Why do projects go wrong and what systemic risks exist in the current design process?

Mining

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Location: Webinar

Key issues with Mine Design

- A key objective of the design process is to design the mine to succeed by optimising value while reducing risk of failure
  - Maximise initial revenue to optimise NPV and repay loans by targeting higher initial grade and minimising time to get into production
  - Minimise initial capital expenditure by deferring stripping or underground development
  - Ensure operating costs are fundamentally low by selecting the best mining methods and equipment

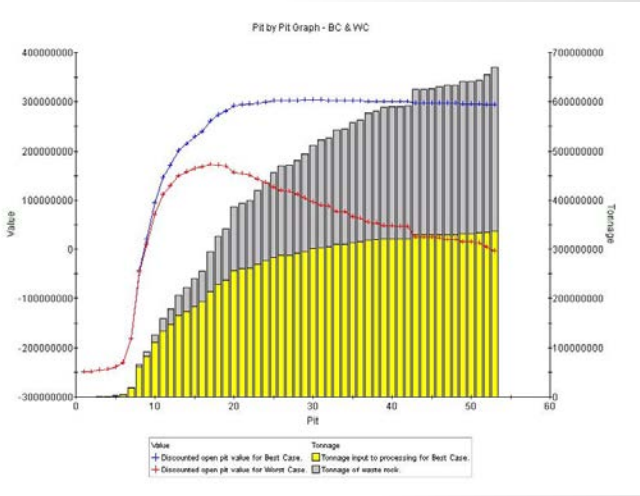
- Generally, the mine design itself is fine. Areas where SRK notes standard approach could be improved include:
  - Avoiding risk of being locked into mining uneconomic material
  - Estimating mining losses and dilution especially for complex orebodies
  - Waste dump design and estimation of haulage effort
  - Understanding how to use cut-backs more effectively to defer waste stripping
  - Blast designs and equipment selection based on classic Russian equipment; not necessarily the most cost-effective
  - Estimating capital and operating costs accurately

- This can lead to late changes in project scope when reviews highlight opportunities or, worse, spending money twice
  - But better to change during the design stage than during construction

Ensuring that the economic limits are economic

Optimisation software now widely used but sometimes also misused

- Which price to use?
  - Historic? Current?
  - Long term future?
- Which costs to include?
  - Typically cash costs are used
  - Ideally should include allowance for sustaining capital and margin
  - Depth adjustment should include waste dump elevation gains
- Which pit shell to choose?
  - Peak?
  - Best or Worst Case?
  - Inflection point?

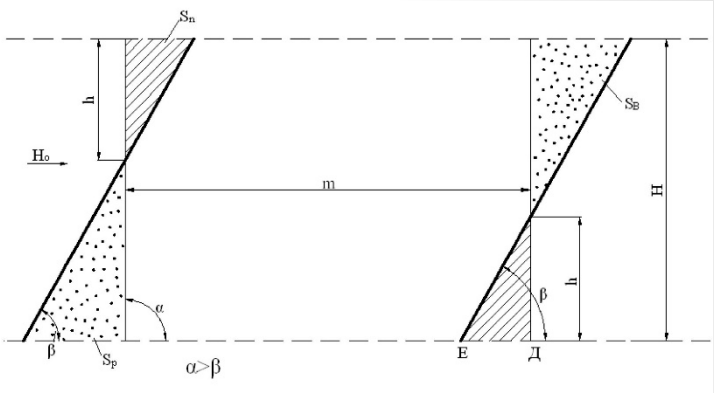


Ideally, cashflow schedules should be developed for different shell options including sustaining capital to verify the selection of the final shell

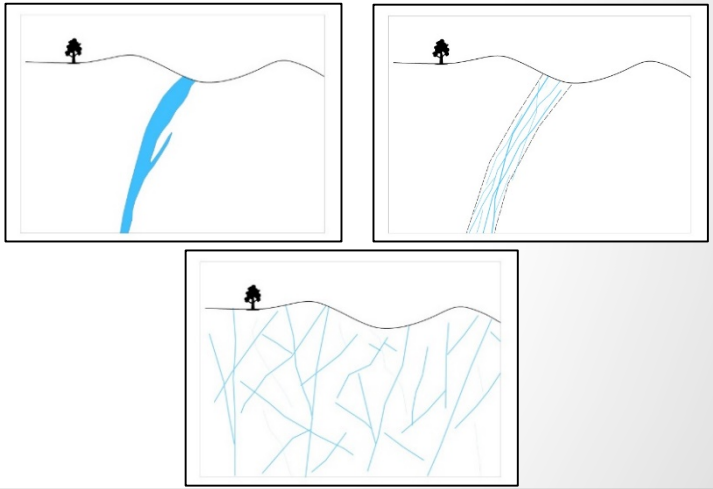
Once the TEO Konditsii has been approved, then it is difficult to change your mind.

Estimating mining losses and dilution – Open Pit

- Classical method suitable if deposit is consistent
- Modern equivalent is “regularisation”
- Not ideal for shallow dipping orebodies
  - Can split benches or use backhoes to reduce losses & dilution



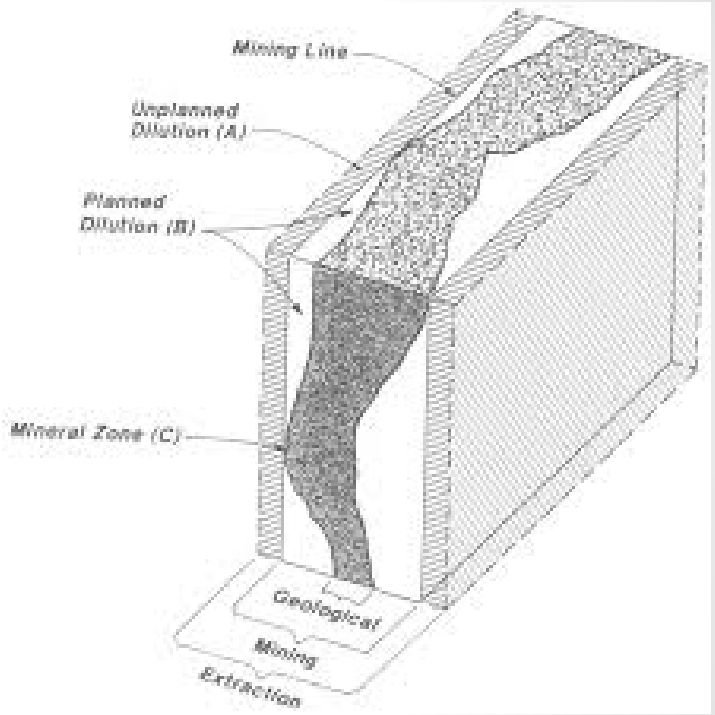
- Principal risk is when an ore:waste ratio is used
  - Likely whole mineralised zone will be mined
  - However, dilution considered “excessive” and manually adjusted
  - Result is an under-estimation of tonnage and over-estimation of grade
  - Leads to under-sizing mill capacity, sometimes incorrect flowsheet, and grossly over-estimated revenue



Estimating mining losses and dilution – underground

- Key elements:
  - Planned loss & dilution
  - Unplanned loss & dilution
- Requires a good understanding of the orebody variability
  - Some dilution included in resources estimate
- Also depends on effectiveness of operational controls …
  - Accuracy of blasthole drilling
- … and orebody geometry
  - It can be difficult to achieve full extraction of shallow dipping orebodies

- Under-estimating dilution can lead to under-sizing shaft capacity which will be expensive, if not impossible, to correct later



Waste dump design & the tonne-kilometre method of estimating haulage effort

- When the strip ratio is say 5m^3/t then 12x more waste mined than ore
- Haulage costs are typically 40-50% of mining costs
  - Optimisation of project costs depends on optimising the waste haulage costs

- Tonne-kilometre is a simple measure of haulage effort
  - Does not distinguish between uphill or flat distances
  - Uphill loaded speed ~ 14kph; flat loaded speed ~30-40 kph

- Dump design should aim to achieve optimum balance between lift & horizontal width
- Also choose the swell factor carefully
  - Varies between 1.1 and 1.5

Optimising the mining sequence & mine layout

- Key points SRK has observed:
  - Potential to use cut-backs to defer stripping
  - Potential to mine less initially and more later, rather than target a constant mining rate
  - Mining layout often uses narrow benches which will reduce efficiency

Cost estimation

- Several options available
  - Analogue, benchmark or historic figures in costs per tonne
  - Budget estimates using databases to determine costs per hour and capital costs
  - Quotes for equipment and consumables
- Areas sometimes overlooked
  - Repair costs
  - Replacement costs
- Need good estimates of work and efficiency
  - Need to reconcile information with actual operations

So why does this happen?

- Limitations of Russian regulations, lack of skill by designers or the way the study process is managed by clients?

- Generally, Russian projects have more global geological information than international projects but less geotechnical and hydrogeological data
  - Issues can arise when detailed geological data does not confirm modelling assumptions

- The division of effort between TEP/TER, TEO Konditsii and Stage P is often not effectively managed to ensure options are evaluated adequately – often too early or too late
  - TEO Konditsii sometimes finalised before necessary geotechnical data is collected
  - Some design options are either evaluated too early or too simply

- Some key decisions need to be made more carefully
  - Selection of mining losses and dilution should be made by engineers working with geologists and based on practical experience
  - TEO Konditsii sometimes done with too many assumptions given that the results are difficult to change

- Some designers lack key skills:
  - Operational experience
  - Understanding of mine economics

All of these points can be managed within the current system

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