Ultra-long ore passes : 250m (+) – can they work, and if so, under what conditions?

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Agenda

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Introduction

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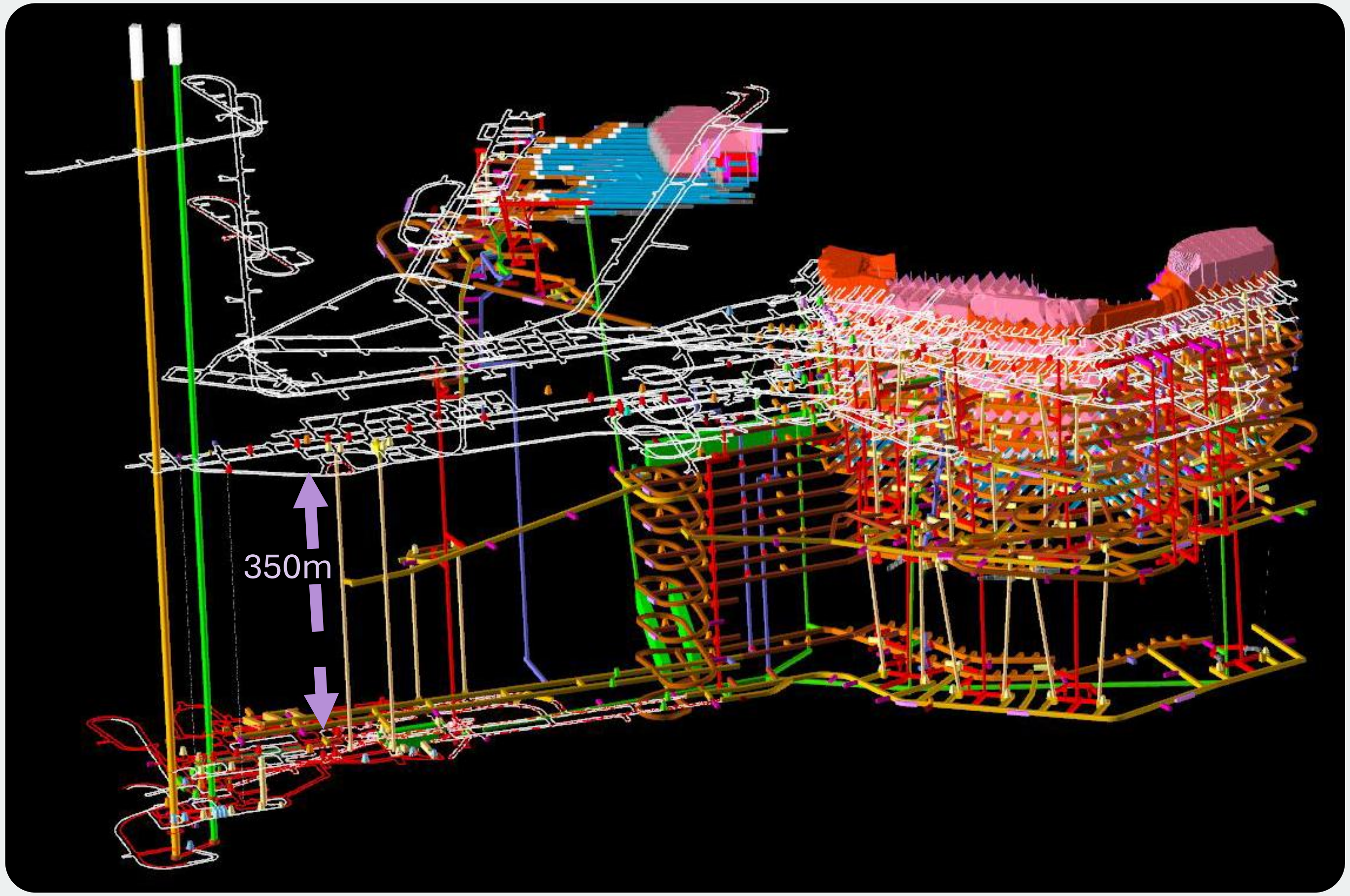
- Orebodies suited to caving can frequently be considered for “macro” style infrastructure layouts
- A “top of mine” connected to “bottom of mine” through 300-400m long vertical passes are an attractive design opportunity
- However, to successfully operate an ultra-long pass system is dependent on several critical dependencies.
- For a case in point a detailed, albeit largely qualitative, risk assessment and risk management strategy was carried out to determine conditions under which an ultra-long pass system would need to be designed and managed, to effectively serve the mine’s production needs.

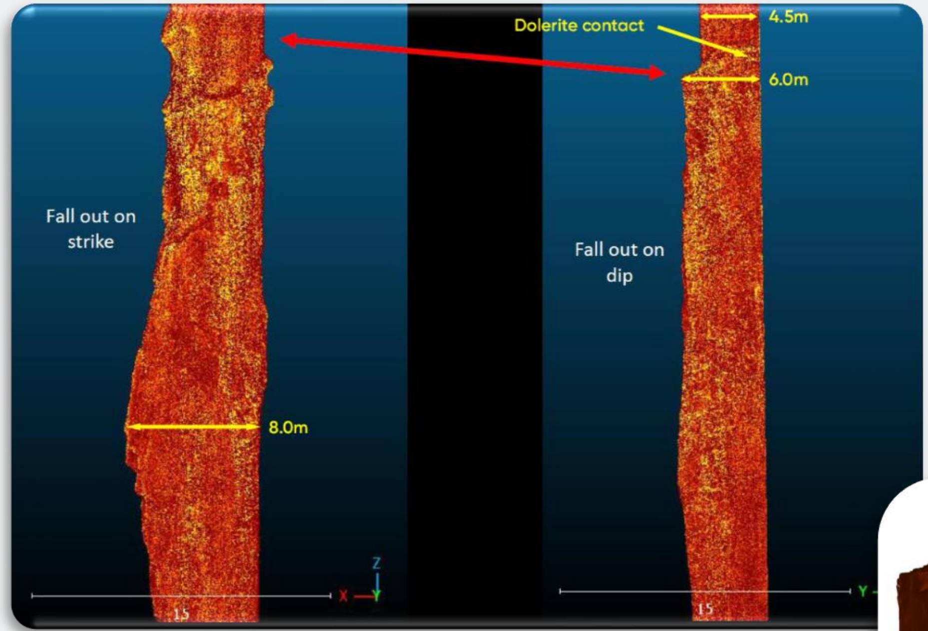


Industry references

Industry examples of ultra-long passes > 300 m *(Salmi, 2024)*

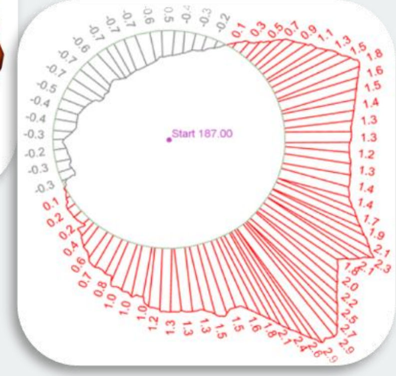
Mine site	Location	Maximum length of ore passes (m)	Method of excavation	Dominant problem	References
Rio Blanco Division, Adina, Codelco	Chile	516	-	Hang-ups due to feeding wet muck	Ascencio (1985), Torres et al. (1981)
Brunswick	Canada	325	Raise-boring	Structural failure, Stress-induced failure	Esmaeili (2010), Hadjigeorgiou et al. (2008)
Grasberg	Indonesia	500 to 650	-	Severe air blast/back blast, dust mitigation issue and serious wear which resulted in significant widening of some passes in the system	Calizaya and Duckworth (2007), Casten et al. (1999), Jarosz (2008), McPherson and Pearson (1997)
Henderson	Colorado, USA	Currently 200 in full length. Mine may use passes with lengths beyond 300 in the future	Raise-boring	Flow dynamic issues and preferential draw in the ore passes' system, significant piston effect, and dust propagation in the system	Callahan and Gillon (2012), Gresham and Turichshev (2016), Nelson and Rutter (2018)
Kiirunavaara	Sweden	Around 350	Raise-boring	Significant wear and deterioration, stress and structural induced failures, issues with oversized fragments blocking ore passes	Manzoor et al. (2023a, b), Sjöberg et al. (2003), Sredniawa et al. (2022, 2023)

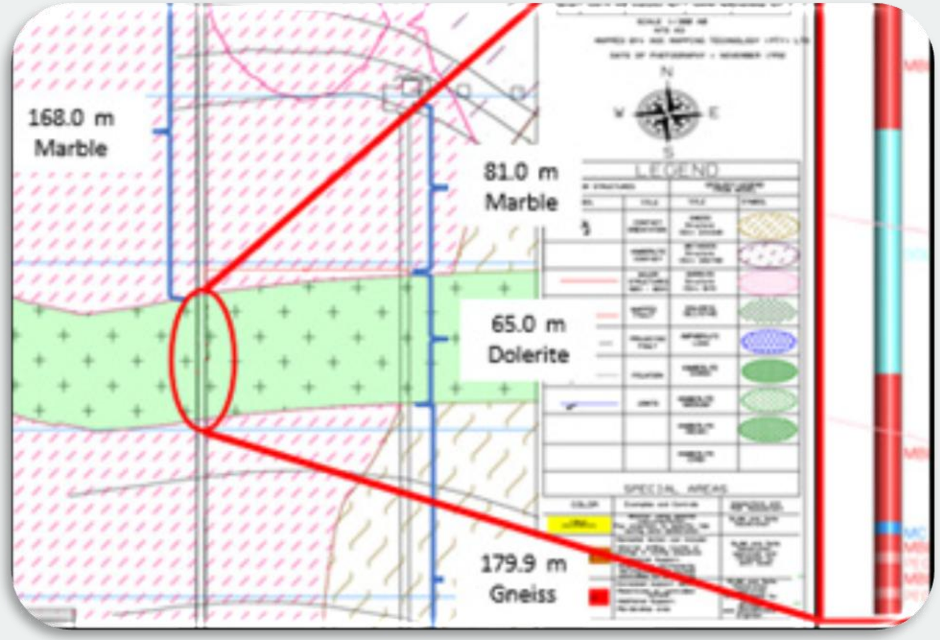
Geotechnical conditions



Scanned adjacent ventilation pass perimeter

Initial blocky unravelling in dolerite on conclusion of reaming





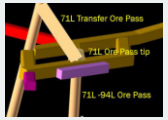
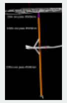
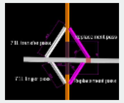
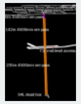
Geological section adjacent ventilation pass

Mining risk management

To ensure a sustainable ore pass utilisation plan, a multi factor analysis was undertaken with input from multiple disciplinary stakeholders, including mining, safety, engineering and operators. Consideration was given to:

- Air blast risk potential as a function of hangup height
- Potential severity of consequence as a function of hangup height release
- Practicalities for hangup release
- Potential for uncontrolled release, and severity as a function of hangup height
- Practicalities of column height monitoring
- Practicalities and dependencies of ore pass functionality through sustained continuous ore flow
- Critical production dependencies
- Water ingress management

Multi Factor Analysis – 54 Level Orepass

	Options	Features	Longevity	Operability	Hangup Management	Constructability	Schedule	Contingency/Mitigation Option	Safety	Opex	Capex	Score
		Weighting%	10%	15%	20%	5%	10%	10%	15%	5%	10%	100%
 	Option 1 - Base case Mid level Transfer with LHD loading	54L Crusher chamber 54L ore pass 3500mm 74L loading area with LHD 74L – 94L Ore Pass 4500mm 94L- 97L Transfer pass 97L Bulkhead with Apron Feeder and CNV Belt	5	7	8	8	5	5	5	2	3	5.70
	Option1a - 54 Mid level transfer with Apron Feeder	54L plug 3500mm 54L – 74L Ore Pass 3500mm 74L transfer feeder 74L – 94L Ore Pass 4500mm 94L- 97L Transfer pass	5	6	6	4	2	2	6	5	4	4.75
	Option1b - Mid level Transfer with Haggloader	*54L ring beam 3500mm 54L – 74L Ore Pass 3500mm 74L Haggloader feeder 74L Flexible Conveyor Train (FCT) 74L – 94L Ore Pass 4500mm 94L- 97L Transfer pass	5	3	7	7	5	5	5	4	2	4.85
	Option 1c- mid level transfer gravity feed	54L – ring beam 3500mm (20m) 54L – 74L Ore Pass 3500mm 74L transfer pass 74L plug on main pass 74L – 94L Ore Pass 4500mm 94L- 97L Transfer pass	2	1	4	1	5	5	4	8	6	3.80
 	Option 2a - mid level transfer gravity feed with finger passes	54L – ring beam 3500mm(20m) 54L – 74L Ore Pass 3500mm 74L transfer pass 74L plug on main ore pass 74L – 94L Ore Pass 4500mm	2	7	4	1	5	5	4	6	6	4.60
	Option 2b - Single 400m vertical pass	Single 400m ore pass between 54L OPA and 94L dead box, with a mid-level access to provide access for identification and unblocking of hang ups	2	8	6	10	7	5	3	7	8	5.90

Multi-factor analysis to determine ore pass design and operation risk management

Conclusions

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- A key outcome of the risk review was the planning of a transfer level from which the ore pass system might be treated for hangups, level monitoring maintained, and/or ultimately bypassed as necessary.
- A more interesting result from the risk review is the initial benefit to conclude a single long (> 300 m) pass, connecting “top” to “bottom of mine”, through which to initiate early production. Simultaneous development of a proactively planned transfer level will then ensure continuance.
- Ultra-long passes have great economic benefit potential and as such will continue to be planned within mine designs wherever possible.
- However, while the cumulative increase in risk management requirements associated with an increase in pass length may be intuitively self-evident, current knowledge remains more largely qualitative than quantitative.
- The length of the pass increases the number of locations at which poorer zones and hangups will occur, and therefore cumulatively increases the likelihood for failure somewhere within the pass. As such the frequency for rehabilitation, release of hangups, and more severe events including air blasts continue to render a long pass system vulnerable.
- Commensurate risk mitigation and management must therefore be explicitly built into the design and management plan to mitigate against potential failure, which is likely to occur sooner rather than later.

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Thank You

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