

Diamond Mining in Canada – An Evolving Mine Engineering Knowledge Base

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Introduction

The Canadian diamond mining industry has made a notable contribution to the knowledge of mining and mining-industry logistics in the extreme Arctic environment. Canadian diamond mining ventures accessed financing on an at-risk basis, with critical dependence on the “bankable” geological, geotechnical and mine engineering knowledge base, specifically of primary diamond deposits. This paper provides a summary of 25 years of diamond mining in Canada and highlights the evolution of mine engineering practices over this period.

Since 1998, eight diamond mines were permitted and constructed in northern Canada (Table 1). Ekati, Diavik, Snap Lake and Gahcho Kué are located in the Northwest Territories, Jericho in Nunavut, Victor in Ontario and Renard in Québec.

Mine	Pipe	Open Pit production		Underground production			Comments
		Start	Closure	Start	Closure	U/G method	
Ekati	Panda	1998	2003	2005	2010	SLR	Mining completed
	Koala North	2000	2001	2002*	2015	SLR	*) Trial SLR 2002-2003
	Koala	2002	2005	2007	2018	SLC, IC	Mining completed
	Beartooth	2004	2009	-	-	-	Mining completed
	Fox	2005	2015	-	-	-	Underground study
	Sable	2018	2024	-	-	-	Underground study
	Lynx	2017	2019	-	-	-	Mining completed
	Misery	2001	2018	2019	est. 2025/26	SLR	Closure dependent on geotech
	Pigeon	2015	2022	-	-	-	Mining completed
Point Lake	2024	est. 2029	-	-	-	Currently in pre-strip	
Jericho	JD-1	2006	2008	-	-	-	Premature care and maintenance
Diavik	A154S	2003	2010	2010	2019	SLR	Mining completed
	A154N	2003	2008	2010	est. 2025	BHOS	Currently mining
	A418	2007	2012	2012	2023	SLR	Mining completed/backfilling
	A21	2018	2023	2025	est. 2030	SLR	Underground mine development
Snap Lake	Snap Lake Dyke	-	-	2007	2015	MRP	Premature care and maintenance
Gahcho Kue	5034	2016	est. 2026	-	-	-	Currently mining
	Hearne	2017	2022	-	-	-	Currently mining
	Tuzo	2020	est. 2030	-	-	-	Currently mining- U/G Study
Victor	Main pipe	2008	2019	-	-	-	Mining completed
Renard	Renard 2	2015	2018	2017	2023	IC	Premature care and maintenance
	Renard 3	2016	2018	2017	2023	IC	Premature care and maintenance
	Renard 65	2018	2023	-	-	-	Mining completed

Table 1: Summary of Canadian diamond mine operations.

Diamond Mines Summary – Mining Methods

Ekati Diamond Mine

Canada's first and largest diamond mine, Ekati, initially operated by BHP, is located in the Lac de Gras region of the Northwest Territories. Production began in 1998 from the Panda kimberlite pipe, followed by other pipes like Koala, Fox and Pigeon. Ekati is known for pioneering Canada's first underground diamond mine – Koala North (Jakubec and Long 2004), which also introduced Sublevel Retreat (SLR) as a new mining method in Canada. Beside open pit mining, Ekati mine also implemented SLR at Misery and Sublevel Caving (SLC) and Incline Caving (IC) at Koala pipe, which was the first successful implementation of this method on diamond mine (Jakubec and Woodward 2020). Ekati also pioneered use of Wirtgen surface cutter technology at Fox pipe (Jakubec et al. 2017). Ekati has played a crucial role in establishing Canada as a major player in the global diamond industry.

Diavik Diamond Mine

Diavik is also situated in an Arctic-lake environment 300 km northeast of Yellowknife. Diavik Diamond Mine is a joint venture between Rio Tinto Group and Dominion Diamond Corporation and commenced operations in 2003. The mine is renowned for producing high-value rough diamonds and has an annual production capacity of around 7 million carats. Diavik pioneered mining of diamond deposits located under lakes, necessitating construction of a sophisticated system of dikes and dewatering to maintain safe mining operations. A154 North and A154 South kimberlite pipes, as well as A418 and A21 pipes were initially mined by the open pit method. After open pit mining was completed, SLR mining was introduced to all but one pipe – the A154N pipe is being mined by the Blasthole Open Stopping method (BHOS) because it is located in the open pit wall. The mine also operates the world's largest wind-diesel hybrid power facility and sets a new benchmark in cold-climate renewable energy production.

Jericho Diamond Mine

Though short-lived from 2006-2008, the Jericho mine made history as Nunavut's first and only diamond producer. Operated by Tahera Diamond Corporation and located on the Haywood Inlet of the Coronation Gulf, this remote site had to overcome logistical challenges of an Arctic supply chain. Jericho's three pipes were mined by the open pit method and produced over 780,000 carats before premature closure. There were several reasons for the closure, including low diamond prices, not following the mine plan, and challenges related to the remote location and operational costs.

Snap Lake Diamond Mine

Located approximately 220 km northeast of Yellowknife, Northwest Territories, Snap Lake holds the distinction of being Canada's first completely underground diamond mine, and the first large-scale mining of a kimberlite sheet that dips approximately 15 degrees under a lake. The selected mining method for this variable, approximately 3-metre-thick dyke was Modified Room & Pillar (MRP). Construction of the mine commenced in 2004, and it officially began commercial production on January 16, 2008, with a target annual production rate of around 1.2 million carats. De Beers put the mine on care and maintenance in 2015, mainly due to a drop in the market price of diamonds.

Gahcho Kué Diamond Mine

Located in the Northwest Territories, the Gahcho Kué diamond mine started commercial production in 2016. It is a joint venture between De Beers and Mountain Province Diamonds and is one of the largest diamond mines in the world. Gahcho Kué has an estimated annual production capacity of around 4.5 million carats. The mine was the first to use remote ultra-deep drilling techniques to delineate its three kimberlite pipes to over 600 m depth.

Renard Diamond Mine

The Renard Diamond Mine, operated by Stornoway Diamonds is Québec's first producing diamond mine. The mine consists of multiple small kimberlite pipes discovered between 2001-2005 in the Otish Mountains with the Renard 2 pipe being the most economically viable. Construction on the project commenced on July 10, 2014, and commercial production by open pit mining of Renard 2 and Renard 3 was declared on January 1, 2017. XXcheckthisprevious2017?? In 2017, the mine went underground, initially with the blasthole stoping method and later converted to an Incline Cave (IC). Average annual diamond production was forecast at 1.8 million carats over the first 10 years of mining. The mine closed prematurely, and it is currently on care and maintenance.

Victor Diamond Mine

Located in the James Bay Lowlands of northern Ontario, the Victor mine was an open pit operation owned by De Beers. It achieved commercial production in 2008 after overcoming logistical challenges associated with the remote swampy terrain of the Canadian North, such as building an all-season access road and designing pit slopes in unconsolidated overburden. Victor mine also studied and tested deep thermosyphons to create a solid freeze wall for hydrogeological purposes. The mine produced over 8 million carats from the Victor Main and Victor Southwest pipes and was successfully closed on-plan in 2019.

Other Engineering Contribution of Canadian Diamond Mines in Arctic

The good financial performance of Canada's large diamond mines made them more open to adopt innovative mine engineering approaches, concepts and technologies - frozen core dams combined with the use of thermosyphons is a good example. Frozen core dams have been built previously but combining them with thermosyphons enabled the use of passive cooling instead of high energy active cooling.

Another aspect of civil engineering in Arctic environment was development of understanding of convective cooling which occurs seasonally inside coarse granular materials such as coarse gravel and waste rock. This passive ground cooling concept has been adopted for some dams and roads (Goering and Xu 2008) to promote improved foundation conditions. It provides benefits in mining waste dumps by restricting water and gas transport.

The northern mining activities also contributed to improve knowledge of mine waste geochemistry (Kyhn and Elberling 2001) and impact of microbiological activity on the oxidation process of reactive mine water. This was important learning for proper engineering of reactive mine waste storage in subzero conditions.

References

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