Comminution Circuit Design vs. Feed Size
or ‘Mine-to-Mill 2.0’

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Mill feed quality issues

- **grade**
  - lower for all metals

- **hardness**
  - evident in SAG/AG pebbles

- **complexity**
  - fine-grained
  - blend of oxide/sulphide minerals
  - contaminated concentrates
  - suitable for pre or multi-stage processing options
Size reduction starts in the mine

Diagram showing the process of size reduction from ROM blocks through crushing, SAG milling, and ball milling to the final product.
Feed size effects

- what size is important?

- historically, Mine-to-Mill has
  - focussed on blasting alone
  - generation of more fines
    - pass through SAG mill onto ball mill circuits
    - higher throughput (e.g. 10% to 30%)
    - coarser grind size (possibly)
Open pit blasting

- more efficient in generating fines

- dependent on rock mass properties

- limitations
  - confinement
  - high-energy blasting
  - geotechnical issues
    - wall stability
    - dilution
    - final wall control
**Underground mass mining methods**

- **‘rock factory’**
  - lack of selectivity
  - accuracy of fragmentation predictions
  - size varies over time
  - preconditioning methods

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**New Afton feed size vs. tonnage**

*“Grinding Optimisation of the New Afton Concentrator”, LaMarsh, SAG 2015 Conference*
Underground mass mining (1)

“Fragmentation measurements to validate effect of rock mass preconditioning at the El Teniente Mine, Chile”, Brzovic & Hurtado, Geomin 2013 Conference.

Cadia East
open pit vs. preconditioned
cave fragmentation
Pebble generation

- evidence of grindability issues
  - is it really ‘critical size’?

Are pebbles worth returning to the mill?

- they have proven themselves to be
  - hard, resilient and challenging
  - a substantial percentage of mill feed

- should they be re-evaluated? deferred? sorted?
  - e.g. Kinross Fort Knox, Rio Tinto Palabora
Feed topsize

趺 higher energy blasting
  – can increase coarse fraction

趺 current SAG mill operating conditions
  – not setup for coarse material

趺 secondary crushed feed
  – eliminate +100mm particles ($P_{80}$ of 60mm)
‘Coarse beneficiation’... exploiting a natural tendency

classification by size
- preferential grade by size deportment

coarse >75mm  medium >25mm  fine <25mm

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

‘ore’  ‘good’  ‘poor’
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.
Circuit design

- attention on hardness
  - variability
  - different test protocols
  - different particle size

- do we plan for feed size?
  - standard primary crushed product ($P_{80}$ of 100mm or 150mm)
  - coarse, low grade vs. fine, high grade?
  - can we divide into fractions?

"What is a competent ore and how does this affect comminution circuit design?", Lane, Procemin 2010 – 7th International Mineral Processing Seminar (2010), p. 33-44.
Circuit design vs. feed size

staged reduction and progressive upgrade

Conclusions (1)

- **mill feed composed of components**
  - different power requirements
  - different recoveries, concentrate qualities
  - should not a different cut-off grade apply?

- **size components**
  - handle variations in size components (more coarse, fine, etc.)
  - coarse = cruiser specific?
  - coarse = defer or reject as not economic?
  - medium = let mill generate pebbles?
  - fines = high value/low operating cost
Conclusions (2)

_tailor feed size to circuit design?_

_tailor circuit design to feed size?_
- limited by ability to predict feed size... limited focus during studies

**need better methods to predict FULL size distribution**

_Mine-to-Mill version 1.0 is only the first step_
- as a retrofit solution/opportunity to an existing, conventional circuit