The importance of quality

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Measure seven times, cut once

https://en.wikipedia.org/wiki/Sergei_Korolev#/media/File:SKorolow.jpg
http://www.b14643.de/Spacerockets_1/East_Europe_1/Semyorka/Gallery/R-7_6big.jpg

Quality: always an issue

https://en.wikipedia.org/wiki/Complaint_tablet_to_Ea-nasir

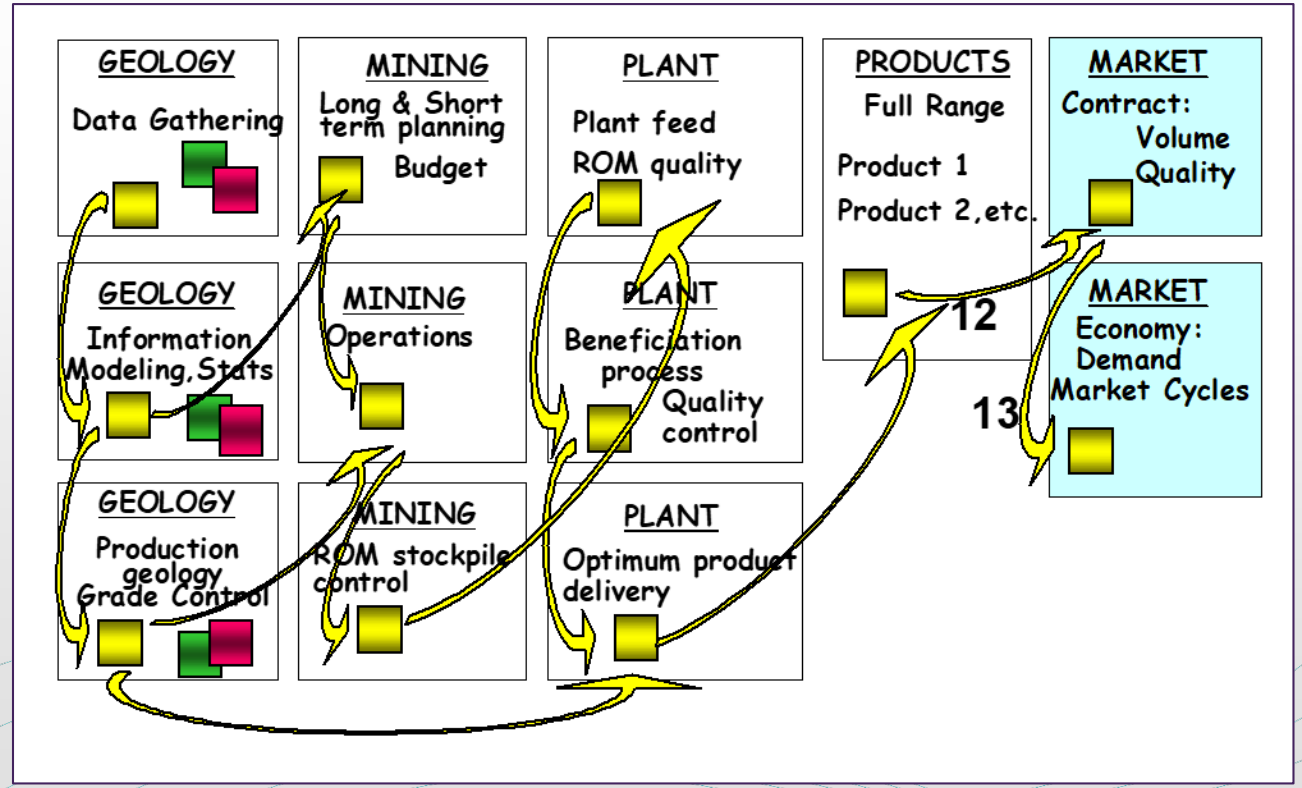
Tell Ea-nasir: Nanni sends the following message:

"When you came, you said to me as follows : "I will give Gimil-Sin (when he comes) fine quality copper ingots." You left then but you did not do what you promised me. You put ingots which were not good before my messenger (Sit-Sin) and said: "If you want to take them, take them; if you do not want to take them, go away!"

.....

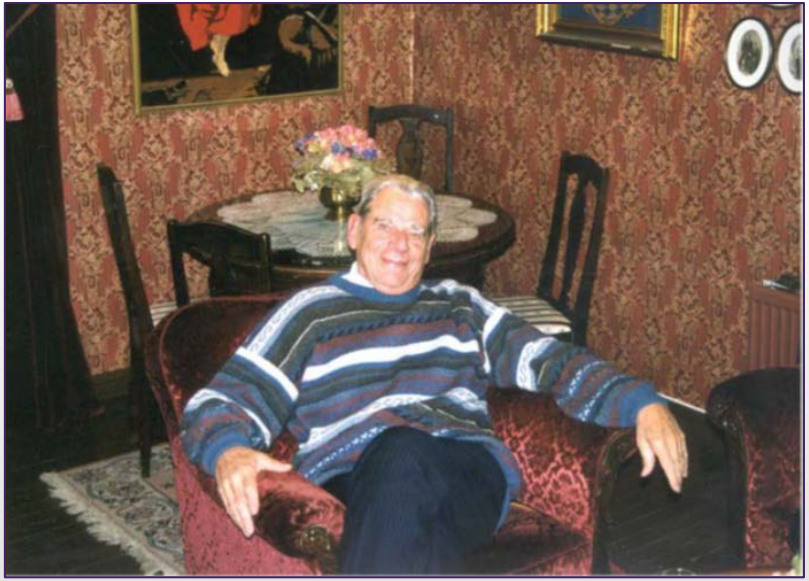
Take cognizance that (from now on) I will not accept here any copper from you that is not of fine quality. I shall (from now on) select and take the ingots individually in my own yard, and I shall exercise against you my right of rejection because you have treated me with contempt."

Geology and quality control



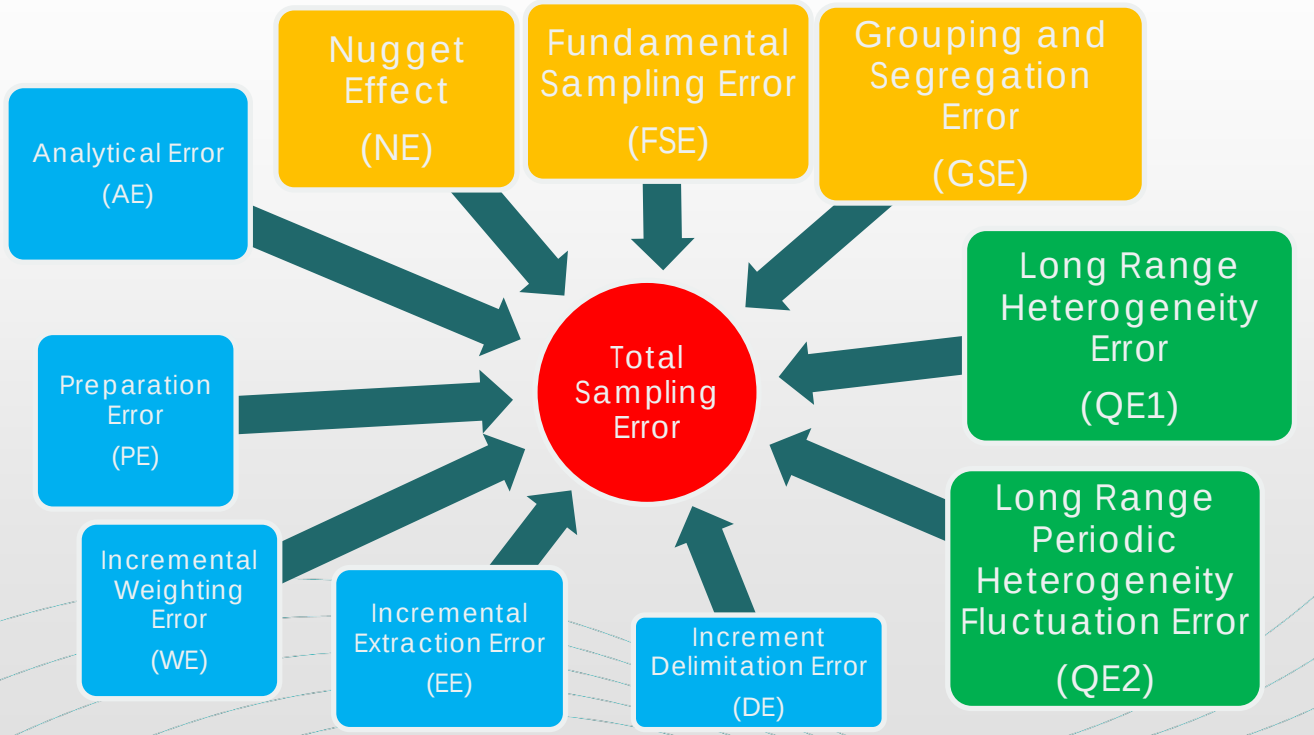
Source: UFS, MRM MSc

Sampling



Pierre Gy created, and developed the Theory of Sampling (TOS) over a period of 25 years (1950-1975) creating a new scientific discipline.

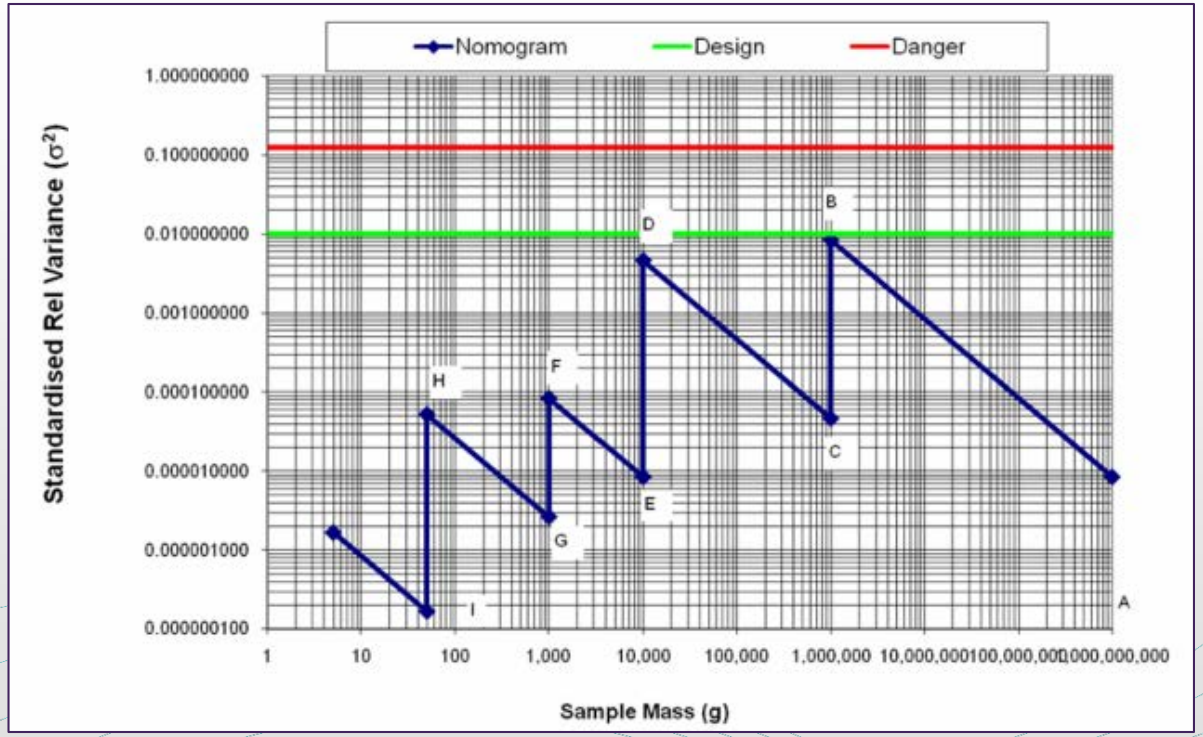
Sampling


Analytical Error
(AE)
Nugget Effect
(NE)
Fundamental Sampling Error
(FSE)
Grouping and Segregation Error
(GSE)
Preparation Error
(PE)
Total Sampling Error
Long Range Heterogeneity Error
(QE1)
Incremental Weighting Error
(WE)
Incremental Extraction Error
(EE)
Increment Delimitation Error
(DE)
Long Range Periodic Heterogeneity Fluctuation Error
(QE2)

Gold nuggets

http://pubs.dggsalaskagov.us/webpubs/usbm/b/text/b356.pdf
http://www.prograDex.com/wp-content/uploads/2016/09/Lyman_23_v2-The-Simple-Facts-about-Sampling-Gold-Ores.pdf
http://silvervein.ca/websites/silvervein.ca/images/Creso%20Gold%20Combined%20Web%20pic%20.jpg

The sampling nomogram



https://www.samcode.co.za/downloads/MiningInAfrica/Basic_Unit_of_Information.pdf

Density measurements

Methods

- Water immersion
- Pitting
- Caliper
- Downhole gamma
- Pycnometer.

Take into account

- Variability within the deposit as function of geology and/or grade
- Porosity and void factors
- Moisture content.

METAL=GRADE × VOLUME × **DENSITY**

Validation

https://blog.weespring.com/27-dos-donts-parents-taking-care-baby/

The cost of mistakes: 1

How much does it cost to fix a mistake?

- First-time mistake: redo

The cost of the fix?

- 1 unit cost + 1 unit cost + 1 unit cost = 3 unit costs

However:

- Real costs of mistakes are 8 to 14 times the cost of getting it correct the first time!

The cost of mistakes: 2

- Loss of competitive advantage
- Reputational damage
- Financial loss (might be bigger than you think)
- Claims, disputes, and litigation
- Failure to deliver against plan
- Regulatory non-compliance

Quality assurance and quality control

Quality assurance (QA)

- Establishment of systems, standards, and procedures
- Ensure quality
- Macro level.

Quality control (QC)

- Use of statistical tools and checks
- Ensure the systems are in statistical control
- Micro level.

Why?

- You don’t know what you don’t know
- You don’t measure what you don’t value
- You can’t value what you don’t measure
- If you can’t measure it, you can’t control it
- If you can’t control it, you can’t improve it.

Quantifying, controlling, and correctly reporting allows you to successfully monitor and control performance.

However...

"The most important figures that one needs for management are unknown or unknowable, but successful management must nevertheless take account of them."

https://www.isixsigma.com/community/blogs/what-you-measure-what-you-get/
http://scrumconnect.com/2018/03/07/how-we-measure-and-manage-quality-and-speed-of-delivery-teams/

Sampling and QA/QC

- Theory of sampling explains the sources of variability.

  Sampling errors will never be zero

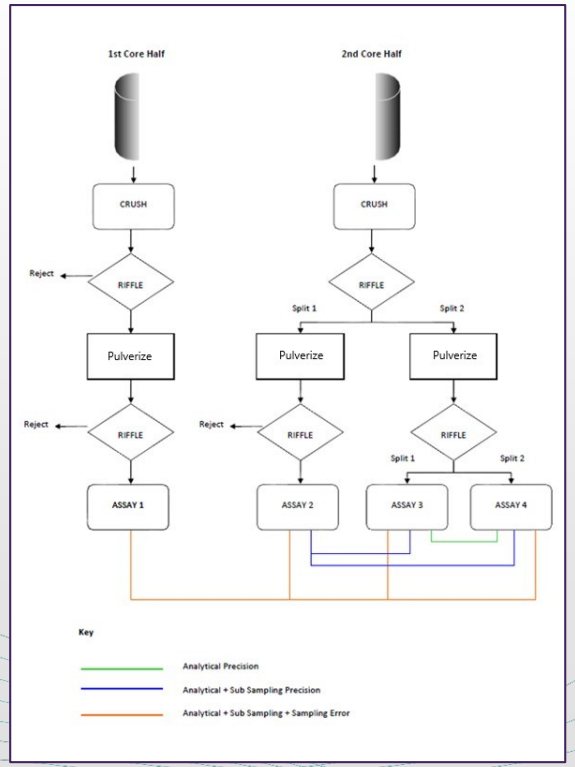
  Errors are additive

  You can't get rid of them.

- QA/QC provides a means of ensuring that correct sampling practices are followed, and errors are quickly identified and corrected.

QA/QC

- Field duplicates
- Coarse duplicates
- Pulp duplicates
- Blanks
- Certified Reference Materials (CRMs)



QA/QC

Aspect	Quality Assurance	Quality Control
Definition	QA is a set of activities for ensuring quality in the processes by which products are developed.	QC is a set of activities for ensuring quality in products. The activities focus on identifying defects in the actual products produced.
Focus on	QA aims to prevent defects with a focus on the process used to make the product. It is a proactive quality process.	QC aims to identify (and correct) defects in the finished product. Quality control, therefore, is a reactive process.
Goal	The goal of QA is to improve development and test processes so that defects do not arise when the product is being developed.	The goal of QC is to identify defects after a product is developed and before it's released.
How	Establish a good quality management system and the assessment of its adequacy. Periodic conformance audits of the operations of the system.	Finding & eliminating sources of quality problems through tools & equipment so that customer's requirements are continually met.
What	Prevention of quality problems through planned and systematic activities including documentation.	The activities or techniques used to achieve and maintain the product quality, process and service.
Responsibility	Everyone on the team involved in developing the product is responsible for quality assurance.	Quality control is usually the responsibility of a specific team that tests the product for defects.
Example	Verification is an example of QA	Validation/Software Testing is an example of QC
Statistical Techniques	Statistical Tools & Techniques can be applied in both QA & QC. When they are applied to processes (process inputs & operational parameters), they are called Statistical Process Control (SPC); & it becomes the part of QA.	When statistical tools & techniques are applied to finished products (process outputs), they are called as Statistical Quality Control (SQC) & comes under QC.
As a tool	QA is a managerial tool	QC is a corrective tool

Source: Bishi, 2014
https://www.appliedgeochemists.org/images/stories/Exploration_07/B_Smee.pdf
https://mrmr.cim.org/media/1080/cim-mineral-exploration-best-practice-guidelines-november-23-2018.pdf

QA/QC insertion rates

Sample Type	Sample Sub-Type	Suggested Insertion Rate %		Minimum (Mandatory) Insertion Rate %
Duplicates	Twin Samples	2	6	5
	Coarse Duplicates	2		
	Pulp Duplicates	2		
CRMs	CRMs	5	5	5
Blanks	Coarse Blanks	3	6	5
	Pulp Blanks	3		
Check Samples	Check Samples	3	3	
Total	**All**	**20**	**20**	**15**

Source: Bishi, 2014
https://pdfs.semanticscholar.org/16c1/c29884784d18eede077d51b72932a4dcd506.pdf

Types of errors

Systematic errors

- Systematic errors are due to identified causes and can, in principle, be eliminated.

Random errors

- Random errors are positive and negative fluctuations that cause about one-half of the measurements to be too high and one-half to be too low. Sources of random errors cannot always be identified.

Blunders/gross error

- A final source of error, is an outright mistake and should not be included in the analysis of data.

Geologists and Geostatisticians

Harry Parker (AMEC) and John Espinoza (BHP)

"Like the late Haddon King, I have found that understanding the geological controls (not the exploration geologist's guides) on ore occurrence to be of tantamount importance. In general, an ounce of geology is worth a pound of geostatistics; this may be disappointing to geostatisticians with no geological background. Tough."

Bias

Availability bias
Data is interpreted using the most recent experience or/and area of expertise.

Anchoring bias
Inability to move beyond the accepted interpretation provided by the “experts”.

Confirmation bias
Data is interpreted to confirm your predetermined conclusion.

Geological modelling: issues

- Errors in raw data measurement or spatial positioning.
- Errors and uncertainty resulting from the amount (or lack) of raw data.
- Errors related to scale or projection of data.
- Uncertainty in the geological theories employed in the interpretation.
- Uncertainty in the accepted interpretation of the regional geology or geological history of the area under study.

http://nora.nerc.ac.uk/id/eprint/509482/1/IR04164.pdf

Geological modelling: issues

- Uncertainty with interpolative or extrapolative techniques.
- Uncertainty in expert knowledge (the limit of knowledge, training or experience of the Scientist making the interpretation).
- Uncertainty in the quality of the data, the method by which they were collected, or the manner in which they have been processed.
- Uncertainty resulting from data conflict.

http://nora.nerc.ac.uk/id/eprint/509482/1/IR04164.pdf

What should I be asking myself?

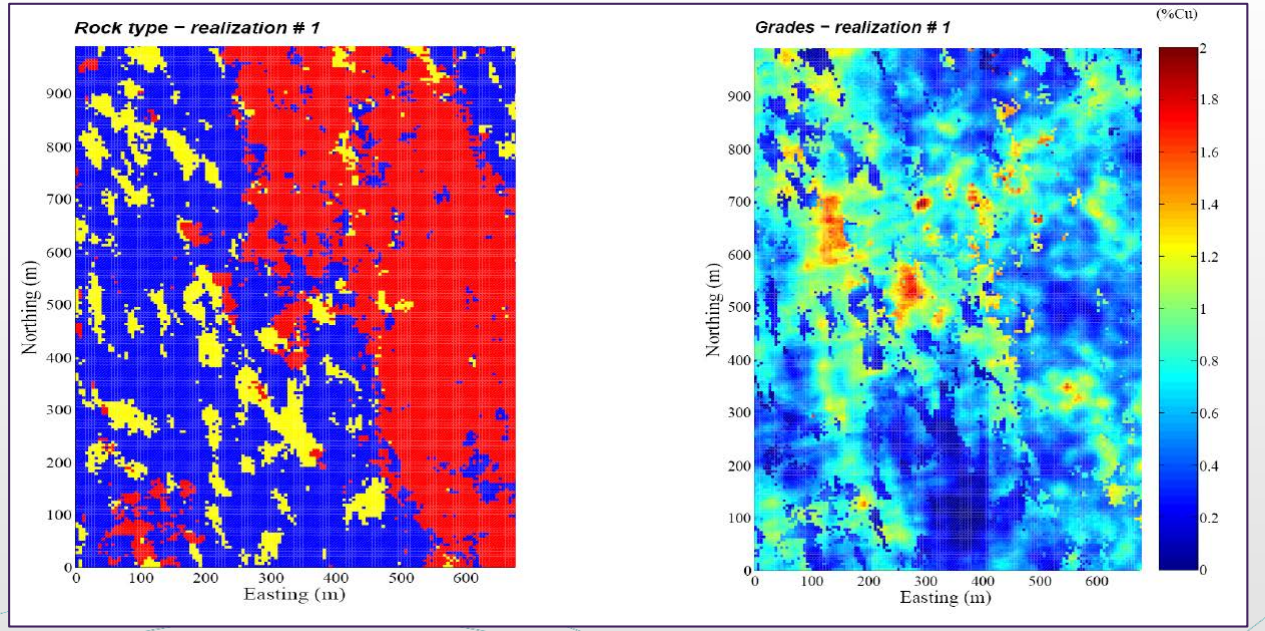
How wrong could my geological interpretation be?

- Data quality?
- Grade variability?
- Geological complexity?
- Presence of marker units?
- Drillhole spacing?
- Survey errors?

What could occur between my current drillhole spacing?

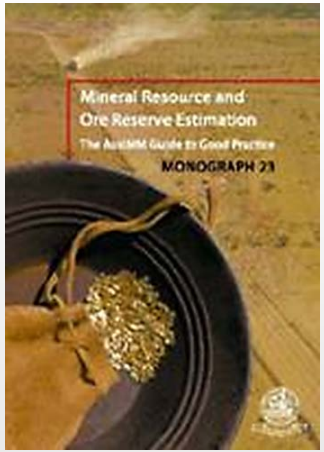
- Mineralization morphology
- Grade variability?
- Faulting/structural complexity?

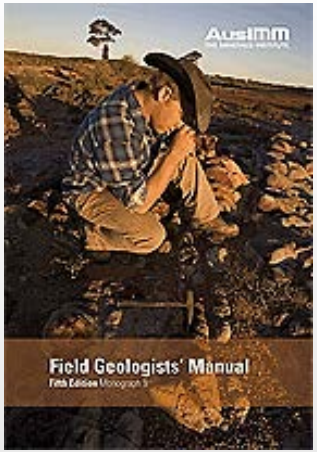
Grade simulation and rock types



Silva and Emery, 2008, Geological control in grade simulation: A comparative study, Geostats 2008.

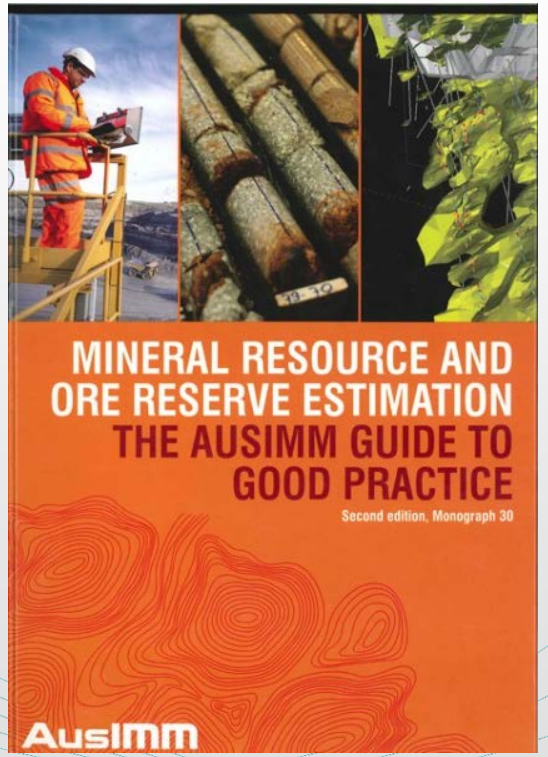
Best practice guidelines





ESTIMATION OF MINERAL RESOURCES
And
MINERAL RESERVES

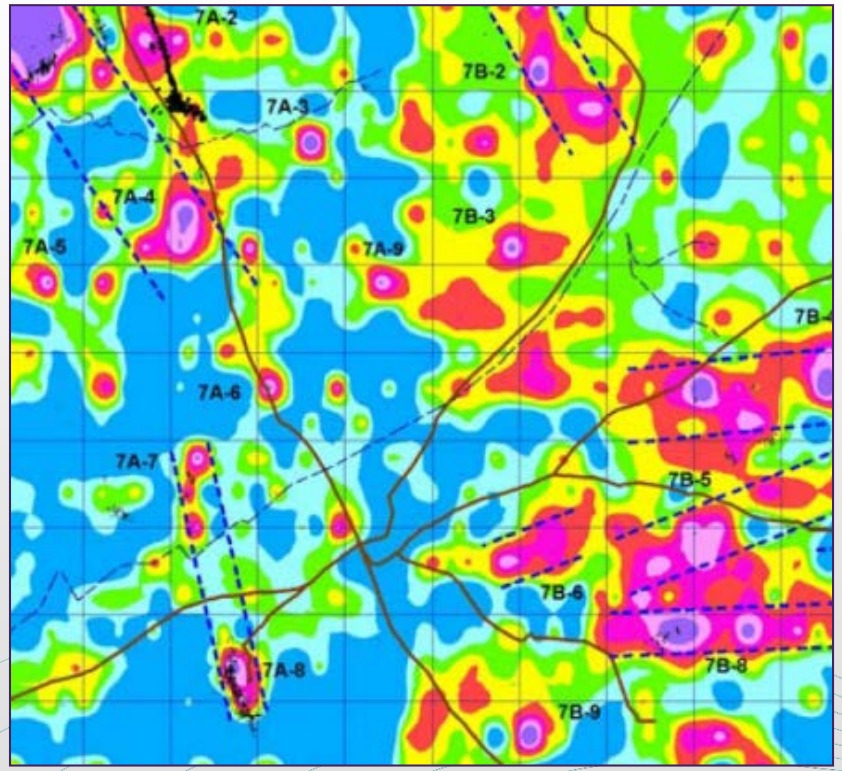
BEST PRACTICE GUIDELINES



Case studies

AMC consultants
mine smarter

Case study 1: exploration



- Large areas were identified for follow-up drilling.
- Drilling was undertaken. However, no gold targets were identified
- An investigation was ordered to determine what had gone wrong.

Case study 1: exploration

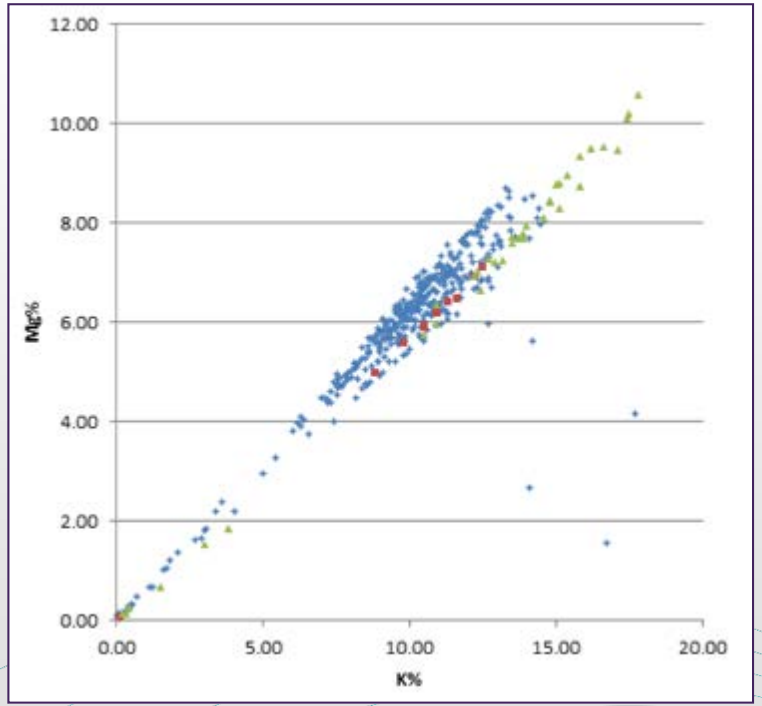
- In order to save costs, mining grade CRMs were sourced.
- The CRMs were stored in bulk bags next to the soil samples.
- It was determined that the CRMs had contaminated the soil samples.
- New CRMs were purchased and stored separately.
- The soil sampling programme had to be redone.
- The drilling programme was revised, and only 30% of the originally planned holes had to be drilled.

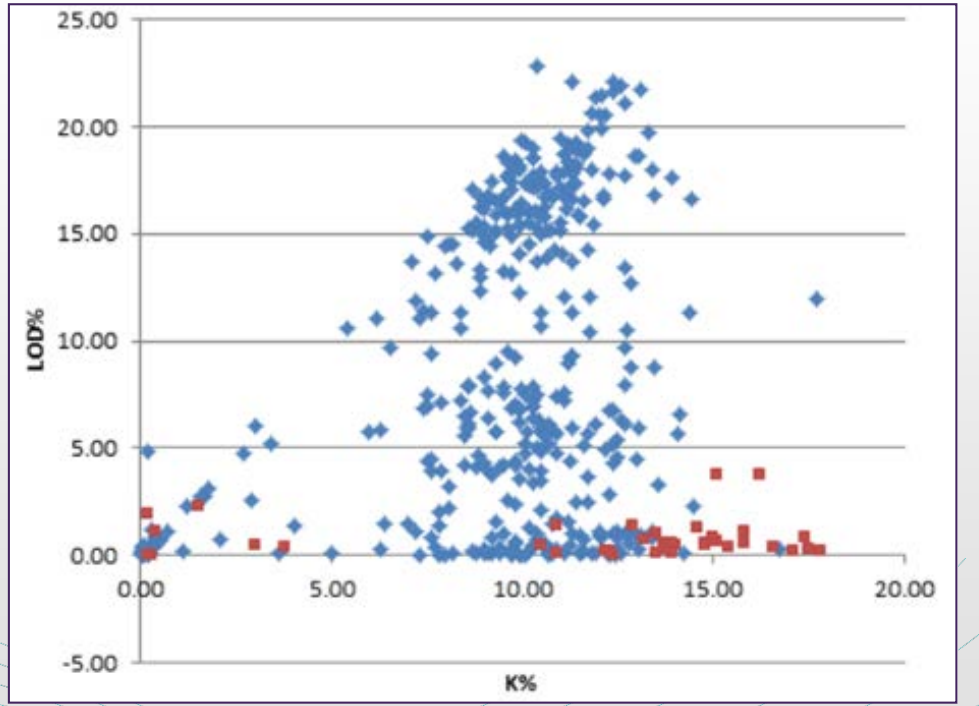
Case study 2: potash assay

- A company drilling for potash received a batch of samples from the assay laboratory that were clearly wrong.
- The laboratory argued that their analysis was correct.
- Why were they wrong?

Hint: Think minerals and their composition…

Case study 2: potash assay





Case study 2: potash assay

- Sylvite: KCl (70%)
- Carnallite: KMgCl3·6H2O (30%).

carnallite + water = sylvite + $MgCl_2$ rich brine

As only sylvinite and carnallitite are present, then a relationship between grade and density can be assumed, i.e. density is proportional to grade.

Case study 3: CIM NI 43-101 compliance review

- One-hundred NI 43-101 randomly selected technical reports were reviewed for compliance (QA/QC section).
- Reports from 2014 onwards considered.
- A range of countries, commodities, and consulting groups were reviewed.

Case study 3: CIM NI 43-101 compliance review

- “Inappropriate” CRMs (“production samples”) used in e.g. soil sampling programmes.
- Duplicates submitted (not always clear what type) at an insertion rate of 0% to 4.5% (3% to 5% appears to be the norm).
- Blank insertion rate varies from 0% to 4.5% (2.5% appears to be the norm).
- Early-stage “blank” failure rate is high as they have not been assayed to confirm they are “blank”.
- Sixteen reports reviewed placed sole reliance on the laboratory QA/QC.

Case study 4: grade control

- Initial drilling not representative of the orebody.
- Flowsheet not fit-for-purpose.
- High variability in ore properties.
- Recovery effecting elements: clay, Fe, As, fines.
- Run-of-mine (ROM) pad as a single running stockpile.
- Two types of As: Scorodite = “good”

  Arsenopyrite = “bad”

Case study 4: grade control

Monthly:

- Samples taken from blasthole cuttings
- Analyse results and update resource model
- Update dig plans
- Changes cascade to short-term planning (daily/weekly/monthly).

Weekly:

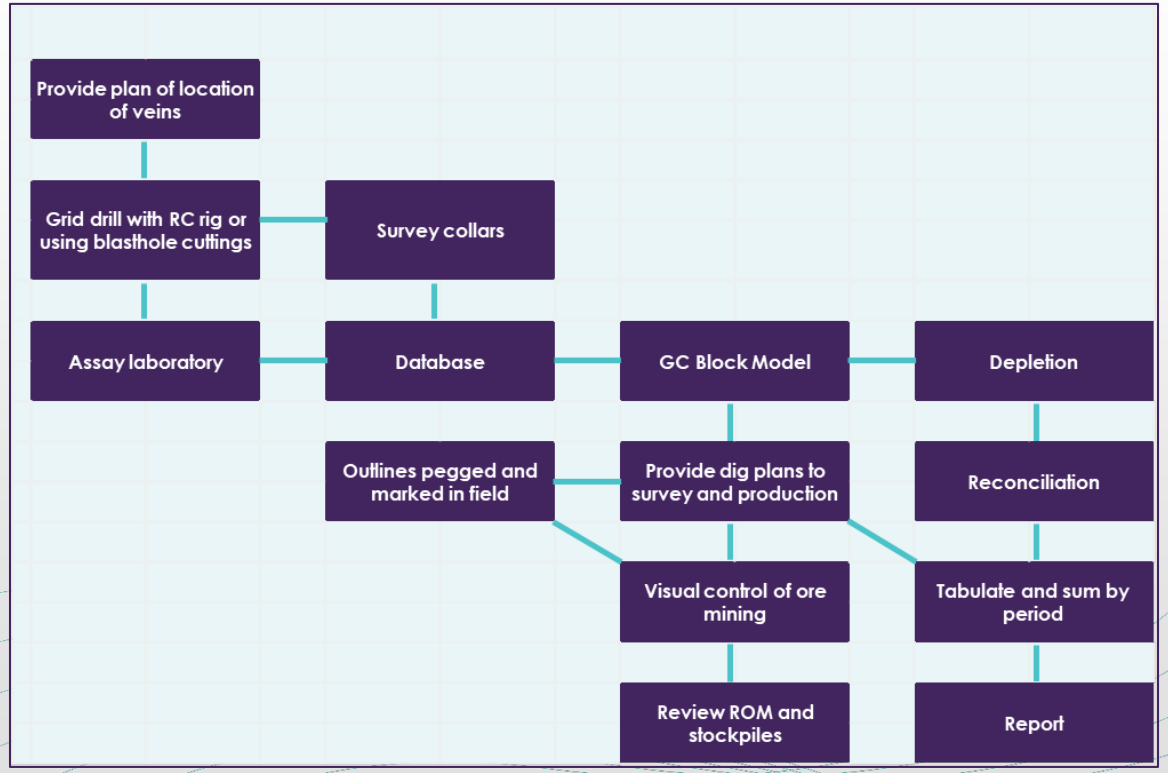
- Reconciliation meeting between:
  - Geology
  - Mining
  - Processing.

to analyse the previous week's performance

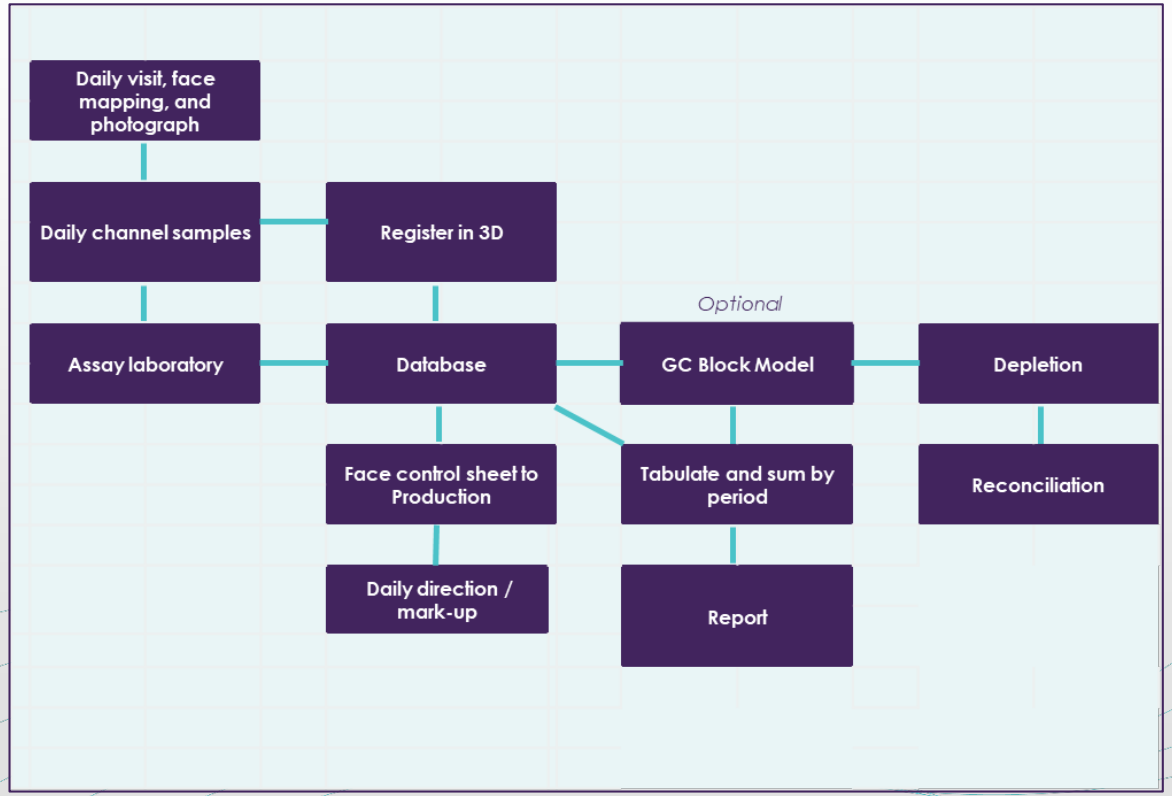
Case study 5: grade control

- Ore mined during daytime only.
- Ore Spotters, Ore Control Engineers, Geologists.
- Grade-control block model.
- Quick assay turnaround.
- Samples taken from blasthole cuttings or reverse circulation (RC) drilling.
- Stockpiles built and closed off (no single running S/P).
- Sampling tails.
- Underground – face mapping.

Case study 5: grade control



Case study 5: grade control



Questions?

Thank you