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A Step Change in Dry Stack Tailings – Our Challenge

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Cameron is a geotechnical engineer specialising in developing responsible solutions for tailings and mine waste challenges. Cameron has experience from the permafrost of the Canadian arctic to the Australian deserts and many environments in between, encompassing a wide variety of commodities and tailings disposal methods, including dry stacking.

Cameron has a good understanding of local and international tailings guidelines and standards having lived and worked in Perth and Vancouver. Cameron's areas of focus are holistic mine waste management practices, evaluation of methods of disposal, feasibility and detailed designs, audits, issue for construction documentation and construction oversight.

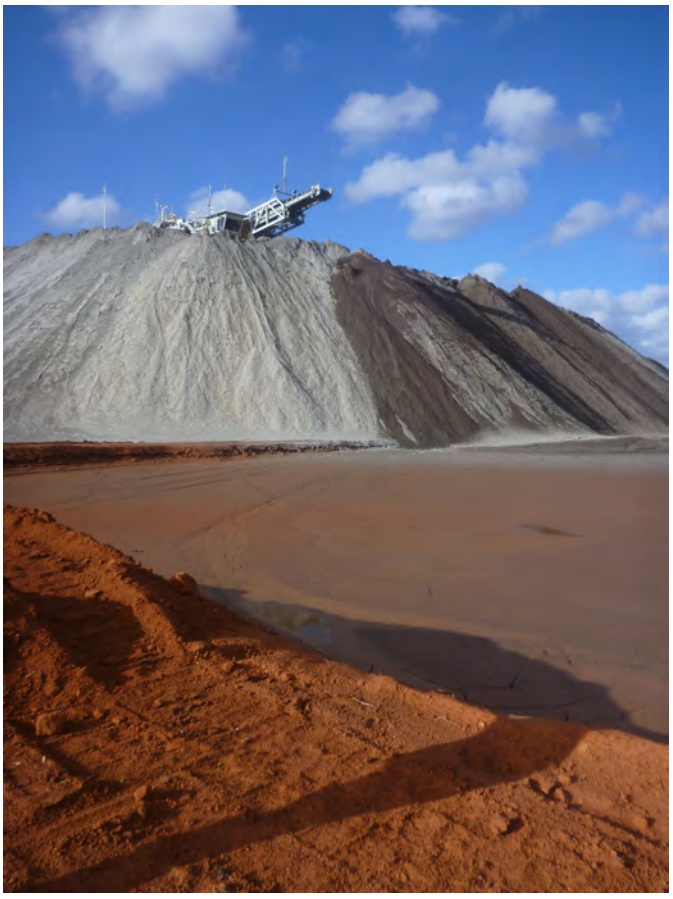
Too often, dry stacking or filtered tailings management is dismissed early in the alternatives assessment process due to the high production rates of many projects.

Broadly, the consideration of tailings filtration and dry stacking is becoming more common, as mining operators seek to align with stated best practices. Changes in risk awareness and risk tolerance are encouraging mining companies and stakeholders to seek alternatives to conventional deposition and dry stacked tailings is often considered a safer, lower risk solution. At the same time, technologies are also catching up to deliver cost savings at economies of scale. However, a singular criterium - high production rate - is often unnecessarily eliminating dry stackings as a viable option, well before the necessary thinking is done on how it might be effectively employed and costed on a project.

The challenges faced by some existing operators have fueled the reputation that dry stacking is complex, expensive and operationally intensive, even though these issues are often simple to solve. Dry stacking is a proven alternative for tailings management at production rates of up to 30,000 tonnes per day (tpd). However, to have a real impact on the mining industry and community at large, our challenge is to achieve a step change in dry stacking that enables production rates of 100,000 tpd and beyond.

Managing Ore Variability

The first question that is often asked is "Can my tailings be filtered?" and the answer is, generally, yes. The more important



questions are around efficiency and variability. Filtering and dry stacking projects are more sensitive to ore variability than conventional tailings management systems. A lack of understanding of the impacts of variability can lead to further operational challenges. To overcome this, the designers and operators need to be well-informed and plans to manage variability must be implemented.

As an example, clay mineralogy zones are often short-lived in terms of the overall life of the mine. When these are encountered, placement strategies can be put in place to manage less-efficiently filtered material, such as placement in non-structural zones. Ensuring communication between tailings facility designers, operators, metallurgists and mine geologists is crucial to avoid potential negative impacts caused by ore variability.

The next key question is "Do I need to filter ALL my tailings?". When dealing with ore zones containing material that is less efficient to filter, separating the tailings material into streams can offer significant improvements to the overall system efficiency and economics.

Taking the focus away from economics of scale and focusing on tackling the challenge in smaller parts can result in a more effective outcome.

Defining Target Moisture Content

Target moisture content is a key factor in the design of a filtration plant and filtered tailings facility, and it is often incorrectly assumed to be 15% or simply related to a proctor result. In truth, there are many key drivers to consider. For example, conveyabilty is affected by the maximum moisture content suitable for a given conveyor angle; truckability and trafficability have different maximum moisture contents; or a certain moisture content may be optimal for compaction.

Some factors are interrelated and others independent, but each needs to be carefully considered to accurately define the target. Moisture content targets are often viewed as a one-dimensional factor but understanding different tailings properties and uses can allow the definition of different targets for each set of circumstances. Understanding these key drivers allows operators to set smarter, more flexible targets.

Consideration for Off-Spec Tailings

Off-spec tailings management must be considered in the design of dry stack tailings facilities, ideally in two key stages: commissioning and operations. During commissioning, the production rate is often lower, but the likelihood of filter underperformance is higher. Additionally, operator focus is typically on mineral recovery and attention tends to be focused on challenges in the process plant. With a plan and allowance in place for off-spec tailings, handling this becomes part of normal operations and major challenges associated with negative reputational risks can be avoided.

During operations, the likelihood of a step change in performances is lower, but with typically higher production rates issues can compound faster. In this stage, there are a range of reasons, aside from filter underperformance, for off-spec tailings, for example: rainfall onto tailings already on the loading pad.

Developing and implementing an off-spec tailings management plan is a low-cost activity that can prevent minor hiccups becoming big problems.

Is Dry Stacking Climate Specific?

A common misconception is that dry stacks are only appropriate for mines in arid climates. Although water availability is a key driver for operations to implement dry-stacking, this is no longer the only reason. Dry stacks can operate in wet and cold climates if designed appropriately such as Buritica in Columbia and Greens Creek in Alaska.

Climate alone, like production rate, should not rule out filtered tailings as a viable option.

Dry Stacks are Not Dry

As production rates increase and stacks get higher, designers and operators need to understand the generation of pore pressure within dry stacks. Saturation level is easily measured at the plant as material leaves the filtration system and when at the surface of the facility, but as the facility grows and loading gets higher, compression is induced, and tailings pore space conditions change. The base layer experiences the most load and is also the most likely to have off-spec or high moisture content tailings. As the height increases, the compression of that tailings material moves it closer to saturation.

When looking at stacks of significant heights, applying critical state soil mechanics can help to understand the limits and response of a given lift to subsequent lifts. Unless a deposition uses thin lifts with compaction, typically at least some of the stack will be contractive. Understanding and managing this risk is crucial and requires instrumentation and monitoring to inform decision-making, as with any other tailings facility.

Co-Mingling Methods

Co-mingling and co-disposal approaches have their own challenges and associated cost considerations, particularly where geochemical issues are present. However, they may offer better operational flexibility and alternative approaches to manage increased production rates, stack heights and potential for changing conditions. This has been demonstrated at several operating stacks and has also been incorporated into several bench and field-scale pilot studies.

Capital Versus Operating Costs

When looking at the costs for implementing dry stacked tailings storage, perspective is important. In isolation, some costs will be higher for a dry stack compared to a conventional slurry facility; however, these costs are often balanced out when viewed from a broader perspective. Capital expenditure costs for a high production rate dry stack operation can be similar, and in some cases less than conventional approaches.

The key difference is often in the operating expenditure. Closing the gap in OpEx costs between dry-stacking and conventional tailings storage is highly dependent on site-specific stacking approaches and management strategies. Haul distance, placement strategy and compactive effort in structural zones can significantly increase the unit cost of a dry stack facility.

However, optimised designs, effective management and monitoring strategies can significantly lower these costs. Reducing risk and uncertainty associated with potentially high OpEx costs requires a close interface between owners, designers, operators and equipment vendors in both the planning and execution stages.

Holistic consideration of the true life-of-mine costs and potential risks (e.g. water costs, land acquisition, risk and closure costs) can bridge the gap in cost comparison between dry stacking and conventional methods. As a result, filter-pressed dry-stacking is increasingly being considered an economically viable – and even preferred – option for higher tonnage projects. However, this requires the necessary thinking and design effort to be undertaken to enable adequate comparison.

Rising to The Challenge

Though there are limitations, dewatering vendors, design engineers and mine operators are rising to the challenges as increasingly more mines are considering a filter-pressed tailings storage approach. However, if we as an industry are to enable a step change in the scale of dry stacking, we need to undertake the thinking and solve the project-specific challenges. That will only happen if we enable large-scale dry stacking to remain a viable option in alternatives assessments and don't misjudge production rate alone as an elimination criteria. Dry-stacking is certainly not the right tailings management strategy for all projects. But, in a landscape of shifting industry sentiment and risk tolerance and increasing advancements in technology, dry-stacking will continue to grow as a viable – and favourable – tailings storage method.