Comminution modelling
in the context of
Integrated Process Prediction

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Integrated process prediction

Predicting the performance of the whole mining process is surely the holy grail of predictive simulation
Objective

Predict the response of the processing chain mining → concentration to changes in the ore type
Application

Greenfields design
• processing options to optimise the overall mine performance
• constraints and aspirations of the greater community
• environment

expansion and optimisation
• Changes in economic drivers
• Changes in ore types
• on-line control – predictive reaction to ongoing changes in ore processing types
Know the rock

- ore characteristics based on in-situ rock properties
- prediction of fragmentation
- predict and track progressive mineral liberation
- response to separation processes as a function of mineralogical properties.
Keynote Objective

• value of this integrated approach
• Challenges
• technology and capability required
• Addressing as a comminution community
DRIVERS

Energy

Massive low-grade ore bodies

Increasing demand

Commination 36±10% mining energy

Ballantyne 2011

Historical Australian Ore Grades

Gold

Copper

Ballantyne 2011
Challenges

- Improved efficiency of process equipment
  - Halve energy use?

Transform processing capability

- Grades at least halving
- Energy intensity of production does not decrease
Future approach

Circuits designed to respond to variable:

- grade
- Competence
- feed size distribution
- liberation size

by processing to varying:

- target required grind size
- recovery options
- cut-off grades

Considerable, worthwhile challenge to ensure sustainability of our industry
Integrated Process knowledge

ipk-comm16-gilt570ada0c\Prezi.exe

INTEGRATED PROCESS KNOWLEDGE

All about the rock
It’s all about the rock

Degree of reduction for high probability of recovery

• Mineral grain size
• Mineral associations
• Texture – intergrowth, veining, etc.
• Mechanical texture
  the energy required and optimal input mechanism
• Recovery process or processes
  – Surface
  – Volume
  – porosity dependent
  – Selectivity
Conduct the minimum degree of breakage required to permit recovery of the valuable minerals
Optimal processing route

- Staged processing
- early and progressive removal of gangue
- Minimise the material to be further processed
- Recovery of values is last stage and objective
The upside of Progressive upgrade

- Large removal in one step 40%
  - Lower recovery
  - Higher risk of erroneous removal

- Staged removal
  - Improved discrimination
  - High recovery per stage
  - Larger energy saving at fine end
  - Greater gangue rejection
  - High overall recovery
The rock particles

To successfully upgrade

• Important to understand the changing distributions of particle mineralogy

• Links to ore body knowledge
Quantitative evaluation of the SC

- Selective Commination Index $SZ$

\[ Q_{3,x} = \sum_{i=1}^{x} M_i \]

Selectivity $S_P$

\[ SZ = S_P - S_F \]
Designer products for recovery

Higher recovery
50% energy (based on SSE)
Designer products for staged upgrade

Upgrade 0.4 removal of gangue
0.4 x 50% = 20% removal = 80% energy and processing downstream
0.4 x 90% = 36%
64%
16% energy and processing saving

![Diagram showing current, improved, and optimal sizes with removal percentages and energy savings.](image-url)
Process performance

Measurement directly influences process choice or changes

- Define target
- Then efficiency as function (target)
- $\sum \text{circuit} \rightarrow \text{entire circuit}$
<table>
<thead>
<tr>
<th>stage</th>
<th>Future integrated process</th>
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| Rock in situ – the ore body   | Measure mineral associations in situ  
|                               | Map into ore-body based on geological structure                                                                                                          |
| mining                        | Plan according to physical constraints and processing needs  
|                               | First stage of processing  
|                               | grade selection, fineness of fragmentation to suit immediate processing                                                                                   |
| Transport                     | Second stage of processing  
|                               | in-pit conveying to different destinations for waste, high grade, low grade, leach, etc.                                                                 |
| Comminution                   | Break rock particles just sufficiently for the next stage of upgrade                                                                                       |
| classification                | Efficiently select coarse particles and recycle for further comminution.                                                                                   |
| Recovery                      | Reject particles that are gangue                                                                                                                          |
| Staged recovery               | Send to the next stage of comminution.                                                                                                                     |
|                               | Final stage targets recovery and grade.                                                                                                                     |
| Waste disposal                | according to size, AFM, toxic or benign, remaining grade, potential future ore body                                                                           |
| Water recycle                 | Recover 99% water from early stages  
|                               | final tailings (with lower slimes)  
|                               | >80% water recovery through thickening, minimum water pumped to tailings dam  
|                               | Fresh water < 5% of process water.                                                                                                                          |
Ore body information

- Size specific Energy (SSE) - linear & additive
- Impact strength
- Abradability & product size
- Texture parameters related to liberation size
- Grade deportment factor - grade by size in blasted rock
- Clay
- Process-specific recovery indicators
  - floatability, magnetic susceptibility, leach response, etc.
- Orebody-specific relationship to parameters
  - Core logging data - alteration, silica content, ……
- Some, but not all, current stored data
  - grades of key minerals and deleterious elements, ………
Fundamentals of breakage

Mineral liberation from breakage tests

strength fn. mineralogy
primary rock properties

- mineral association
- mineral strengths
- rock strengths in these mineral associations
- Mineralogical liberation

- in-situ rock
  - mapped back into the ore body
  - carried along the process chain
  - calculating processing properties at every stage

- common rock language
  - Ore body – mining – comminution – recovery - final products, waste water recovery
The vision

- Shift our paradigm of processing costs and effectiveness
- Integrated processing prediction approach
- Multi-stages of progressive upgrade in a usable circuit
- Flexible processing utilises natural variability of ore

JKMRC and GCC built many base tools launching as comprehensive research thrust Significant uplift to the mining industry