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Case study: Media Luna paste system

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Abstract

In 2019, Torex Gold Resources (Torex) sought to expands its operations at the El-Limon Guajes (ELG) site in Guerrero State, Mexico, by developing a new underground resource known as the Media Luna (ML) deposit. This deposit, which contains significant gold, copper and silver mineralisation, presented several interesting challenges due to its separation from the existing site infrastructure by the Rio Balsas: a large river in the mountainous region of Guerrero. To access the new orebodies, Torex elected to construct a 6.5 km tunnel under the Rio Balsas to connect the existing ELG infrastructure to the ML deposit.

At the outset of the ML project, Paterson & Cooke (P&C) and Torex agreed to take a collaborative approach, which extended from the early stages of feasibility assessments through to detailed design. The team initially focused on trade-offs and test work to determine an effective strategy to provide paste backfill to the underground mine. The inclusion of new copper and iron sulphide flotation circuits in the existing ELG process plant, which will generate two tailings streams with differing material properties, influenced the design of the paste plant. Material characterisation test work revealed a high pyrrhotite content ranging from 60 to 75%, in one of the tailings streams, prompting additional test work including self-heating and geochemical kinetic tests.

Given the challenging terrain and early mineralogical findings, careful consideration was required to determine a suitable paste plant location that would ensure efficient tailings and binder delivery, and, ultimately, delivery of high-quality paste backfill to the underground stopes. This paper reflects on the unique challenges encountered throughout the project and the team's tenacity in handling adversity while making difficult yet necessary decisions to ensure that Torex will have a world-class paste plant when backfill operations start-up in 2025.

Keywords: *paste backfill, plant design, optimisation, test work, trade-off studies*

1 Introduction

Torex Gold Resources (Torex), a Canadian-based gold producer, is engaged in the exploration, development and operation of its 29,000-hectare Morelos property, located in the highly prospective Guerrero Gold Belt in Guerrero State, Mexico. The property hosts the Morelos Complex, which consists of the ELG Mine Complex, the Media Luna (ML) project, a processing facility and related infrastructure. Commercial production commenced in 2016, and in 2023 the site delivered 453,778 ounces of gold, marking the highest gold production in Mexico for that calendar year.

The ML project is a key development that will extend the life of mine through to at least 2033. The mining methods employed include longhole open stoping (LHOS) for a majority of the ore, supplemented by cut-and-fill stoping where necessary.

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The ML project stands as Torex's flagship initiative, and is supported by substantial capital investment. Given the scale and complexity of the project, defining early challenges and making well-considered design decisions were crucial to its success. Since the beginning of the ML project, Paterson & Cooke (P&C) and Torex have collaborated on various stages of feasibility assessments. This work has since progressed through detailed design, with construction of the paste backfill system expected to be completed in early 2025. The team initially focused on trade-offs and test work to determine an effective strategy to provide paste backfill to the underground mine.

Two primary challenges faced the team. Firstly, the inclusion of new copper and iron sulphides flotation circuits in the existing ELG process plant, which will generate two tailings streams (leached Fe-S concentrate and leached Fe-S tailings) with differing material properties, influenced the design of the paste plant and emphasised a need for the team to approach the test work strategically. Secondly, mountainous terrain and a large river, the Rio Balsas, separate the orebody from the existing mine infrastructure, including the ELG processing plant and tailings filter plant located approximately 7.5 km away. Figure 1 illustrates the site layout. A key driver for the ML project was connecting the orebody to the existing ELG infrastructure, including developing access to the mine as well as the transport of workers, equipment and materials between the mine and existing infrastructure.

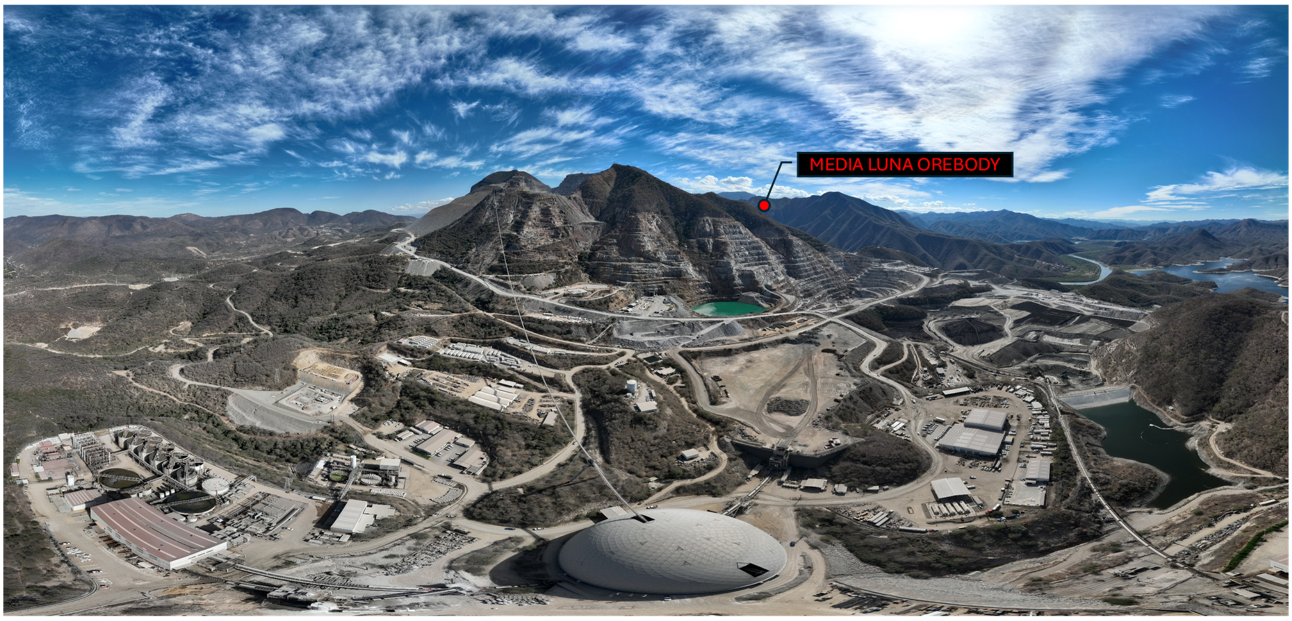

Figure 1 Site layout: El-Limon Guajes Complex (foreground) and Media Luna orebody (background) (courtesy of M3 Engineering)

This paper explores the key studies conducted during development of the ML project, particularly those related to the backfill system, which aided in making appropriate design decisions in the early stages of the project. It also reflects on the unique challenges encountered throughout the project and the team's tenacity in handling adversity while making the difficult yet necessary decisions to ensure that Torex will have a world-class paste plant when backfill operations start-up in early 2025.

2 Unique project challenges and design constraints

David Rockwell's well-known quote, 'Every project is an opportunity to learn, to figure out problems and challenges, to invent and reinvent' (AZ Quotes n.d.) is fitting and this project was no exception. From the outset it was clear that the topography and distance between the existing ELG infrastructure and the new ML orebody would pose challenges for the paste fill system design. The paste fill plant is in the middle of it all, requiring tailings generated from the process plant to produce a paste fill product and distribute it to the stopes in the ML orebody. Locating the paste fill plant appropriately was critical to the project's success.

As the backfill work began, decisions had already been made to tunnel under the Rio Balsas, allowing access to the lower extremities of the ML orebody. While this was largely decided in the context of accessibility for workers and the retrieval of ore for sending back to the processing facility, there was also no interest at that time in constructing infrastructure on the south side of Rio Balsas, including a paste plant, to avoid expanding the project footprint. This proved to be a significant constraint at the pre-feasibility study (PFS) stage as it limited the potential paste fill plant locations and introduced challenges with pumping high-pressure paste up through the orebody. Typically, it is best practice to locate a paste fill plant above the orebody, with gravity working in your favour.

While it is not uncommon to receive limited tailings samples for a greenfield project, this constraint was compounded when the initial material characterisation results revealed a high pyrrhotite content ranging between 60 and 75% in the leached Fe-S concentrate tailings stream. This finding prompted the project team to scrutinise and strategically plan the test work. The elevated pyrrhotite content also necessitated additional self-heating and geochemical leach test work, as a key environmental objective for the ML project was to place a significant portion of the tailings underground as paste fill.

The team took these challenges in its stride and the sections that follow discuss the strategic approach that was undertaken with respect to test work and trade-off studies such that informed decisions could be made to advance the project.

3 Test work

P&C completed the test work in two stages. The first stage spanned the PFS and feasibility study (FS) stages of the project, and aimed to gain an appreciation of the materials to determine practical paste recipes. The second stage focused on long-term unconfined compressive strengths (UCS). Both stages used two tailings types produced by Base Met Laboratories as part of the metallurgical testing campaign: leached Fe-S concentrate (Fe-S Cons) and leached Fe-S tailings (Fe-S Tails). These represented the two tailings streams that will be blended and delivered to the paste plant during operation.

During the first stage, high pyrrhotite content was identified in the Fe-S Cons, prompting the team to refine and develop a strategic test plan. This included conducting UCS tests to assess various blends of Fe-S Cons and Fe-S Tails. Additional self-heating test work was included as there have been instances of fires underground due to the self-heating nature of materials with high sulphide content (O'Brien & Bank 1926; Payant 2010). Geochemical test work was also undertaken as there was concern that leaching of the paste fill could occur decades later if groundwater were to rebound after mining ceased. Given the above, the team knew it was important that the final paste blend satisfied the results and recommendations of the self-heating, geochemical and UCS test work.

The following summarises the main outcomes of the first stage of test work, which influenced the design and decision-making throughout the project:

- Mineralogy – the ML tailings are composed mainly of diopside (silicate), magnetite (oxide), annite (phyllosilicate), clinochlore (phyllosilicate), pyrrhotite (sulphide), and pyrite (sulphide). The presence of sulphides poses long-term strength degradation risks in the cemented paste backfill. Magnetite content requires careful consideration in the selection of paste plant instrumentation.
- Sulphides – the Fe-S Cons stream exhibited high sulphides with pyrite ranging from 1 to 5% and pyrrhotite ranging from 60 to 75%. The Fe-S Tails stream had lower sulphides, with pyrrhotite ranging between 3 and 8%.
- Particle size – the Fe-S Tails are fine, with 23% passing 20 µm, and the Fe-S Cons are very fine, with 65% passing 20 µm and 30% passing 8 µm.
- Solids densities – the Fe-S Cons averaged 4,300 kg/m^3 while Fe-S Tails averaged 3,960 kg/m^3.
- Thickening – dynamic batch consolidation test work achieved 70% bed concentration within one hour.

- Filtration – a laboratory-scale vertical plate filter press was used to simulate the filtration form step. The 1,500 kPa form step achieved ~16% cake moisture content with one minute form time using a 32 mm chamber width and 66.1%m tailings feed. Final cake concentration reached ~85.8%m after three minutes. No membrane squeeze or air blow steps were required to achieve the target process requirements.
- Rheology – cemented paste rheology for 1:1 (green) and 0:1 (red) blends of Fe-S Cons and Fe-S Tails is shown in Figure 2. Blends transferred to the paste plant will fall within this range and it is expected that the rheology will not differ significantly for other blends of 1:2, 1:3, etc. FeS Cons (blue) tailings will not be used on its own to produce cemented paste backfill due to its high sulphides content.

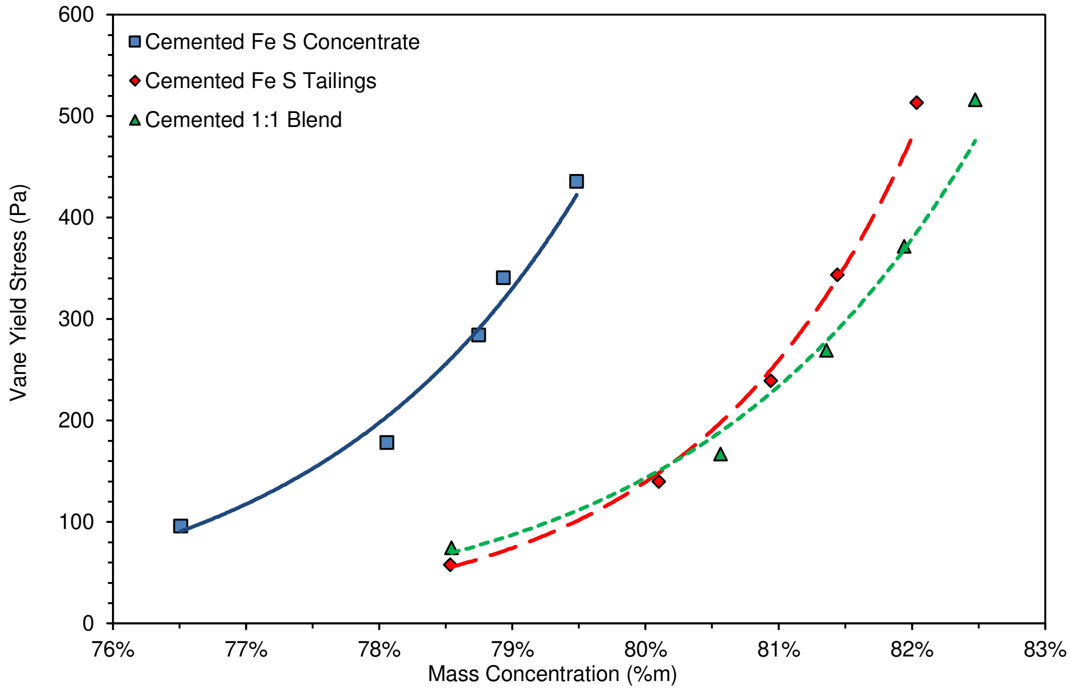

Figure 2 Vane (static) yield stress versus mass concentration

UCS – Results demonstrated strength degradation at higher ratios of Fe-S Cons to Fe-S Tails, notably in the 2:1 and 1:1 blends (Cons:Tails). Blends of 1:2 or lower maintained strength. It must be noted that material quantity constraints did not allow for a comprehensive test campaign (i.e. the team had to be selective in which tests could be completed). The findings above represent blends with a binder concentration of 9.4%. For the lower-bracketed binder concentration tested (1.6%), the strength degradation at 180 days was so significant that tests could not be carried out.

Regarding geochemistry, extensive kinetic testing by NewFields indicated no mixtures produced acid leachate within the expected range of groundwater pH and oxygen levels.

Self-heating tests by BBA Inc (BBA) indicated that paste mix designs with binder content above 2.9% and Fe-S levels of 30% or less were sufficient to designate material blends at a safe level.

In consideration of the UCS, geochemical and self-heating test work, the project team decided that a maximum ratio of 1:2 Fe-S Cons to Fe-S Tails would be targeted. The binder content (Moctezuma CPC 40RS binder) was determined to be ~4.3% on average, subject to cure periods, based on the paste strength targets at the time of the study (2,100 kPa, 430 kPa and 350 kPa for mining below paste, standard transverse stopes and standard longitudinal stopes, respectively) and the intent to fill 100% of stopes with paste fill.

4 Concept level and pre-feasibility study trade-off studies

During the concept level trade-off studies, key assumptions and design criteria were established based on a mining rate of 10,000 tpd. As the project progressed to the PFS design, the mining rate was refined to 8,500 tpd, which resulted in changes to the process design criteria. At the detailed design stage, the mining rate was further reduced to 7,500 tpd. Despite these changes, the trade-off outcomes remained relevant.

The concept level trade-off studies were evaluated on the basis that access to the orebodies from the ELG Complex was via a tunnel below Rio Balsas. Torex initially identified three potential paste plant locations (PB#1, 2 and 3) while P&C added two additional options (PB#4 and 5) for consideration. Figure 3 shows all considered locations.

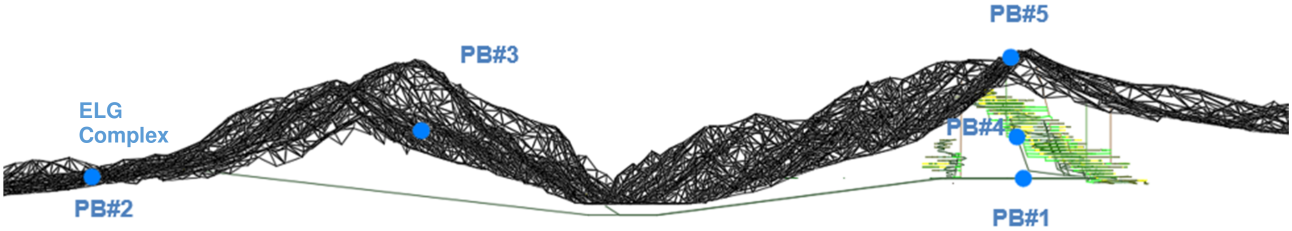

Figure 3 Paste plant location options

Locations PB#2 and 3 were initially assessed and discarded as the number of paste booster stations required to deliver paste to the ML orebodies would be exceptionally challenging to operate. PB#5 was also discarded to avoid increasing the project footprint, with the team deciding this would not be explored further at the PFS stage.

P&C then evaluated the remaining options, PB#1 and 4, focusing on tailings, binder and paste delivery. PB#1 was set at 655 L, while PB#4 was set at 965 L.

4.1 Paste delivery

Paste delivery was evaluated first, considering six deposition points. The deposition points considered include deposition points to the EPO orebody which is located near the ML deposit. Average level piping lengths were used to determine the expected duty head and paste rheology operating envelopes. Figure 4 shows the analysed deposition points, paste plant and booster station locations.

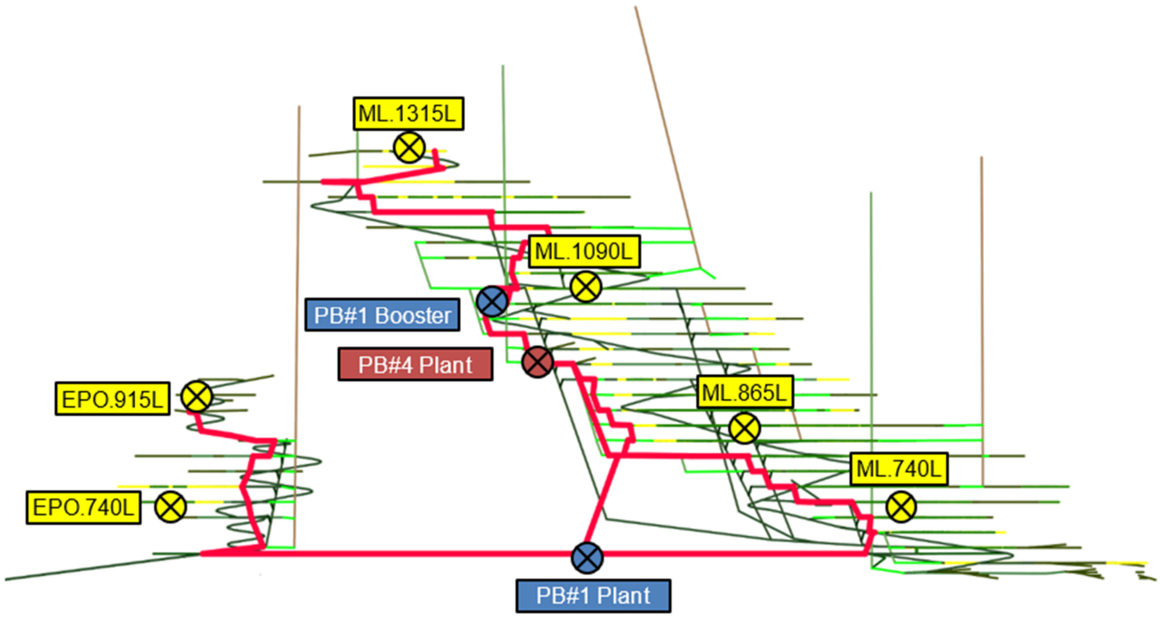

Figure 4 Media Luna and EPO long section

The hydraulic analysis determined that PB#1 would require a booster station at 1090 L to deliver paste to the highest mine elevation: 1315 L. The analysis was based on selecting 15 MPa-rated pumps with a nominal pump discharge pressure of 13.5 MPa. In contrast, PB#4, located at 965 L, was able to deliver paste to the upper mine levels without a booster station. Both options could deliver paste with a yield stress greater than 150 Pa to 1315 L. Table 1 summarises the findings of the paste delivery study trade-off.

Table 1 Paste delivery operating ranges

Deposition point	Paste yield stress range (Pa)			
	PB#1 with booster station at 1090 L		PB#4 without booster station	
	Minimum	Maximum	Minimum	Maximum
EPO.740 L	100	408	117	455
EPO.915 L	100	235	100	273
ML.740 L	100	500	222	500
ML.865 L	100	500	255	500
ML. 1090 L	100	329	100	500
ML.1315 L	100	228	100	152

The trade-off concluded that while both systems produce similar operating ranges, option PB#4 had an advantage in delivering slightly higher yield stress material to the stopes. PB#1 required a booster pump to deliver paste backfill to the upper levels of the ML orebody, which would introduce operational complexity and cost.

4.2 Tailings delivery

Both PB#1 and PB#4 required tailings to be delivered from the ELG Complex to the respective underground paste plant locations. Three alternatives were considered for tailings delivery:

- TD#1 – slurry tailings pumping
- TD#2 – filtered tailings on a two-way ore conveyor
- TD#3 – filtered tailings on a Railveyor (a proprietary system that uses light rail for mining and industrial applications; https://www.railveyor.com)

For TD#1 (slurry tailings pumping), the plan involved a blend of Fe-S Cons and Fe-S Tails delivered to the paste plant at a suitable mass concentration (> 60 %m) for dewatering via vacuum disc filters. To maximise the quantity of Fe-S Cons reporting underground, agitated storage tanks would be required at the ELG Complex to allow storage of Fe-S Cons when the paste plant was not operating. At the time of this trade-off the test work was still underway and filtration test work was not yet completed. It was later determined that the filtration characteristics of the tailings were poor, making pressure filtration the more appropriate selection. Not knowing this, the trade-offs forged ahead to meet the project timelines while assuming vacuum filtration. The hydraulics were evaluated and it was determined that four 6 × 6 centrifugal pumps in series could deliver tailings to PB#1, while a piston diaphragm pump would be required for delivery to PB#4.

For TD#2 (filtered tailings on a two-way ore conveyor), the two tailings streams would be processed through existing pressure filters at the ELG Complex to generate a filtered tailings product. To dewater the filter feed to approximately 60 %m, the Fe-S Tails would first undergo thickening. Given the mineralogy of the Fe-S Cons, the team planned to store the filtered tailings separately within a building, complete with a containment berm and collection sumps to direct leach run-off to a treatment facility for neutralisation. Given only ~50% of tailings could be returned underground, there were ongoing studies by others regarding disposal of a portion of the Fe-S Cons within the surface storage facilities in a manner that would mitigate oxidation and self-heating while adhering to environmental regulations. Filtered tailings from each stream would then be blended and loaded onto a conveyor for transport from the ELG Complex through the under-river tunnel to the underground paste plant at either PB#1 or PB#4. Torex had been planning an 800 tph conveyor to transport ore from the mine to the ELG Complex. This option involved upgrading the conveyor to a two-way conveyor, allowing simultaneous delivery of ore to the ELG Complex and filtered tailings to the paste plant. At the paste plant, dual-stage mixing was included with both a conditioning mixer and paste mixer included. The conditioning mixer is advantageous when receiving the filtered tailings as it facilitates re-pulping of the filter cake into a more manageable mixture before adding binder to produce a homogenous paste mixture.

For TD#3 (filtered tailings on a Railveyor), tailings would be dewatered and stored as in TD#2. However, they would then be blended and delivered underground via Railveyor. This option would need to be a holistic decision for the mine as the cost would be prohibitive for use with the paste plant alone. The Railveyor concept was assessed by the project team for its potential to transport 800 tph of ore from the mine. As with TD#2, P&C included a conditioning mixer at the paste plant.

The opportunities and risks associated with the three tailings delivery options are summarised in Table 2.

Table 2 Tailings delivery opportunities and risks

Deposition point	Opportunities	Risks
TD#1: Slurry tailings pumping	• Alleviates concern with oxidation and self-heating of Fe-S Cons • Slurry pumping is not impacted by weather (no muck or dusting conditions) • Pump station would be accessible at ELG Complex for maintenance and operations staff • Conditioning mixer is not required underground • Reduced power requirements • Proven technology	• Agitated storage tanks required at ELG for Fe-S Cons • Thickener process upsets at ELG Complex may impact filtration performance at the paste plant • Increased process infrastructure required underground (agitated slurry tank, disc filtration [assumption for PFS]) • Introduces more water underground through filtration, requiring pumping back to surface
TD#2: Filtered tailings on a two-way ore conveyor	• Filtration equipment is not required underground • Significant savings on infrastructure by upgrading planned ore conveyor versus dedicated conveyors for the ore and tailings systems • Additional water is not introduced underground • Offers flexibility for a second plant underground to service future mining zones	• Potential for self-heating of filtered tailings • Potential for oxidation of Fe-S Cons, which would be detrimental to backfill strengths • Tailings would need to be filtered at the surface with existing aged equipment (high operating cost) • Building and bermed containment required for leached Fe-S concentrate • Conditioning mixer required underground to re-pulp filtered tailings
TD#3: Filtered tailings on a Railveyor	• Filtration equipment is not required underground • Additional water is not introduced underground • Fully automated system with remote operator control • Flexible system (allows for extending drive stations and track) • Offers flexibility for a second plant underground to service future mining zones	• Refer to risks associated with TD#2 above • High capital cost

Based on the information available and decisions made at the time, TD#1 was deemed advantageous for the following reasons:

- reduced self-heating and oxidation risk. Slurry pumping mitigates risks associated with Fe-S Cons, including potential self-heating and oxidation, offering a cleaner solution for storage of Fe-S Cons, blending of the two tailings streams and transport to the paste plant
- independent tailings transport. A slurry pipeline running below the river would operate independently of other planned equipment. In addition, a pipeline would not take up significant space, cause dusting issues or require frequent spillage clean up
- high operational costs for existing filtration equipment. Operating the existing pressure filtration equipment was known to be very costly.

4.3 Binder delivery

In addition to tailings, binder had to be delivered from the ELG Complex to the respective paste plant locations, PB#1 and 4. Based on an assumption of 4% binder at the time (as test work was still in progress), approximately 280 t of binder was required for 24 hours of continuous operation.

The following binder delivery methods were considered:

- BD#1 – dry bulk containers with a 28-tonne net capacity, requiring ~10 containers over a 24-hour period
- BD#2 – binder slurry. This option involved dry binder storage near the ELG Complex and preparing a binder slurry using colloidal mixers. The binder slurry would be pumped to the paste plant location. The project team agreed that a long-distance binder slurry pipeline presented significant operating challenges, such as the risk of plugging and maintaining a clean pipeline. Any unscheduled downtime at the paste plant would require that the pipeline contents be dumped and thoroughly flushed. This option was discarded due to high operational risk and the potential for wasting binder
- BD#3 – enclosed pipe conveyor. A fully enclosed conveyor system dedicated for the binder system. The pipe conveyor would fully isolate binder from any moisture or water sources
- BD#4 – dual use of tailings conveyor. This option would extend the TD#2 option, transporting binder on top of the tailings. This option was discarded due to risks of hydration during transport, potential dust control issues underground and poor dosage control
- BD#5 – pneumatic conveyance. A pneumatic conveyance system was considered, though most existing systems do not operate beyond a length of 1 to 2 km. After consulting with specialist vendors it was determined that extending to the required 7.5 km distance would not be cost-effective or feasible. Given that the technology over this distance was not proven, the project team discarded this option.
- BD#6 – Binder on Railveyor: The team investigated using the Railveyor system to transport binder. Although there were no Railveyor cars specifically designed for this application at the time, the vendor confirmed that a car could be developed.

Table 3 summarises the opportunities and risks associated with the three binder delivery options.

Table 3 Binder delivery opportunities and risks

Binder delivery option	Opportunities	Risks
BD#1: Dry bulk containers	• Proven technology; used at other mines • Low capital investment • Mitigates risk of binder hydration • Mitigates risk of dust control issues underground • Avoids need for any permanent infrastructure installed within the underground access tunnel • Does not introduce significant infrastructure requiring maintenance	• Potential delays in transport of binder to paste plant; logistics concerns
BD#3: Enclosed pipe conveyor	• Mitigates risk of binder hydration • Mitigates risk of dust control issues underground • Avoids any trucking constraints or congestion within the tunnel	• Significant infrastructure required for conveyor system • Introduces 7.5 km conveyor that requires maintenance • High capital investment for low-tonnage conveyor
BD#6: Binder on Railveyor	• Railveyor system allows for transport of multiple materials (filtered tailings, ore and binder) • Mitigates risk of binder hydration • Mitigates risk of dust control issues underground • Avoids any trucking constraints or congestion within the tunnel	• At the time, Railveyor did not have enclosed cars to transport binder but noted it was possible • Significant infrastructure required for Railveyor system • Railveyor system will require maintenance • High capital investment

Following a review of the binder delivery alternatives, the team selected the dry bulk container option (BD#1), given the following benefits:

- Containers could be customised for transport on a proprietary system that Torex was considering.
- Low capex investment and reasonable opex were achievable.
- Storage in containers mitigated the potential for binder hydration or dusting issues underground.

5 Feasibility trade-off studies

As the project progressed to the FS stage, two key things changed. Firstly, other aspects of the project were requiring critical mine infrastructure and access on the south side of Rio Balsas. This included ventilation raises and portal access at two elevations. With the mine daylighting on the south side of Rio Balsas, mindsets began to shift, prompting reconsideration of a surface paste plant. The second, and very important, item was that preliminary filtration results appeared unfavourable for vacuum disc-type filtration.

The shift in mindset and preliminary test work results prompted several trade-offs at the FS stage; however, the most significant trade-off remained the location of the paste plant. Torex had established that a portal would be constructed at approximately 1105 L (referred to as the South Portal) and noted that a pad could be constructed at this location for the paste plant. The South Portal also offered improved access to construct and service an underground paste plant at elevation.

Although initial filtration results appeared unfavourable for vacuum disc-type filtration, the full suite of filtration test work was still underway, and a trade-off had not yet been completed to determine the optimal filtration equipment. As such, the surface and underground plant locations options were considered, assuming vacuum disc filtration would remain the path forward.

Figure 5 identifies the two potential locations for a paste plant (options 1 and 2), which formed the basis of the trade-off study. Table 4 summarises the design criteria and options evaluated in this FS stage trade-off. Table 5 provides a summary of the trade-off assessment, comparing each option and noting the relative outcomes.

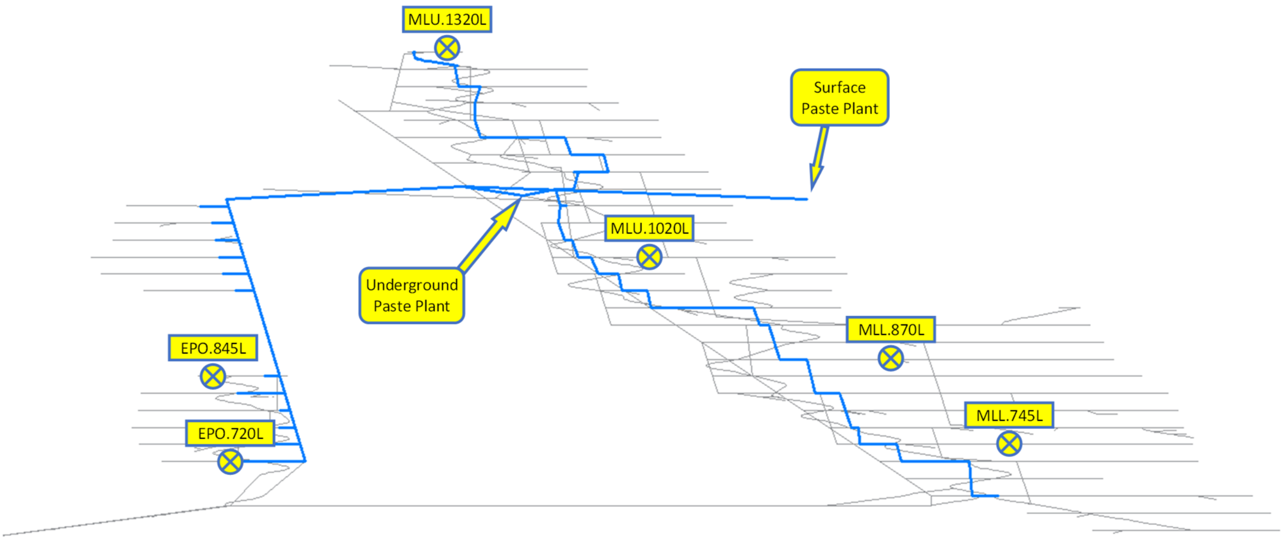

Figure 5 Paste plant locations considered

Table 4 Paste plant location trade-off (during feasibility study): design criteria and options considered

Item	Details/description
Design criteria	8,500 tpd mine plan 960,000 m³/year paste requirement 180 m³/h plant throughput (~60% utilisation)
Option 1: South Portal surface paste plant	Paste plant located on a pad at South Portal (1105 L), serviced with slurry tailings from the ELG Complex (~9.1 km) and binder delivery via truck to bulk storage on the surface. A 15 MPa hydraulic piston pump would deliver paste to the underground stopes.
Option 2: Underground paste plant at 1100 L	Underground paste plant at 1100 L, serviced with slurry tailings from the ELG Complex (~8.3 km) and binder delivery via truck to bulk storage on the surface, with 1.3 km pneumatic conveyance to the underground plant location. A 10 MPa hydraulic piston pump would deliver paste to the underground stopes.

Table 5 Paste plant location trade-off comparison and outcomes

Item	Option 1: South portal surface paste plant	Option 2: Underground paste plant at 1100 L	Assessment outcome(s)
Tailings delivery	• 9.1 km DN 300 pipeline	• 8.3 km DN 300 pipeline	• Option 2 was marginally favourable given the shorter distance, but both involved long-distance pumping of tailings
Binder delivery	• Delivered via truck to South Portal • Binder storage adjacent to plant	• Delivered via truck to South Portal • Binder storage adjacent to plant • 1.3 km pneumatic conveyance to underground plant	• Option 1 was favourable as it offered a much simpler process for binder delivery. Less equipment, less maintenance and lower potential for delivery issues
Paste plant	• Enclosed or partially enclosed paste plant with supporting infrastructure (tanks, binder storage, containment, etc.) • 9.1 km DN 300 return water line • 15 MPa-rated pump for paste delivery	• Extensive underground development to accommodate paste plant • 8.3 km DN 300 return water line • 10 MPa-rated pump for paste delivery	• In this instance, both options were comparable, with a building structure required for the surface plant but extensive development required for the underground plant. Shorter distance for return water line with option 2 and a lower pressure 10 MPa paste pump, which would save costs on the reticulation system and paste delivery
Operations/ maintenance	• Ability to pour through a blast with proper procedures and communication protocols in place • Simplified access for shift changeover, maintenance, etc.	• Not typical to pour through a blast if the paste plant is located underground • Accessibility is reduced with an underground plant location	• Option 1 considered highly advantageous from an operations and maintenance perspective • Shutting down during a blast was a concern as it may impact the ability to meet the required plant utilisation

Constructability/ construction schedule	• Improved construction schedule as there is no need to wait for underground development • Constructability is greatly improved when compared to an underground plant	• From a schedule perspective, must wait until underground development is complete. This also pulls critical mine equipment away from tunnelling and advancement to orebodies • Constructability difficult underground	• Option 1 was highly advantageous from a scheduling perspective • Option 1 was also considered highly advantageous from a constructability perspective as it offered better access for people and equipment, and improved working conditions
Flexibility for expansion	• Site footprint on surface is easier to expand for filtration and dewatering requirements	• Constrained in terms of expansion	• Option 1 was advantageous in that the footprint could be expanded if there was a need to move towards pressure filtration (which there was in the end)
Costing	• Underground development costs saved • Moderately lower capex and similar opex in comparison with underground plant	• Significant underground development costs • Some savings on 10 MPa paste pump, minor improvement in paste delivery operating ranges (lowering opex), but overall higher capex and similar opex to surface plant	• Option 1 was considered favourable from a capex perspective (~USD 10 M difference) and the opex difference between the two options was < 4%

This trade-off study evaluated the same items assessed at the PFS stage; however, each option was well-defined at the outset in terms of the tailings, binder and paste delivery methods. The project team was able to examine the details more thoroughly and better assess both the capex and opex associated with each option. Additionally, factors such as access, operation, constructability, scheduling and flexibility for future expansion were carefully considered.

Following the location trade-off study during the FS, and based on other trade-offs completed, a decision was made by the project team to carry out the FS based on a South Portal surface paste plant (option 1). The FS design was refined to reflect a process change from vacuum disc filtration to pressure filtration as the filtration test work had revealed the filtration characteristics of the tailings were poor, making pressure filtration the more favourable technology. The project advanced through to detailed design, and the plant is now under construction, with commissioning planned for the first half of 2025. The current state of construction is shown in Figure 6.

Figure 6 Media Luna paste plant construction (15 October 2024, courtesy of M3 Engineering)

6 Lessons learned

The key lessons learned during the ML project included:

- team collaboration. Working with the owners' team, mine planners, operations and other stakeholders is important to create a balanced solution that meets the project needs. Early engagement helps align the project expectations and avoids delays
- material challenges. The high pyrrhotite content in the Fe-S Cons required specialised testing to optimise binder recipes in consideration of leaching potential, self-heating and strength development. The filtration test work results were also critical in defining the process requirements for the plant

- scheduling test work. Perform test work early: it will save valuable time and streamline efficiencies on the project. In this case most of the test work was completed through our in-house laboratory, allowing our team timely access to test work results. This was important as we were able to quickly make design decisions and adjustments without introducing schedule constraints
- importance of trade-off studies. There are several critical aspects in a paste system (binder, tailings and paste delivery, plant location, etc.). While it is important to look at each aspect individually, it is equally important to step back and look at the holistic system to determine the most favourable approach in consideration of the unique project constraints. As a project progresses, new information or changes to project constraints may be introduced. Don't be afraid to revisit trade-off studies when this happens. This is the time to make adjustments, as it will be far more costly to make changes later in the project. This is evident in review of the timeline for this project, as assumptions needed to be made early in the project and, in some cases, trade-offs were revisited to validate decisions. The timeline for the paste system from PFS and initial test work through to commissioning (estimated) is presented in Figure 7.

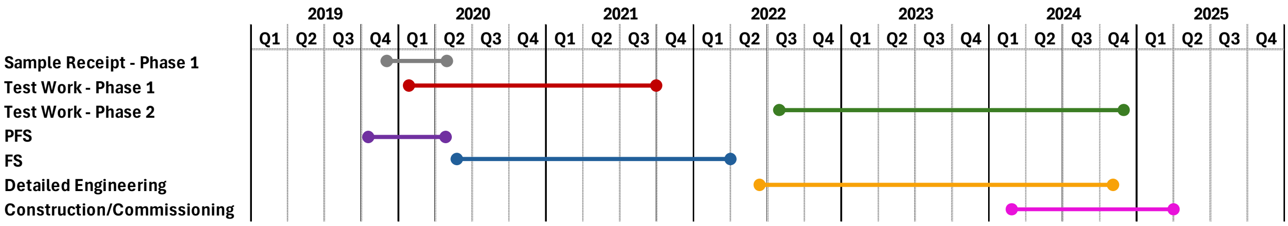

Figure 7 Media Luna paste plant project timeline

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