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A21 - Diavik's Newest Underground Mine

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Diavik Site
Diavik Diamond Mine is owned and operated by Rio Tinto. It is a remote site, accessible by winter road for two months of the year and by plane for 12 months using its 1,500m gravel runway. Construction began in 2001 with production commencing in 2003. Commercial production is expected to be completed by 2026 followed by the completion of closure activities. During its life, four diamond bearing kimberlite ore bodies have been mined through both open pit and underground methods (A154S, A154N, A418, A21). Ore bodies were originally under water in Lac de Gras, requiring the construction of water retention dikes and lake dewatering before mining.

Underground
The original site plan in 2000 included underground mines at all orebodies except A21 due to its small size relative to the others at the operation. The A154/A418 underground projects planned to use the underhand cut and fill (UCF) method for poor ground and a blasthole stoping (BHS) method for good ground. Once evaluated, the A21 underground designs also incorporated the use of UCF due to the expected poor ground conditions. Due to the size of the orebody, and its distance from the site backfill plant, underground mining at A21 was originally deemed uneconomic.

After collecting additional geotechnical information during open pit mining, the method applied at A154S and A418 changed to the sublevel retreat (SLR) method. The highly competent host rock allowed large unsupported highwalls while maintaining overall stability. This method comes with lower costs and higher productivity than UCF. The A154N orebody has continued with BHS due to its proximity to the A154 water retention dike. With the experience gained at A154S and A418, an underground mine at A21 was re-evaluated as economic using the SLR method.

Geology
The kimberlite orebodies at Diavik were formed when diamonds were incorporated into magma as it rose through the mantle and then erupted as a volcano. Material from the volcano then flowed back into the crater created by the eruption. The orebodies include various types of kimberlites, mudstones, and waste rock that has resedimented in the crater. A21 is the smallest of the four orebodies mined at Diavik.

Water Retention Dike Construction
In order to access the kimberlite orebodies in the lake bottom, water retention dikes were required. Construction of water retention dikes at Diavik required the following steps:

1. Dredging of foundation
2. Placement of graded crushed rock
3. Vibrodensification of the core
4. Cutter soil mixing to create the plastic concrete diaphragm wall
5. Jet grouting the diaphragm wall foundation
6. Grout curtain in bedrock

The cost of dike construction is exponential with depth of water; the dike was designed to follow the shallowest path in the lake to control capital cost. This dike footprint then constrained the final pit design.

Open Pit
Open pit mining at A21 was undertaken as a conventional truck and shovel operation from 2018-2023. Benches were mined in 10m stages, resulting in final benches of 30m.

Exploration Decline (2005-2007)
An exploration decline was developed for a kimberlite bulk sample between 2005 and 2007. This allowed for characterization and diamond price analysis in support of the feasibility for the A21 dike and open pit. The decline extended 1.2km, approximately half in permafrost below land, and half under the lake where there was no permafrost. The bulk samples were mined approximately 180m below the lake bottom.

The first bulk sample drift (220 Bulk Sample Drift) proved to be extremely difficult to mine due to poor ground and water ingress. Mechanical cutters were used advancing 1m at a time to reduce exposure to unsupported ground. Shotcrete, grouted spiles, and steel sets were used to support the weak rock. The high levels of water ingress encountered were possibly due to poorly grouted holes connecting to the lake nearby. A second bulk sample drift (240 Bulk Sample Drift) was excavated with minimal difficulty, highlighting the variability of ground conditions within the kimberlite. Floor benching in this second more competent drift was completed for additional bulk sample volume resulting in drift walls over 8m in height with no concerns noted.

The exploration decline was allowed to flood as it was not anticipated to be needed in the future.

Re-accessing Exploration Decline (2019-2022)
Once the A21 pit and dike were complete, operational studies for an underground mine using the SLR method began again in 2019. Early on it was determined that the exploration decline could be used in support of the studies and potentially as part of a future mine. Use of the decline would require mining of ice through the upper section of 600m of permafrost, pumping out the lower section, evaluation of historic installed ground support, and potential rehabilitation throughout.

Due to the high cost of heating, the area was slowly re-accessed during the summers in 2019-2022 reaching the bottom of the decline in 2022. . Work in the decline for the feasibility study included an underground diamond drilling program and a test drift into the orebody. The test drift confirmed the ability to develop through the weak ore once dewatering was completed. This was necessary after the difficult mining conditions encountered in the first bulk sample drift. The test drift also allowed testing of longhole drilling required for the SLR method.

Mining Method
The SLR mining method is planned for extraction of the A21 orebody from underground. It is a top-down method with no backfill, leaving an unsupported crater. A blanket of ore is maintained at the bottom of the crater to protect underground drawpoints from falling rocks.

In order to maintain safety of the underground workforce, several controls are required: monitoring of the unsupported crater, draw control to maintain the ore blanket, operator training to avoid opening drawpoint and mudrush identification, a mudrush management plan, remote mucking operations, and dewatering before production mining begins.

Mine Design

Ground conditions at A21 are expected to be poor and similar to those encountered in A418. Four production levels are planned. Given the short life and shallow depth, all material movement will use haul trucks to a portal in the A21 pit. Production will augment plant feed from the A154N and A154S pipes.

The total life of A21 is three years with approximately half of that in production. The A418 pipe completed mining at the end of 2022, allowing infrastructure from A418 to be re-purposed for A21. This included mine air heaters, pumps and tanks, electrical equipment, escapeway segments, and refuge stations. The mine uses the same workforce and equipment from A154/A418, providing continuity in employment.

Dewatering

All pits at Diavik have required water retention dikes which prevent water ingress from the lake. However, faults and structures deep below the dikes connect pits and underground workings to the lake. During pit mining, surface depressurization wells were drilled to ensure pit wall stability.

Further dewatering to lower the water table below underground mining horizons is required for ore development, mudrush and inundation prevention. Similar to the A418/A154 pipes, drainage galleries are being constructed to divert water into the pumping system before it reaches mine workings. These drainage galleries consist of diamond drill holes bored into the structures, which then gravity flow into pump stations through a dedicated piping network.

In the A154/A418 pipes, drainage galleries were required 50m below the active production mining location to lower the phreatic water surface. The same is planned for A21. Pump stations are located every 50m vertically, and cascade water up to the next pump station. For simplicity and due to the short mine life, pumping is a mixed clean and dirty water system. Some of the clean water from the drainage galleries is redirected before it enters the mixed system for use as service water.

Other Infrastructure

Additional infrastructure required for the new mine include:

- Mine air heater at surface portal
- Underground Fan Chamber constructed to provide positive ventilation pressure
- Ventilation raises
- Pit portal and headcover for haulage
- Electrical substations
- Maintenance bay
- Magazines
- Escapeways
- Portable refuge stations

References

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