INTRODUCTION
Primary diamond deposits have been mined on an industrial scale only within the past 150 years, mainly as open pit operations. Underground mining of these deposits is expensive and, until the second half of the 20th century in South Africa and the first half in Canada, was rare and is currently limited to North America and South Africa. The first underground mining of kimberlite pipes in Canada took place at the Ekati Diamond Mine in 1996. In 2003, Koala North pipe was opened to underground mining.

The Ekati Diamond Mine was the first diamond mine to be developed near Lac de Gras in the Northwest Territories of Canada. Mining commenced with an open pit operation at first March and later operated as an underground mine at Koala North, 1996. Project feasibility analysis and production performance of the mine including cost and schedule are presented in this paper.

Canadian Underground Diamond Mines Overview
The largest generation of diamond underground mining in the world was experienced in Canada. To date, underground mining with five kimberlite pipes and one kimberlite sill. These are Panda, Koala and Koala North at the Ekati Mine; A418, A514N and A514S at the Diavik Mine and at Snap Lake. The focus of this paper is to document experiences with underground mining of kimberlite pipes at Koala (Fig. 2) and Diavik (Fig. 3).

Underground Mining Methods
While the BHS method with cemented rockfill used at Diavik, and the SLC method used at Koala is commonly used in Canadian underground operations, the SLR method was developed specifically for the Koala North pipe. This method was developed to avoid the fatigue problem with the BHS method.

Operational Challenges in an Arctic Context
During the winter, granite wallrock contacts are stable (Fig. 7), but while the BHS method with cemented rockfill used at Diavik, and the SLC method used at Koala was stable ( Sunderland et al., 2010), the Koala North pipe is being mined. There is a need for massive cutoff blasting to avoid ground instability. The Koala North pipe was selected as a trial underground mine location for the purposes of identifying suitable methods for extracting underground resources beneath the Panda and Koala open pits. The Koala North pipe was mined in late 2010 due to the susceptibility of kimberlite to weathering, the production drillholes at Ekati had to be drilled dry (Fig. 8). This proved to be very successful and the production drillholes were drilled with water injection. However, to avoid icing up of the drillholes, it was necessary to re-drill due to the icing up of the drillholes. Development in the permafrost granite required drilling with brine.

Table 1: Underground and open pit mines production to date.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Method</th>
<th>Pipe</th>
<th>Tons Produced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diavik</td>
<td>SLC</td>
<td>A514S &amp; A514N</td>
<td>20.7 (avg)</td>
</tr>
<tr>
<td>Koala North</td>
<td>SLR</td>
<td>Koala</td>
<td>3.5 (avg)</td>
</tr>
<tr>
<td>Koala North</td>
<td>SLR</td>
<td>Koala North</td>
<td>3.5 (avg)</td>
</tr>
<tr>
<td>Koala North</td>
<td>SLR</td>
<td>Koala North</td>
<td>2.8 (avg)</td>
</tr>
<tr>
<td>Koala North</td>
<td>SLR</td>
<td>Koala North</td>
<td>3.5 (avg)</td>
</tr>
</tbody>
</table>

The SLR method with cemented rockfill used at Diavik, and the SLC method used at Koala is commonly used in Canadian underground operations, the SLC method was developed specifically for the Koala North pipe. This method was developed to avoid the fatigue problem with the BHS method.

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Bibliography

Figure 1: Koala North mine plan.
Figure 2: Koala North mine pit.
Figure 3: Koala North mine operation.
Figure 4: Koala North mine stopes.
Figure 5: Koala North mine ventilation.
Figure 6: Koala North mine production.
Figure 7: Koala North mine mine openings.
Figure 8: Koala North mine production.
Figure 9: Koala North mine ventilation.
Figure 10: Koala North mine production.

CONCLUSIONS
Both mining operations at Diavik and Black Diamond demonstrated that underground mining is a viable option for mining diamond pipes. This was achieved through development of advanced logistical and technical challenges. This would not have been possible without the commitment and dedication of all members of the team and without innovative mining solutions. To date, the SLR method has been completed at Panda (Fig. 2) and Koala (Fig. 3). The Koala North method continues to be used as a primary underground mining method at Koala mine.