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Analyzing degradation of ore pass walls in Kiirunavaara mine using scanning data

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Ore passes play a vital role in underground mining operations by facilitating the gravity-driven movement of ore from production levels to lower levels. Failure of the ore pass has serious consequences, including possible production disruptions and substantial financial investments in reconstruction or rehabilitation. Failure mechanisms are often associated with rock mass quality, stress conditions, and wear of the ore pass walls. This study investigated the degradation of ore pass walls using scanning data at LKAB's Kiirunavaara mine in Sweden. Geotechnical information obtained from various sources aided in further understanding the ore passes' conditions. The study revealed variations in the ore pass growth rates, highlighting potential stability concerns and the correlation between throughput and pass growth. The findings underscore the need for continuous monitoring and regular inspection to manage wall degradation. The paper proposes potential rehabilitation measures to ensure the stability and safety of ore passes in mining operations.

KEYWORDS

ore passes, wall degradation, growth rate, scanning data, monitoring, underground mining

1 Introduction

Ore passes are a critical component of underground mining operations, used to transfer ore by gravity from production levels to the levels below (Hambley, 1987; Beus et al., 2001; Esmaieli et al., 2013; Skawina et al., 2018). An ore pass failure causes significant problems; redevelopment or rehabilitation of the pass often leads to production disturbances and requires large financial investments (Esmaieli et al., 2013; Skawina et al., 2018). Mechanisms leading to ore pass failure are often associated with the quality of the rock mass, stress conditions, and wearing of the ore pass walls (Stacey and Swart, 1997; Beus et al., 2001). The extent of the damage can be significantly affected by the mechanical properties of the rock mass of the ore pass walls; that is, the weaker the rock, the greater the wear of the walls (Stacey and Swart, 1997; Hadjigeorgiou et al., 2005; Hadjigeorgiou and Mercier-Langevin, 2008; Esmaieli and Hadjigeorgiou, 2009). Particle shape, hardness, density, and size distribution are key material properties responsible for the wearing of the walls (Esmaieli and Hadjigeorgiou, 2009). The orientation of an ore pass is another significant factor affecting ore pass stability; unfavorable orientation, along the bedding, can accelerate the ore pass expansion (Stacey et al., 2005; Hadjigeorgiou and Mercier-Langevin, 2008). The wear of ore pass walls is intensified when repeated blasting aims at restoring material flow (Hadjigeorgiou and Mercier-Langevin, 2008). To prevent excessive wear, ore passes are often

lined with abrasion-resistant materials (De La Vergne, 2003). Some studies suggest keeping the ore pass full can reduce the wear of the walls (Hambley, 1987; Hadjigeorgiou and Mercier-Langevin, 2008; Skawina et al., 2022). Sjoberg et al. (2003) conducted a research project at the LKAB Kiirunavaara mine in Sweden, analyzing the stability of the ore passes with a combination of numerical modeling, empirical data, and engineering judgment. They found rock conditions, stress state, and wear were the most important controlling factors. The study of ore pass degradation is complex, as it is usually the result of multiple mechanisms operating simultaneously (Hadjigeorgiou et al., 2005). Hadjigeorgiou et al. (2005) studied the probable failure mechanisms in Canadian mines and found 53% of the studied ore passes experienced structural failure; 27% of the failures were caused by abrasion, 23% were caused by an impact, and 17% were stress-related. Hadjigeorgiou et al. (2005) observed that the rate of abrasion is influenced by the abrasive nature of the ore pass walls and by the density of the transported material. It has also been observed that the structural integrity of the ore pass does not appear to be compromised by wall wear when only a relatively few fractures, such as joints, faults, dykes, and veins, are present (Hadjigeorgiou et al., 2005). Wear zones or impact damage can be caused by falling material and boulder collisions (Sjoberg et al., 2003) or due to the interaction of moving material with the ore pass walls (Hadjigeorgiou et al., 2005). The area where wall damage is caused by impact tends to be at the intersection of ore pass and finger raises (Hadjigeorgiou et al., 2005; Hadjigeorgiou and Mercier-Langevin, 2008; Esmaieli and Hadjigeorgiou, 2009). In general, the footwall surface of the ore pass has the highest wear, but this may not always be the case when there is an interaction with weak rock and stress scaling (Stacey and Swart, 1997). Scaling is a stress-induced fracture, and it occurs when the stress on the ore pass walls is higher than the rock's strength (Stacey and Swart, 1997; Stacey et al., 2005). Scaling is an issue, especially in deep mines, as it results in significant enlargement of the ore pass (Stacey et al., 2005) and can intensify the wear of the ore pass walls (Stacey and Swart, 1997; Esmaieli and Hadjigeorgiou, 2009; Esmaieli et al., 2013).

Recent studies employ scans and numerical models to simulate the mechanical behavior of the rock mass under specific conditions. Esmaieli et al. (2013) used a two-stage numerical method to enhance understanding of ore pass failure mechanisms and Esmaieli and Hadjigeorgiou (2014) conducted a series of numerical experiments to explore how rock mass foliation affects damage on ore pass walls from impacts. Gohl et al. (2014) assessed the feasibility of utilizing a micro aerial vehicle (MAV) for autonomous inspection and 3D reconstruction of underground mines, they also evaluated the accuracy of the data and its potential for use in a fully autonomous mine inspection setup. Li and Qin (2016) introduced a novel ore pass repair method, that incorporates precise detection and modeling techniques, enabling the integration of repair and protection processes. Benecke et al. (2017), presented advancements in technology for inspecting mine shafts, including completed developments and ongoing projects Adjiski et al. (2020) investigated the impact of different angles between the ore pass and finger raise configurations using Discrete Element Method (DEM), with the objective to minimize both hang-ups and damage to ore pass walls. Parhusip et al. (2021) provided a comprehensive description of the utilization of LiDAR drone technology in underground mines, concluding that this technology has the potential to improve the quality of survey data in a safe manner, and support sustainable production.

This study analyzed the degradation process of ore pass walls using scanning data. The findings highlight the importance of continuous inspection of ore passes in mining operations where regular inspections and monitoring of the pass condition are necessary to manage degradation.

2 Case study - Kiirunavaara mine

The LKAB-owned Kiirunavaara mine, situated in northern Sweden, is an underground mine (Table 1). Using the sublevel caving method, the mine extracts iron ore from a 4 km long, 80 m thick orebody of unknown depth, with an annual 26.9 Mtonnes (2018) of iron ore production. The rock mass quality in Kiirunavaara is typically good, with an average Rock Mass Rating (RMR) of 60 for the footwall. However, it is important to note that rock conditions vary. The dominant joint orientations in the area are north-south (parallel to the orebody) and east-west; both have steep dip angles (Sjoberg et al., 2003). The 'roof' of the ore pass is in the hangingwall, and its 'floor' is located in the footwall (Sjoberg et al., 2003). The footwall is categorized into three groups: trachyandesite rocks, also known as 'syenite porphyries' (Sp1,2,4), nodular porphyries (Sp3), and altered volcanic rocks (Sp5) (Andersson, 2021). Brick-red granite is common in the lower sections (Andersson, 2021). Rhyodacites, known as 'quartz-bearing porphyries' (Qp), are in the hangingwall, along with a network of porphyry dyke (Dp) rocks (Andersson, 2021).

The primary hauling level is currently located at the 1,365 level. The mine is divided into 10 main production blocks, each consisting of two to four ore passes. The ore passes are spaced 30–50 m apart and split into three sections, allowing rehabilitation and inspection of specific sections rather than the entire shaft length. The ore passes have a circular cross-section with a designed diameter of 3 m and an inclination of approximately 60°. A simplified version of ore pass configuration is presented in Figure 1.

3 Methodology

This study focuses on four shafts (OP1 to OP4). The primary consideration for selecting a shaft was to maximize the number of available scans. The scanning process in Kiirunavaara uses ore pass 'buggies' fitted with video recording cameras and drones equipped with LiDAR. The LiDAR drone technology proves to be a valuable tool, offering a safer, more efficient, and data-rich solution for surveying tasks in underground mining environments (Parhusip et al., 2021). Data collected from scans and information provided by the mine were used to determine the rate of wear of the ore passes. The volume growth between each scan was estimated by subtracting the volume of the previous scan from the volume of the current scan. The scans were processed in Deswik.CAD and include information about the quantity of material passing through the shafts between scans, collected by the GIRON system. The area above 1,022 m was excluded from calculations and analyses since it is located above the

10.3389/fbuil.2023.1250671

TABLE 1 Kiirunavaara mine information.

Kiirunavaara mine		
Location	Kiruna, Northern Sweden	
Ownership	LKAB	
Commodity	Iron	
Production	26.9 Mtonnes (2018)	
Orebody size	4 km long, 80 m thick, unknown depth	
Mining method	Sublevel caving	
Current main haulage level	1,365	
Rock type (Andersson, 2021)	Footwall	Hangingwall:
	Syenite porphyries (Sp1,2,4)	Quartz-bearing porphyries (Qp)
	Nodular porphyries (Sp3)	Porphyry dyke (Dp)
	Altered volcanic rocks (Sp5)	

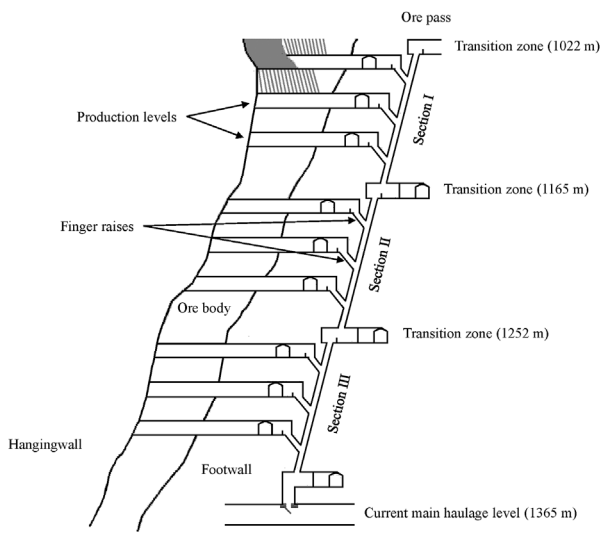

FIGURE 1
Simplified version of the ore pass configuration in Kiirunavaara mine.

previous main haulage level. The ore passes are divided into three sections: Section 1—from 1,022 to 1,165 m; Section 2—from 1,165 to 1,252 m; Section 3—from 1,252 to 1,338 m. Each section was analyzed separately in each ore pass. Another important criterion was that the chosen shaft had not undergone prior rehabilitation. This criterion was established to observe the natural growth of the ore pass before any rehabilitation efforts took place. In this mine, shaft rehabilitation involves the pouring of concrete over the shafts and subsequently raise bored to their original form.

3.1 Ore pass information

Geotechnical information included data from drill cores, internal reports, and interviews with qualified specialists from the mine. However, some information was unavailable. In such instances, the parameters were estimated by considering data from the surrounding area and consulting with experts in conversations and discussions. The GIRON program (a program used by LKAB to store operational data) provided the throughput information, and the forecasted tonnes yet to pass through the ore pass were derived from the life of mine plan (LOMP). Additional information was obtained using Deswik.CAD and internal reports. A summary of the collected data is presented in Table 2.

All ore passes in this study are raise bored, with a diameter of 3 m. The length of the ore passes ranges from 350 to 355 m. The ore passes are operated empty with a scalper screening infrastructure, and no reinforcement or lining is used. All the studied ore passes have a favorable orientation with respect to the bedding. It was observed that there was a significant amount of water in OP1, and not a lot of water in the other ore passes.

The extraction level of OP1 is currently at a depth of 993 m. By 2022, approximately 5.41 Mt of ore had been extracted through the OP1 shaft, and the mine expects another 31 Mt (this value can vary depending on the production plan changes and availability of the ore pass) to be pushed through that ore pass. The walls of the ore pass primarily consist of syenite porphyries and nodular porphyries. Overall, the rock quality is competent, with a moderate level of stress. There is no significant presence of major structures, or no specific information on them is available. The shortest distances measured for OP1 show that OP1 is located 58 m from the entry to the production area, 20 m from the footwall drift, and 28 m from the media drift. The closest ore pass is 27 m away.

The extraction level of OP2 is situated at a depth of 1,022 m. By 2022, 11.8 Mt of ore had been transported through the shaft, with an estimated 3 Mt remaining to be pushed through. The walls of the ore pass mainly comprise syenite porphyries. The overall rock quality is considered to be fairly good, with low levels of stress. As in OP1, according to current information, there is no significant presence of major structures. The shortest distance between the entry to the production area and OP2 is 20.5 m. The footwall drift is 26 m away, the media drift is 5.7 m away, and the closest ore pass is 48.5 m away.

10.3389/fbuil.2023.1250671

TABLE 2 Ore pass information (June 2023).

Ore pass	Time it went into operation and current extraction level	Total throughput up to today and estimated tonnes to pass	Basic information	Geotechnical parameters	Nearest infrastructure
OP1	Year—2013 Current level - 993	Throughput—5.41 Mt (2022) Estimated tonnes to pass—31 Mt	Length - 350 m Diameter—3 m Excavation method—raise bored Screening infrastructure—one rail No reinforcement Fingers—one finger per each production level Rehabilitation - none	Lithology—Sp, Sp4, Sp3 RMR—40–50 Major structures—not found Orientation—favorable Stress regime—moderate stress Water conditions—a lot of water	Entry to the production area—58 m Footwall drift—20 m Media drift—28 m Closest ore pass—27 m
OP2	Year—2013 Current level −1,022	Throughput—11.8 Mt (2022) Estimated tonnes to pass—3 Mt	Length—356 m Diameter—3 m Excavation method- raise bored Screening infrastructure—one rail No reinforcement Fingers—one finger per each production level Rehabilitation - none	Lithology—Sp4 RMR—50 Major structures—not found Orientation—favorable Stress regime—low stress Water conditions - good	Entry to the production area—20.5 m Footwall drift—26 m Media drift—5.7 m Closest ore pass—48.5 m
OP3	Year—2013 Current level −1,022	Throughput—4.4 Mt (2022) Estimated tonnes to pass—26 Mt	Length—355 m Diameter—3 m Excavation method - raise bored Screening infrastructure—one rail No reinforcement Fingers—one finger per each production level Rehabilitation - none	Lithology—Sp2, Sp4 RMR—60–65 Major structures—Dp Orientation—favorable Stress regime—low stress Water conditions—good	Entry to the production area—126.3 m Footwall drift—36.8 m Media drift—3.5 m Closest ore pass—20 m
OP4	Year—2013 Current level—1,022	Throughput—2.2 Mt (2022) Estimated tonnes to pass—27 Mt	Length—355 m Diameter—3 m Excavation method - raise bored Screening infrastructure—one rail No reinforcement Fingers—one finger per each production level Rehabilitation - none	Lithology—Sp2, Sp4, Sp5 RMR—50 Major structures—Dp Orientation—favorable Stress regime—low to moderate Water conditions—good	Entry to the production area—10 m Footwall drift—35.6 m Media drift—10 m Closest ore pass—24 m

The extraction level of OP3 is situated at a depth of 1,022 m. By 2022, 4.4 Mt of ore had passed through the shaft, with an estimated remaining 26 Mt yet to be pushed through. The walls of the ore pass are primarily composed of syenite porphyries. There is a porphyry dyke located in close proximity to the shaft. The shortest distance between OP3 and the entry to the production area is 126 m. The footwall drift is 36.8 m away, the media drift is 3.5 m away, and the closest ore pass is 20 m away.

The current extraction level of OP4 is at a depth of 1,022 m. By 2022, 2.2 Mt of ore had been pushed through the shaft, leaving an estimated 27 Mt yet to be transported. The walls of the ore pass mainly consist of syenite porphyries. The overall rock quality is considered to be good, with low to moderate stress levels. A porphyry dyke is situated in the vicinity of the shaft. The shortest distance to the entry to the production area is located 10 m from OP4. The footwall drift is 35.6 m away, the media drift is 10 m away, and the closest ore pass is 24 m away.

3.2 Scans

Scans were collected from the mine at different times between 2016 and 2022. Regular scans were not previously

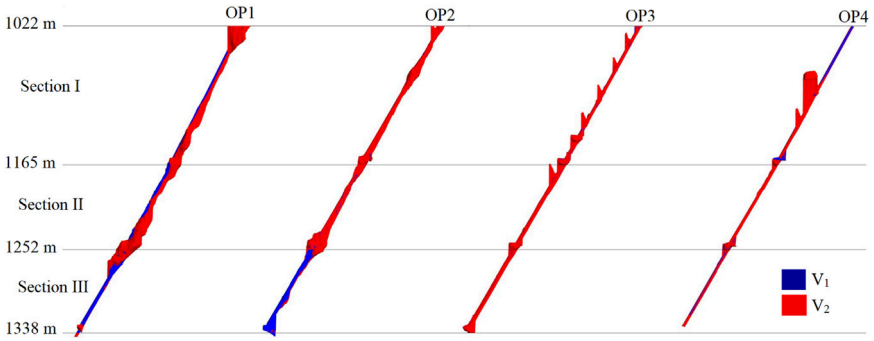

FIGURE 2
Scans of selected ore passes.

TABLE 3 Data from scans.

Ore pass		Volume [m³]		
		V_0	V_1	V_2
OP1	Section 1	1,078	1763	6,756
	Section 2	639	1,494	7,968
	Section 3	648	1752	3,368
	Whole shaft	**2,366**	**5,008**	**18092**
OP2	Section 1	1,101	3,025	4,374
	Section 2	652	2,535	3,743
	Section 3	656	2,169	2,679
	Whole shaft	**2,409**	**7,729**	**10797**
OP3	Section 1	1,101	1750	2,963
	Section 2	660	1,394	1959
	Section 3	658	1,657	2,134
	Whole shaft	**2,419**	**4,801**	**7,056**
OP4	Section 1	1,097	5,008	4,665
	Section 2	656	7,729	1,336
	Section 3	659	4,801	786
	Whole shaft	**2,412**	**3,629**	**6,687**

conducted, so there was a limited quantity of available data. In some cases, the scanning process was conducted only in one section, thus requiring the extrapolation of data from previous scans. In such cases, it is possible that the ore passes may have already undergone enlargement, but this was not visually observed. To determine the rate of wear of the ore passes, the volume growth between each scan was estimated by subtracting the volume of the previous scan from the volume of the current scan. The scans were processed in Deswik.CAD (Figure 2). The designed volume of the ore passes is indicated by V_0, and they were put into operation in 2013. The V_1 scans vary: OP1 V_1 stands for the 2017 scan, OP2 V_1 indicates the 2016 scan, and OP3 V_1 and OP4 V_1 are the 2020 scan. V_2 stands for the 2022 scan.

TABLE 4 Material passing through the shafts.

Ore pass	Throughput [Mt]		
	V_1 - V_0	V_2 - V_1	Total
OP1	1.2	4.2	5.4
OP2	8.1	3.7	11.8
OP3	3.2	1.2	4.4
OP4	0.3	1.9	2.2

Table 3 contains the data on the volume of the shafts obtained from scans using Deswik.CAD. Table 4 includes information about the quantity of material passing through the shafts between scans, collected by the GIRON system.

4 Results

This study evaluated the growth of ore passes using scanning data and other information collected from the Kiirunavaara mine. The Deswik.CAD software was used during the analysis for estimating the volumes. The volumes from the scans are also used for estimating the costs and time required for rehabilitation activities. The results of the growth rates of the ore passes are shown in Figure 3. As the figure shows, the passes had different growth patterns with the highest growth for OP1.

In addition, Table 5 contains information on increments in volume for each section of the four studied ore passes and the results of the collected scans presented in Table 3.

5 Discussion

Based on the information in Figure 3 and Table 3–5, and the scans conducted in OP1 in May 2017 (V_1) and March 2022 (V_2) show a 210% increase from the designed value (V_0) of the first scan,

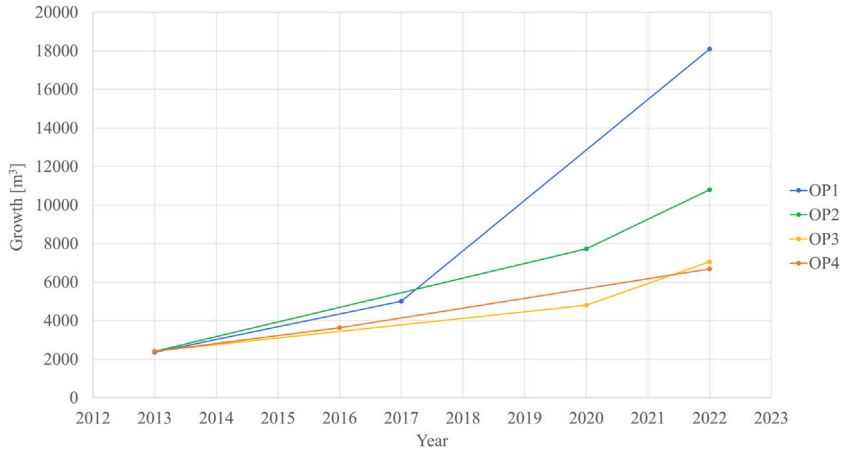

FIGURE 3
Growth chart.

TABLE 5 Ore pass growth data.

Ore pass		Growth [%]		
		V_1/V_0	V_2/V_1	Total
OP1	Section 1	160	380	630
	Section 2	230	530	1,250
	Section 3	270	190	520
	Whole shaft	**210**	**360**	**760**
OP2	Section 1	270	140	400
	Section 2	390	150	570
	Section 3	330	120	410
	Whole shaft	**320**	**140**	**450**
OP3	Section 1	160	170	270
	Section 2	210	140	300
	Section 3	250	130	320
	Whole shaft	**200**	**150**	**290**
OP4	Section 1	160	270	420
	Section 2	170	120	200
	Section 3	120	No scan	120
	Whole shaft	**150**	**180**	**280**

with a throughput of 1.24 Mt. Between the first and second scans, the ore pass increased 3.6 times and passed a total of 4.17 Mt of material. Over the whole period, the ore pass grew 7.65 times and passed 5.41 Mt of material. This represents a significant increase in volume, indicating the ore pass experienced accelerated growth over time which is a concern for future stability in OP1. Further investigation and monitoring of this ore pass are recommended to ensure its stability and to address any potential issues arising from the growth patterns. Moreover, the presence of water in OP1 poses additional risks, such as degradation and mud rushes. Scans conducted in OP2 in December 2020 (V_1) and February 2022 (V_2) show an increase of 320%, with a throughput of 8.1 Mt. Between the first and second scans, the ore pass increased 1.4 times and passed 3.73 Mt of material. In total, the ore pass grew 4.4 times and passed 11.8 Mt of material. OP2 exhibited moderate growth between the scans, with the largest increase observed in Section 2. Despite handling the largest amount of material among all ore passes, OP2 did not experience the greatest growth among the others. It is probably relatively better rock quality and lower stress contributing to less structural damage. Regular monitoring and scanning are recommended to manage OP2's growth and ensure safe and efficient mining operations. Scans conducted in OP3 in November 2020 (V_1) and May 2022 (V_2) show an increase of 200%, with a throughput of 3.2 Mt. Between the first and second scans, the ore pass increased 1.4 times and passed 1.2 Mt of material. Overall, the ore pass grew almost 3 times and passed 4.4 Mt of material. The largest increase was observed in the last section. OP3 exhibited a relatively lower growth rate than the other passes. The shape of the enlargements in Section 1 is caused by the finger raises. While no immediate rehabilitation is needed, regular monitoring and scanning are recommended to ensure the continued safe operation of OP3. Scans conducted in OP4 in May 2016 (V_1) and December 2022 (V_2) show an increase of 150%, with a throughput of 0.3 Mt. Between the first and second scans, the ore pass grew 1.8 times and passed 1.86 Mt material. Overall, the ore pass increased its volume 2.8 times and let through 2.17 Mt of material. The biggest increase was observed in the first section, in the finger raise. Rehabilitation and regular inspections are recommended to manage the growth in the finger raise in Section 1 and ensure its continued safe and efficient operation.

The recommendations and potential cause on the ore pass growth is shown in Table 6. As the table shows, in the first two ore passes (OP1 and OP2), the potential cause was the impact of falling and bouncing rock; in the other two (OP3 and OP4), the potential cause was the closeness of nearby infrastructure and other openings. The table also provides recommendations for each ore pass.

For all the shafts, the more transported material, the greater the growth. This observation suggests a potential correlation between the volume of transported material and the extent of ore pass growth. It also suggests the unfavorable stress regime and

TABLE 6 Ore pass recommendation.

Ore pass		Total growth (%)	Throughput (Mt)	Potential cause	Recommendation
OP1	Section 1	630	5.4	The impact of falling and bouncing rock	Plan rehab for Section 2
	Section 2	1,250			Perform annual scanning and quarterly inspections
	Section 3	520			
	Whole shaft	**760**			
OP2	Section 1	400	11.8	The impact of falling and bouncing rock	Observe growth increase through more frequent inspections. Scan every 1-2 years
	Section 2	570			
	Section 3	410			
	Whole shaft	**450**			
OP3	Section 1	270	4.4	Cavity expansion in the finger raises—close to other media drift and adjacent ore pass	No need for rehabilitation. Scan every 1-2 years
	Section 2	300			
	Section 3	320			
	Whole shaft	**290**			
OP4	Section 1	420	2.2	Cavity expansion in the finger raises—close to production area entry and media drift	Plan rehabilitation for finger raise in section 1. Perform frequent finger raise inspections. Scan finger raises quarterly and whole shaft once every 1-2 years
	Section 2	200			
	Section 3	120			
	Whole shaft	**280**			

geotechnical conditions speed up the growth process. Information gathered from inspections and scans can provide information on the overbreak of ore passes and suggest guidelines on when rehabilitation should start. Further observations can be made if caving does not influence the stability of nearby infrastructure or cause production disturbances.

6 Conclusion

This study analysed the degradation of ore pass walls in Kiirunavaara mine in northern Sweden using scanning data and found the growth rates of the ore passes varied. The findings indicate the importance of the continuous inspection of ore passes in mining operations; however, the frequency of scanning was found to be subject to various considerations, including the availability of resources, implementation plans, and challenges faced by the mine. The current method of analyzing the scans has its limitation related to the type of equipment used and frequency and historical information of the past scans as in some cases there are not many scans available. The credibility of the result was confirmed by video inspections.

Based on the analysis of the data, the following conclusions have been reached.

- OP1 showed a significant volume increase over time, indicating accelerated growth. OP1 had the highest expansion overall, which could have been caused by lower rock and stress conditions. Water presence in OP1 may accelerate degradation and lead to potential issues such as mud rushes.
- OP2 showed moderate growth. OP2 has better rock quality than the other ore passes; this may explain why its structural damage was not as severe despite handling the largest amount of material.
- OP3 and OP4 had slow growth rates. The first sections showed the most significant growth, in the finger raises. In OP3, it might be sufficient to rehabilitate only this specific area. However, as throughput increases, it is recommended to increase the frequency of inspections. The volumes revealed by scans can serve as the basis for the estimation of the costs and time required for rehabilitation.
- Ideally, ore passes with increased throughput should be scanned every 1–2 years. However, when critical overgrowth is observed, more frequent scanning is advisable, i.e., every few months.

To ensure the long-term stability and structural integrity of ore passes, it is essential to conduct comprehensive investigations into the causes of the observed growth patterns. Factors such as geological conditions, design specifications, and operational practices should be thoroughly evaluated. Implementing monitoring systems to track the growth and structural behavior of ore passes over time would provide valuable data for ongoing assessment and timely intervention if necessary. By addressing these issues proactively, the mine can mitigate potential risks and ensure the continued safe and efficient operation of the ore pass systems.

The future work should include implementation of continuous monitoring systems to track the growth and structural behavior of ore passes over time. The scanning process can be optimized by develop techniques to minimize the time required for scanning, such as improved scanning methodologies or scanning during scheduled maintenance shutdowns to reduce production stops.

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

WS and BS contributed to the conception and design of the study. JR and JG collected the data. WS, JG, and BS performed the analysis of the collected data. WS wrote the first draft of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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