often associated with old beach ridges are drier, and support shrub and tree communities (Cowell et al. 1991). Sedges and grasses with some Tamarack typify evolving fens. Continuing build up of organic material resulted in nutrient-rich fens becoming progressively removed from the underlying mineral-rich clays, The nutrient-rich fens have then given way to nutrient-deficient bogs typified sphagnum mosses and black spruce.

3.3 Water

The majority of environmental issues for the project involve water. There is the question of diverting South Granny Creek, which flows within 25 metres of the perimeter of the proposed open pit. If this creek is not diverted, there is real risk of the pit flooding. While it is relatively easy to reduce the volume of surface waters within the muskeg by pumping, because of the limited water flow within the muskeg and peat, underground waters are more problematical. A number of alternatives have been considered, including dewatering using a well field around the pit perimeter to create a temporary (Life of Mine) depression in the water table, freeze walls and a grout curtain. Engineering and trade-off studies indicate that the preferred alternative is to establish a well field around the perimeter of the pit, and pump to dewater the pit area. As the open pit nears its design depth limit, a second ring of well points will have to be installed to capture ground water that flows around the outer ring of wells.

3.3.1 Surface

Surface waters are typical of a muskeg environment. They contain high iron and manganese, with a pH ranging between 6.0 and 7.9, depending upon the time of year and the water body. Typically, when drainage ditches are cut into peat or muskeg, dewatering takes place, with a local cone of exhaustion extending back a

few metres from the drainage point. While water continues to seep into the ditch or to a central draw don point, the flow reduces rapidly to a slow trickle.

3.3.2 Groundwater

Groundwater in the vicinity of the Victor kimberlites consists of four main aquifers. These are related to the shallower Palaeozoic carbonate sequence, which typically has salinity contents in the 1270-1360 mg/L range, and extends from the top of the bedrock to around 30m below surface. The second, intermediate, layer extends from about 98-178 metres below surface, and this has a typical salinity range ranging from 960-1,500 mg/L. The third zone ranges from 220 metres down to around 260 metres where the salinity is around 2,100-mg/L associated with carbonates and evaporates.. There is a final aquifer associated with the Palaeozoic-Precambrian contact zone: here salinity values range from 4,200-4,700 mg/L. No information is available for depths below 278 metres below surface.

4. Possible Mitigation Routes

The main issue is the elevated salinity for the groundwater. The elevated salinity values have resulted in a number of alternatives being considered. Preliminary tests and hydrological modelling indicate that between 60,000 and 110,000 m³ per day will have to be pumped to keep the pit reasonably dry. Volumes of this order of magnitude present problems in handling, as well as processing. Simms, (2002) states

> "Treating well field water using desalination technologies is neither economically feasible nor practical. Desalination technologies currently in use are pressurised membrane technologies such as reverse osmosis, and distillation technologies. Through the use of either technology, lower salinity water can be produced, but the capital and energy costs are extremely high. Of the two technologies, reverse osmosis is the most widely used because of the far higher energy costs associated with distillation. Typical reverse osmosis plants generate fresh water at a cost of from $2 to S4/m³, depending upon desired efficiencies (de Villiers, 1999). But these costs would easily be doubled at Victor site because of the high cost of energy production at such a remote site. Therefore, if a cost of $6/m³ of fresh water is assumed, and if it is further assumed that the efficiency of fresh water production is 50% of the feed volume, then desalination cost to the project would be in the order of $150,000,000 per year. Notwithstanding the cost, the other major drawback with either desalination technology is the production of large quantities of concentrated brines (in the order of 50% to 65% of the feed volume) that would still require disposal (de Villiers 1999). There would be nowhere to dispose of this concentrated saline water, unless the saline water was fed to evaporators, in which case the recovered dry salts could be land filled on site. However, the energy cost of providing evaporation on site would be even higher than that required for desalination, and could not be supported by the project. Land filling the dry salts in a manner that would not result in subsequent near-term releases to the environment, given that the water table is at surface virtually everywhere, would also be difficult, if not improbable undertaking."

The most acceptable solution appears to be discharge of the moderately saline water to a receiving water that has the assimilation capacity to accommodate this inflow without adverse effect to either water quality or to aquatic life. The rivers and creeks close to the pit are all too small to be receptors. The Attawapiskat River is the only large river, and studies suggest that by discharging the waste water into the Attawapiskat, there would be a dilution of about 345:1 under average flow conditions, and dilution of a minimum of 64.7:1 under 7Q20 low flow conditions. Both chronic and acute toxicity tests were undertaken. Acute tests were performed on rainbow trout and *Daphnia magna*: chronic tests were performed on

fathead minnow and *Cerodaphnia dubia*. Acute tests showed no effect on either rainbow trout or *Daphnia magna* with 100% survival. For chronic tests, greater than 50% of the flathead minnow survived 100% strength by volume, but there was an effect on the *Cerodaphnia Dubia*. Results for the latter depended upon the waters being tested. Dilution of up to 12.2:1 would be required in some instances to meet IC25 reproductive test criteria. Since dilution in the Attawapiskat River would be a minimum of 64:1 under even the most adverse low flow conditions, this would appear to be the preferred alternative. For comparison, average salinities in sea water worldwide is about 35,000 mg/L and in James Bay, the salinity varies, but averages around 15,000 mg/L. Even at the lowest flow conditions in the Attawapiskat River, the salinity levels from discharge of the groundwater into the Attawapiskat River result in salinity levels orders of magnitude less that the naturally occurring salinity levels in the Nayshkootayaow River, which flows a few kilometres to the south of Victor.

5. Environmental Management System

De Beers has environmental management systems (EMS) for all of its operations in Canada. Currently, the Victor Project is included within the De Beers Canada Exploration environmental management system, and it is registered to ISO 14001. There are plans to migrate this management system from exploration to a mining-based management system, which will better address the significant aspects associated with development such as construction, production and, eventually, closure. All of De Beers' activities in Canada are covered by a single environmental policy (Policy). All the major programmes and the majority of the minor projects are ISO 14001 registered, and those that are not registered will be added once the registrar's auditors can visit them.

The management system embraces the identification of environmental aspects, preparation of suitable procedures and work instructions to reduce the risk associated with these, and ensure a formal framework for inspections, documentation and emergency response. At the same time, this provides a mechanism for legal compliance and identifying changes in legislation, as well as identifying training needs and ensuring that these are addressed in a timely fashion. Continual improvement is one of the three basic tenets of ISO 14001 (the others are legislative compliance and pollution prevention), and De Beers embraces this philosophy, as Safety Health and the Environment are at the top of the corporate values.

Currently, De Beers is considering the integration of its environmental management system with a safety management system. It is anticipated that a safety management system along the lines of OHSAS 18001 will be adopted, but no decision has been made as to whether the company will seek accreditation for this.

6. Aboriginal Issues

The Attawapiskat First Nation is the main aboriginal community to be affected by the project. Attawapiskat is a member of the Mushkegowuk Council, which is the tribal council grouping for the communities on the west side of James Bay that are colloquially referred to as the "Swampy Cree". The Attawapiskat First Nation is also a signatory to Treaty #9, and is a member of the Nishnawbe Aski Nation.

The community, according to Indian and Northern Affairs Canada, has 2,6980 members of whom 1,536 reside on-reserve. This means that 42.9% of the band members reside off-reserve. Roughly 70% of the population is under 21.

7. Permitting

A number of the activities planned for any future development of the Victor resource involve water, and there are a number of triggers for the Canadian Environmental Assessment Act (CEAA). Currently, a lead Responsible Authority has not been appointed, neither has a formal scoping been undertaken.

The main CEAA triggers include the diversion of South Granny Creek, the construction of barge handling facilities near Attawapiskat itself, construction of a 1,600 metre long airstrip at site, and possibly the erection of an explosives mixing facility near to the project site.

In addition, there are a host of provincial permitting requirements to cover taking water associated with dewatering the site, taking water for potable water supply, taking water for ore processing, disposal of waste water from the pit dewatering, disposal of process water, disposal of sewage, non-hazardous wastes and the like. Disposal of non-hazardous wastes presents a problem because the high groundwater level precludes using an in-ground landfill facility. Thus, alternatives have to be found and evaluated. There are also permits for air discharges from power generation and equipment at site, blasting and noise et cetera.

8. Conclusions

The Victor diamond project is currently undergoing a Feasibility Study for an open cast diamond mine. If this study the four things mentioned above (positive feasibility study, IBA, permits and funding) within the proposed timeframe, work would commence on local road and pads to receive equipment and buildings over winter in 2003-2004. Construction would take place between 2004 and 2006, with production commissioning commencing at the end of 2006 and climbing to full production by mid-2007. This would be Ontario's first diamond mine.

9. Acknowledgements

The assistance of the many co-workers in De Beers Canada and colleagues at AMEC Earth & Environmental Ltd is gratefully acknowledged. Without the teams' efforts, the work, upon which this paper is based, would not have happened.

10. References

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Policy

DE BEERS CANADA

POLICY STATEMENT
ENVIRONMENTAL MANAGEMENT

De Beers Canada*, active in diamond exploration and mining, is committed to the concept of sustainable development, which requires balancing good stewardship of the natural environment with economic growth. Accordingly, De Beers Canada will:

• Conduct all activities in compliance with applicable legislation, and other requirements, providing for the protection of the environment, employees and the public;
• Apply appropriate good management practices in the absence of legislation or where De Beers believes more stringent criteria than those required by law are needed to advance environmental protection and to minimize environmental risks;
• Integrate the management of environmental, social, cultural and economic issues into company business and planning;
• Protect the environment through the wise use of resources and prevention of adverse environmental impacts;
• Implement, maintain and improve appropriate management systems and programmes to achieve environmental objectives, and to continually improve environmental performance through a process of regular review;
• Ensure awareness among employees and contractors of this environmental policy, promote shared responsibility and accountability for environmental obligations, and provide the support and training necessary to achieve these objectives; and
• Communicate openly with governments, employees, local communities and the public to sustain mutual understanding of environmental, social and economic issues.

**Unless otherwise stated, the term De Beers Canada means De Beers Canada Corporation, De Beers Canada Mining Inc. and De Beers Canada Exploration Inc.*

PS.01.02	**President and Chief Executive Officer** **R.G. Molyneux**	**Date:** **June 1, 2002**	**Page 1 of 1**

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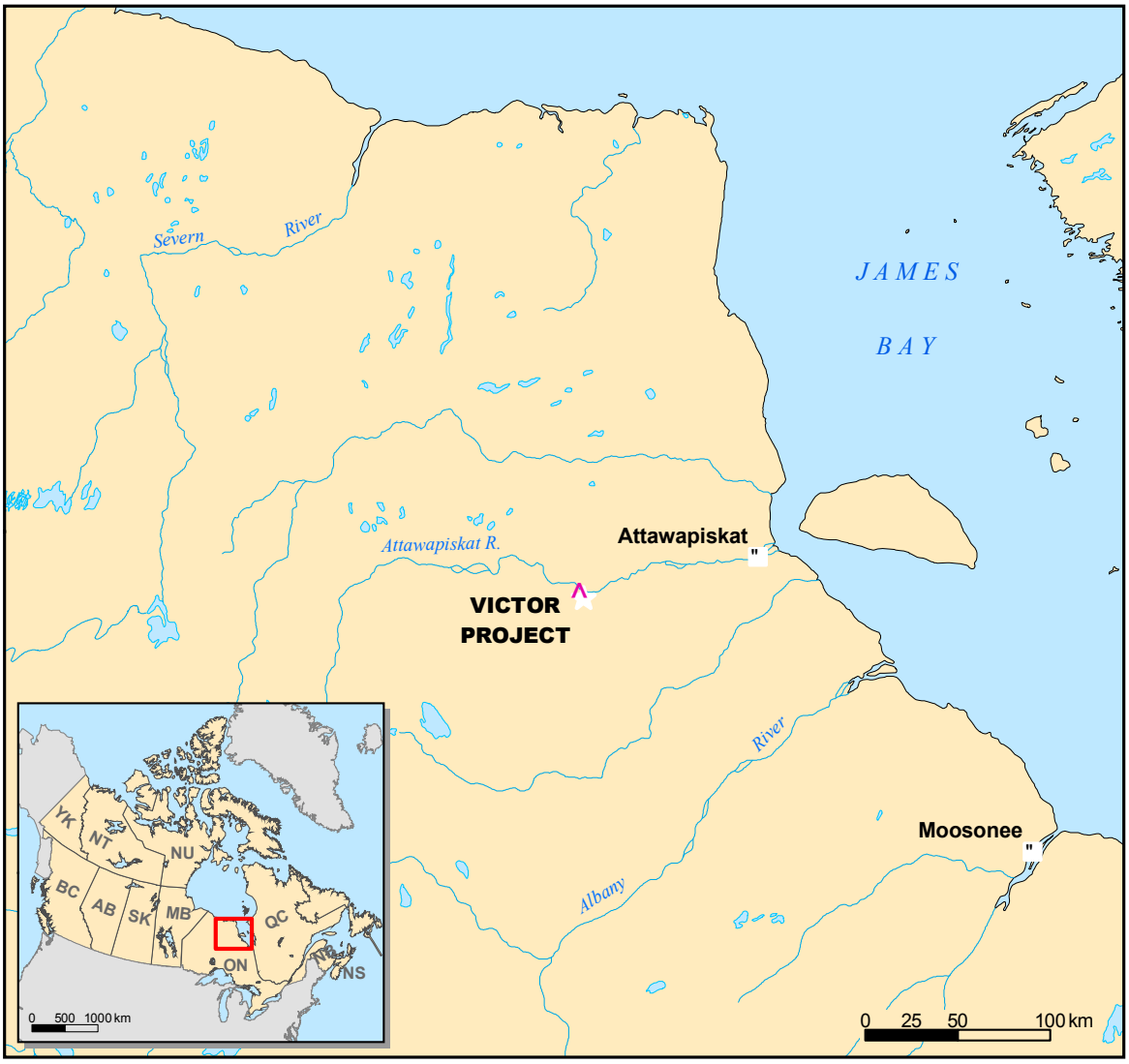
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Figure 2

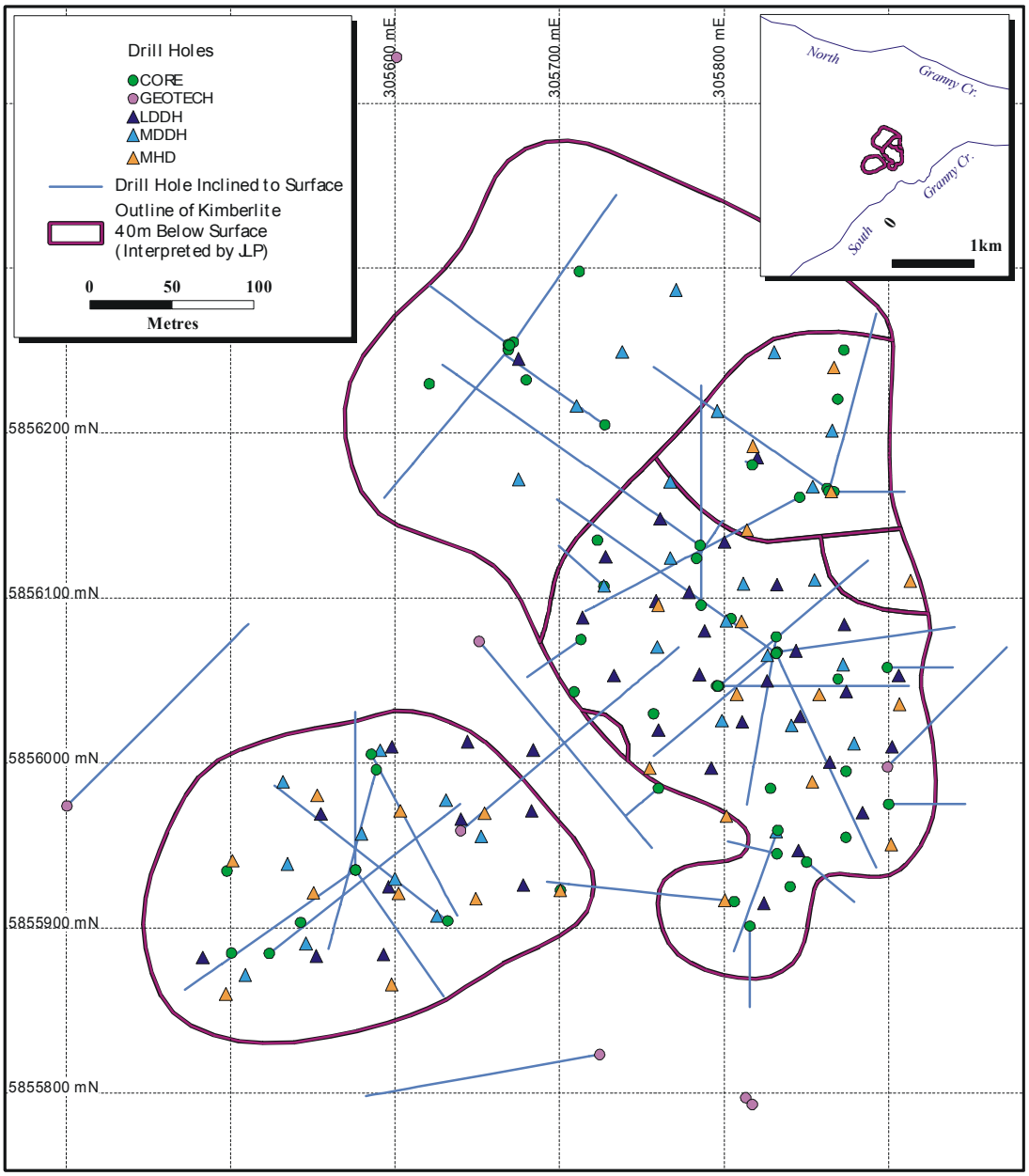

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Figure 3

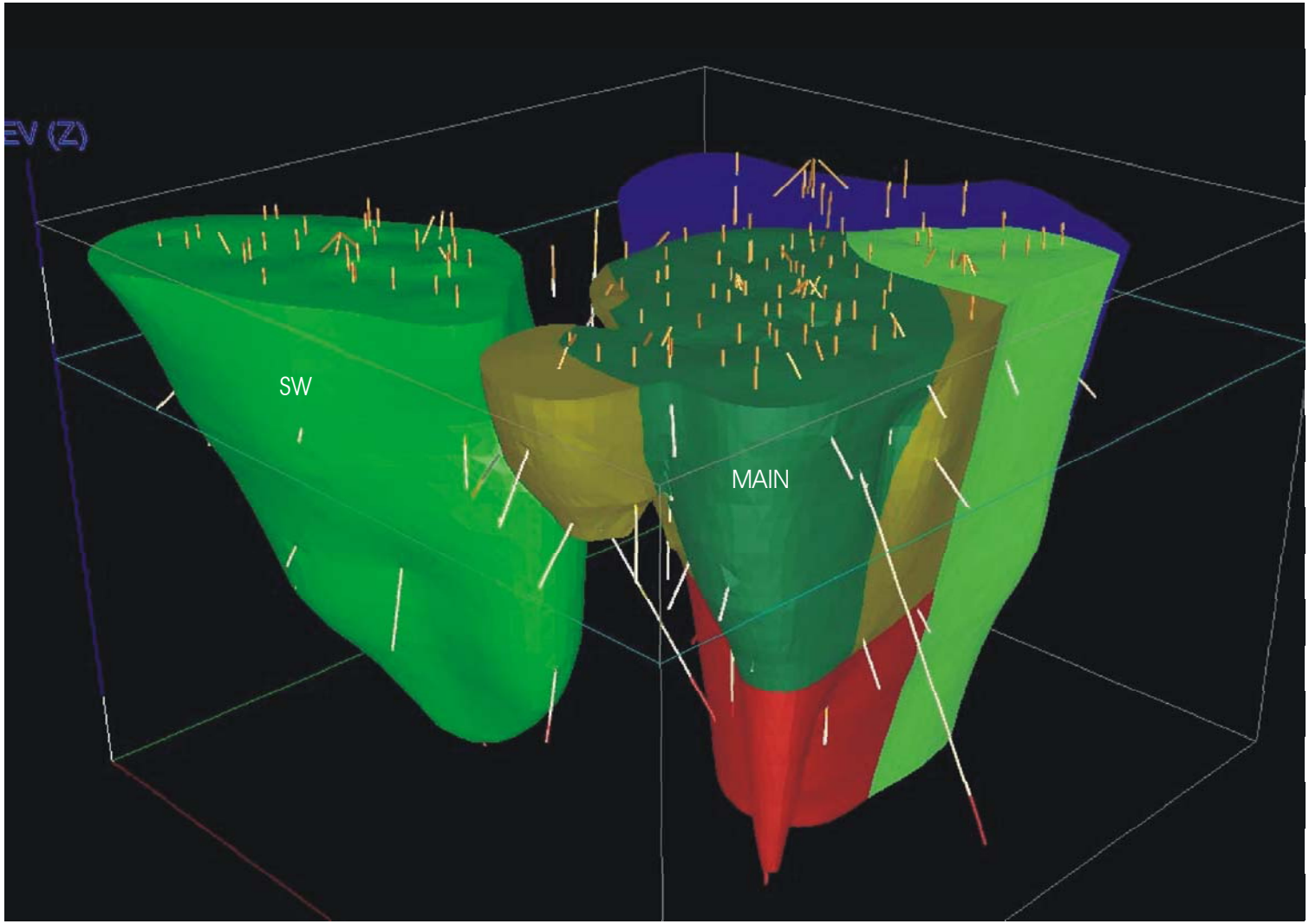
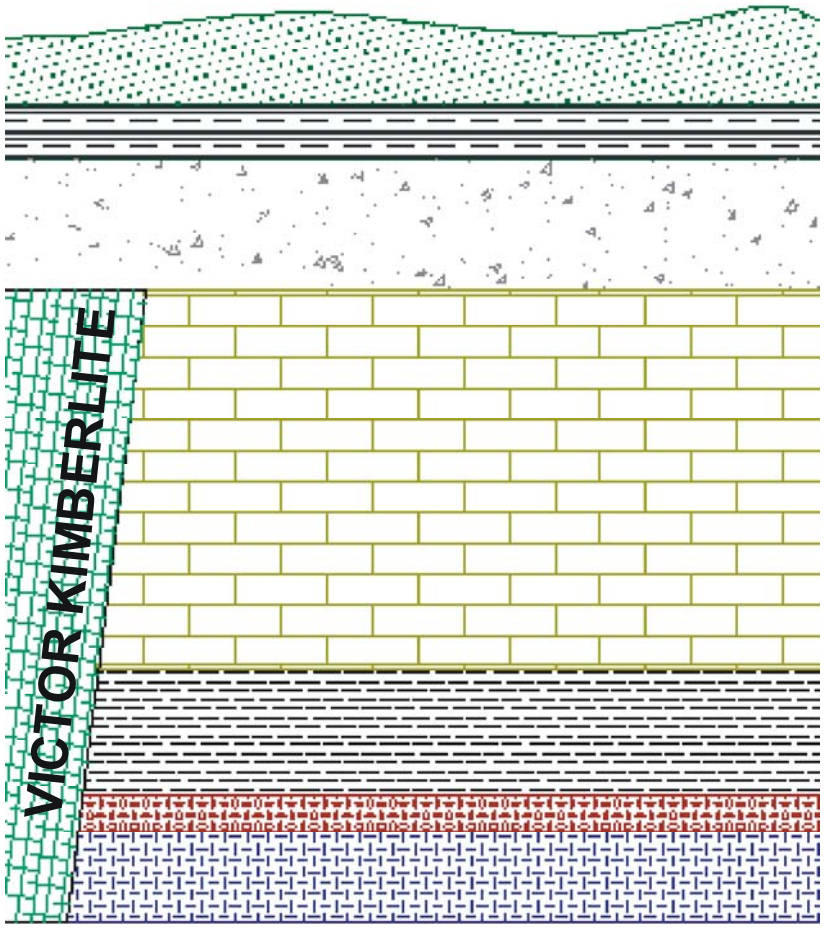


Figure 4



Muskeg (Aquifer 1)

Marine Clay (Excellent Aquitard)

Overburden (Semi-consolidated to unconsolidated glacial till)

Limestone (Aquifer 2)

Mudstone (Excellent Aquitard)

Basal Sandstone (Aquifer 3)

Altered Granitoid + Precambrian Basement

Not to Scale