BC & Yukon Branch

Mill Feed Quality: where did all the waste come from?

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SRK Consulting (Canada) Inc.

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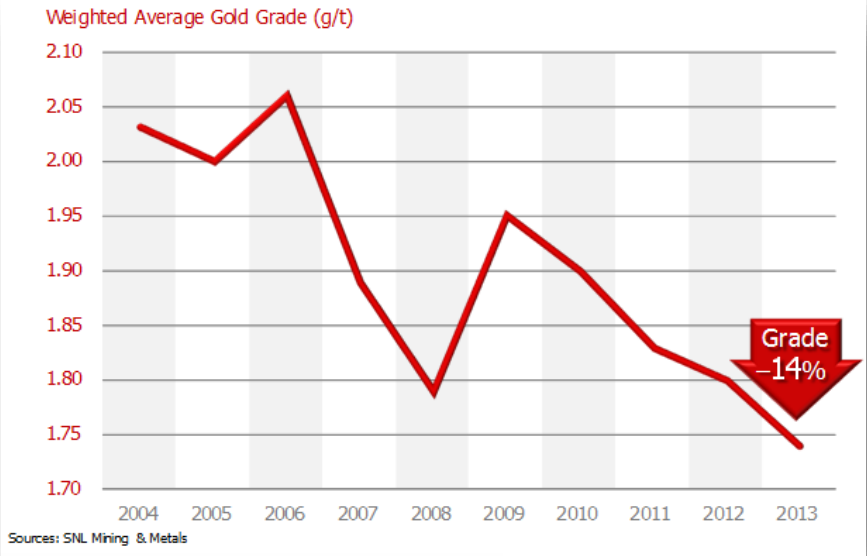
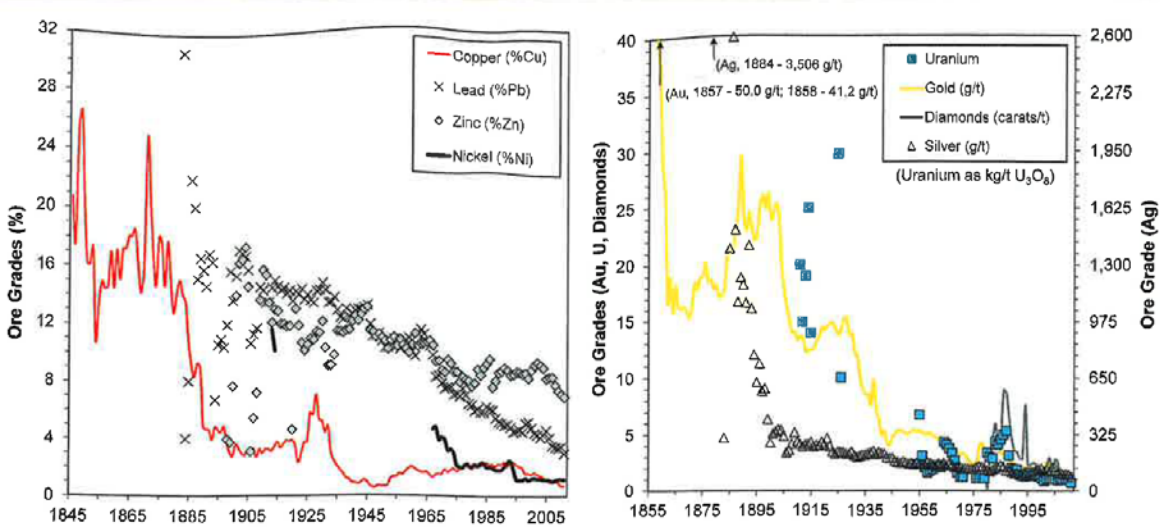
Mill feed quality issues (1)

Grade

- lower for all metals





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Mill feed quality issues (2)

Hardness

- evident in SAG/AG pebbles

Complexity

- fine-grained
- blend of oxide/sulphide minerals
- contaminated concentrates
- suitable for pre or multi-stage processing options

Dilution

Lack of selectivity

- large, open pit equipment
- mass underground mining methods

Internal dilution

- grade heterogeneity

Ore vs. waste

- do they have similar properties?
- can they be separated?

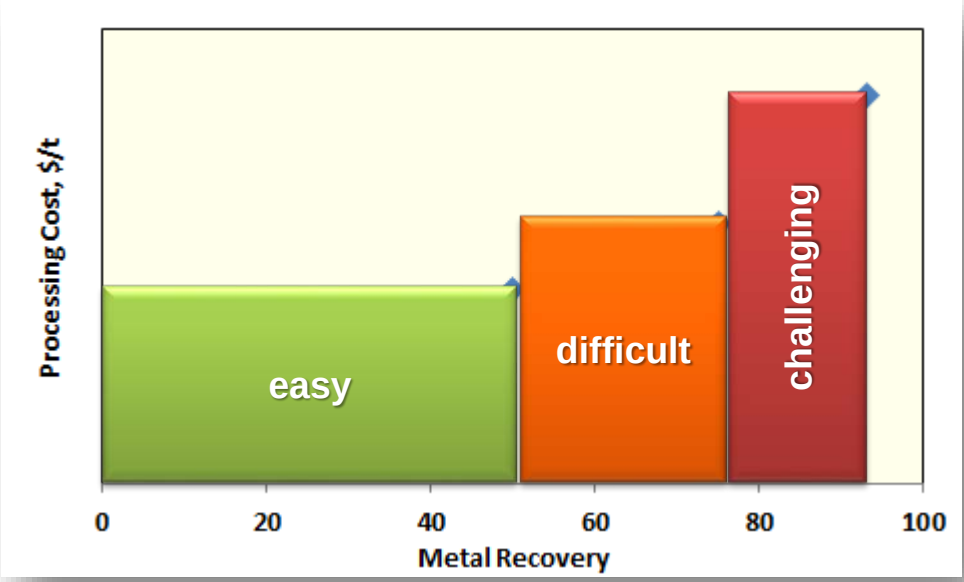
▲ Glory hole at the Henderson molybdenum mine in Clear Creek County

Opportunities to selectively process?

Consider mill feed components

- easy to recover — at lower cost
- difficult to recover — at higher cost

- incremental cost?
  - *75% to 85% to 95% recovery*
  - *finer grind, expensive reagents*

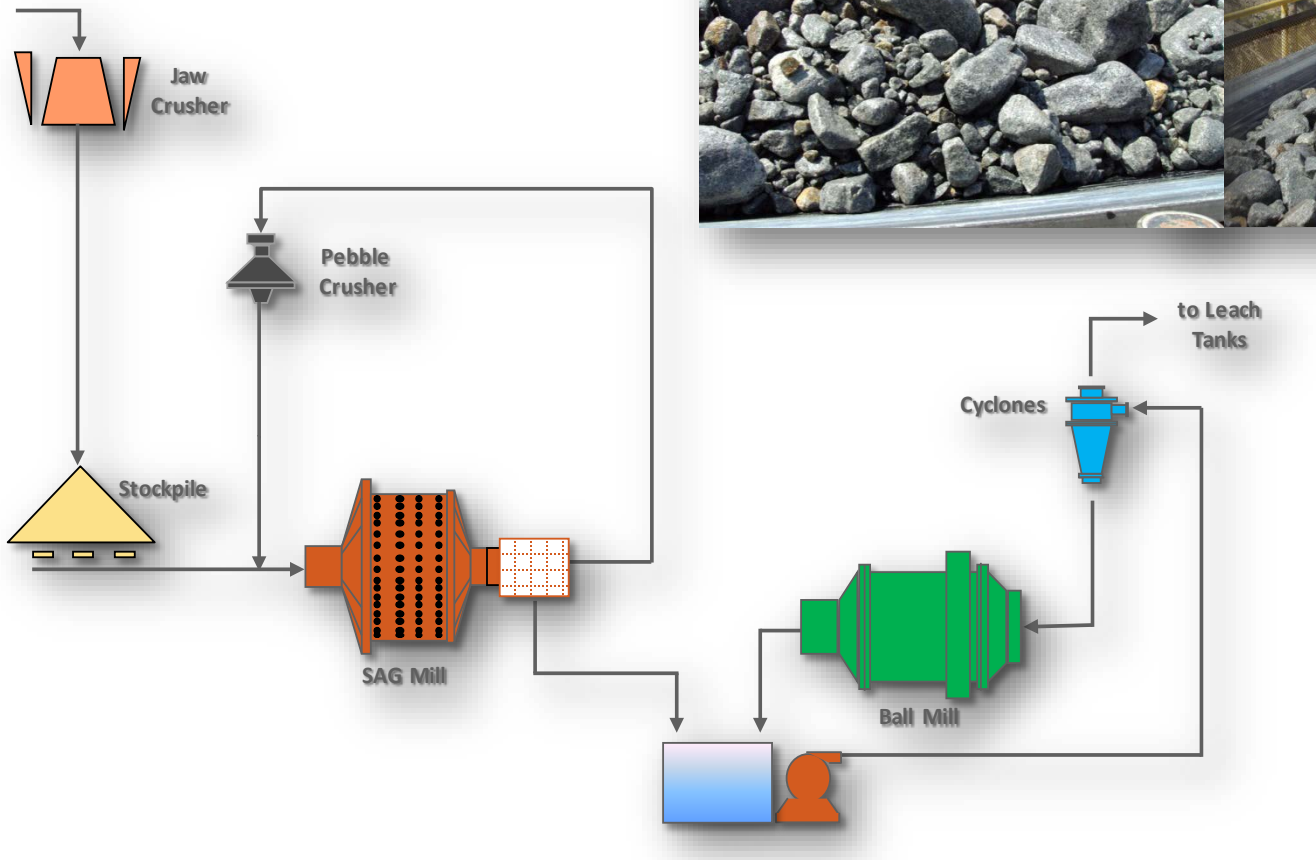


- each component
  - *if isolated, is it 'ore' or should it be subject to a higher cut-off?*

- for example
  - *coarse material after blasting & primary crushing*

AG/SAG mill pebbles (1)

Are they worth returning?



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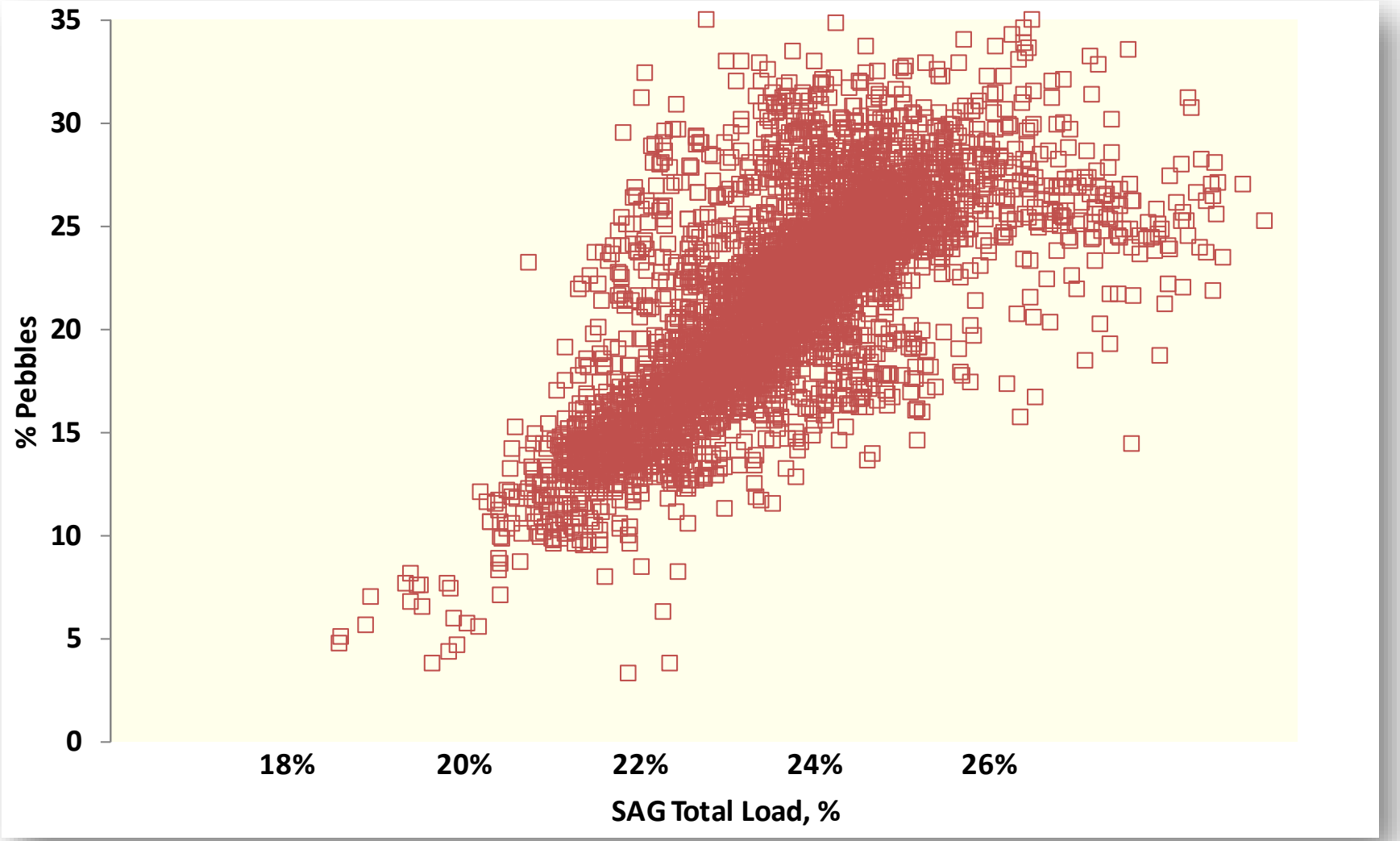
AG/SAG mill pebbles (2)



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Effect of pebbles (1)

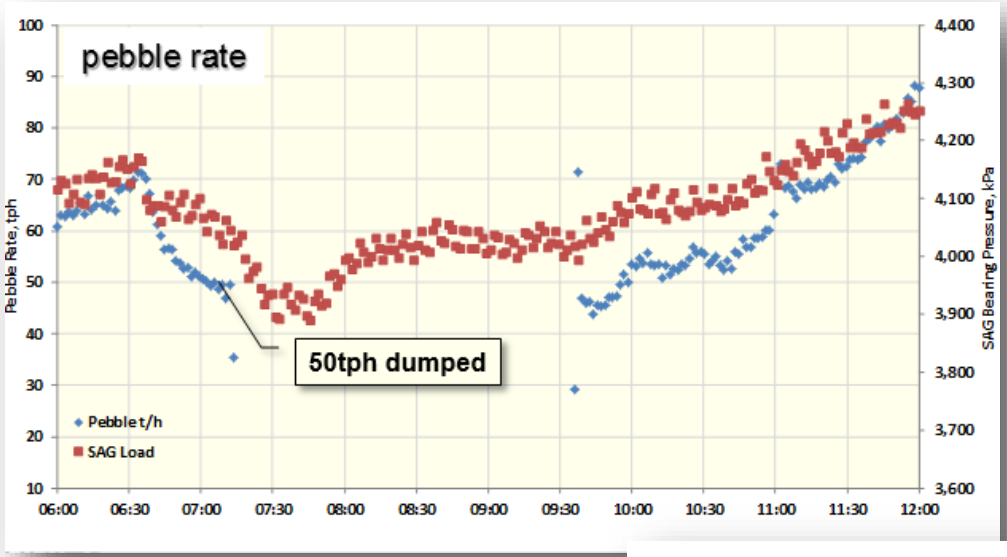
On competent feed

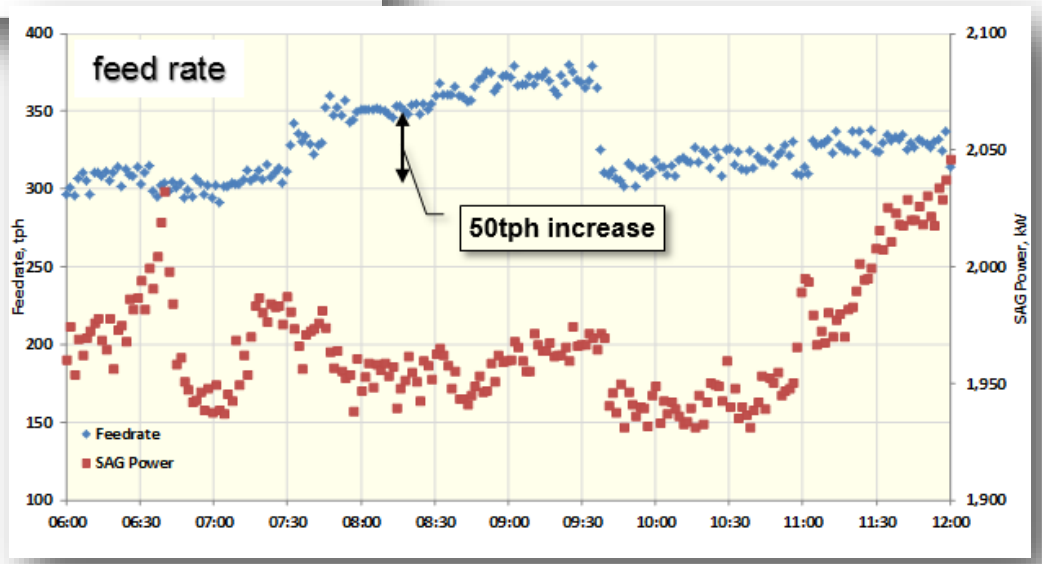
- % pebbles proportional to load
- up to… “1 tph pebbles ≡ 1 tph fresh”

Pebble distribution

- very little broken material
- well rounded, coarse pebbles

Effect of pebbles (2)





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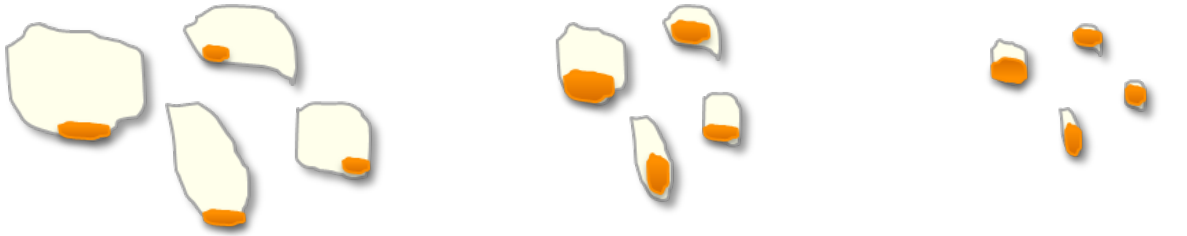
‘Coarse Beneficiation’… exploiting a natural tendency

Classification by size

- preferential grade by size deportment



After two applications of energy…

- why recombine **competent**, **coarse** material with **softer**, **fine** material?
- coarse material requires higher kWh/t to process
- competent material should be evaluated at a higher cut-off grade

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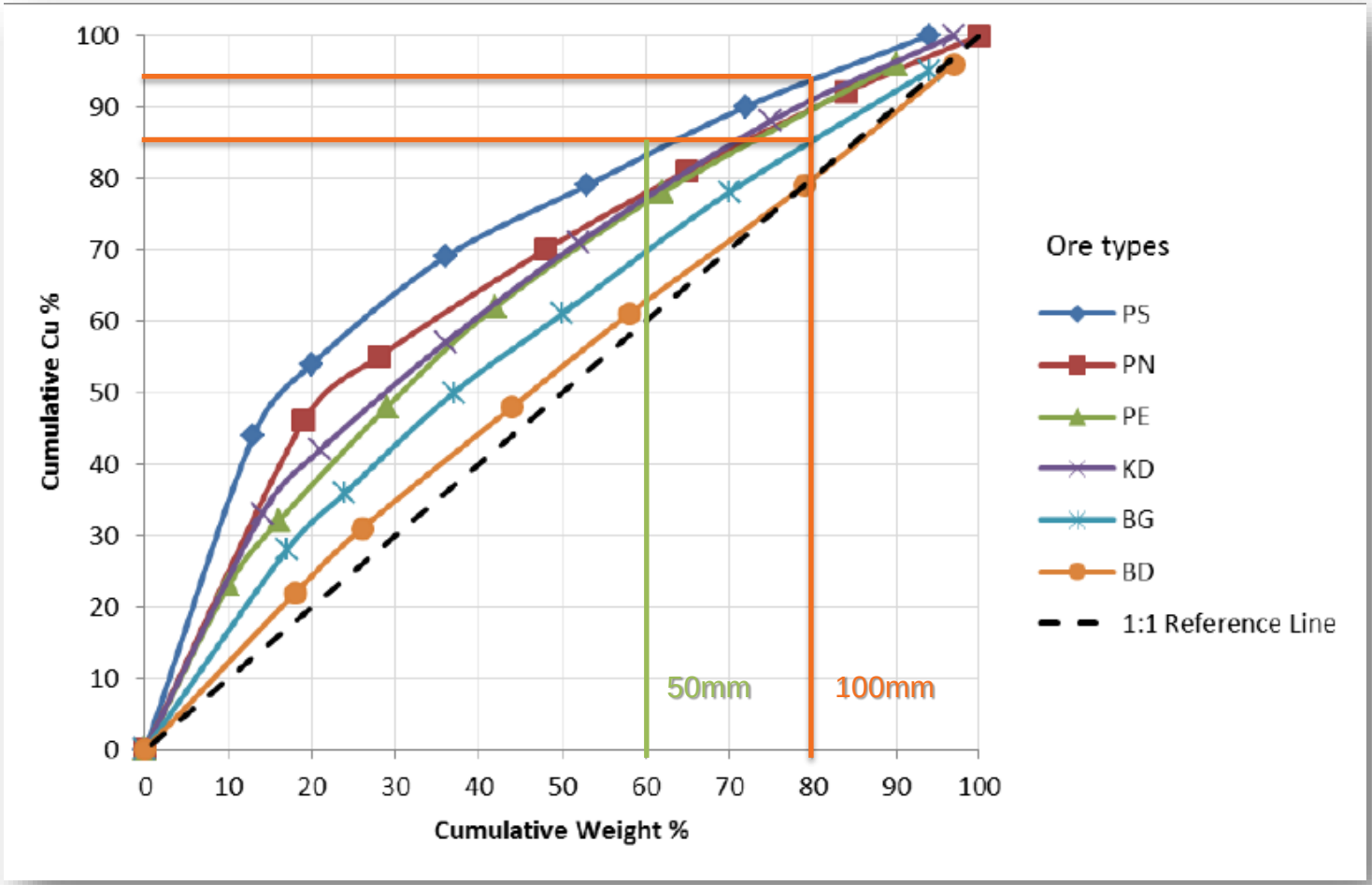
Metal vs. size distribution

Bougainville Copper 1986



"The Application of Pre-concentration by Screening at Bouganville Copper Limited", Burns, R., Grimes, A., 1986.

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“Grade Engineering”®

(CRC ORE)

Grade by Size Au Example

An extensive belt-scale sampling program of a gold operation indicated significant grade by size response. Three screened size fractions show major preferential deportment of Au during blasting and crushing.

Pie diagrams represent %Au and the bar charts represent %mass. In this case 64% of the feed mass contains Au well below economic cut-off. 88% of Au is contained in 36% of the mass below 19mm.

This is not a result of ‘dilution’. The in-situ feed grade represents current resource definition practice.

Grade by size data is typically not collected as a processing attribute.

“Transforming Mining Productivity with Grade Engineering®, CRC ORE, **www.crcORE.org.au**

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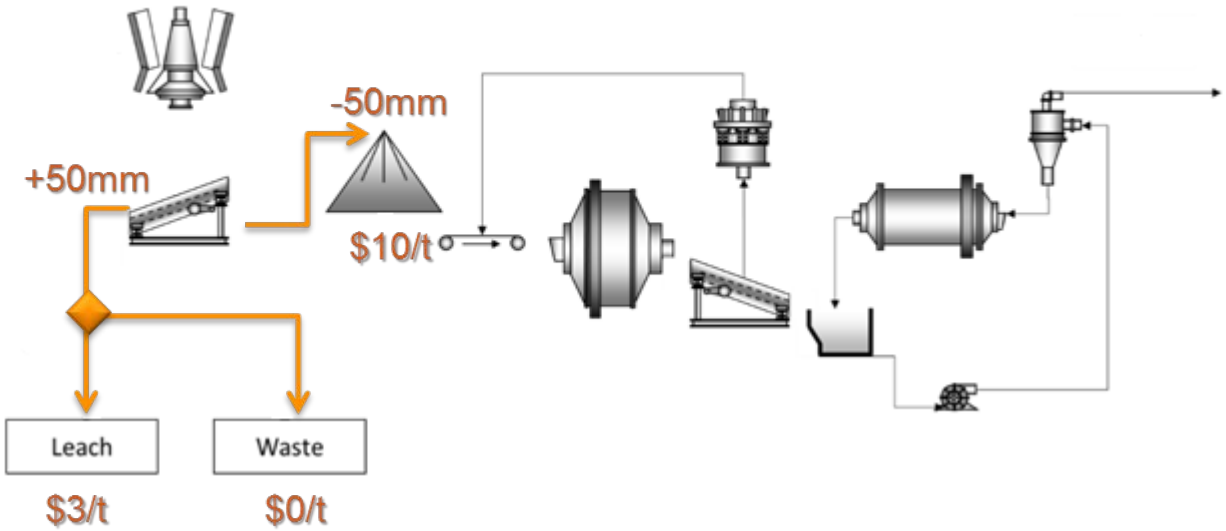
Deferring difficult material

Coarse screening

- eliminate competent component
- increase mill throughput (lower kWh/t)
  - *15% to 20% higher tonnage*
- possibly lower grade
  - *suitable for cheaper processing options*



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Challenge…how to assess based on drillcore?

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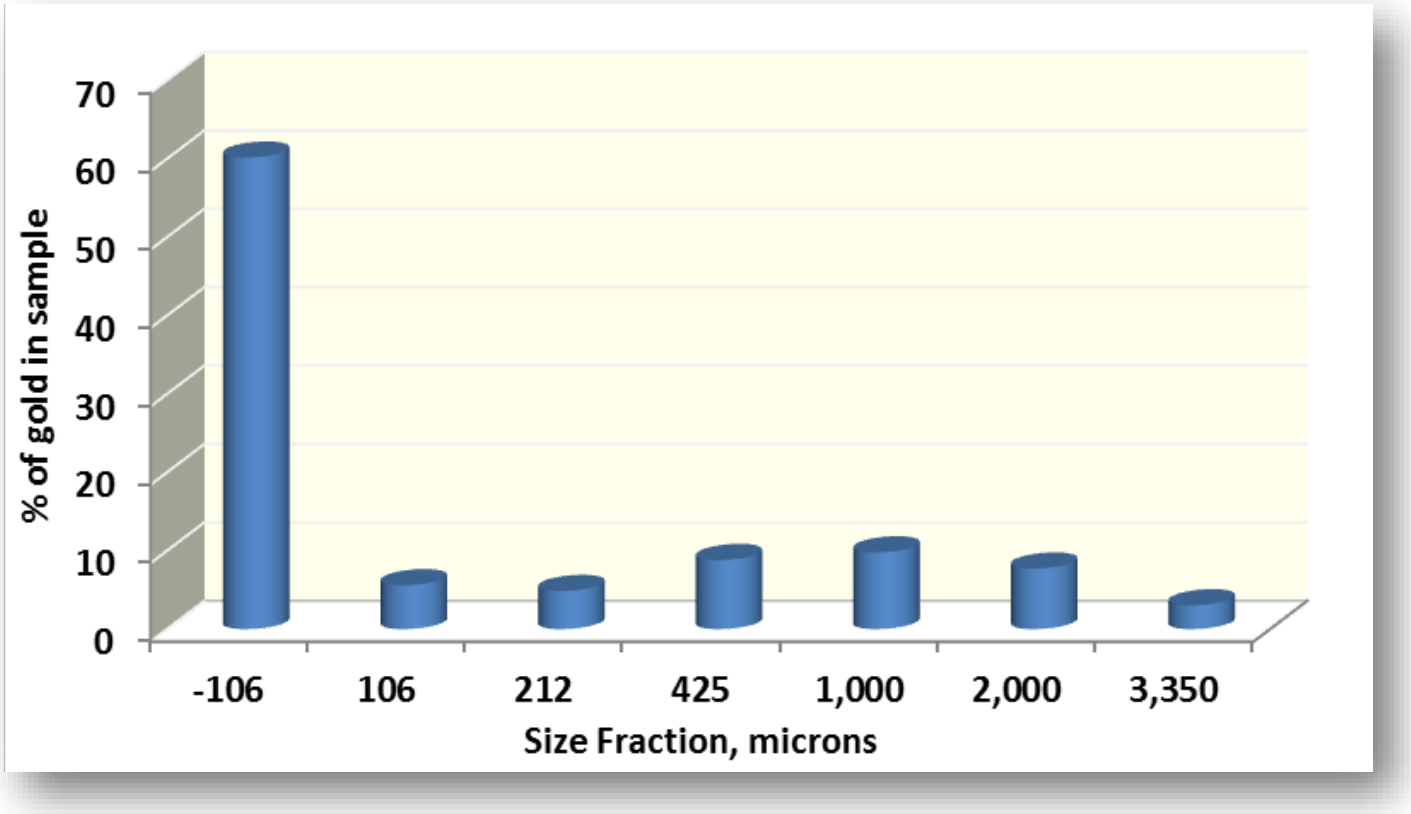
Example drillcore test results (1)



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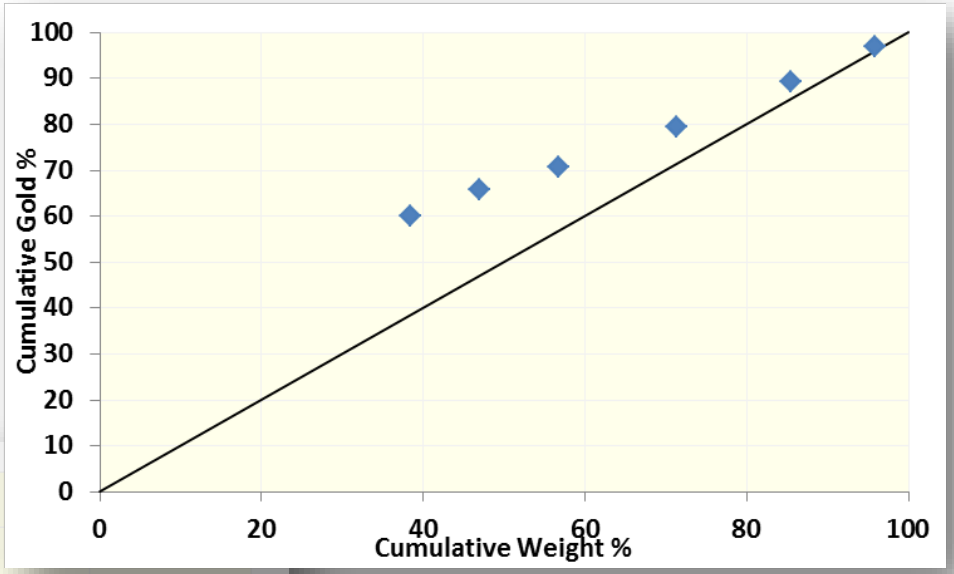
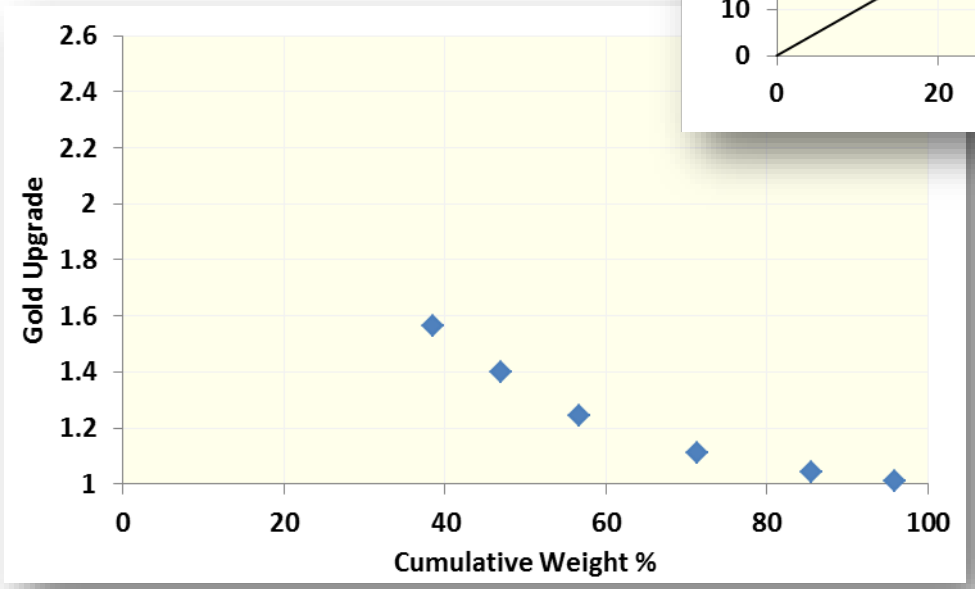
Example drillcore test results (2)





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Example drillcore test results (3)

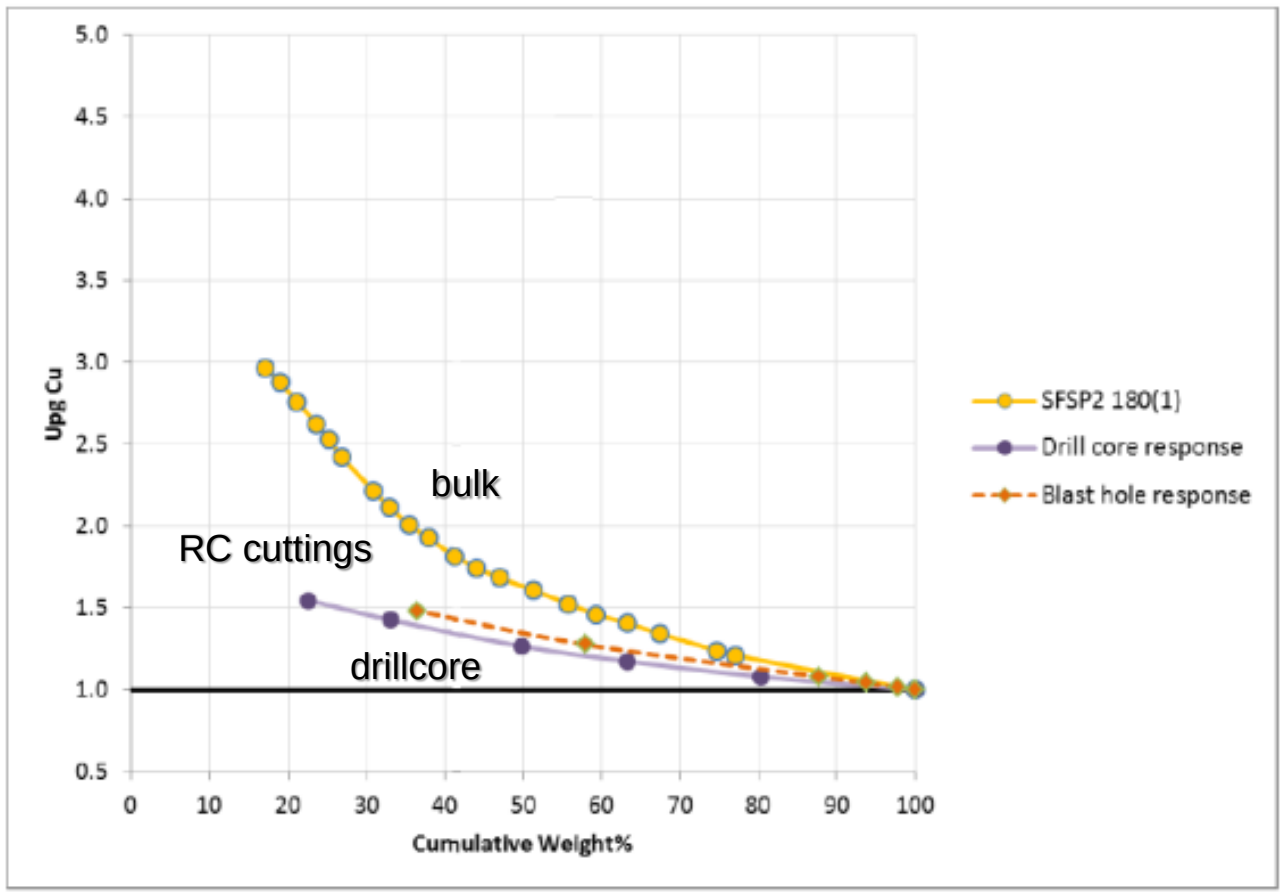

Figure 19. Upgrade Cu SF SP2 180 (1) bulk sample and the blast hole and drill core response related.

"Development of Geometallurgical Laboratory Tests to Characterize Metal Pre-concentration by Size", Carrasco, C., Keeney, L. & Walters, S. IMPC 2014

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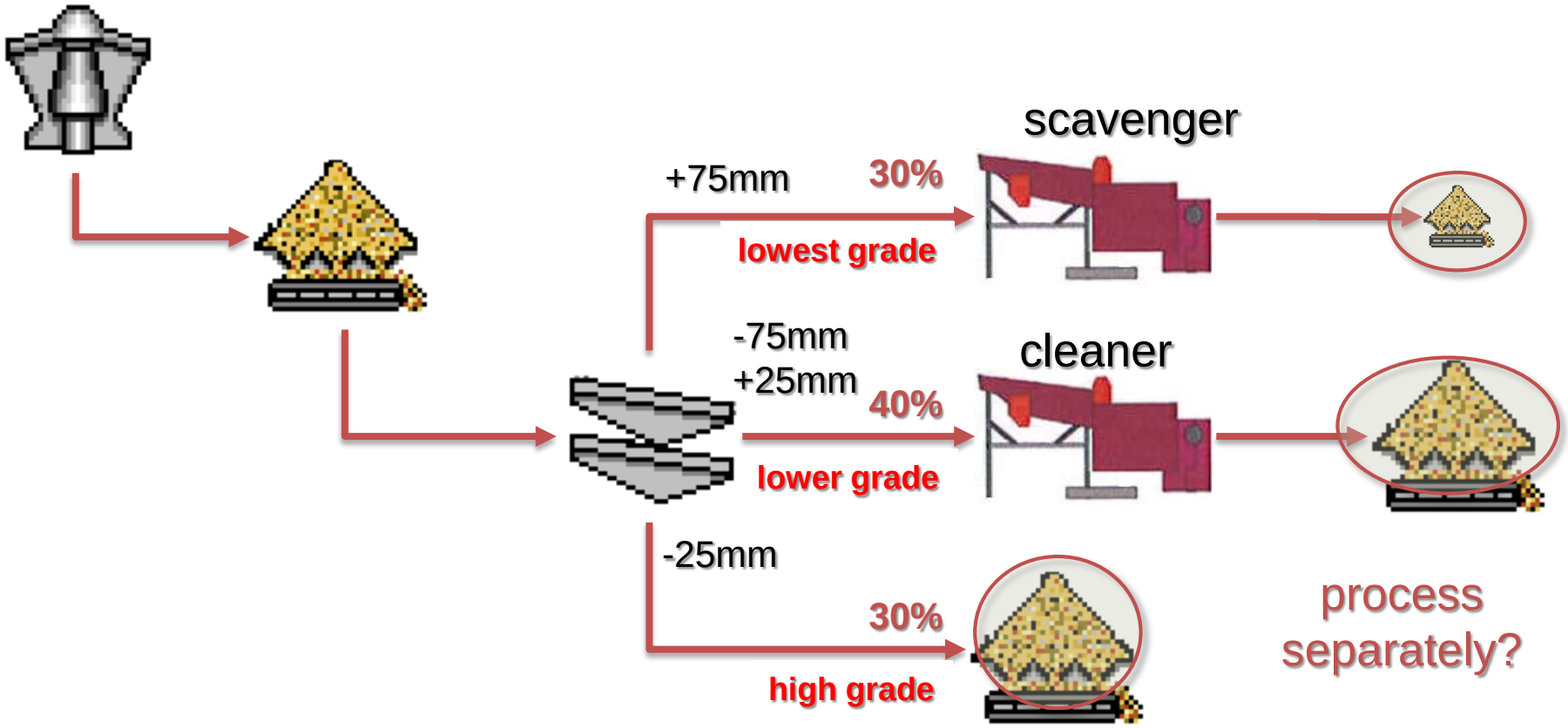
Example flowsheet
(involving ore sorters)



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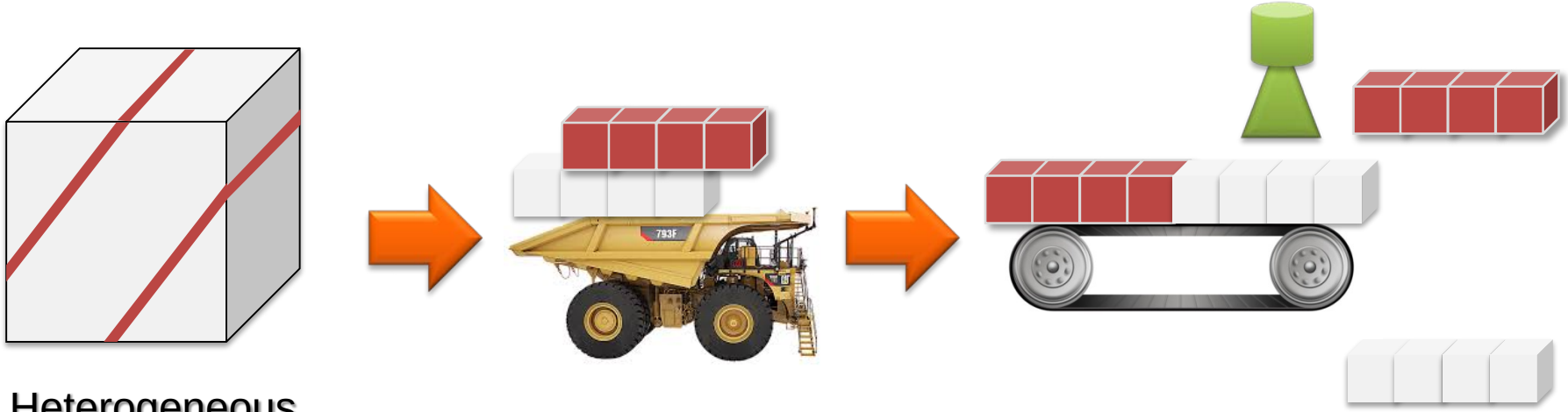
Bulk/particle concentration

Homogenous



Heterogeneous

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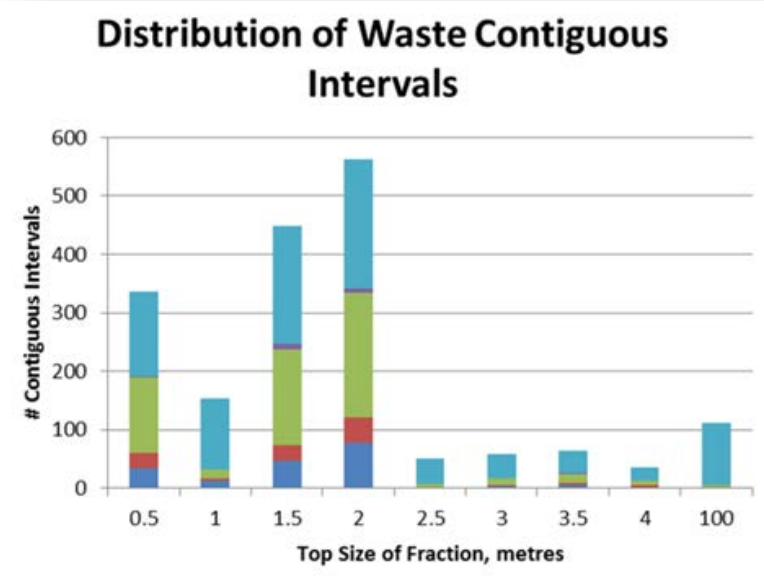
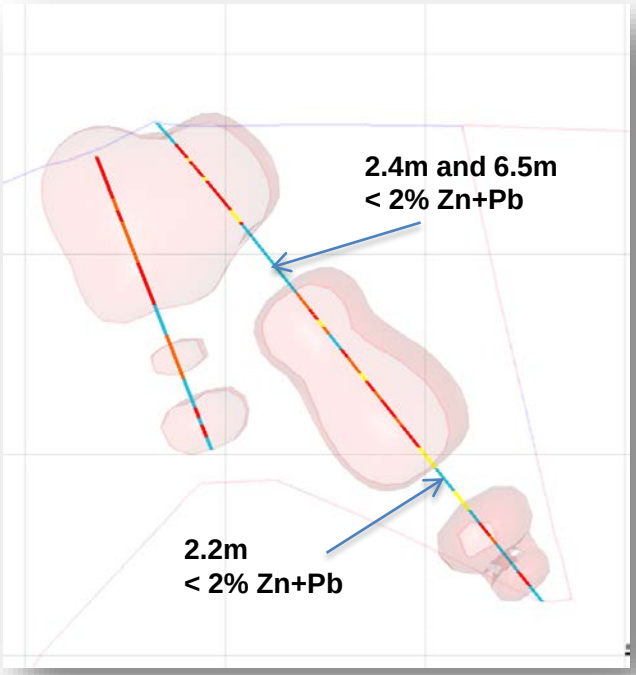
Heterogeneity assessment

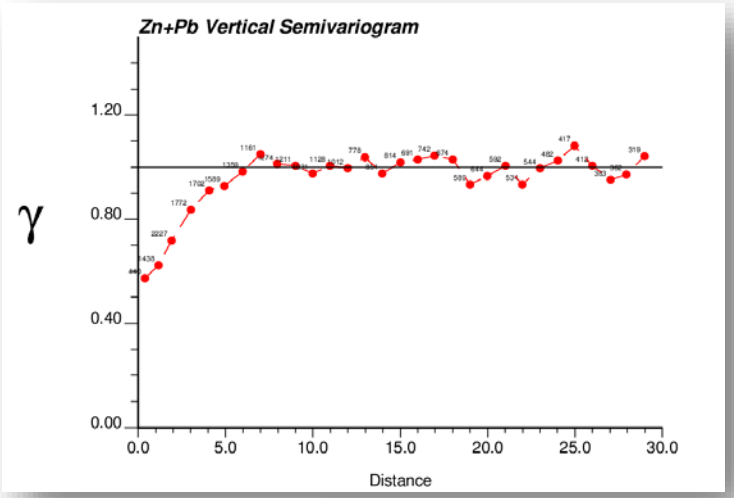
Analysis of drillcore assays



Spatial assessment



Variograms



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Summary

Facing more challenging mill feed

- lower grade, harder, more complex
- is all of it worth processing?
- should some of it be separated, deferred or returned to the source?

Options

- upgrade before it hits the grinding circuit
- upgrade after it exits the AG/SAG mill

What is the cost of 'optimal' metal recovery?

- are we paying a high cost/low efficiency for maximum recovery?