What and why geometallurgy?

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GMT’s offer

• GMT GeoMet Tech brings
  – The leading geometallurgical methodologies to be applied to your new project
  – MetMatch product will benchmark your project and guide you on what to consider for the project development
    • (MetMatch to be launched Jan 2010)

• This will
  – Help reduce your project technical risk
  – Enable you to learn from similar operations and fast track the project development
  – Enable you to economically optimise the project
Introduction

- Geometallurgy is the study of the drivers of metallurgical response that lie in the geology and mineralogy of the rock that is exploited.

- Why is that important?
  - It provides us a framework or methodology to go about new project development
  - It enables us to technically optimise a new project’s economic return
  - Enables us to learn from existing / past operations
The Geometallurgical Framework

- Rooted in the geological / mineralogical sub-domains that exist in a deposit
- Considers metallurgical parameters at an early stage of project development
- Take spatially discrete samples of all those sub-domains for metallurgical flow sheet development
- Characterisation of samples for mineralogy, grindability and metallurgy
- Data is handled through the block model using geostatistics
- Metallurgical / economic models built to forecast response
Geometallurgy for Project Technical / Economic Optimisation

- Probable recovery is factored in economic and strategic considerations throughout project life
- Variable metallurgical response is calculated into project economics
- The whole deposit can be considered in techno-economic optimisation
- Sub-domains are weighted to their relative abundance
- Should be integrated with the project feasibility mine plan for cash flow forecast and optimisation
Learning from existing or past operations

- There are similar geology / mineralogy type deposits in the world
- Learn from these for early project strategic assessment when you have limited information about your new project
- Benchmark your project from development through to operation
- Alternative or new technological routes are indicated
- Fast track project development facilitated, applying past experience
How does this help?

• Reduces risk of problems at operation
• Learn from the past – faster track to development
• Optimise cash flow
• Optimise project design
• Maximise economic return
• Build investor and financial partner confidence
So why is this not widely practised now?

• Traditional, compartmentalised approach
  - We explore
  - We develop our resource base
  - We do pre-feasibility study / feasibility study with metallurgy
  - Metallurgist “receives” the sample
  - Gap in understanding between geologists and metallurgists
About GMT GeoMet Tech Ltd

• Formed in 2010
• Senior experienced professionals with broad mining project experience
• Metallurgists and geologists
• Database of mines / deposits of the world past and present
  – With geological, mineralogical and metallurgical information
• Specialised software to describe, compare and match ore types
Products
(Jan 2011 release)

• MetMatch
  • Matches a project to similar project(s) and based on that describes the metallurgy that will result, the recovery anticipated, geology and mineralogy, flowsheet, comminution, issues and opportunities, and recommendations for project development.

• MetMatch Mini
  • Fits a project to similar project(s) and based on that describes the metallurgy that will result, the recovery anticipated, geology and mineralogy.

• Project Benchmark
  • Does some preliminary QEMScan analysis on 4 selected samples of this project plus a diagnostic flotation test and based on this and a prior MetMatch refines the anticipated metallurgical response and recovery and updates recommendations for project develop.

• 43-101 reports
  • Write the metallurgical section for 43-101 reports
Consulting Services

• GMT GeoMet Tech offers consulting services for geometallurgy and metallurgy.

• GMT GeoMet Tech consulting services cover:
  – Guidance on how to include geometallurgy in your project development
  – Project benchmarking
  – Strategic guidance for project metallurgical development
  – Sample selection for flow sheet development test work applying geometallurgical methodology
  – Interpretation and evaluation of geometallurgical / metallurgical test work
  – Geometallurgical implementation with block models
  – Project representation for the client to board room, financiers, analysts
  – Project planning and project management for process development
  – Test work definition for flow sheet development
  – Forecasting model development
Key Players

- Steve Williams, President – senior metallurgical engineer with 30+ yrs experience and unique geometallurgy knowledge. Technical author and CIM Distinguished Lecturer on Geometallurgy
- Clinton Smyth, VP Geology – senior geochemist with 30+ yrs experience in geological exploration and unique experience in comparative geological modelling
- Chris Martin, Director – senior metallurgical engineer with 25+ yrs experience and unique knowledge in mineralogy as it drives metallurgy, having applied this to +100 projects
Example

- Porphyry Cu deposit
  - High degree of variability across the deposit
  - Large number of geological sub-domains
  - Many sub-domains with important mineralogical variability leading to variable metallurgical response
  - Rock type x Alteration x Mineralogy = up to 40 important sub-domains
A porphyry Cu deposit

Figure 50. Cartoon cross section illustrating generalized model for porphyry Cu deposits showing relation of ore minerals, alteration zoning, supergene enrichment and associated skarn, replacement, and vein deposits.
Porphyry Cu Metallurgy

• Comminution
  – Large range in variability at the SAG mill size from (Rod WI) from 8 – 24 kwhr/t is common
  – This means large potential variability in throughput
  – Overall, tend to be hard ores
  – Large tonnage operations means very large equipment / large capital cost / extremely long lead time
Porphyry Cu Metallurgy

• Flotation
  – Large range in variability in metallurgical response
  – Key mineralogical variables are:
    • Copper mineralogy: Chalcopyrite, secondary sulphides, oxides
    • Pyrite content
    • Gangue type – particularly clays / sericite
    • Grain size / liberation
    • Association
    • Au association
    • Mo distribution / grain size
    • Contaminant elements such as As
  – Cu recovery can vary from 65% - 93%; typically 85 – 88%
## Porphyry Cu Metallurgy
- actual data 2009

### Table 16-4: Locked-Cycle Flotation Test Results

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<th>Ajax 9</th>
<th>Ajax 2/6</th>
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