Mining Magazine Congress 2010
Drill & Blast... Load & Haul... Crushing & Conveying... Processing

Mine-to-Mill: A Proven Method For Increasing Plant Efficiency

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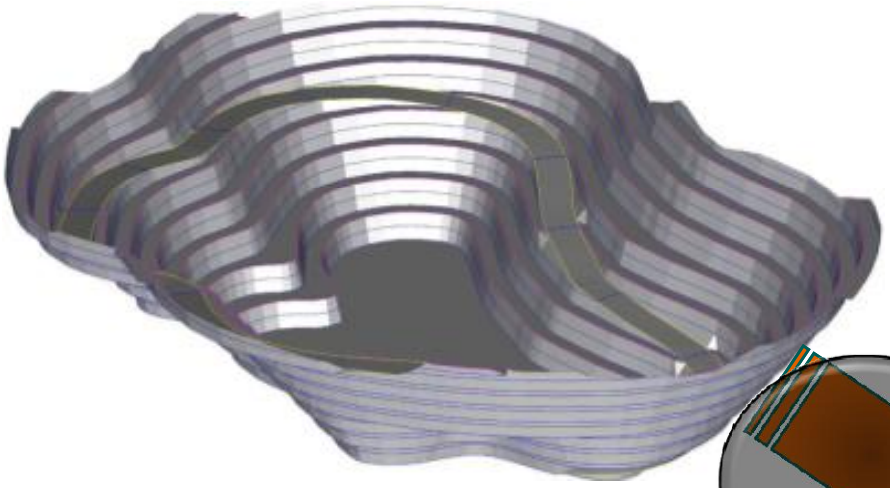
What is “Mine-to-Mill”?

- **Consider ALL steps of ore handling/processing towards achieving a common goal**
  - *“metal manufacturing”*

- **Inherently as material becomes higher quality (more valuable), cost to process ($/t) increases**
  - *able to make changes in ‘cheaper’ upstream stages that positively affect downstream process?*
  - *quite often changes may involve cost increases that are recovered in same stage*

- **Work cooperatively and not in geographical ‘silos’**

Current Situation…



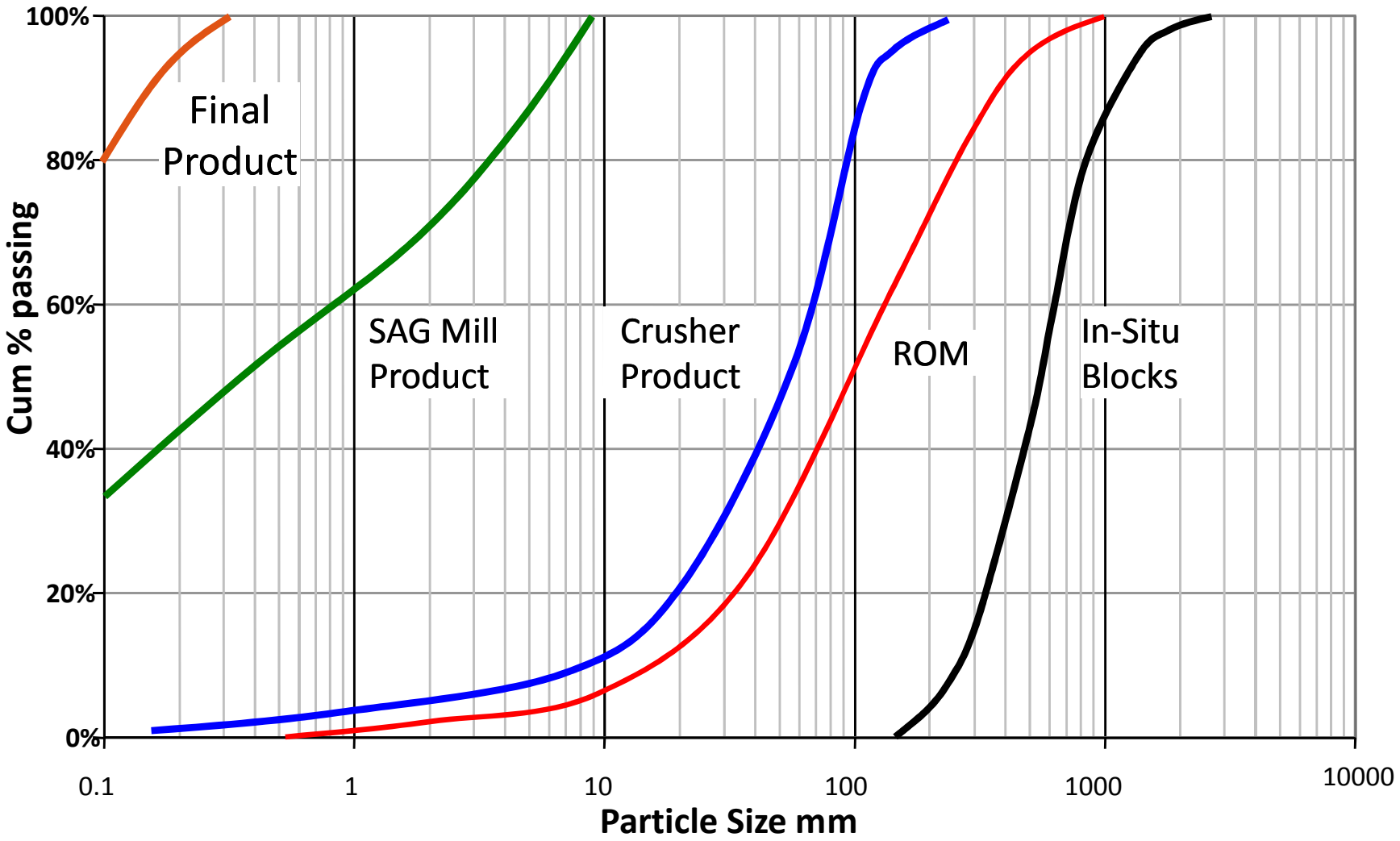
Mill features (customer):

- appreciates balance sheet
- unsure of feed quality requirements
- expects uncertainty

Mine features (supplier):

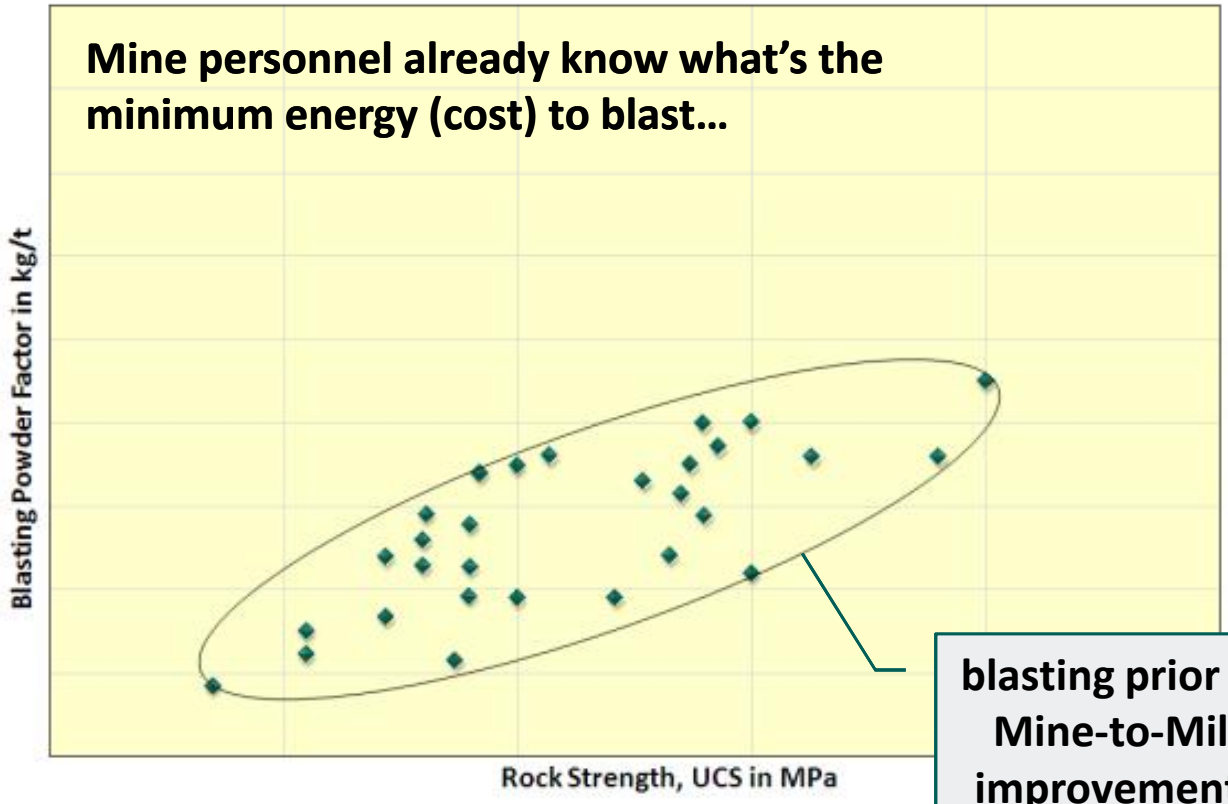
- cost-centric (no saleable product)
- focus on quantity & not quality
- unpredictability

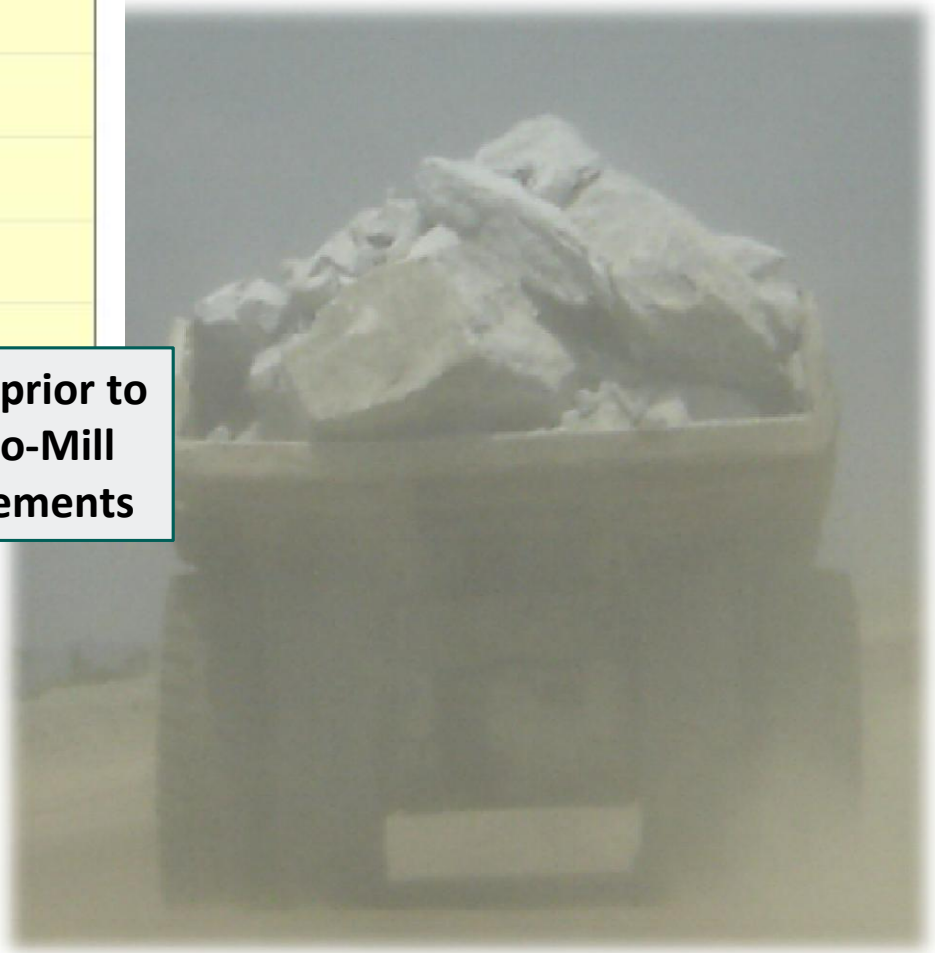
Size Reduction Starts in the Mine…



Pure Cost Minimisation...

Leads to inefficiency





Economic Justification

Mine

- **Drill & Blast costs**
  - *$0.15/tonne*
- **Cost increase to improve feed**
  - *100% or $0.30/tonne*
- **Net increase**
  - *$0.15/tonne*

Mill

- **Grinding costs**
  - *$6.00/tonne*
- **Performance improvement**
  - *10% higher tonnage*
- **Net decrease**
  - *$0.55/tonne*

Leverage:
every $1 spent to improve feed in mine gains $4 in mill
(for 20% higher tonnage, factor is 7x)

Note: *typically, mine gains in productivity pay for increased D&B costs*

Different Sources & Different Requirements

Matching mine deliverables to mill circuit strengths

- **Underground**
  - *finer fragmentation*
  - *blending of sources*
- **Open pit**
  - *variable fragmentation*
  - *less blending of sources*
- **Block/sub level caving**
  - *unknown/uncontrolled fragmentation*
  - *changes in sources due to blockages*
- **Multi-stage crushing + milling**
  - *prepared feed & steady tonnage (predictable)*
  - *does not handle variability*
- **Primary crushing + SAG milling**
  - *handles variability but passes along to next stage (unpredictable)*
  - *still benefits from quality feed*
- **Multi-stage crushing + HPGR**
  - *prepared feed to HPGR to exploit efficiency*

Metso PTI Methodology

"Process Integration & Optimisation" (PIO)

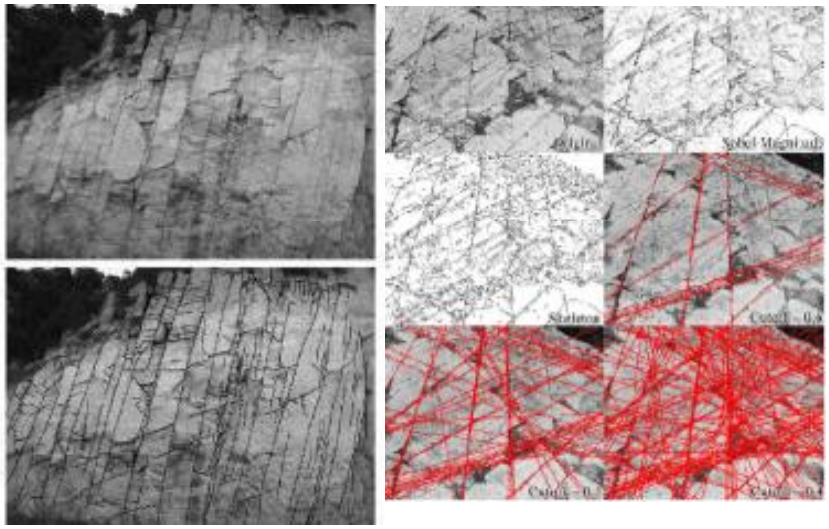
- **Site-based data collection**
  - *multi-phase project over a few months*
  - *benchmarking of current practices*
  - *ore characterisation*

- **Development of interactive models**
  - *blasting, crushing, grinding, flotation…*
  - *recommendations of operating/equipment changes*

- **Implementation/validation**
  - *site-based trials*
  - *long term maintenance*

Ore Characteristics

Structure



Hardness

Point Load Test

Drop Weight Test

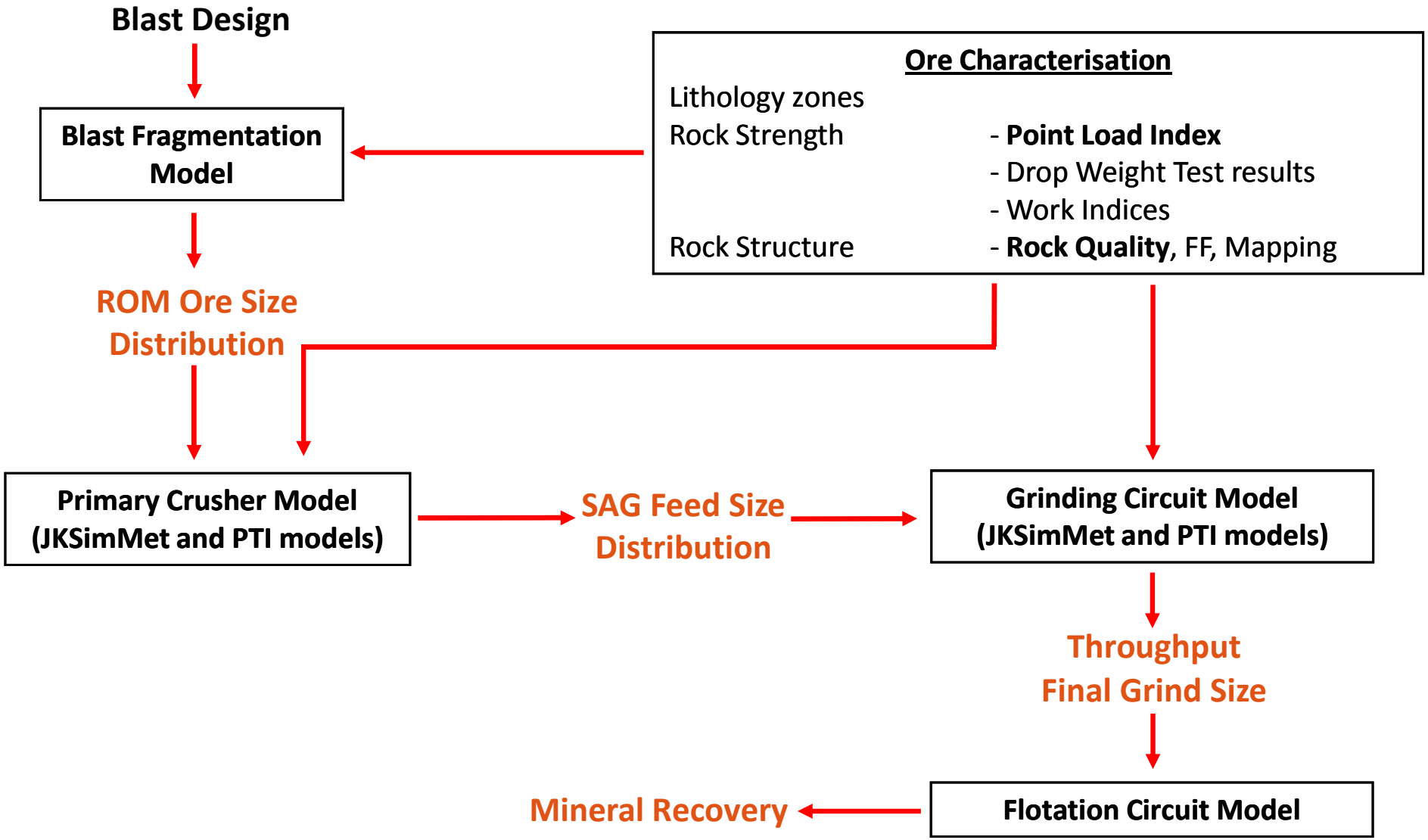
Domain Definition

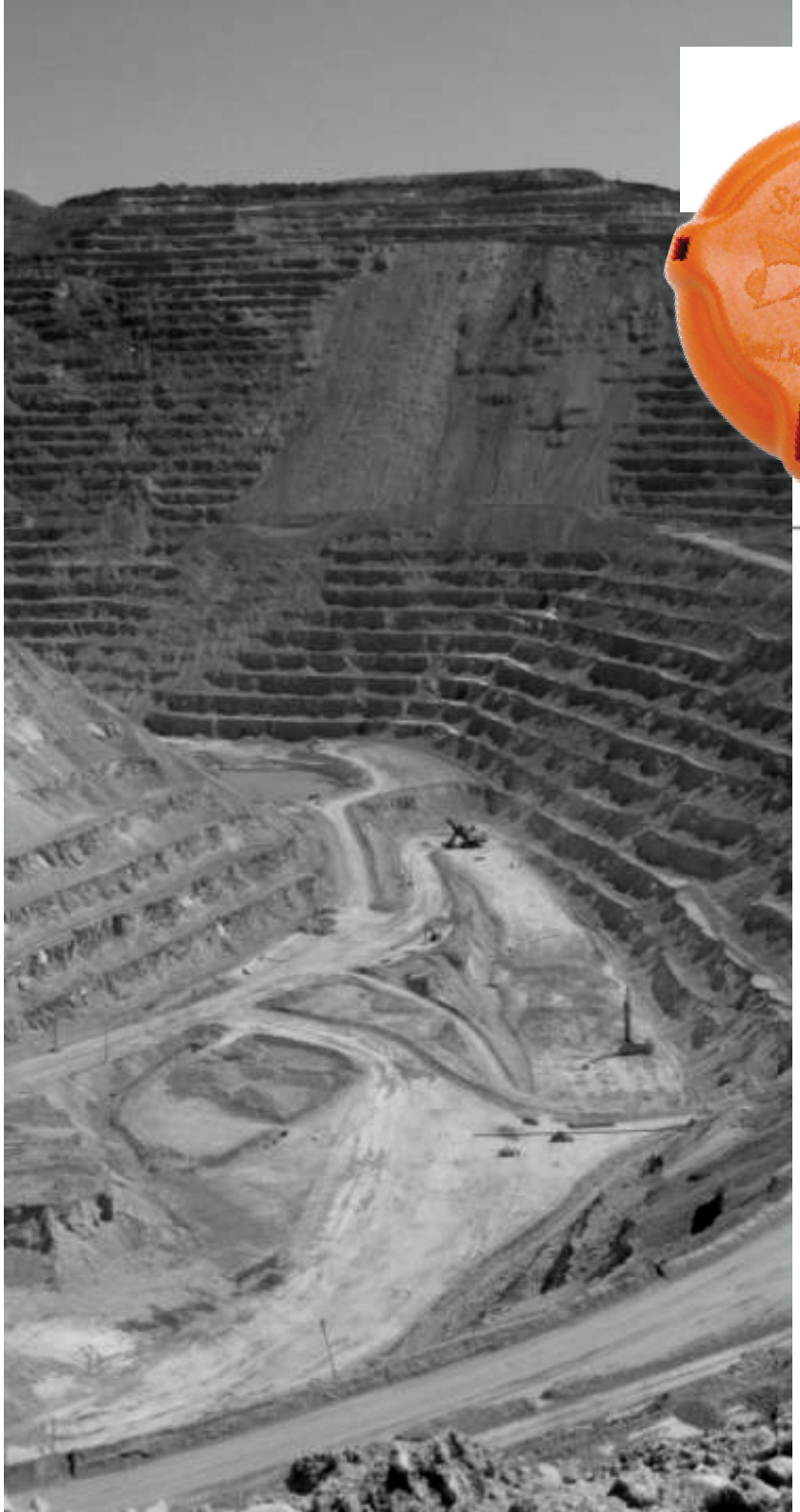
Process Audits

Mine and Mill

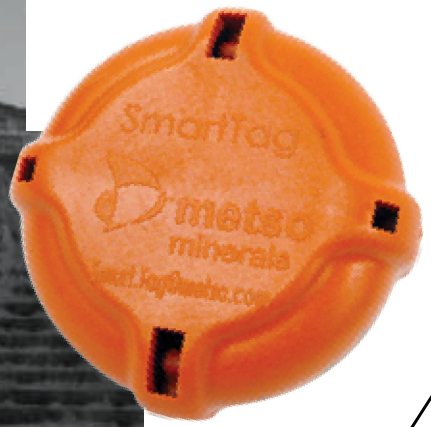
Modelling & Simulation

Mine and Mill





SmartTag™ Ore Tracking



tags placed in blastholes or on muckpile

[ID, X, Y, Z]

tags detected after crusher

[ID, TIME]

tags detected before grinding

[ID, TIME]

SAG Mill Feed

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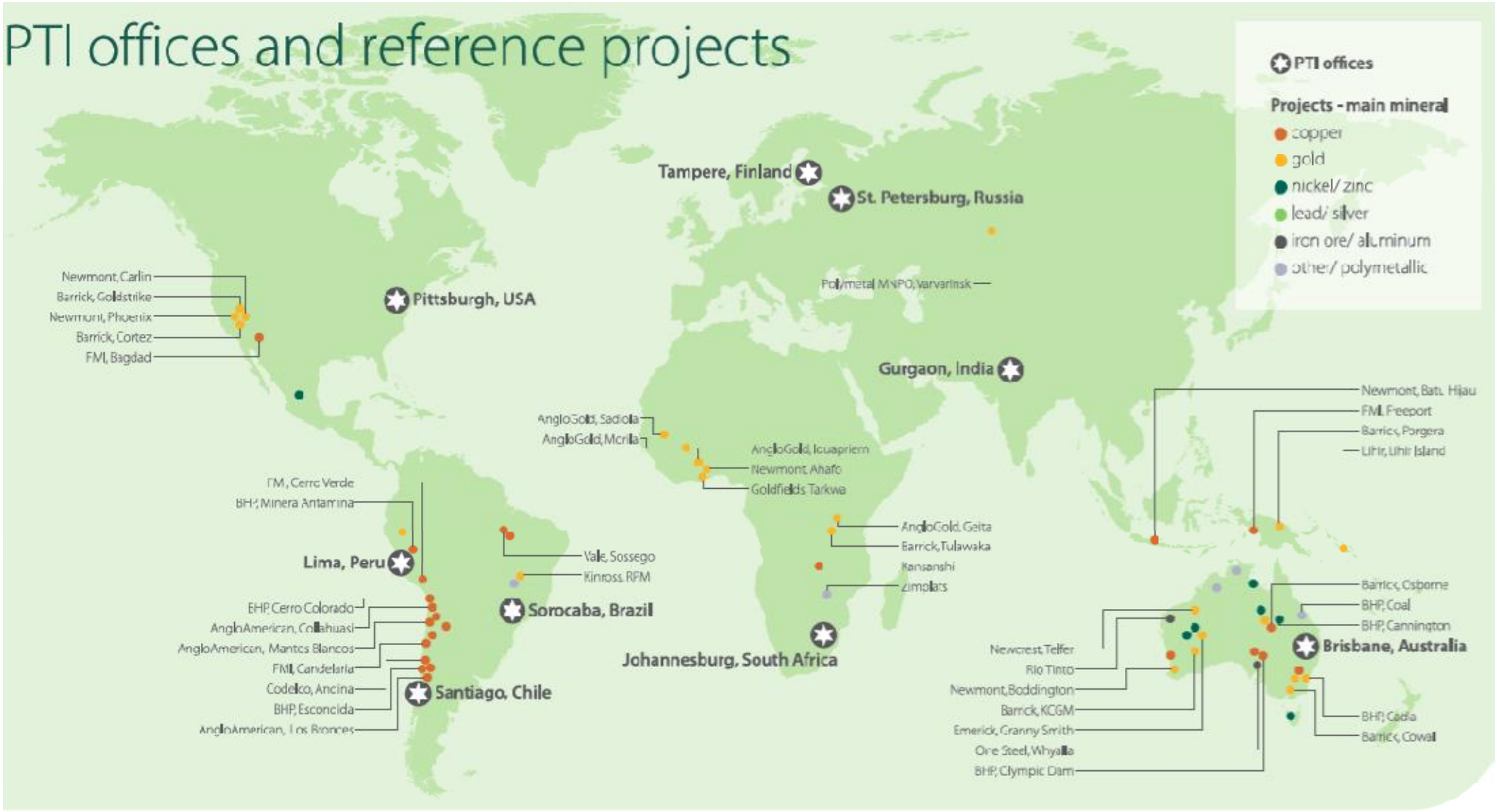
Issues?

Case Studies

Examples of how Mine-to-Mill works

PTI Methodology Applied Worldwide…



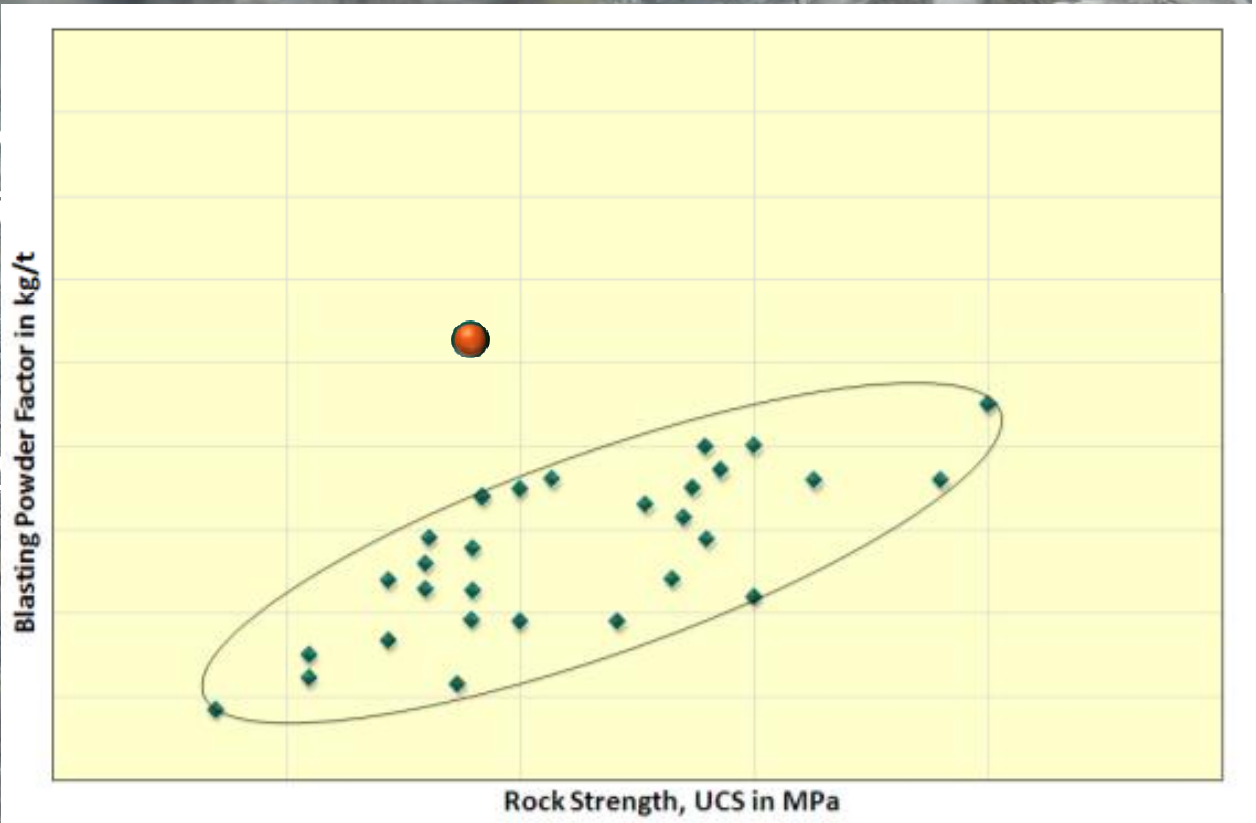
Case Study 1: Large Cu & Pb/Zn Mine

Increased throughput on hard ore types

- **Objective:**
  - *audit drill & blast, crushing & grinding practices on harder ore types*
  - *identify opportunities for higher throughput*

- **Recommendations:**
  - *blast design changes in tv*
  - *crushing & grinding circui*

- **Outcomes:**
  - *throughput increases of 1*
  - *reduction in mill operatin*



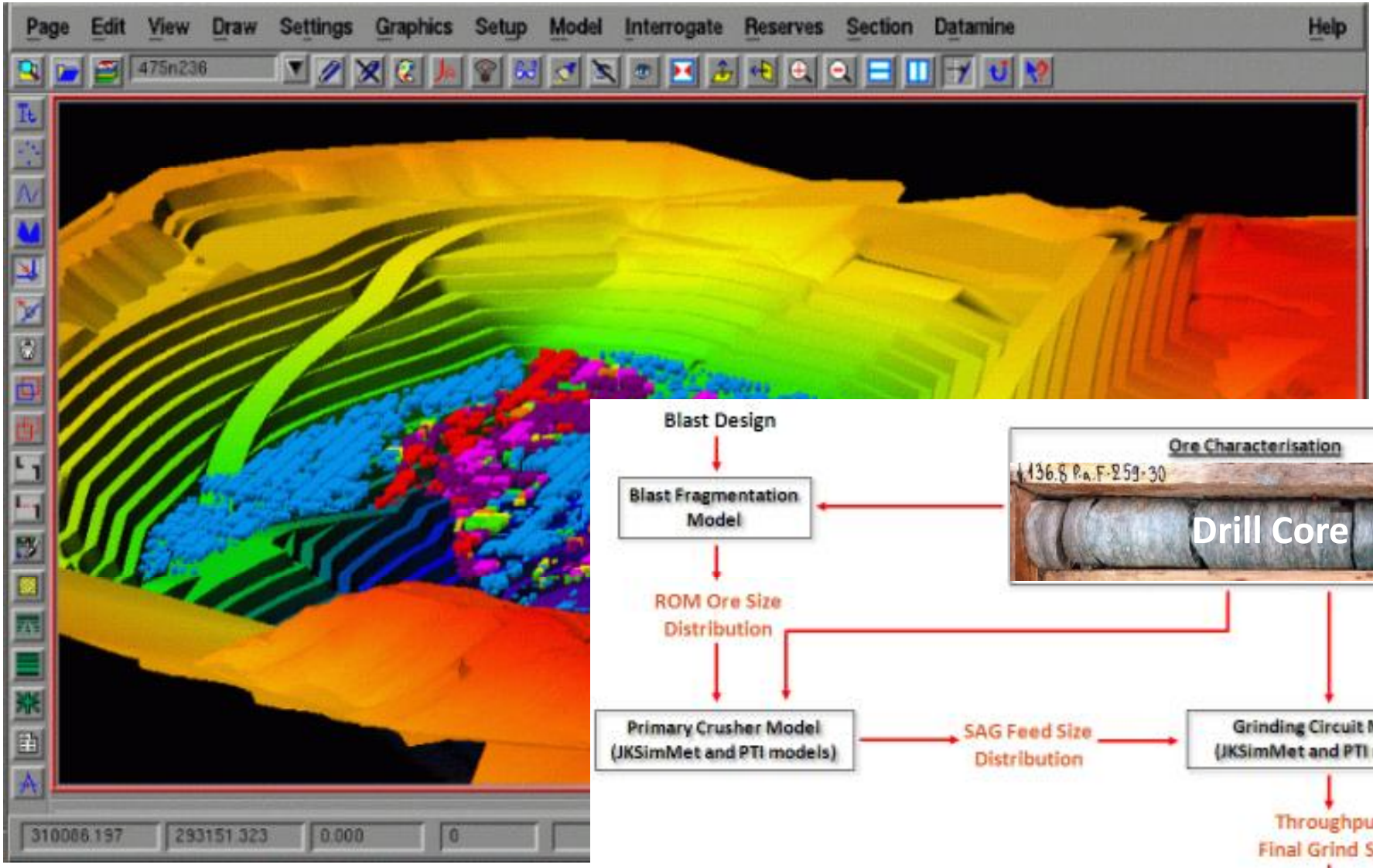
Case Study 2: Large Cu/Au Mine

Throughput forecasting

- **Objective:**
  - *review of blasting, crushing and grinding practices*
  - *development of blast domains based on rock properties*
  - *improvement to existing throughput forecasting model*
- **Recommendations:**
  - *standardise on blast patterns that vary with rock properties*
  - *use mill throughput estimates in mine planning (block model)*
- **Outcomes:**
  - *10 to 20% increase in mill throughput for harder domains*
  - *more consistent mill feed size*
  - *use of throughput forecasting tool in daily planning*

Geometallurgical Modelling

Mill performance associated with ore blocks



Case Study 3: Au Mine

Circuit issues for greenfield project

- **Objective:**
  - *review suitability of circuit design & capacity based on drillcore*
  - *how can blasting/circuit changes change over mine life?*
- **Recommendations:**
  - *ore properties expected to worsen over mine life of 35 years*
  - *circuit will work initially but not meet capacity later on*
  - *can maintain throughput on harder ores with blasting changes*
  - *over time, circuit capacity (installed power) will need to increase*
- **Outcomes:**
  - *predicted circuit shortfall very early in project*
  - *identified options for sustaining throughput with finer feed from blasting*
  - *delayed capital investment until later in project*

Summary

- **PTI have developed a proven Mine-to-Mill methodology**
  - *applied at many large open pit operations around the world*
  - *involves rock characterisation, benchmarking and process modelling*
- **Mine-to-Mill has much wider applications**
  - *"Mine-to-Float", "Mine-to-Leach", "Mine-to-Smelt"*
  - *aggregate & cement industries*
- **Issues facing success are not technical ones**
  - *cultural change, sustained implementation*
  - *challenges also faced by Business Improvement, Lean and Six Sigma initiatives*