ADVANCED MINERALOGY NETWORK

- Lab network providing automated process mineralogy services
  - QEMSCAN (10 yrs experience, 200+ projects, 10 instruments, 4 countries)
  - XRD, SEM, electron microprobe
  - Image analysis
  - Petrography (PTS, PS)

- Applications
  - Exploration mineralogy
  - Geometallurgy
  - Metallurgical flowsheet design support
  - Ore variability characterization
  - Plant control and optimization
  - Environmental and mine planning
ADVANCED MINERALOGY NETWORK

- Laboratories dedicated to providing high definition mineralogy services to high volume users
  - Several instruments, technologies
  - Set of methods to provide “fit-for-purpose” data
  - Staffed by technicians backed by scientific expertise
  - Statistically grounded, quality control monitored

- Operational model similar to geochemical laboratory
  - Fee schedule with different test packages
  - High volume, high through-put
  - Standardized methods
  - Custom work available on request
  - Pay-as-you-go or strategic partnership
  - Consulting is separate and readily available
WHERE MINERALOGY REALLY CONTRIBUTES

Exploration

Resource Development

Pre-feasibility

Preproduction

Feasibility

Production

Recycling

Closure

Geophysics

Mapping Geochem

Drilling 1-20

50-100

100++

Geomechanics

Explomin

Trenching

Resource, reserve development

Bulk Sample

Met testing scoping flowsheet dev pilot

MINING

On-site lab and mill

Production forecasting

Metal trading

Certification

Social Aspects

Environment

baseline studies testing monitoring
OUR SCOPE OF SERVICE

- Gold
- PGM
- Uranium
- Base metals (Cu, Zn, Pb, Ni, Co)
- Heavy mineral sands (Ti, Zr, REE)
- Diamonds
- Tin, tungsten, tantalum, niobium
- Iron Ore, manganese and chrome
- Industrial minerals
- Refractories, slag & smelter products
MINERALOGICAL SERVICES

- Exploration mineralogy
- Ore characterization
- Petrographic descriptions
- Paragenesis, ore associations & modeling
- Precious metal deportment (Au, PGE)
- Mineral identification by XRD
- High definition mineralogy and liberation analysis
- Process mineralogy (predictive metallurgy, trouble shooting, process control, plant optimization, etc)
- Geometallurgical mapping
- Environmental mineralogy
- Forensic mineralogy
- Sample preparation and custom lapidary services
VALUE OF ADVANCED MINERALOGY SERVICES

- Exploration target definition
- Risk reduction
- Control and optimization
- Feed-forward control
- Ore-type definition
- Mining planning strategies
- Environmental planning
- Economic analysis
- Future cash-flow forecast
WHAT IS QEMSCAN?

- **Quantitative Evaluation of Minerals Using Scanning Electron Microscopy**
  - Mineralogical instrument that generates high volume, rapid, reproducible analysis.
  - Consists of:
    - Zeiss EVO 50 scanning electron microscope
    - Gresham SiLi LN2 energy dispersive X-ray fluorescence
    - iExplorer software
QEMSCAN OPERATIONAL PRINCIPLES

- SEM maps all grains in the section
  - Measures and maps particles at a defined resolution (2–10 µm)
- iExplorer selects particles based on the backscatter electron intensity
  - Creates pseudo-images in false color
- ED-XF identifies minerals on basis of chemistry
- iExplorer extrapolates the locking-liberation characteristics
QEMSCAN AUTOMATED MINERALOGY

- SEM Backscattered Image
- Minerals ID EDXRF and shown in false color
- Grain Size & Mineralogy
- Legend
- Pixel Distribution
- 3D Liberation Chart
- Data Display
- Particle Map
QEMSCAN MEASUREMENT STYLE

Data collected and measured:
- Identification of all minerals
- Grain size and abundance
- Modal mineralogy
- Particle size, shape factor
- Liberation characteristics
- Mineral associations

Pixel spacing and count time determine statistics
TYPICAL QEMSCAN OUTPUT

- Data available
  - Particle size
  - Mineral content
  - Mineral grain size
  - Mineral liberation
  - Mineral-mineral ass’n
  - Shape factor
EXAMPLES OF QEM DATA

Cumulative Pentlandite (Violarite) Liberation
Ni-sulphide Ore -1.7mm

Cumulative Pyrrhotite Liberation
Ni-sulphide Ore -1.7mm

Galena Mineral Recovery (%)
Comp 1  Comp 2  Comp 3  Comp 4  Comp 5

Combined Pb Grade (%)
X-RAY DIFFRACTOMETER
MINERAL IDENTIFICATION BY CRYSTALLOGRAPHY
High Definition Mineralogy

QEMSCAN, electron microprobe, XRD, image analysis, optical petrography

Geometallurgy, exploration mineralogy, ore characterization, liberation modeling
SANTIAGO, CHILE AMF

- High Definition Mineralogy
- Geometallurgy
- Ore characterization
- Metallurgical product analysis
QEMSCAN MEASUREMENT STYLE

- High Definition Mineralogy
- Precious metal deportment
- Geometallurgy
- Ore characterization
- High Definition Mineralogy
- QEMSCAN, image analysis, optical petrography
- Geometallurgy, exploration mineralogy, ore characterization
QEMSCAN - APPLICATIONS

- Exploration
- Geometallurgy
- Process design and development
- Plant metallurgical quality control
- Plant optimization
- Production forecasting