Communicating Data Quality for Polymetallic Nodule Projects

Underwater Minerals Conference

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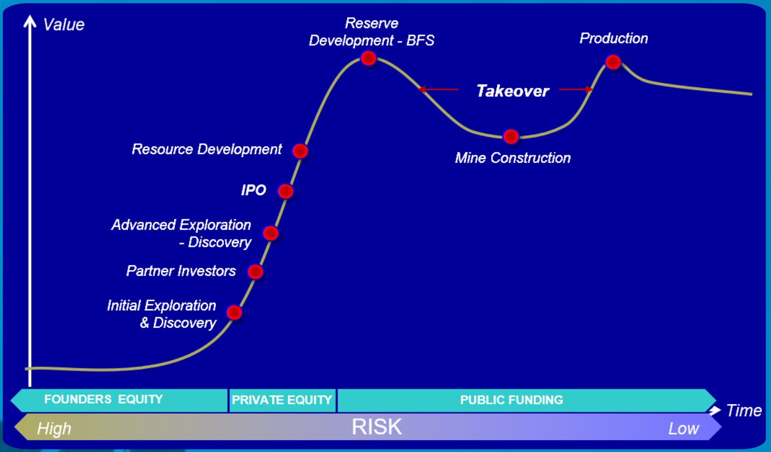
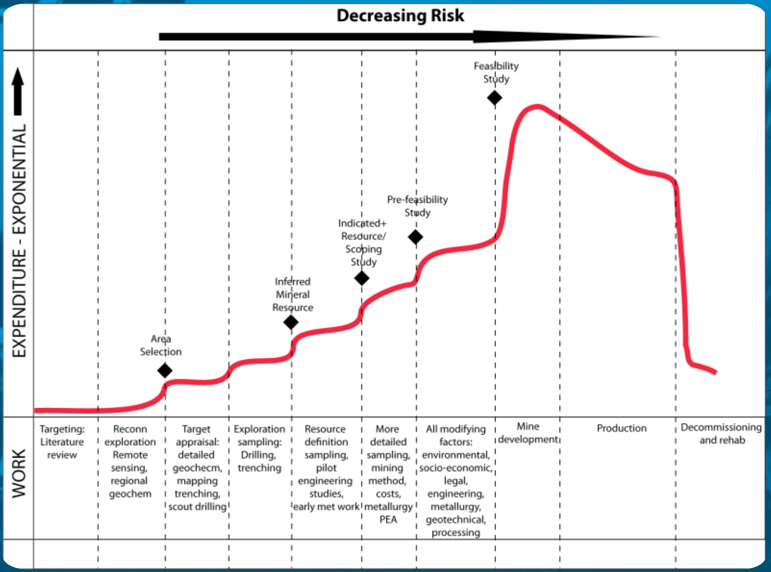
4 October 2022

INTRODUCTION

Many of our decisions in exploration, resource development and mining (investment, project development, mining decisions, etc.) come down to two things:

- Knowing the quantity, abundance and concentration of an economic component of interest; and
- The confidence we have in those numbers, so that we can put them into context with our position in the mining value chain, when making our decisions at each milestone.





THE MINERAL RESOURCE ESTIMATE PROCESS

Input →

Numeric data

Quality

Geology data

Understanding the sediments & rocks

Process →

Data analysis and Prep

Common sense & geo-statistics

MRE

Interpolation, extrapolation

Output →

Communicating results

Risk, confidence, PURPOSE

ISA, NI43-101, JORC

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What sort of data go into a Seabed Nodule Resource Estimate?

Sampling

SC/BC	Spade Core (also known as Box Corer). Sizes 0.5 x 0.5 or 0.75 x 0.75
AET	Addie-Ewing-TAAF cabled box corer
FFG	Freefall Grab
EFFG	ED1 Freefall Grab
OG	Okean-70 grab
MD	Manganese nodule dredge
BG	Boomerang grab
BFFC	Benthos free-fall corer
KPC	Kullenberg piston corer
LC	Large gravity corer
LC	Long Core
GC	Gravity corer
AD	Armed nodule dredge
MC	Multicorer

Acoustic/Sonar

NBS	Narrow beam echo sounder
MBES	Multi-beam echosounder
MFES	Multi-frequency exploration systems
SSS	Side-scan sonar
SAS	Interferometric synthetic aperture sonar
DVL	Doppler velocity log
SBP	Sub-bottom profiler

Positioning/Location

PDR	Precision depth recorder
UTP	Underwater transponder positioning
INS	Aided inertial navigation system
USBL	Ultra-short baseline transponder
GAPS	Global acoustic positioning system
DGPS	Differential-GPS
INS	Inertial Navigation System
TRANSIT	based on the Doppler Effect

Photo/Video/ROR/AUV

AUV	Autonomous underwater vehicle
CDC	Continuous deep-sea camera
DTV	Deep-sea TV camera
FDC	Finder installed deep-sea camera
SMSC	Sampler-mounted still camera
RAIE	Remorquage Abyssal d'Instruments d'Exploration
Epaulard	Continuous deep-sea camera

DATA QUALITY MANAGEMENT SYSTEM

Data Quality Management System outline

Data Quality Objectives (DQO)	• Set out the purpose and quality thresholds
Quality Assurance (QA)	• Specify standard operating procedures that everyone needs to follow to reduce variance and bias
Quality Control (QC)	• Monitor the sampling/measuring process by constantly evaluating checks and balances
Quality Acceptance Testing (QAT)	• Determine whether the data that we collected from a process matches our DQOs and it's fit for the stated purpose
Data Verification	• A due diligence process of post-collection data checking
Audits	• Auditing (internal/external) to ensure the DQMS is working properly

DQMS - DATA QUALITY OBJECTIVE

First, we must agree on a purpose:

- What is the objective of the sampling/measuring campaign?
- What target quality threshold do we want to achieve?
- What is our Data Quality Objective (DQO) — Confidence

Inferred	Indicated
Only FFG samples	Good coverage by large box core
No camera control	Camera control for all samples
Limited geological knowledge at high resolution	Continuous photo nodule coverage
Poor sample spacing	Grid sample spacing, reasonable density
Limited density/porosity data	Good SOPs
Poor location control	Process audited
Poor bathemetry resolution	Good QC on most data
	Good geological control through backscatter, etc
	Good bathymetry resolution

JORC Code, 2012 Edition

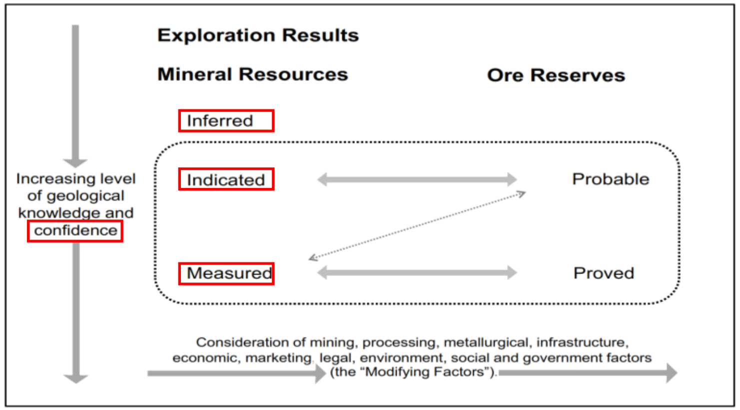
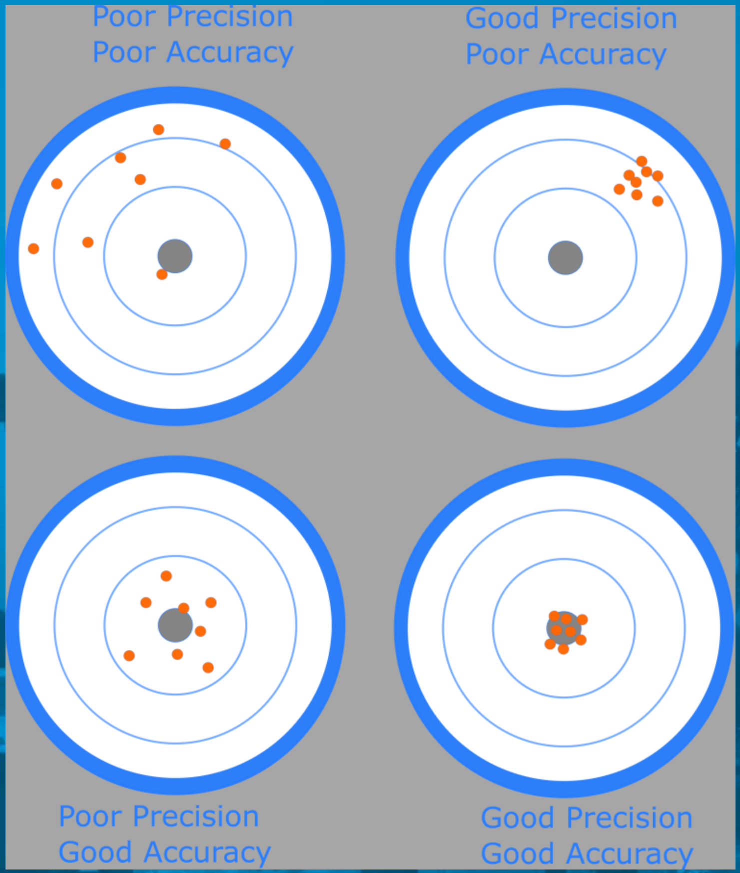


Figure 1 General relationship between Exploration Results, Mineral Resources and Ore Reserves.

DQMS – QA/QC/QAT

Before sampling/measuring	During sampling/measuring	After sampling/measuring
QA	QC	QAT

- Quality is expressed by using the terms Accuracy, Precision.
- Data with “good” accuracy and “good” precision can be regarded as “good” quality.
- We also use the terminology “**representative**” when precision and accuracy are within *acceptable tolerances.*



DQMS - QA

How do we make sure that the data *we are going to collect*, and the data *we are* collecting are of suitable quality?

QA and QC are two **different** things but are almost always incorrectly used as a one-size-fits-all term for those situations where geologists talk about 'something to do with standards, blanks and duplicates'.

Quality assurance means assuring the quality of the data by having a set of standard operating procedures (SOPs) in place, aiming to **prevent** errors being made in the sampling or measuring process.

SOPs should be prepared for each data collection process, including location data, primary sample (FFG/BC), sample splitting, sample analysis etc.

A good SOP:

1. has an index in which the structure is quickly and easily visible;
2. has a sensible layout that shows purpose, DQO, scope, responsibilities, detailed procedures, QC, QAT and references for further information;
3. has an acknowledgement form for each employee to sign (accountability); and
4. has any data recording sheets attached.

DORD

02-0205 - POLYMETALLIC NODULE VOLUME STANDARD OPERATING PROCEDURE
DEEP OCEAN RESEARCH AND DEVELOPMENT CO., LTD.

1 **Contents**

Document Name:	DORD Nodule Volume SOP					Document ID	02-0203
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DQMS-QC

Quality Control (QC) is in place to monitor measuring/ sampling/ assaying during the process, and correcting immediately when the process is observed to go out of control.

How do we do this? By constantly inserting checks and balances in the measuring/assaying/sampling process and continuously evaluating these.

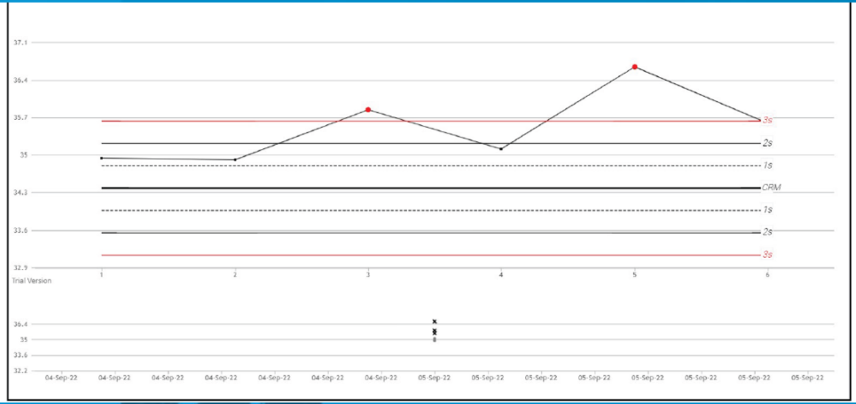
In the terrestrial mining industry, ‘checks and balances’ are often referred to as ‘standards’ and ‘duplicates’, but be aware of nomenclature here (e.g. CRMs, SRMs, IRMs, replicates, repeats).

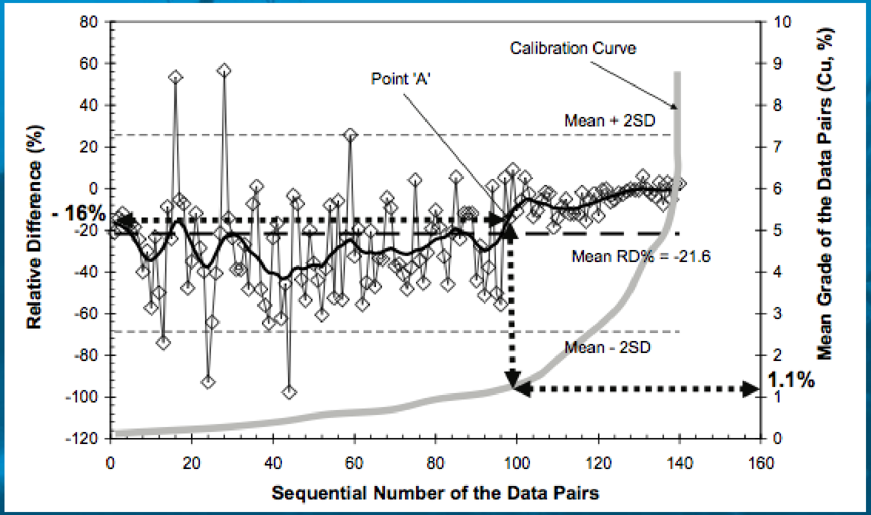
We use statistical process control (SPC) to help us determine whether the system or process is in or out of control.

DQMS-QC

Taking the analytical stage as an example:

- We can monitor/control, through a process of SPC, whether our analytical measuring system is **in control**.
- We can do this by plotting the measurement results of ‘standards’ and ‘duplicates’/’replicates’ over time, noticing when the system goes out of control, and then taking action.





Hygroscopic materials (including polymetallic nodules) are highly sensitive to moisture fluctuation, depending on the atmospheric conditions, such as air temperature and humidity.

Moisture content affects the accuracy and precision of XRF analysis, where increasing moisture content results in a decrease in the elemental concentrations reported.

SO… be careful with custom-made reference materials made from nodules.

DQMS - QAT

We have now ensured that we know the target quality of our data by setting **DQOs**.

We also know our data is going to be good by following our SOPs (**QA**), and we have determined that the processes delivering our data were delivering consistent data (**QC**).

Now we need to either **reject** or **accept** our data.

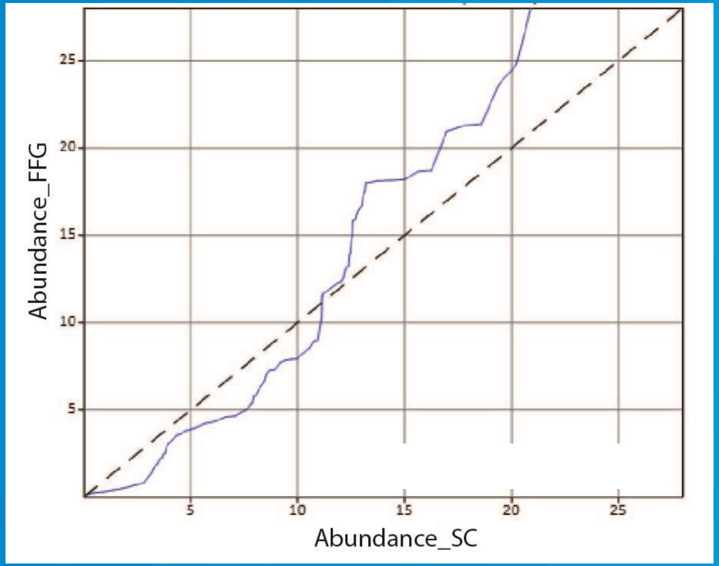
Therefore, we need to somehow agree to a system where we set **thresholds** for **accuracy** and **precision**, depending on the **purpose**.

In order to accept or reject the accuracy of a sample or value, we need to be able to compare the results of our data with some threshold or benchmark.

DQMS - QAT

Comparing lab results of CRM with certified values of CRM:

- Comparing means is simple and can be done with the student's t-test.
- Several test types available, depending on outliers, distribution of the data.



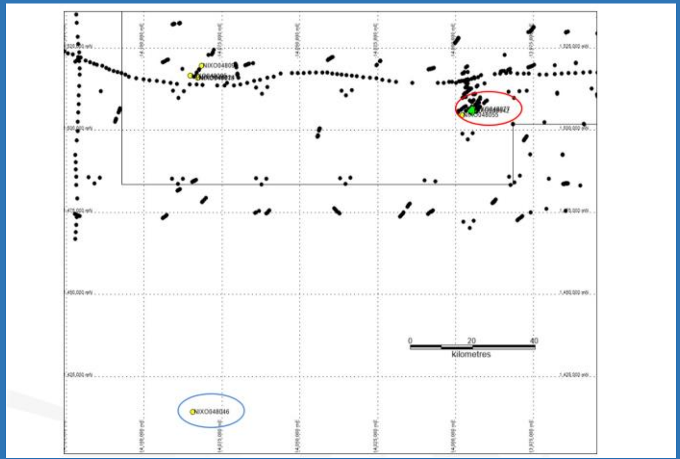
Try sampling the same area representatively with a superior technique and then compare the results using quantile-quantile plots (QQ).

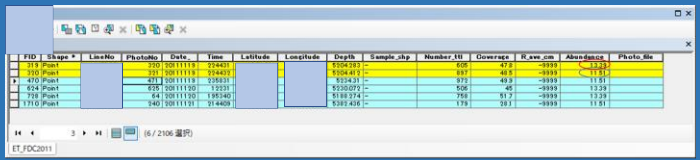
Be careful correcting for bias for two datasets of which neither is known to be correct.

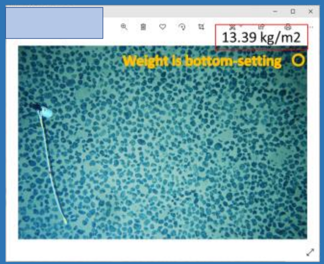
DQMS – DATA VERIFICATION

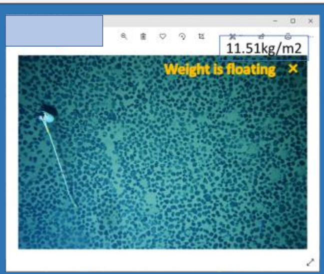
It is good practice to verify data frequently:

- check paper logs against database entries;
- check photos against abundance values;
- check sample location data visually;
- review bathymetry for strange artefacts;
- check for duplicate entries; and
- report results to demonstrate due diligence.







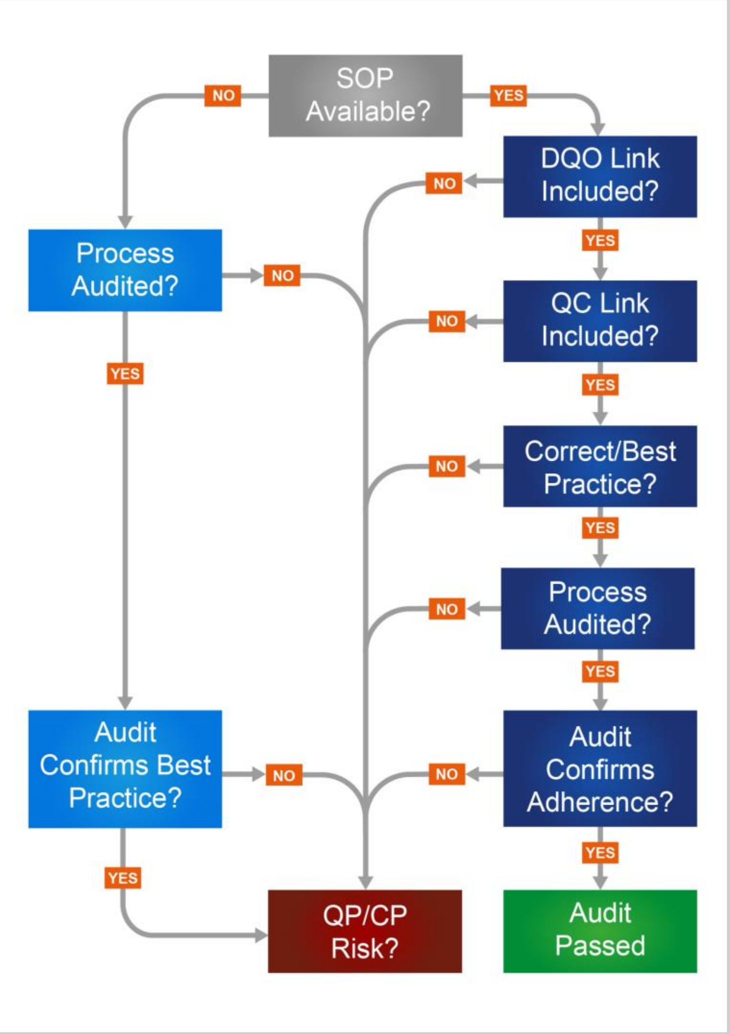


Database		Original logs		Difference degrees		Difference km
x	y	x	y	x	y	
				0.000	-0.333	37.069
				0.004	-0.009	1.111

AUDITS

It is good practice to audit the DQMS:

- Carry out internal audits by senior technical management staff.
- Carry out external audits by consultants.
- Audits work best if the auditor can check processes against SOPs.
- Are people and equipment following due process?
- What is the risk for the data quality?
- Report results as a demonstration of due diligence for third-party stakeholders.



SUMMARY

Take some time to take stock: What are you doing at your operation?

- Do you have a DQMS?
- Do you have a specified DQO?
- How are you assuring the quality of your data?
- How are you controlling the quality?
- How do you decide whether data is acceptable or not?
- Do you have a data verification process?
- When is the last time you audited the system and documented this?

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