

# Construcción y Aplicación de Modelos Geometalúrgicos

Sergio Spichiger Blumel  
Anglo American

# ¿Geometalurgia?

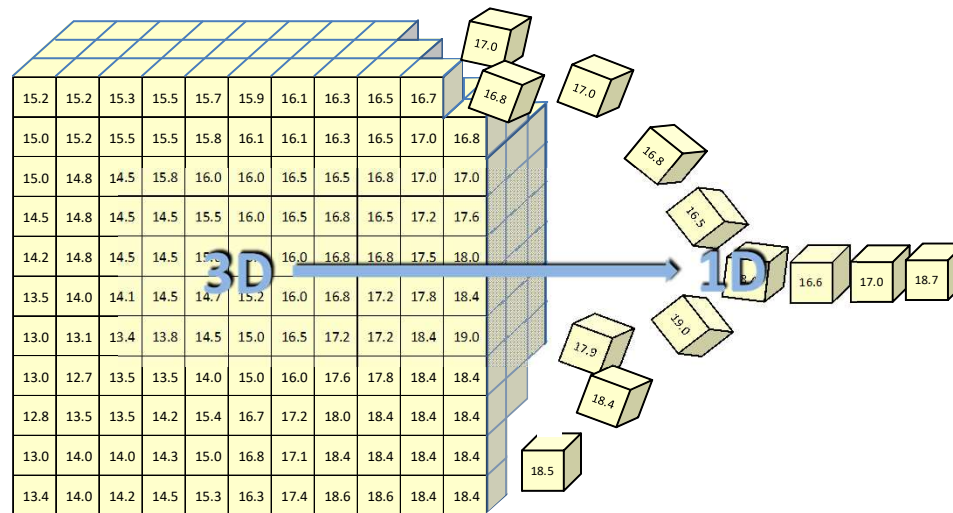


*“Integración de la geología y la metalurgia, orientada a la caracterización espacial de variables de proceso y la consiguiente predicción del comportamiento metalúrgico de un recurso mineral...”*



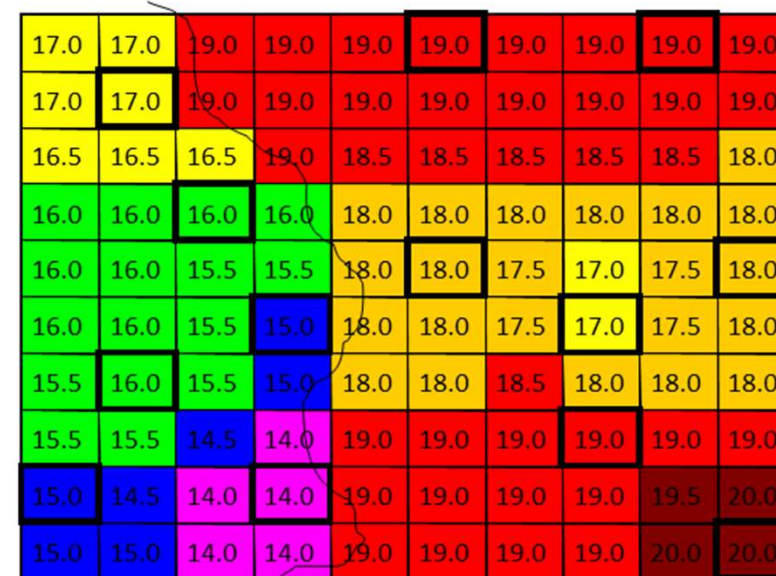
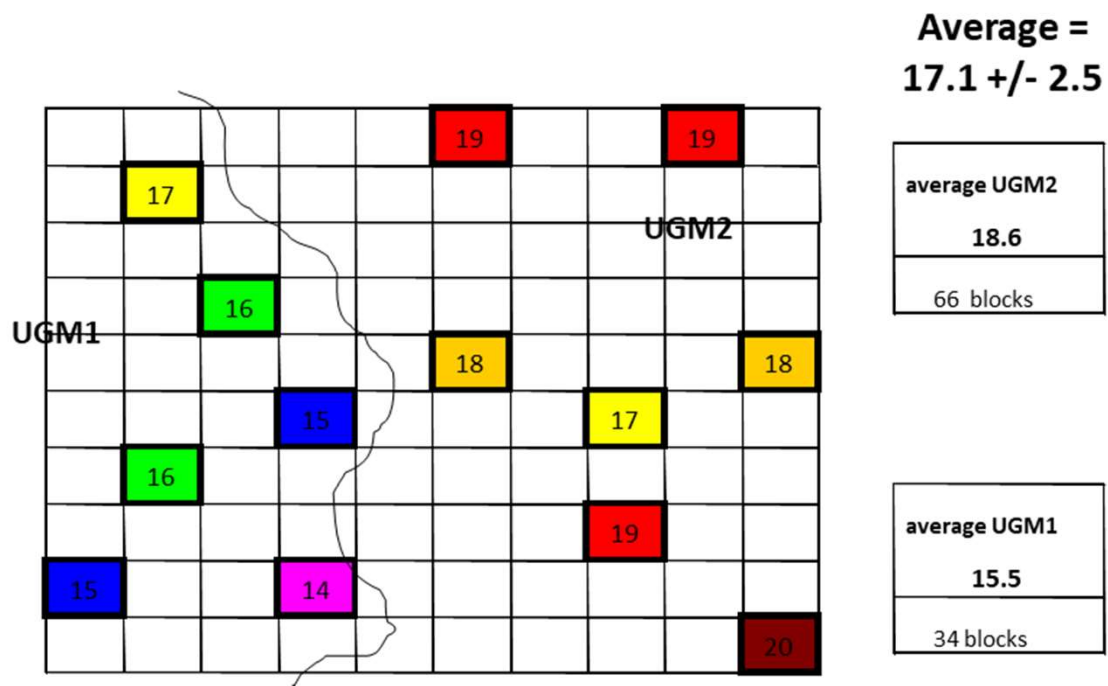
*... para tomar las mejores decisiones de negocio en el plan minero”*

Planificación Minera => transforma una representación tridimensional en una secuencia lineal



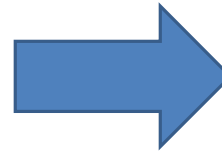
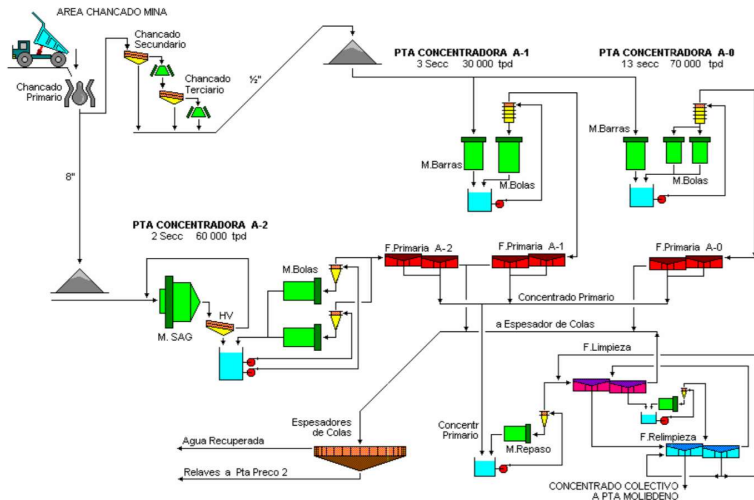
- El plan minero transforma la variabilidad especial (3D) en variabilidad temporal (1D)

# Estimación local de variables geometalúrgicas



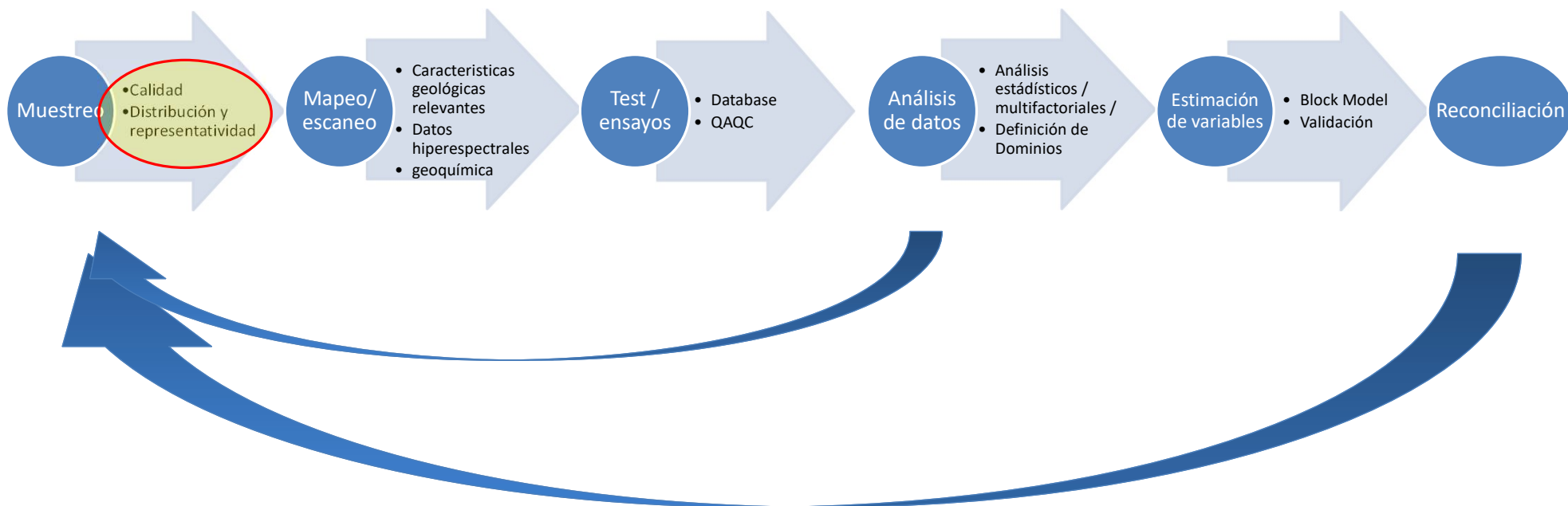
## Test

## Proceso



- % Recovery / extraction
- BMWI
- SMC
- SPI
- CI
- Density
- Magnetic susceptibility
- Washability test
- Others

# Ciclo Modelo Geometalúrgico



# Calidad del Muestreo

- Calidad de la muestra estará determinada por múltiples factores:
  - Tamaño muestra: peso, volumen
  - granulometría
  - Espacio representado
- Número de muestras – variabilidad
- Distribución - densidad espacial del muestreo - variabilidad
- Distribución – Plan Minero



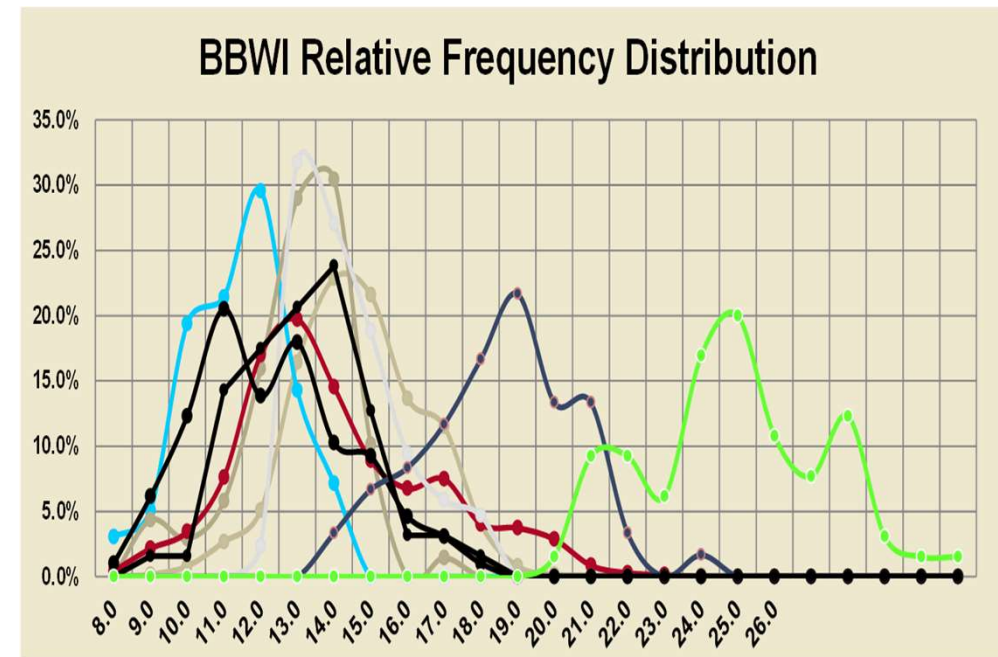
# Variabilidad de un parámetros metalúrgico

## Test

- % Recovery / extraction
- BMWI
- SMC
- SPI
- CI
- Density
- Magnetic susceptibility
- Washability test
- Others

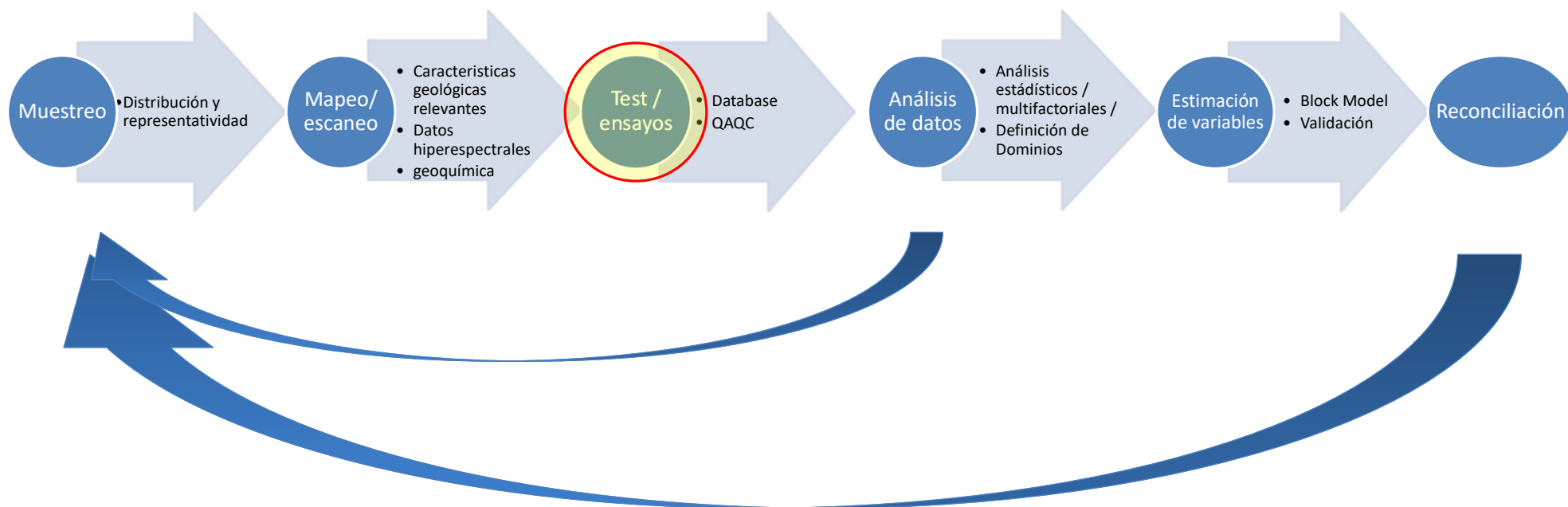
## ¿Número de muestras?

## Variabilidad



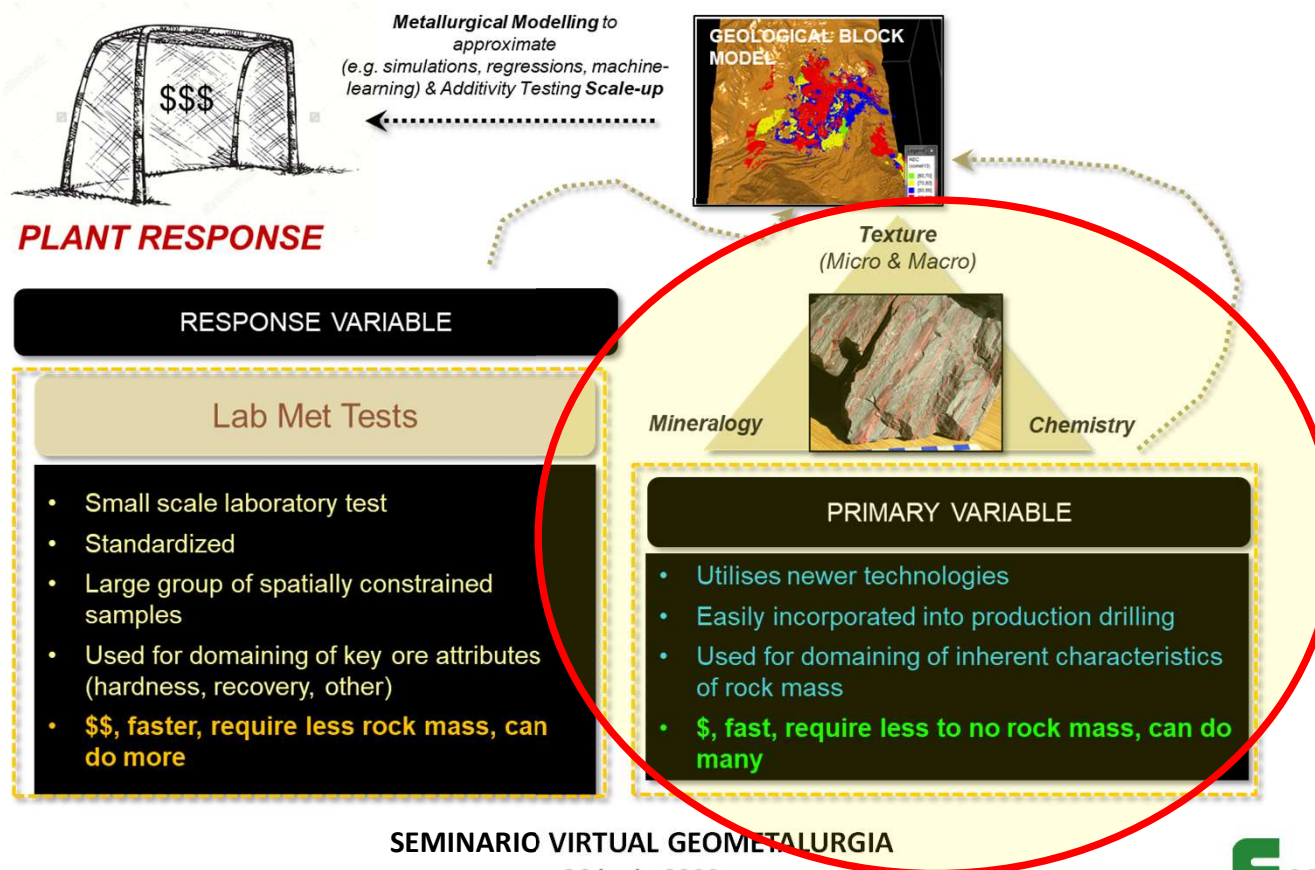


# Ciclo Geometalúrgico

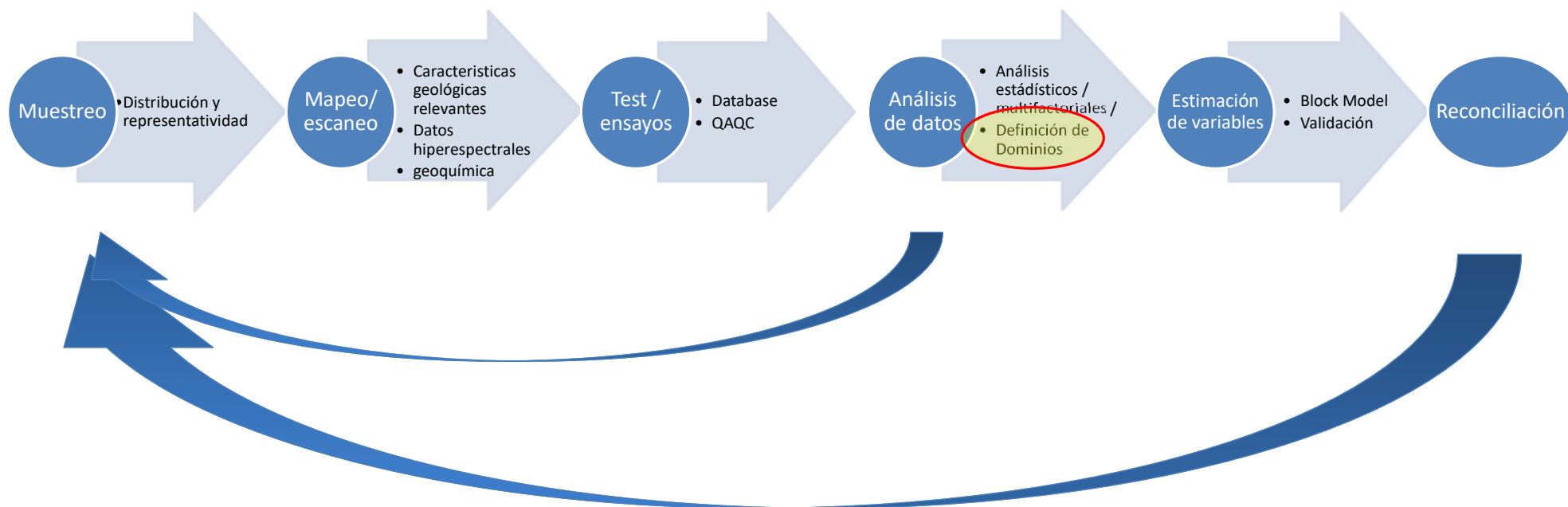


# Desarrollo de sensores proxy de tests

Adapted from: Coward, Vann, Dunham & Stewart (2009)

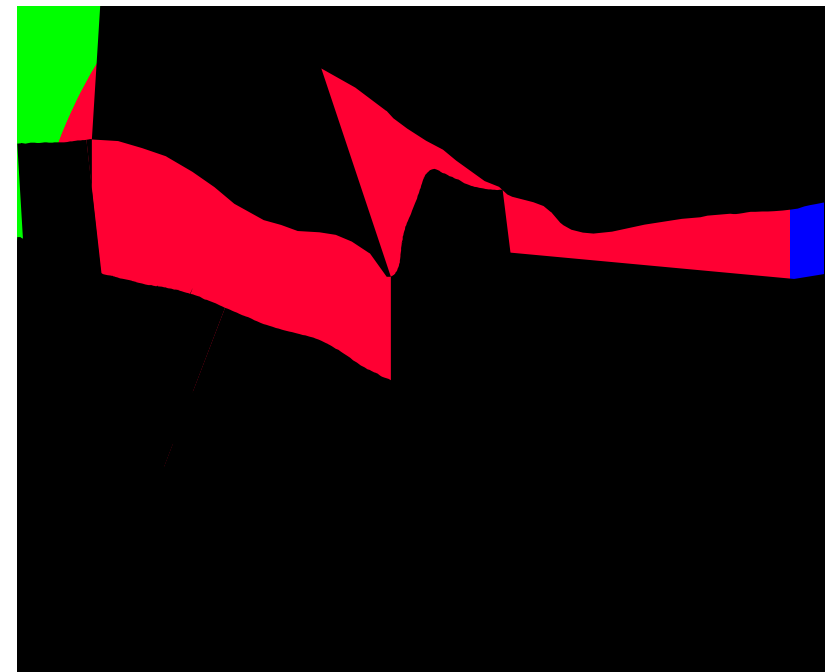
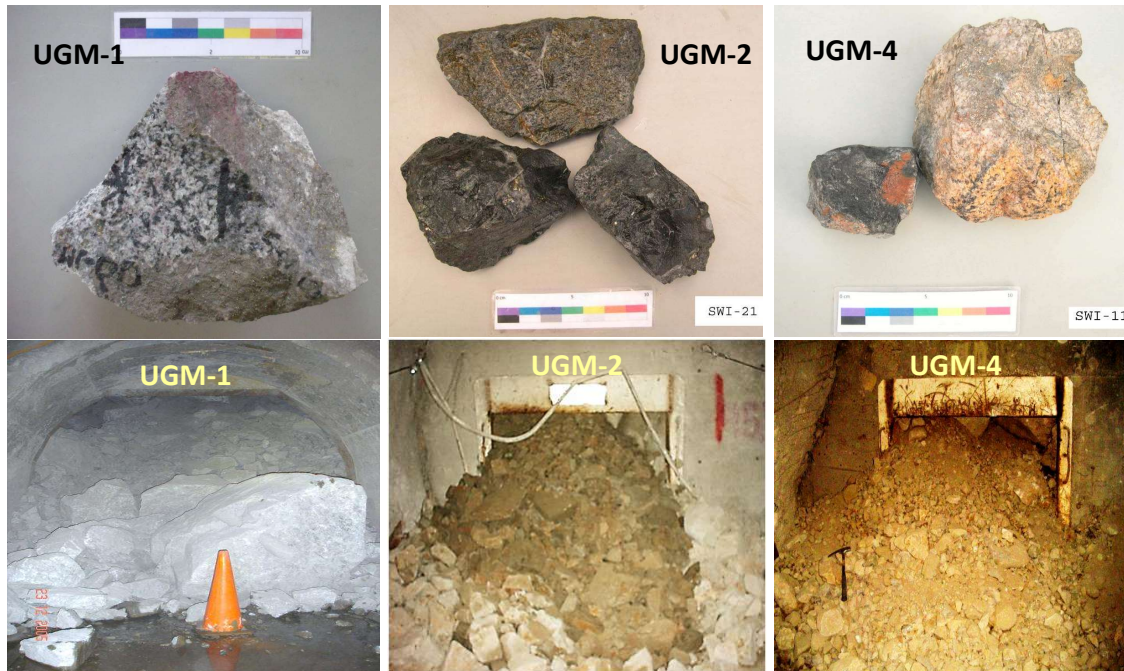


# Ciclo Geometalúrgico

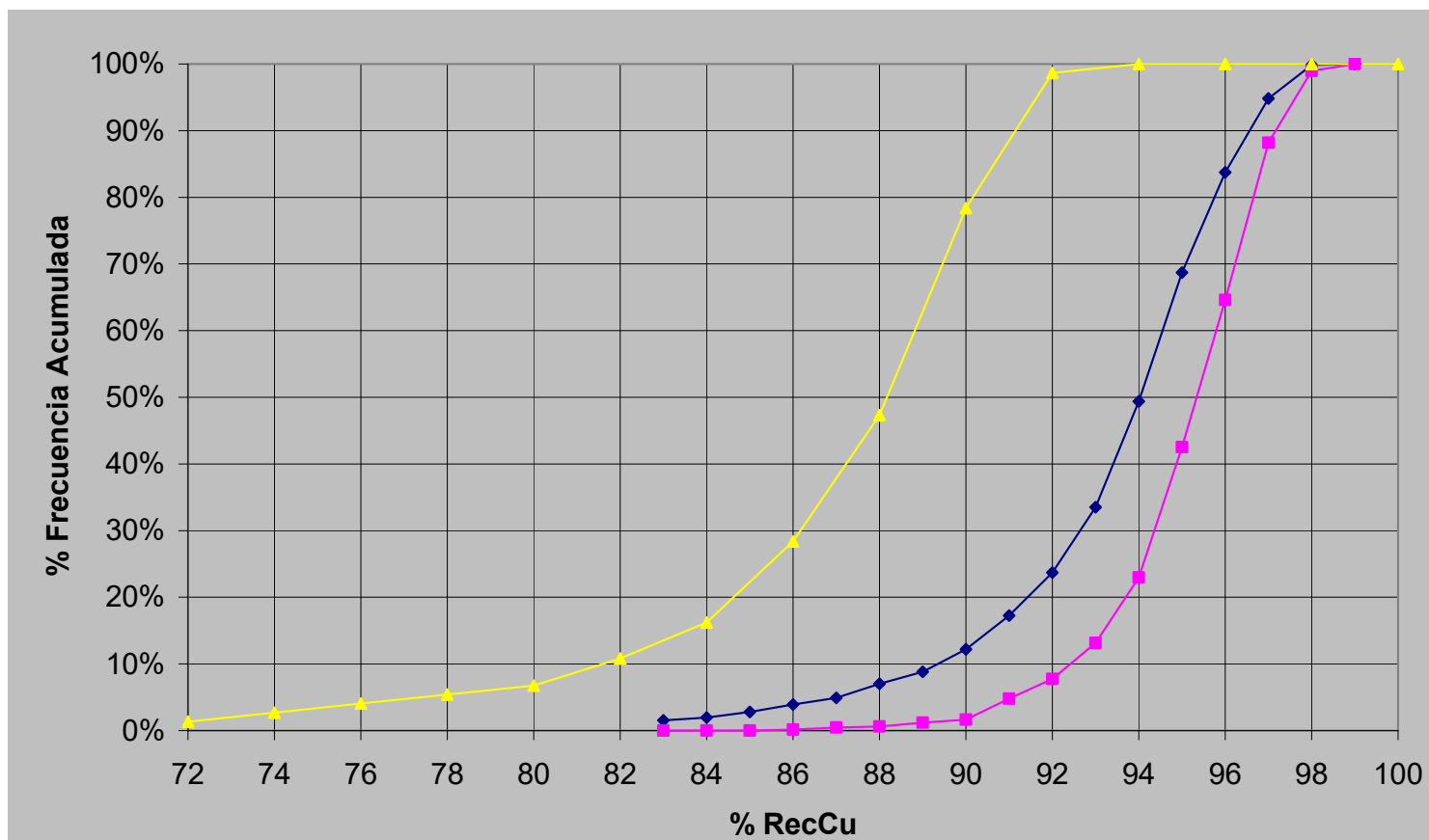


# Ejemplo Definición de Dominios

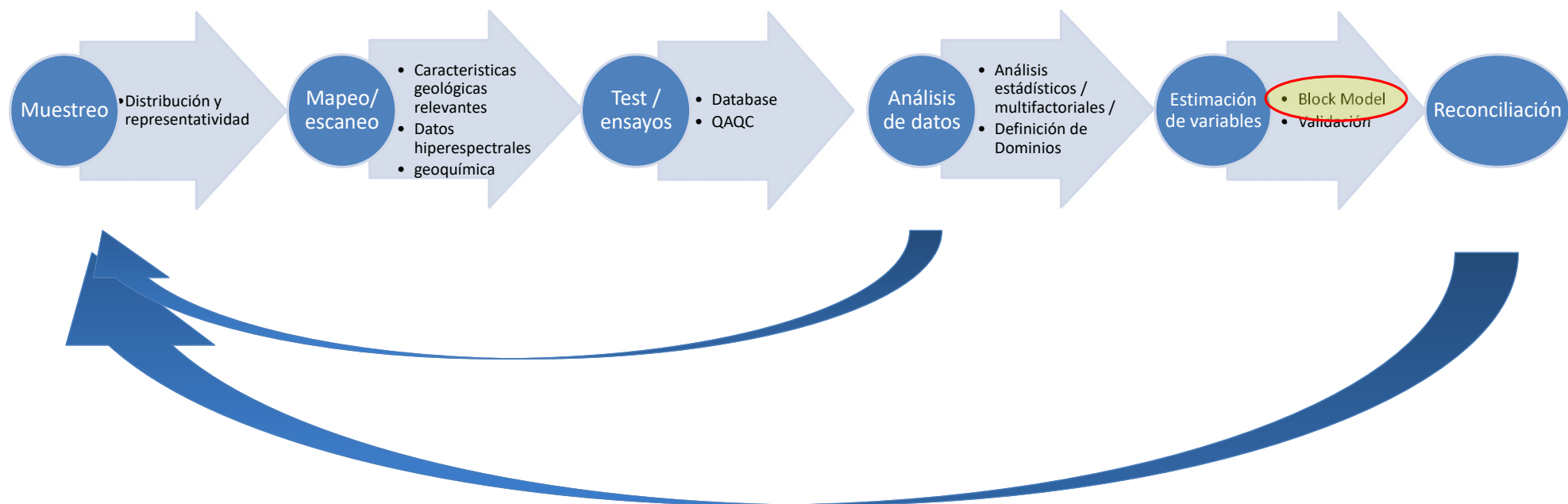
¿Criterio utilizado? => Alteración Supérgena



# Análisis estadístico de dominios



# Ciclo Geometalúrgico

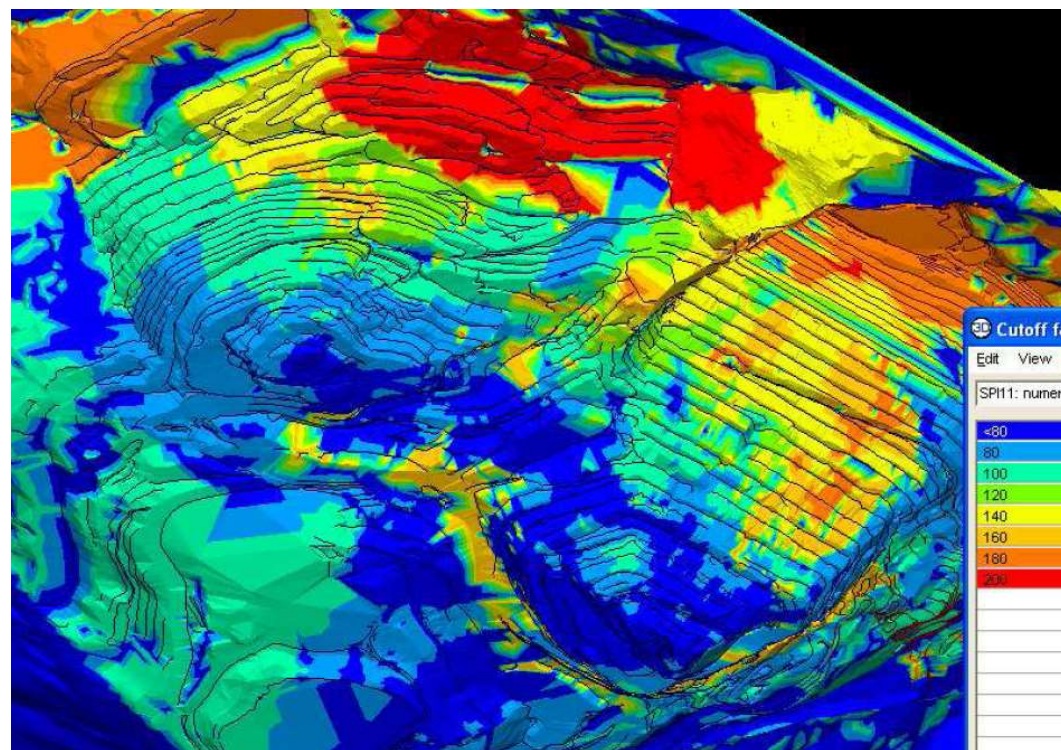
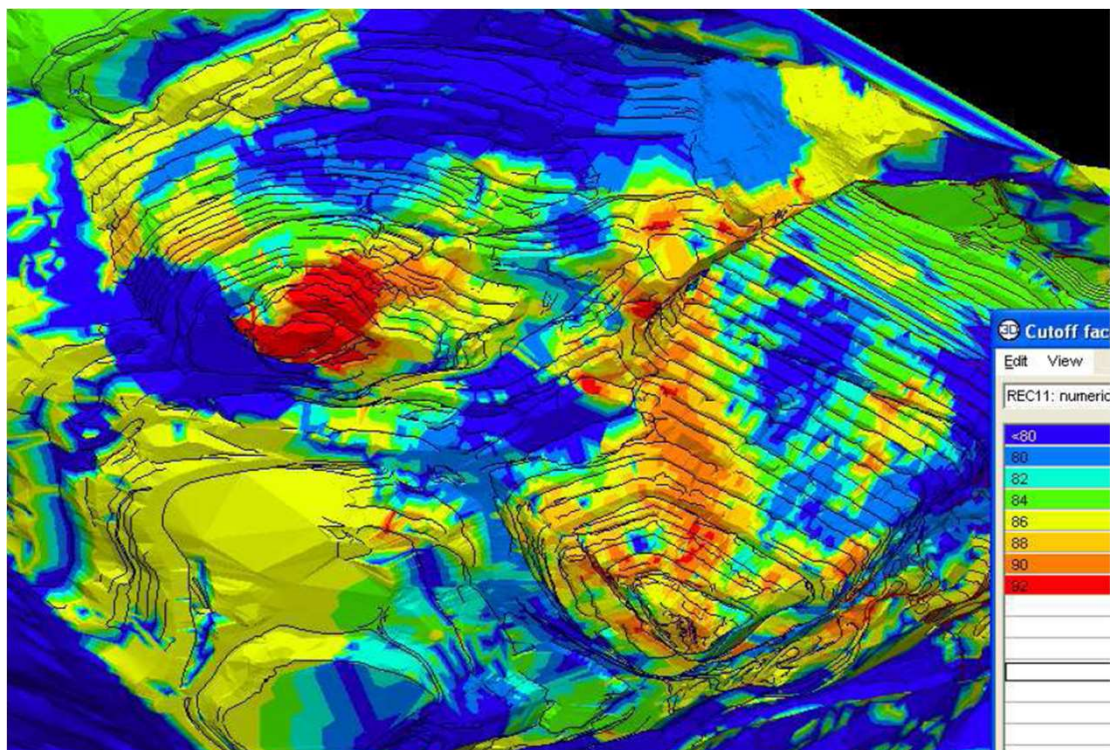




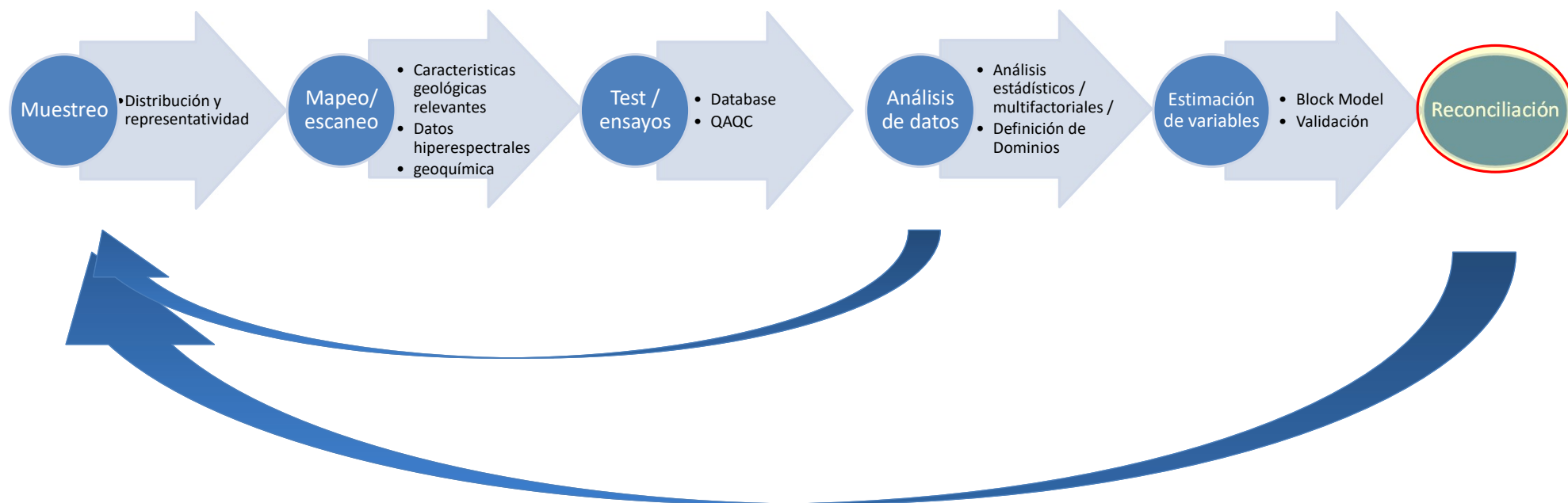
## Estimación local – Modelo de bloques

C1. Recovery Estimation using Kriging

C2. Hardness Estimation using Kriging



# Ciclo Geometalúrgico



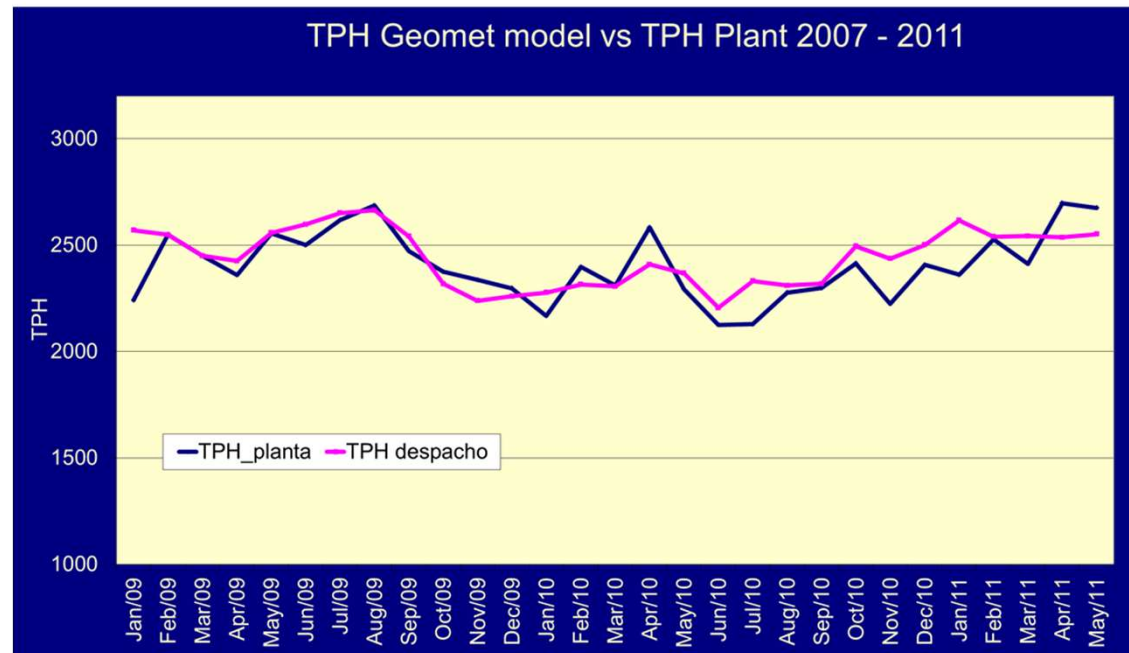


# Reconciliación de Modelos Geometalúrgicos

Hardness and Tph

Last 12 month

|                   |       |
|-------------------|-------|
| • Tph Plant       | 2,347 |
| • Model           | 2,433 |
| • acum error      | -3.5% |
| • error @90% conf | 9.5%  |





# Aplicación de un Modelo Geometalúrgico al Negocio Minero



SEMINARIO VIRTUAL GEOMETALURGIA  
26 junio 2020

*IMetChile agradece a sus auspiciadores*



Plan Minero tradicional  
Ley de corte – Recuperación  
media)

|         |        |        |        |        |        |
|---------|--------|--------|--------|--------|--------|
| %Cu     | 1.29%  | 1.22%  | 1.00%  | 0.98%  | 0.94%  |
| %Rec    | 90%    | 90%    | 90%    | 90%    | 90%    |
| t/h     | 500    | 500    | 500    | 500    | 500    |
| Cu fino | 52,245 | 49,410 | 40,500 | 39,690 | 38,070 |

Plan Minero tradicional  
Ley de corte – Recuperación  
real)

|         |        |        |        |        |        |
|---------|--------|--------|--------|--------|--------|
| %Cu     | 1.29%  | 1.22%  | 1.00%  | 0.98%  | 0.94%  |
| %Rec    | 87%    | 93%    | 86%    | 93%    | 91%    |
| t/h     | 430    | 530    | 480    | 550    | 510    |
| Cu fino | 43,433 | 54,120 | 37,152 | 45,114 | 39,263 |

Plan minero basado en valor  
(cobre fino de corte)

|         |        |        |        |        |        |
|---------|--------|--------|--------|--------|--------|
| %Cu     | 1.22%  | 0.98%  | 1.29%  | 0.94%  | 1.00%  |
| %Rec    | 93%    | 93%    | 87%    | 91%    | 86%    |
| t/h     | 530    | 550    | 430    | 510    | 480    |
| Cu fino | 54,120 | 45,114 | 43,433 | 39,263 | 37,152 |

VBOC

## ¿Cuál camión tiene mayor valor?

# 1

Tonnage: 350  
Grade: 1.3% Cu



Rock type: Porphyry  
Copper minerals: Cu(ox) 0.3% Cu(Sul) 1.0%  
Recovery: 80%  
**Value: US\$18,200 per truck**

Hardness: 14 (BWI)  
Throughput per hour: 3,000tph

**Total value of feed over 1 hour: US\$156,000**  
**Total value of feed over 1 year: US\$1,367M**

# 2

Tonnage: 350  
Grade: 1.3% Cu



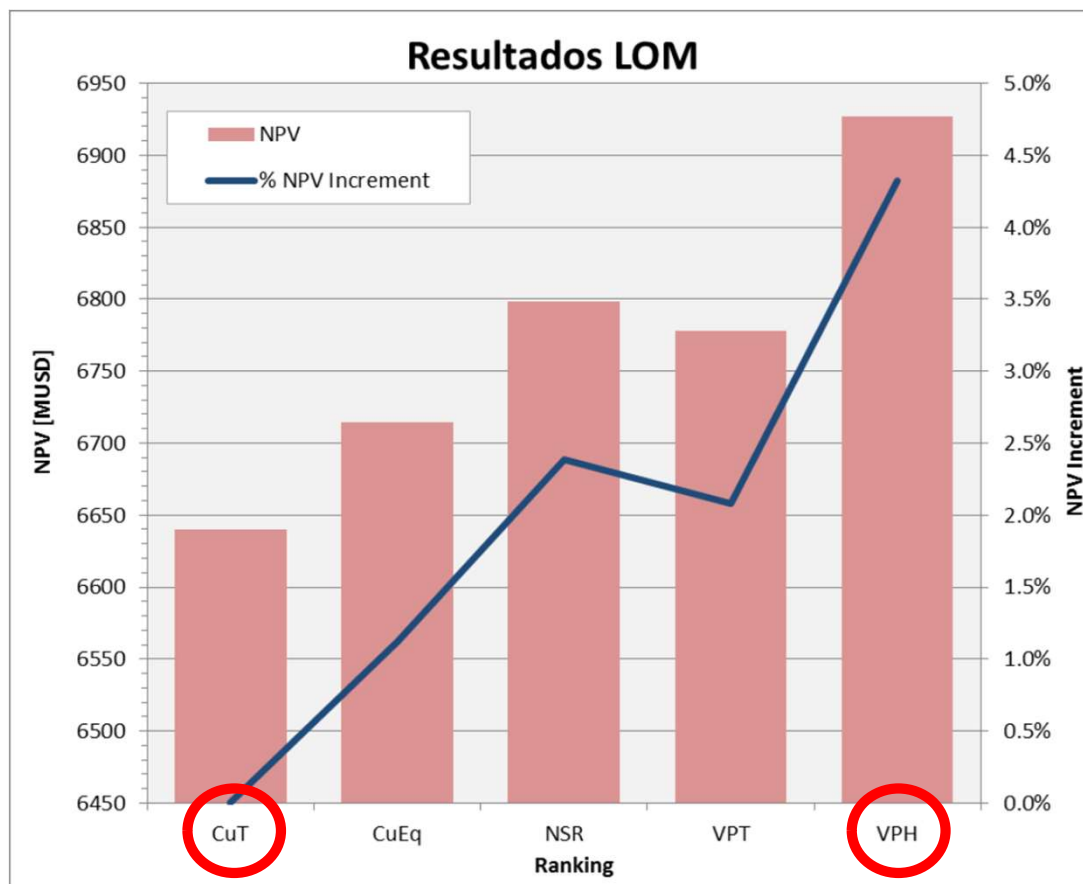
Rock type: Breccia  
Copper minerals: Cu(ox) 0.1% Cu(Sul) 1.2%  
Recovery: 85%  
**Value: US\$23,205 per truck**

Hardness: 13 (BWI)  
Throughput per hour: 3,500tph

**Total value of feed over 1 hour: US\$232,050**  
**Total value of feed over 1 year: US\$2,033M**

*(Extracted from C. Morley, 2019)*

## Incremento del valor en planes de largo plazo



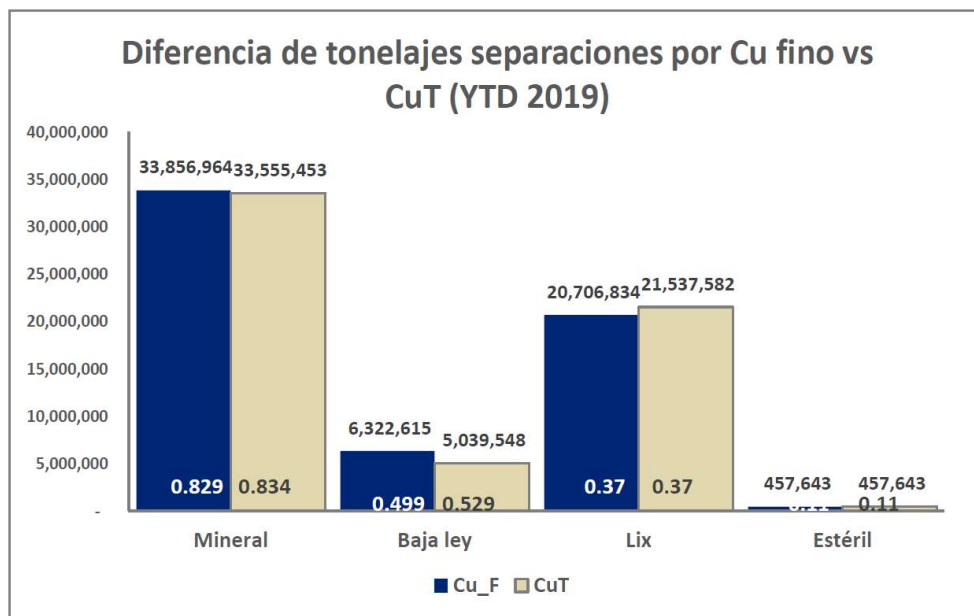
SEMINARIO VIRTUAL GEOMETALURGIA  
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# Incremento del valor en Ore Control

| TOTAL    | VBOC       |       |       |       |           |       |       |           |      |         | Separacion por Ley de corte |       |       |       |           |       |       |           |      |         |
|----------|------------|-------|-------|-------|-----------|-------|-------|-----------|------|---------|-----------------------------|-------|-------|-------|-----------|-------|-------|-----------|------|---------|
|          | Ton        | CuT   | PchLB | PchCF | PCh total | Rec1  | Rec2  | Rec total | LCL  | CuFin   | Ton                         | CuT   | PchLB | PchCF | PCh total | Rec1  | Rec2  | Rec total | LCL  | CuFin   |
| Mineral  | 33,856,964 | 0.829 | 2,271 | 3987  | 6,258     | 83.40 | 86.66 | 83.92     |      | 235,550 | 33,555,453                  | 0.834 | 2,262 | 3,966 | 6,227     | 83.36 | 86.62 | 83.89     |      | 234,569 |
| Baja ley | 6,322,615  | 0.503 | 2,268 | 3998  | 6,267     | 82.24 | 85.47 | 82.74     |      | 26,308  | 5,039,548                   | 0.524 | 2,260 | 3,989 | 6,249     | 81.25 | 84.48 | 81.74     |      | 21,585  |
| Lix      | 20,706,834 | 0.37  |       |       |           |       |       |           | 0.14 | 30,059  | 21,537,582                  | 0.37  |       |       |           |       |       |           | 0.15 | 31,463  |
| Estéril  | 2,820,420  | 0.23  |       |       |           |       |       |           |      |         | 3,574,251                   | 0.23  |       |       |           |       |       |           |      |         |

|                    |         |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |         |
|--------------------|---------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---------|
| Cobre fino Min+Lix | 291,918 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 287,616 |
| Delta              |         |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 4,301   |



| Diferencia VBOD vs CuT (YTD) |           |         |
|------------------------------|-----------|---------|
|                              | Ton       | Cu fino |
| Min x Rec                    | 301,511   | 982     |
| BL x Rec                     | 1,283,067 | 4,723   |
| Min x Tph                    | 165,473   | 1,079   |
| Lix                          | 830,748   | 1,403   |
| Esteril                      | 753,831   |         |
| Total                        |           | 5,380   |



# GRACIAS

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