



# Technical Risk Assessment in the Competent Person Report

-Geology and Mineral Resources

A gold mine is a hole in the ground with a **liar** on top.

# China Overseas Mining Investment Case

3

## Resource

Marry River Iron Mine, Baffin Island, Canada

## Cost

Vientiane potash basin, Laos

## Price

CITIC Pacific acquires Western Australian iron ore mine  
Carrara Project of Ansteel Group

## Politics

Libya civil war, China 's nearly \$ 20 billion project put on hold, CNPC stopped mining.

In June 2009, Chinalco's acquisition of Rio Tinto failed, and Rio Tinto unilaterally broke its contract.

In September 2012, Chalco's US \$ 920 million acquisition of South Gobi Resources Ltd

Zijin Mining's acquisition of Congo Copper Mine was thwarted

## Infrastructure

In 2008, Sinosteel acquired Weld Range iron ore project in Western Australia for 1.36 billion , and the project was suspended

## Social

Myanmar's Letpadaung copper mine shut down twice

# CONTENTS

- 01 Introduction of Western Mineral Reporting Standards
- 02 Introduction of Independent Technical Report
- 03 Data Quality Management Analysis
- 04 Resource estimation risk assessment



# Introduction of Mineral Reporting Standards

- Background
- Classification
- Comparison

# Grimes Graves, Neolithic Flint Mine



# Development of Mineral Standards

## Chaos

A long time after the start of mining, the market for mineral rights trading was small.

1

## Developing

From the beginning to the middle of the 20th century, Africa, the Soviet Union, the United States, and Western Europe successively proposed their own classification standards, with the distinction between Mineral Resources and Ore Reserves.

3

## Perfecting

1997 – Russia  
2003 – CIM  
2012 – CRIRSCO  
2012 – JORC  
2016 – SAMREC

5

2

## Beginning

At the beginning of the 20th century, British, American, and International Geological Associations successively proposed the Mineral Resource classification standard - the prototype of Mineral Resource classification.

4

## Uniform

1973 – the United States  
1981 – Canada  
1978 – the United Nations  
1989 – Australia  
1997 – Foundation of CRIRSCO

# Classification of Current Major Mineral Standards



## CRIRSCO Major western countries

- The Committee for Mineral Reserves International Reporting Standards was established in 1997, and the standard was updated in 2013.
- Emphasize the role of CP / QP
- Divided into two categories – Mineral Resources and Ore Reserves based on economic and confidence levels, each with its own sub-category.
- Members have their own standards, but are roughly similar.
- Conditions for mutual recognition of Qualified Person in different countries

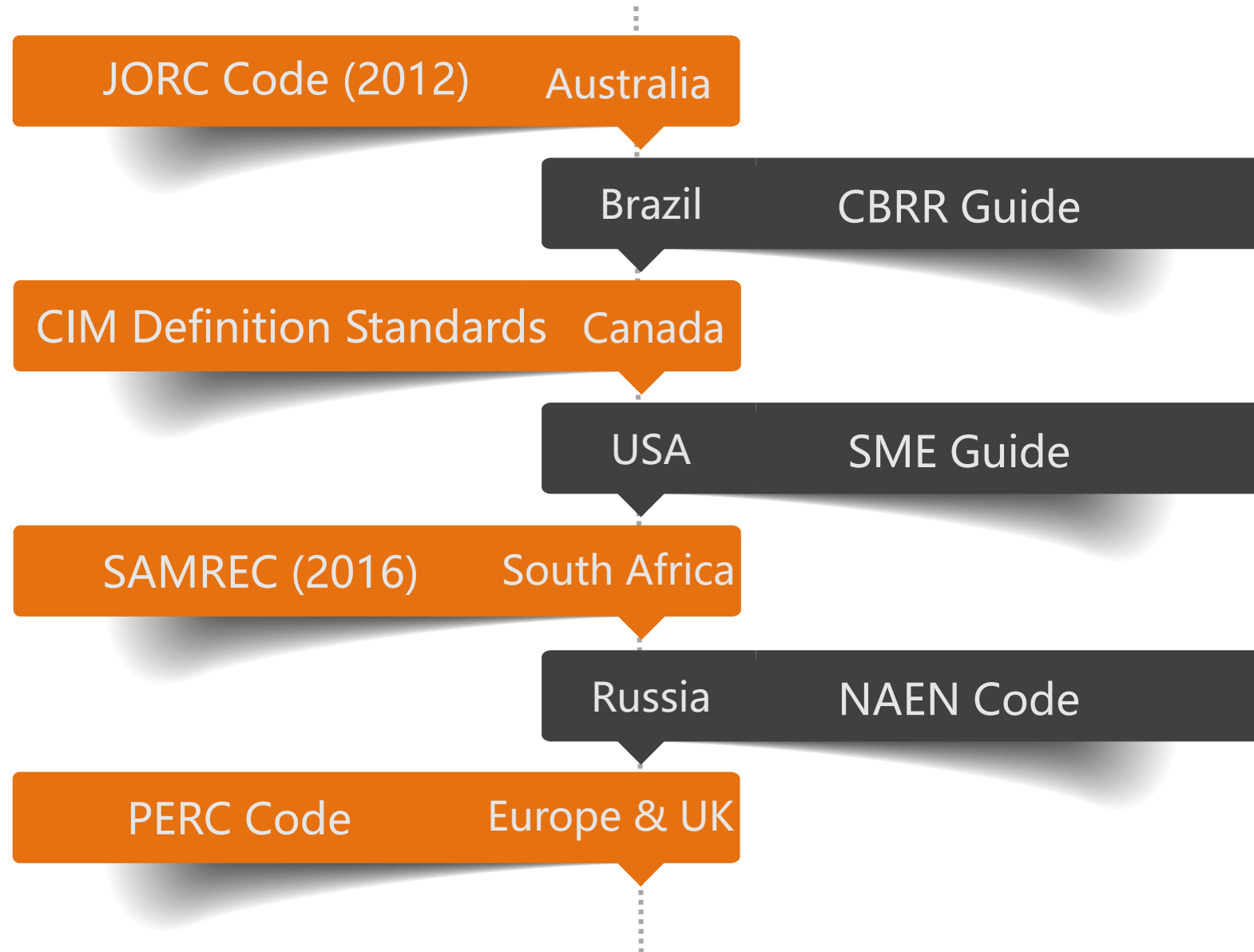


## UNFC China, India, etc.

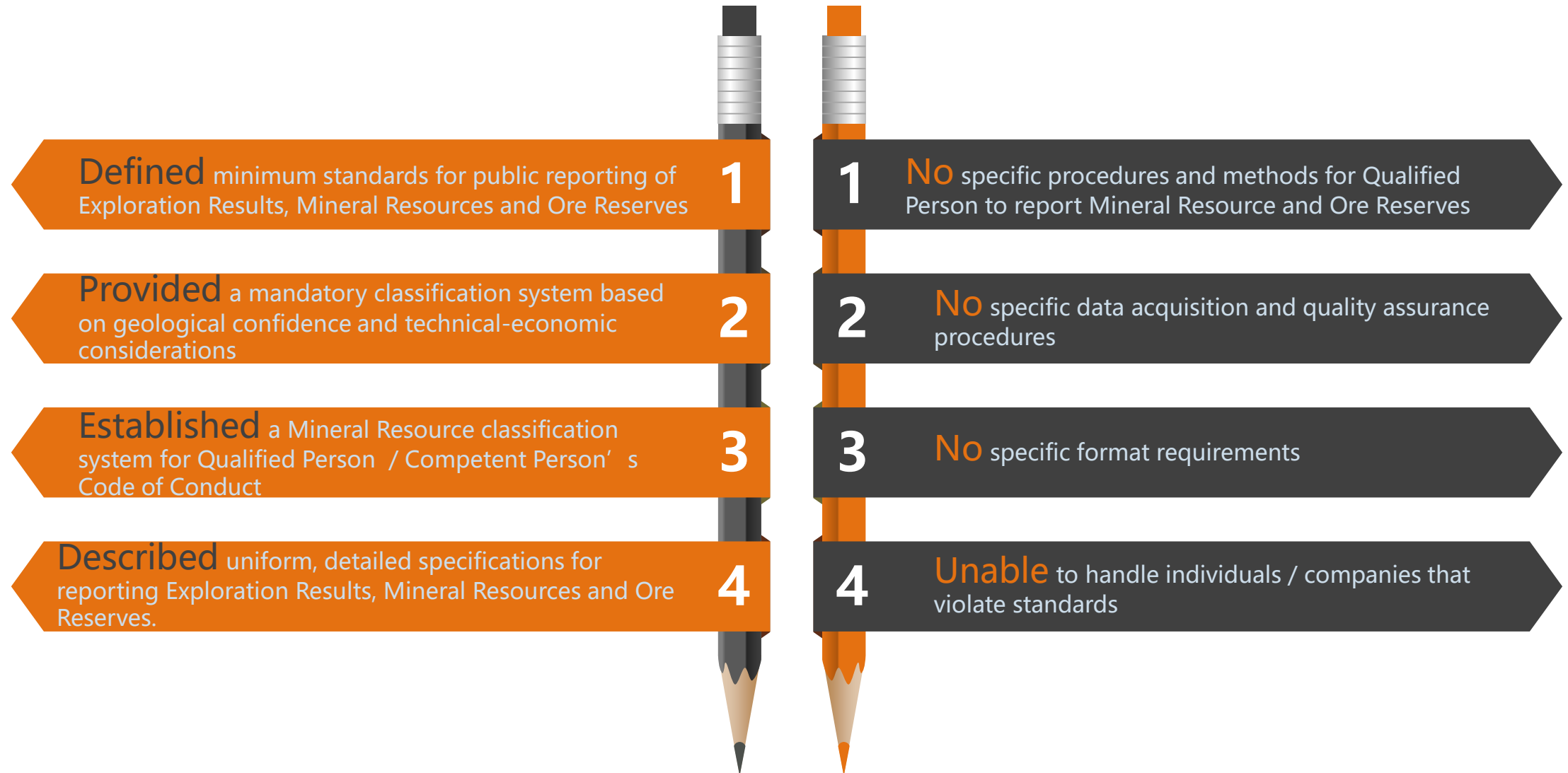
- United Nations Framework Classification for Fossil Energy and Mineral Resources was put forward in 1997, and it was updated in 2009.
- Classification from three aspects: known degree of geology, project feasibility and socioeconomic stability
- This classification system is mainly used by China, India and some Eastern European countries.



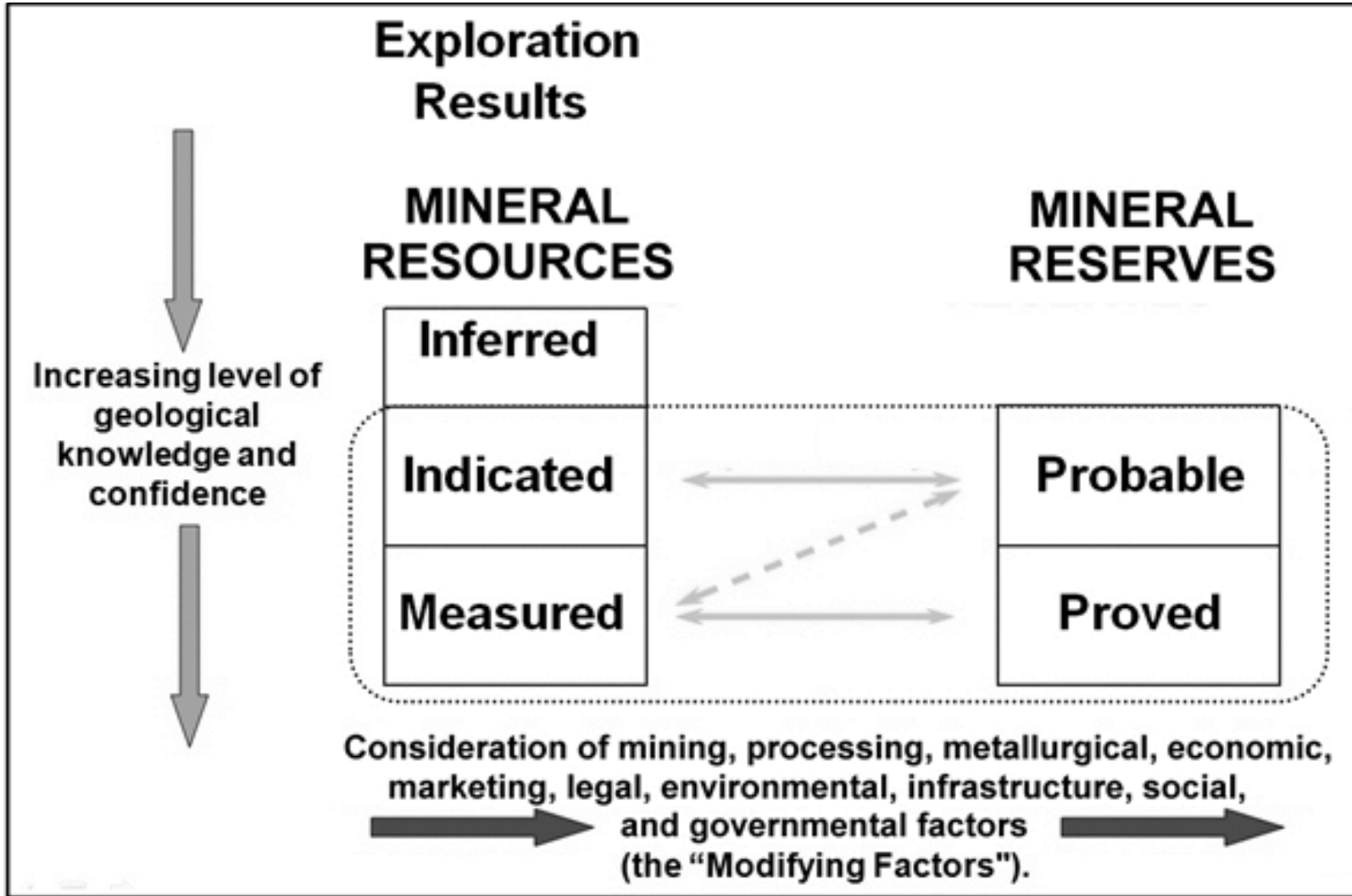
# The main members of CRIRSCO and their respective standards



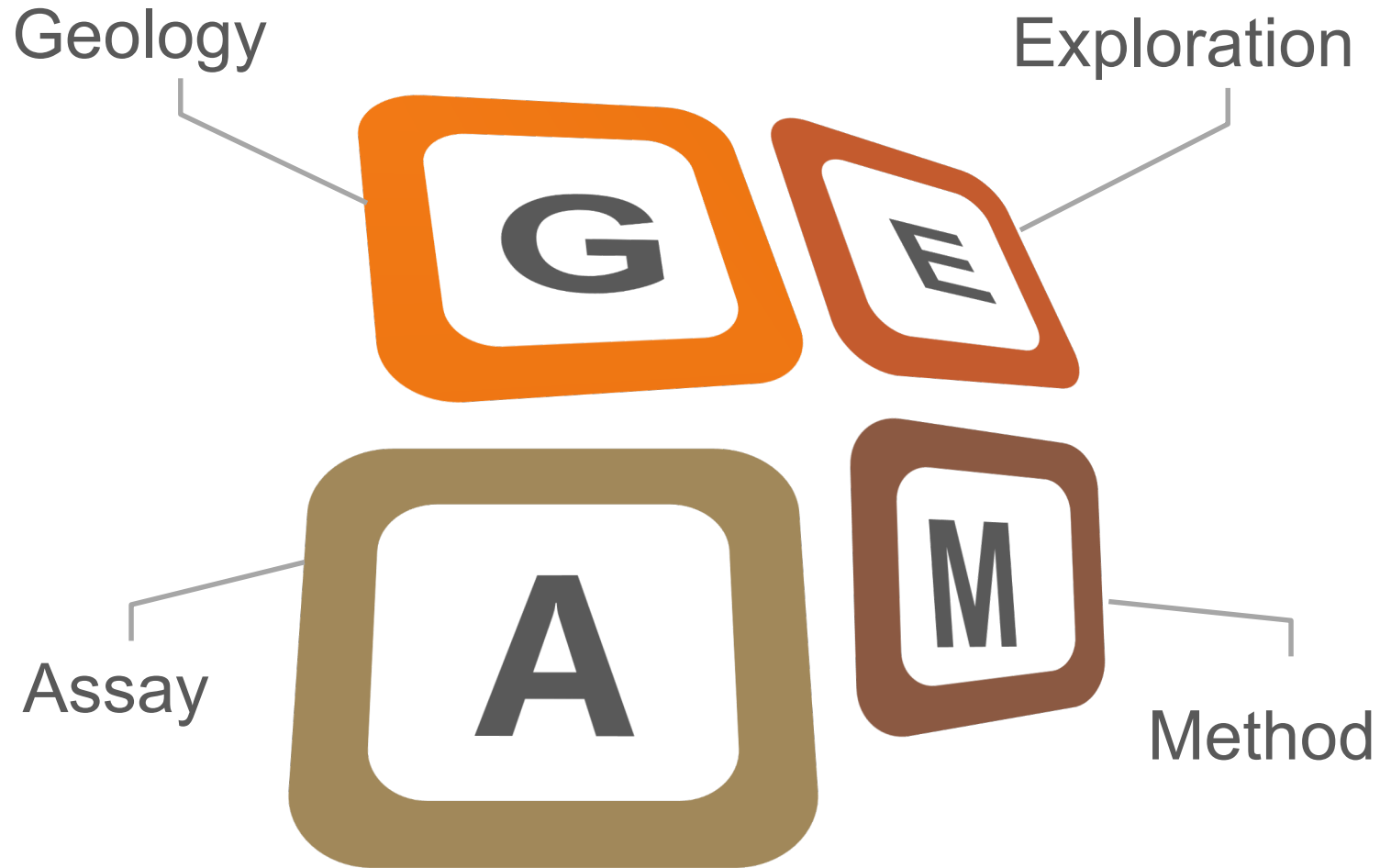
# CRIRSCO International Reporting Template



# CRIRSCO Mineral Resource and Ore Reserve Classification System



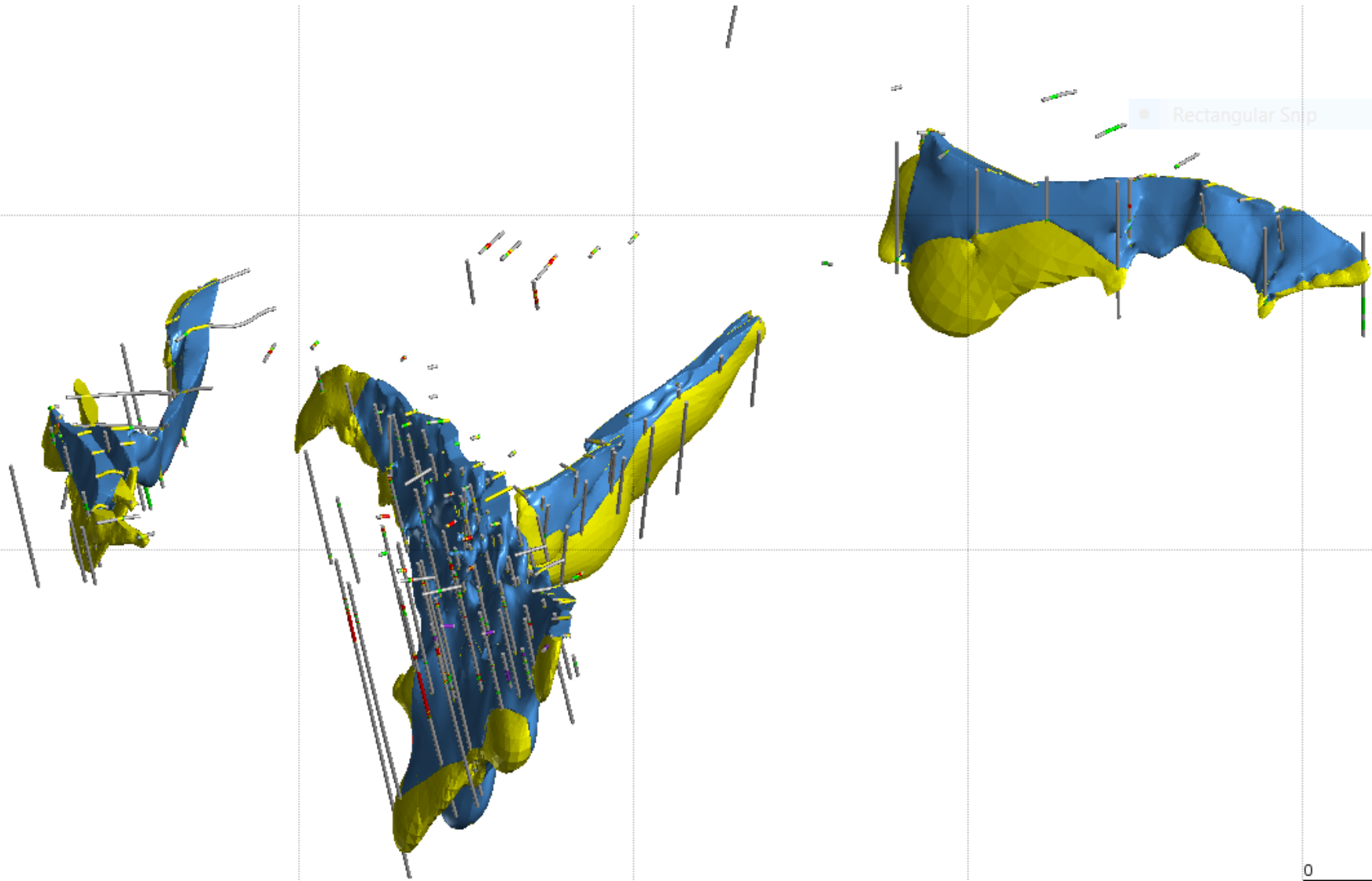
# Geological Confidence Level



# Modifying Factors



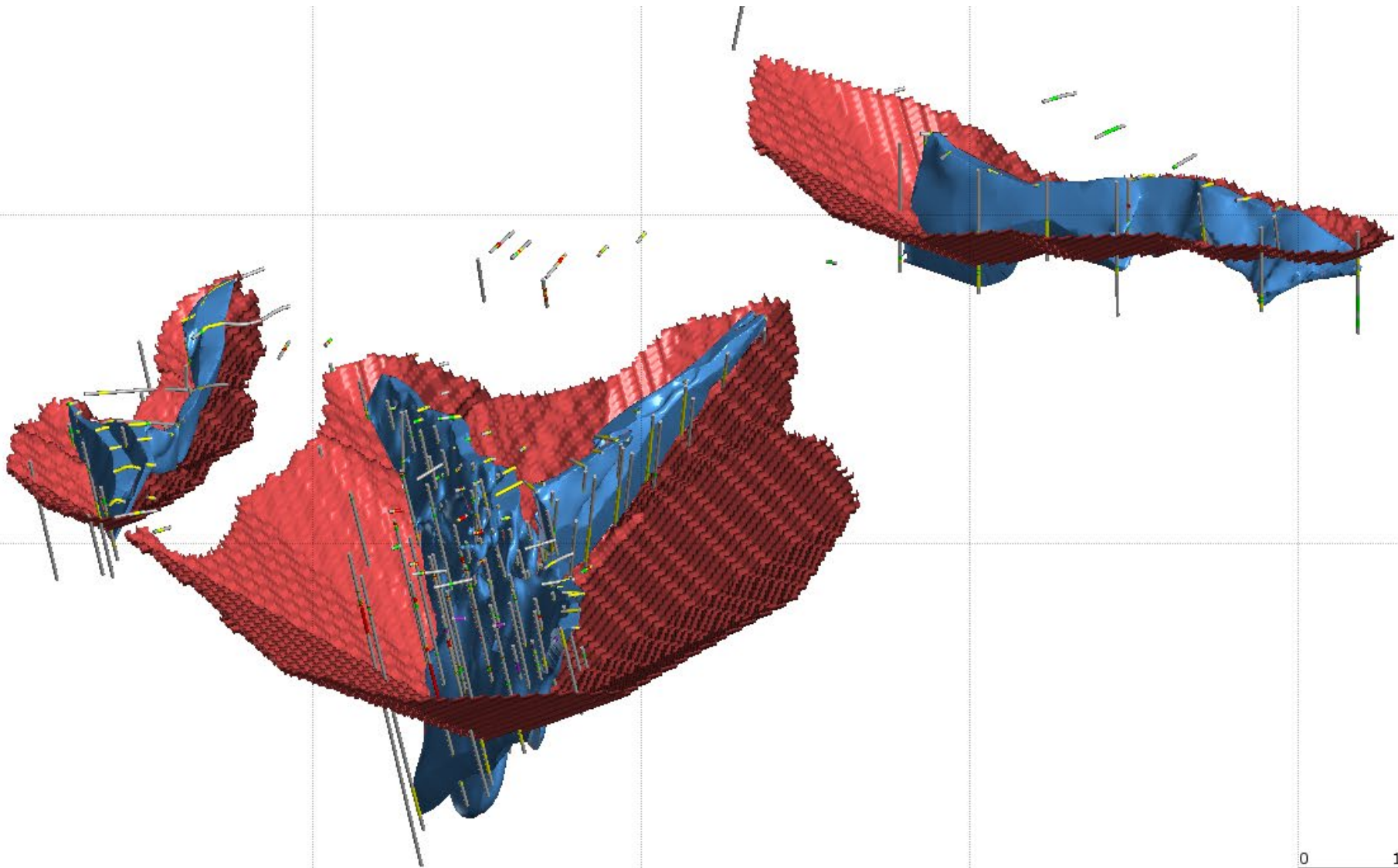
# Resource



Plunge +41  
Azimuth 022

0 100 200 300

# Reserve



Plunge +41  
Azimuth 022

0 100 200 300



# Competent Person Report

- Introduction
- Feature
- Format



# ITR/CPR Template

- CRIRSCO' s International Reporting Template
- Each standard specifies the general content
  - JORC
  - CIM
  - SAMREC
  - SME
- Exchanges have their own legal constraints
  - ASX listing rules
  - HKEx Chapter 18
  - NI-43-101
  - Guide 7

# Feature

- It is a summary of the material technical information of the project;
- Its readers are public investors or their investment advisers;
- Report must be concise but contain sufficient technical information and cautionary language to allow investors to make informed decisions

# Format (JORC)

**Executive Summary**

**Disclaimer**

**List of Abbreviations**

- 1 Introduction and Scope of Report**
- 2 Program Objectives and Work Program**
  - 2.1 Purpose of the Report
  - 2.2 Reporting Standard
  - 2.3 Work Program
  - 2.4 Project Team
  - 2.5 Indemnities
  - 2.6 Compliance Statement
  - 2.7 Limitations Statement
  - 2.8 Forward Looking Statement

### **3 Property Description and Location**

3.1 Tenure – tenure type, conditions and renewal dates

3.2 Operational Licenses and Permits

3.2.1 *Business License*

3.2.2 *Mining License*

3.2.3 *Safety Operational Permit*

3.2.4 *Other Operational Permits*

### **4 Accessibility, Climate, Local Resources, Infrastructure and Physiography**

4.1 Accessibility

4.2 Local Resources and Infrastructure

4.3 Climate

4.4 Physiography

## **5 Geological Setting and Mineralization**

5.1 Regional Geology

5.2 Deposit Geology

5.3 Mineralization

5.3.1 *Mineralized Zones/Bodies*

5.3.2 *Mineralogical Characteristics*

The geological characteristics of the project and what geological factors have a significant impact on controlling the mineralization.

The distribution of the identified mineralized bodies, the characteristics of the surrounding rock of the orebody, the geological factors controlling the orebody, the length, width and depth of the mineralized body, and the continuity of mineralization.

Mineral composition and ore type

Further exploration potential

## **6 Exploration, Sample Preparation, Analyses, and Security**

6.1 Exploration History

6.2 Trenching [if applicable]

6.3 Underground Tunneling [if applicable]

6.4 Drilling

6.5 Sampling, Sample Preparation and Analyses

6.5.1 *Sampling*

6.5.2 *Sample Preparation and Analyses*

6.5.3 *Specific Gravity Data*

6.6 Quality Assurance and Quality Control Programs

6.7 Data Verification

- 7 Mineral Resource Estimates**
- 7.1 Introduction
- 7.2 Resource Estimation Procedures
- 7.3 Resource Database
- 7.4 Solid Body Modelling
- 7.5 Specific Gravity
- 7.6 Compositing
- 7.7 Evaluation of Outliers
- 7.8 Statistical Analysis and Variography
- 7.9 Block Model and Grade Estimation
- 7.10 Model Validation and Sensitivity
- 7.11 Mineral Resource Classification
- 7.12 Mineral Resource Statement
- 7.13 Grade Sensitivity Analysis
- 7.14 Previous Resource Estimates (if publicly disclosed)
- 7.15 Exploration Potential and Recommendations (any other issues)

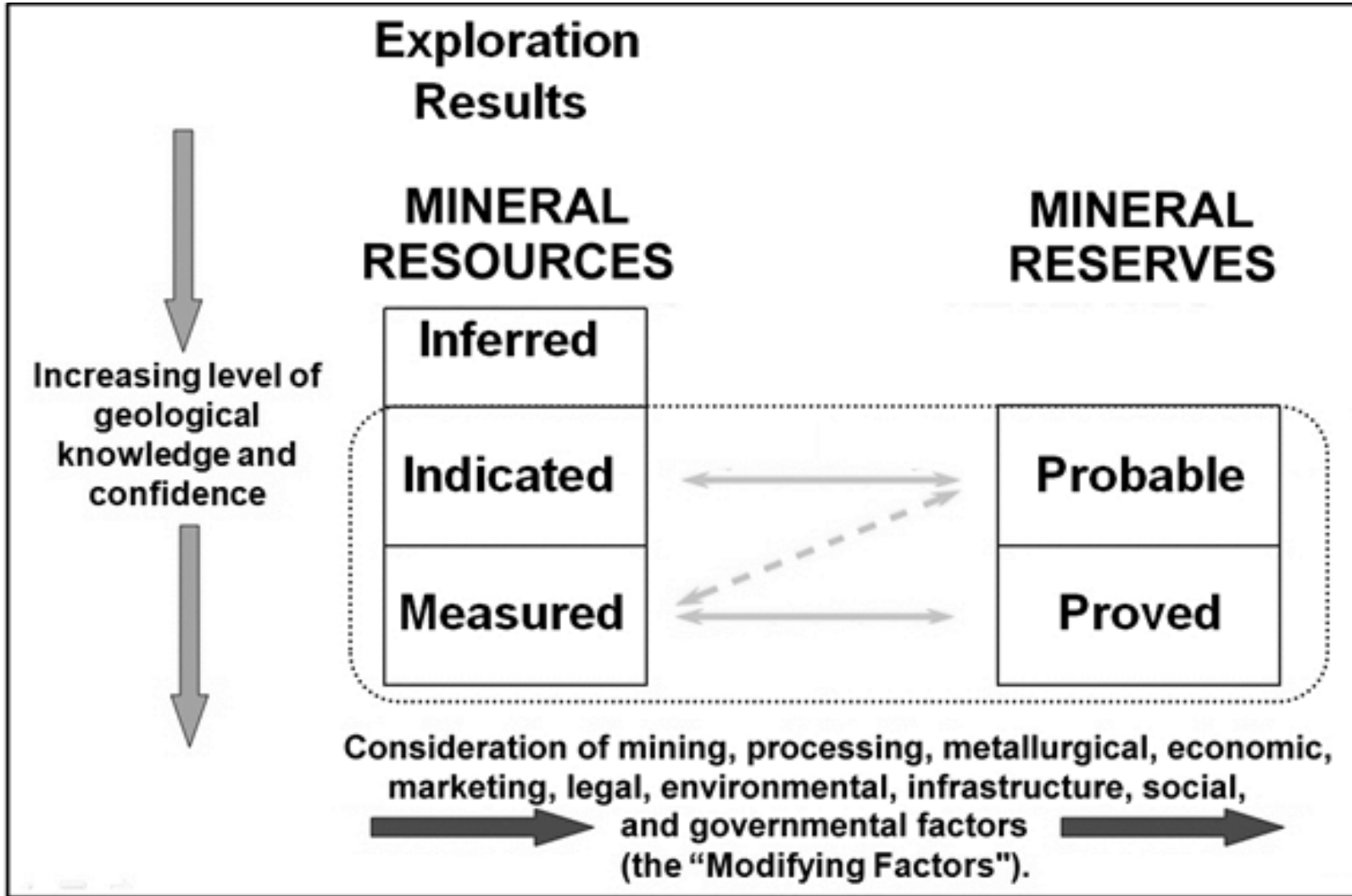
## **Advanced Projects**

- 8 Mining and Ore Reserve Estimates**
- 9 Metallurgical and Processing**
- 10 Workforce Assessment**
- 11 Project Infrastructure**
- 12 Occupational Health and Safety**
- 13 Capital and Operating Costs**
- 14 Economic Analysis**
- 15 Environmental Studies, Permitting, and Social or Community Impact**
- 16 Risk Assessment**
- 17 Conclusions and Recommendations**
- 18 References**

## **APPENDIX**

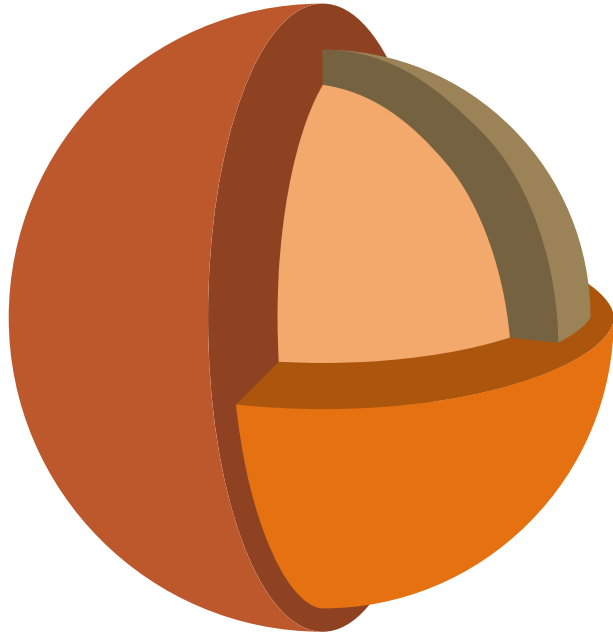


# CRIRSCO Mineral Resource and Ore Reserve Classification System



A gold mine is a hole in the ground with a **CPR** on top.

# Foundation of Mining Project - Resource



**Reserve/LOM**



**Mining Method**



**Processing Process**



**Tailings discharge/Environment Rehabilitation**



**Product Price**

# Geology and Resource Section of the Report

**Core:** Report to readers the results of Mineral Resource estimates and express the reasonableness and reliability of the estimates.

## The Basis of Mineral Resource Estimation:

Geological Setting and Mineralization (Occurrence of Orebody and Factors Affecting Orebody)

Exploration, Sample Preparation, Analyses, and Security (Quality of Data)

Mineral Resource Estimates (Estimation Method)



# Data Quality Management Analysis

- Acquisition
- Analysis
- Verification

# Busang Gold Mine

**May, 1993**

Bre-X announced that it will implement a joint exploration project of gold mine in the Busang area of Kalimantan, Indonesia. At the same time the stock is listed in Toronto with a stock price of CA\$0.45

**Oct. 1995**

Kilborn Engineering Submitted a maiden Mineral Resource of 85.5t of contained gold for the Busang Gold Deposit, with the Bre-X share price rising to CA\$47.5

**Dec. 1996**

The Busang Gold Mine's Mineral Resources increase several times, reaching 1,780t of contained gold.

**April, 1994**

Bre-X release "Good news". A new Gold deposit with a thickness of tens of meters was found by exploration, with grade ranging from 2 g/t to 10 g/t, and the Share Price rose to CA\$1.50.

**Jan. 1996**

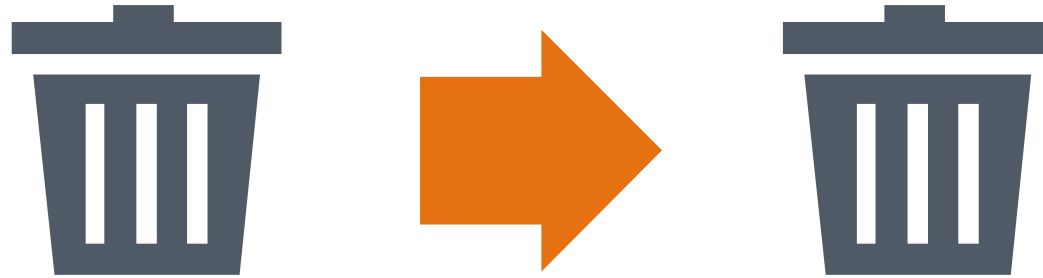
Bre-X release exploration results for the No. 61 and No. 62 boreholes stating orebody intersections of 301 m, at an average grade of 4.42 g/t and 137 m, at an average grade of 5.71 g/t. An updated Mineral Resource estimated had increased the contained gold 404 t. The Bre-X share Price rises to CA\$95.

**Mar. 1997**

Before its scam was exposed, the Mineral Resources were expected to reach 2200-6200t of contained gold, and the Bre-X share price exceeded CA\$ 270.

# The Importance of Data

Rubbish in, rubbish out



# Geological Data Type and Acquisition Method

## Geological Data

Geological data can reflect local geological conditions however the data needs to be interpreted and modelled in order to understand it's context.



### Geophysical Exploration

Geophysical method to measure anomalies



### Topographic Survey

Obtaining terrain data with specific instruments



### Geochemical Exploration

Geochemical method to measure anomalies



### Trenching

Obtaining surface or underground data from trenching.



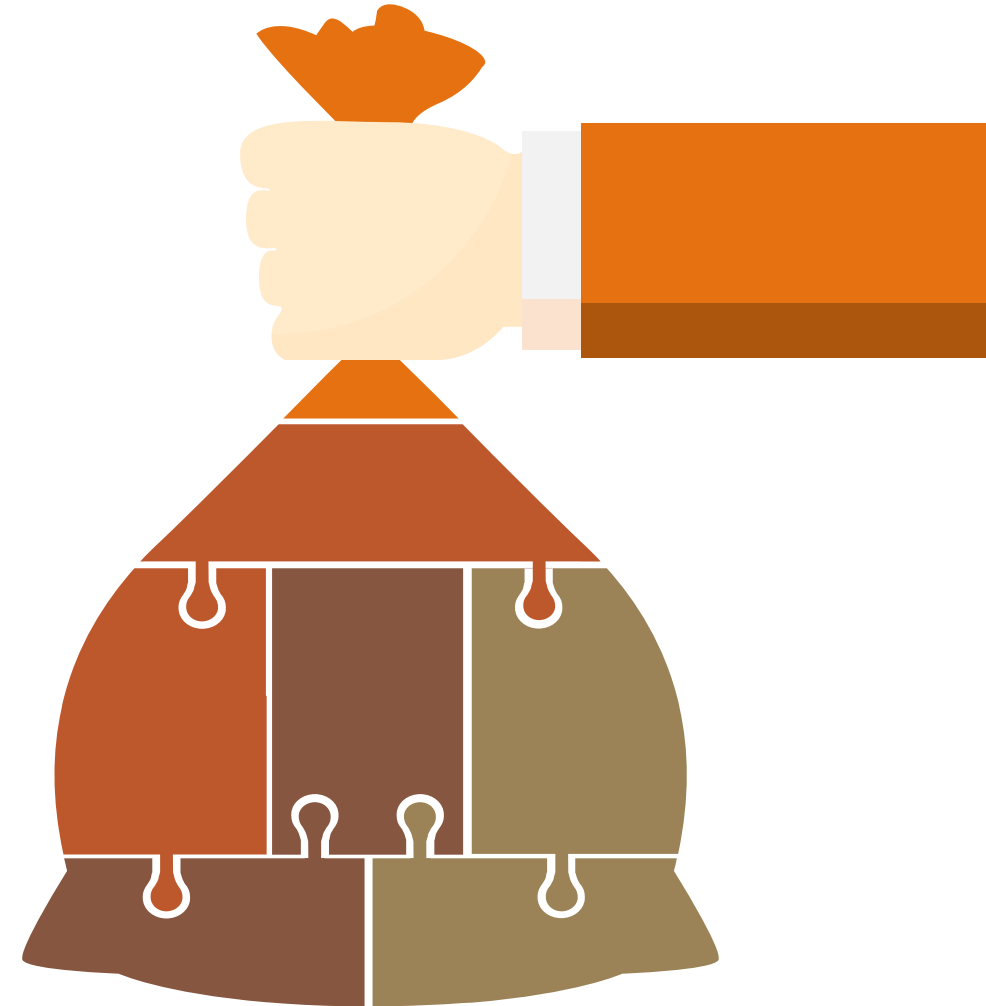
### Geological Mapping

Field observation and measurement of geological bodies and geological phenomena.



### Drilling

Obtaining sub-surface data through drilling





# Trenching and Drilling

Different ways to obtain basic data



# Quality Evaluation of Exploration Data

## Representativeness

The amount of data collected should be adequate enough to represent the in-situ deposit.

## Integrity

Data loss should be kept to a minimum.

## Precision

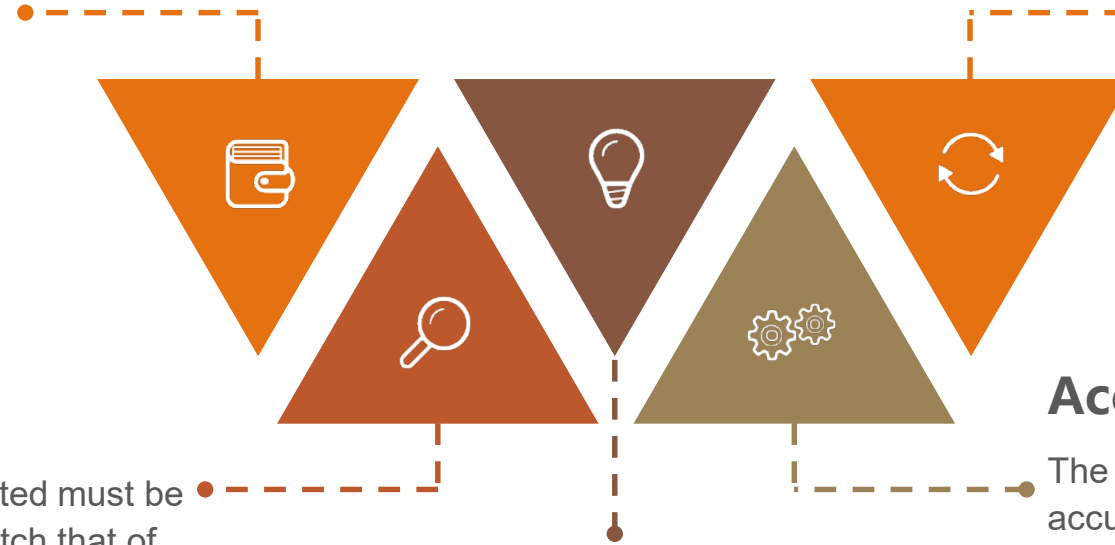
The data collected must be precise and match that of the in-situ deposit.

## Accuracy

The data collected must be accurate and repeatable.

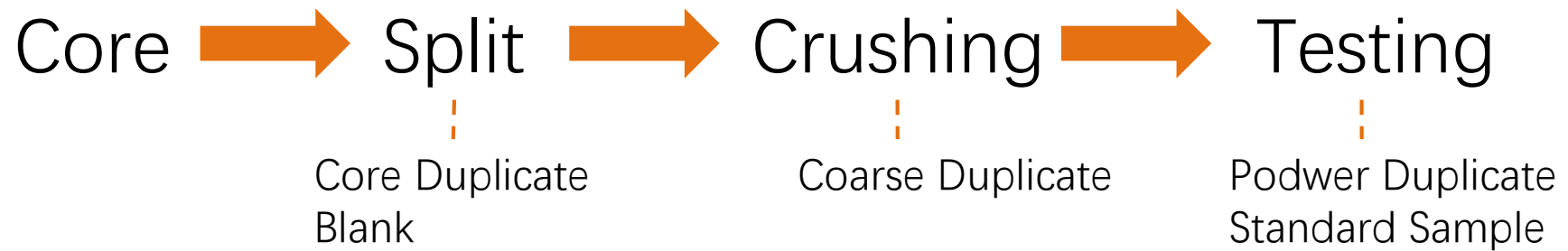
## Timeliness

Prompt processing of samples



# QA/QC Control Sample

**Purpose:** Ensure the precision and accuracy of data during sample processing and testing

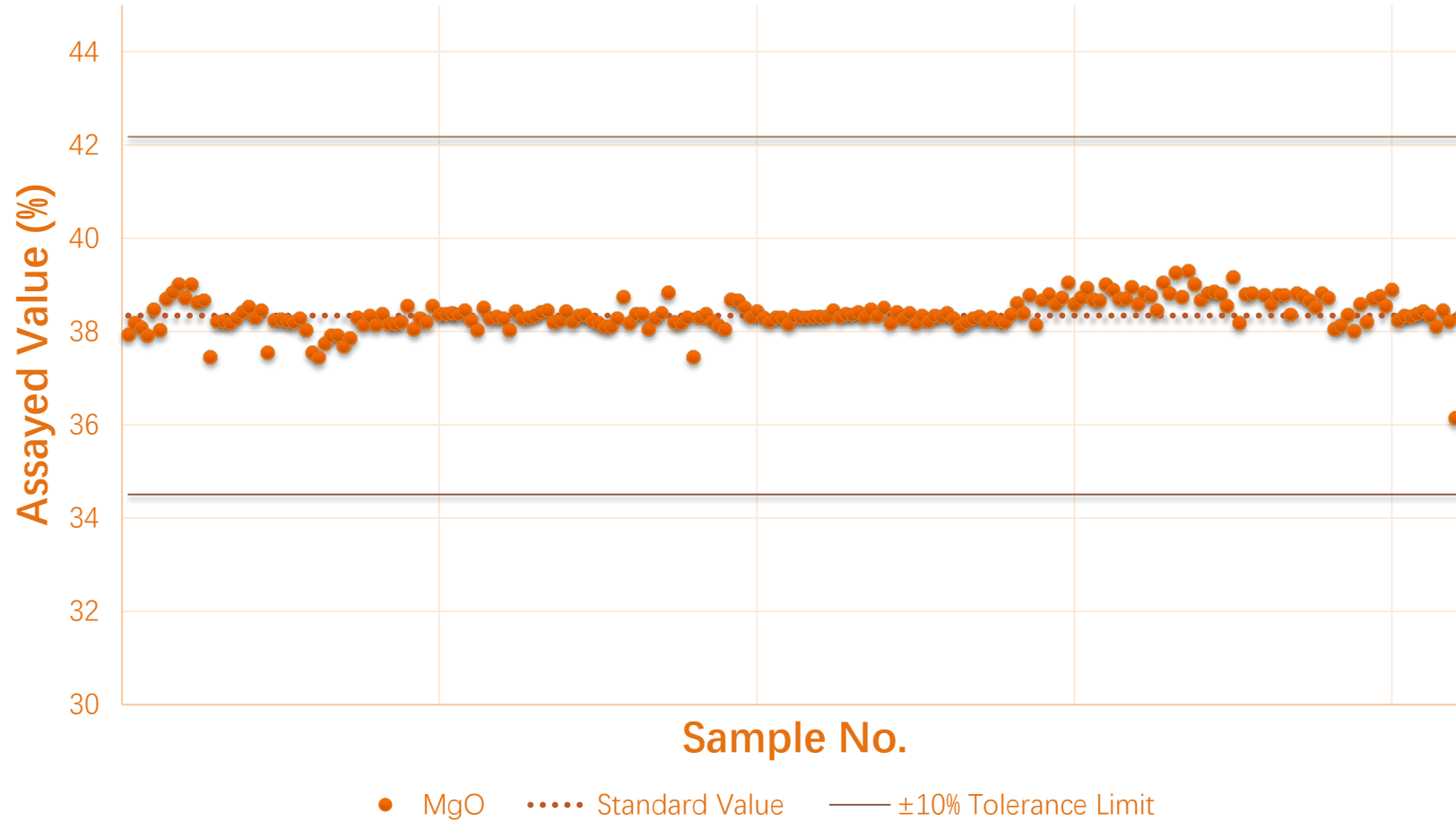


# Blank Sample Performance

- Tests for sample contamination during sample preparation
- Coarse crushing, division, grinding, and testing with core samples
- With sufficient hardness and large particles.

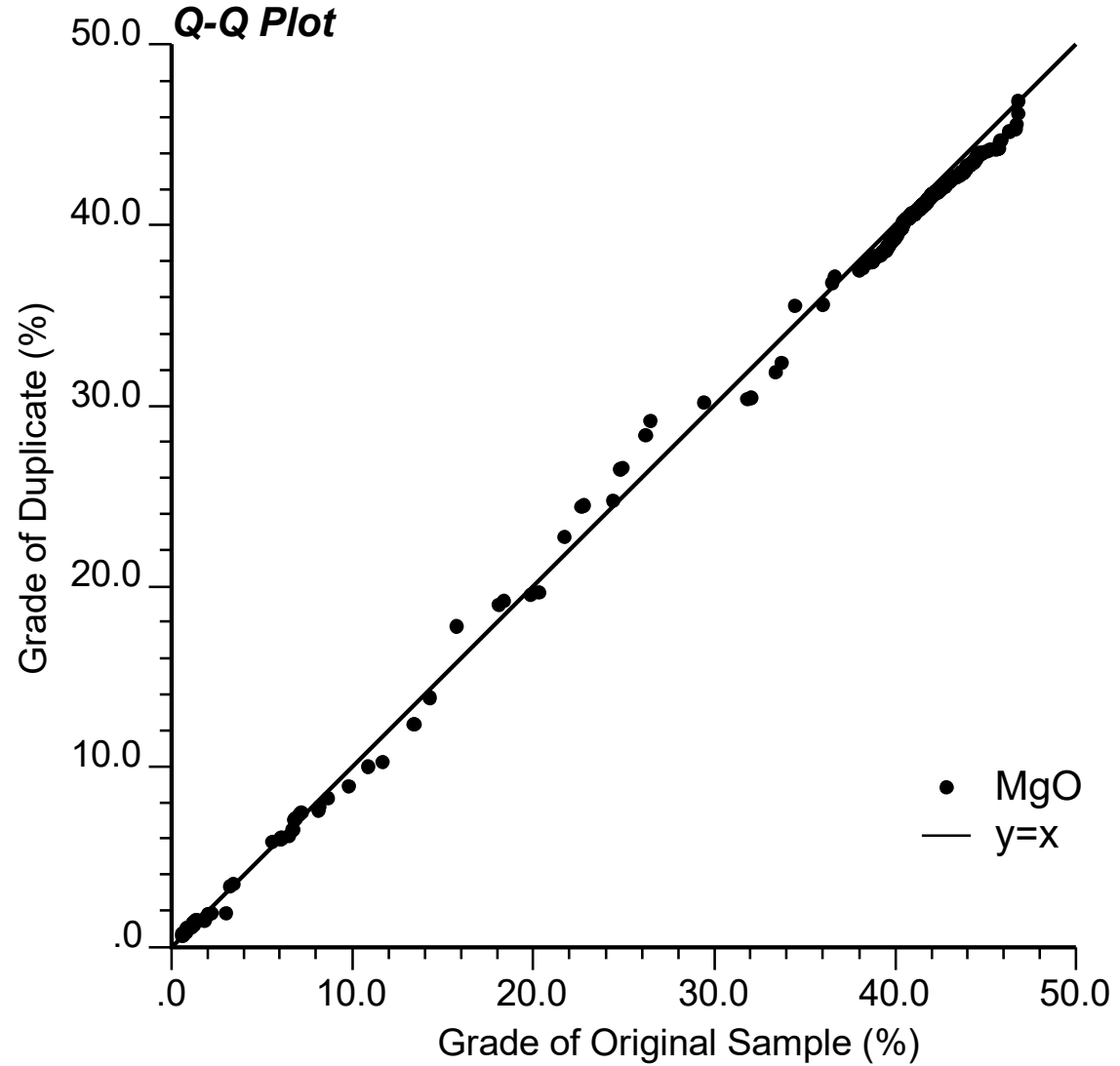
**Test result of a single blank  $\leq 160\%$  Detection Limit**  
**Blank Mean  $\leq$  Detection Limit**

# Standard Sample Performance – Assaying Accuracy

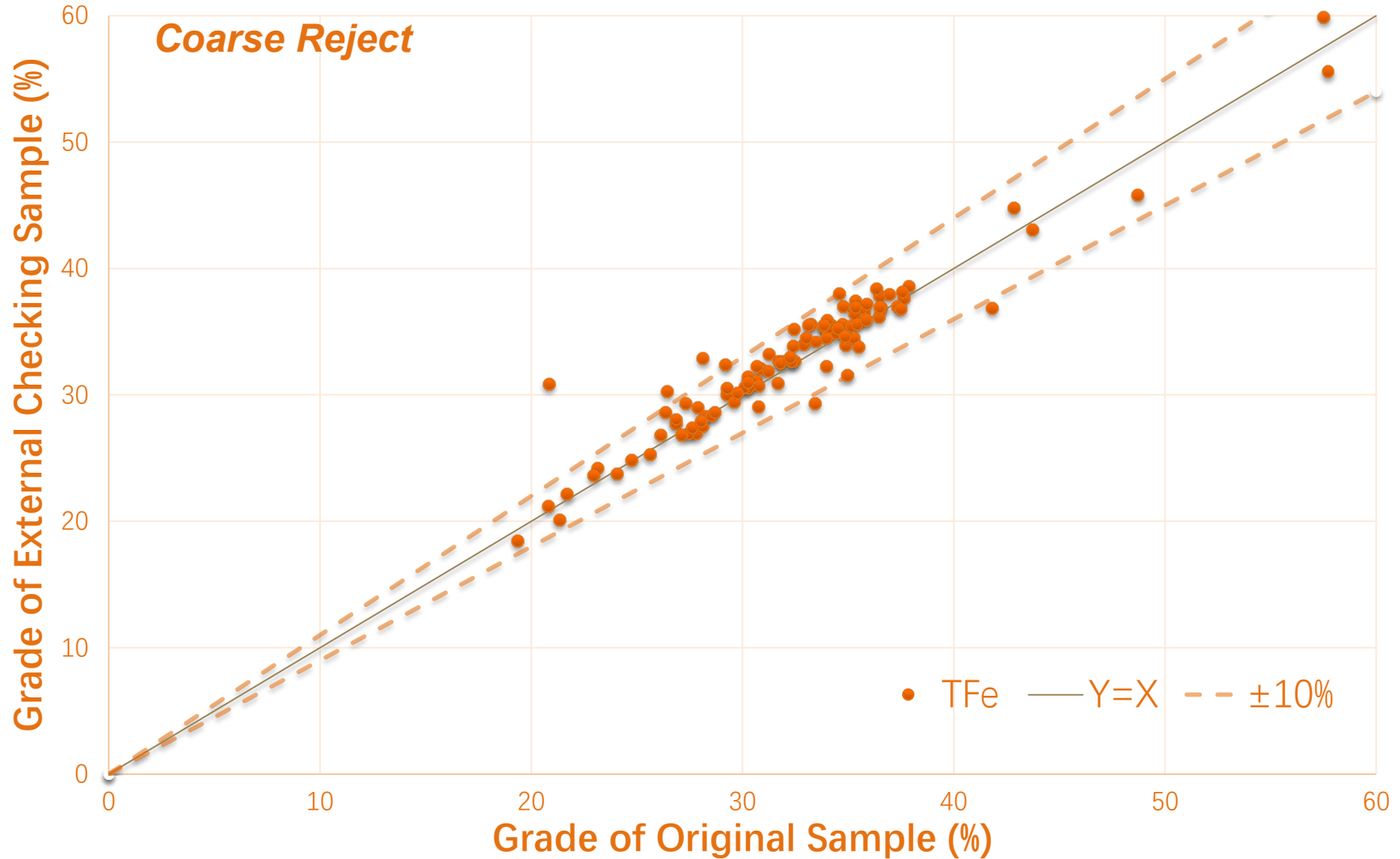


# Duplicate Performance – QQ Plot

Describe the distribution of quantiles occupied by corresponding grades

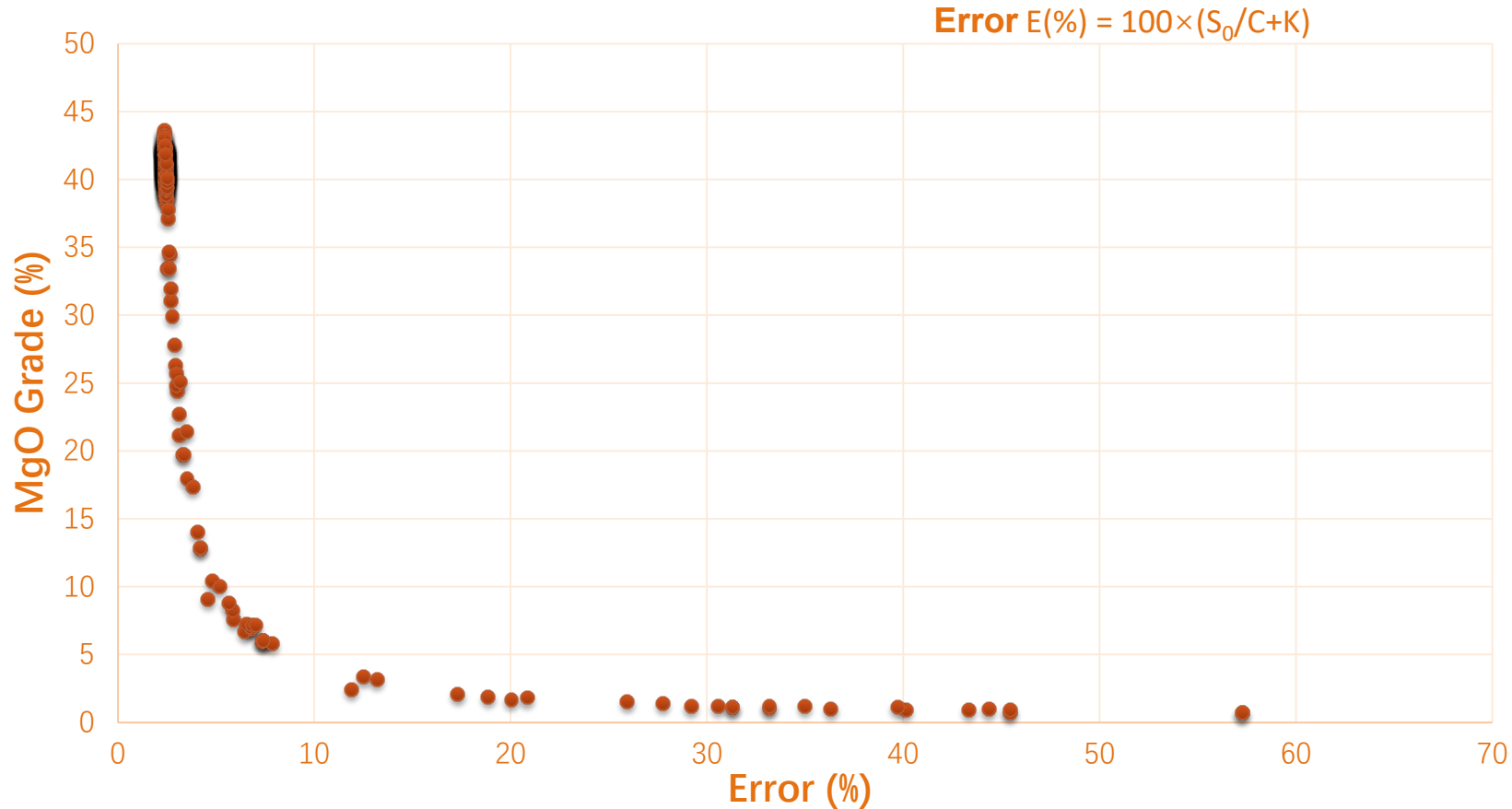


# Duplicate Performance – Scatter Plot



# Duplicate Performance – Thompson-Howarth Plot

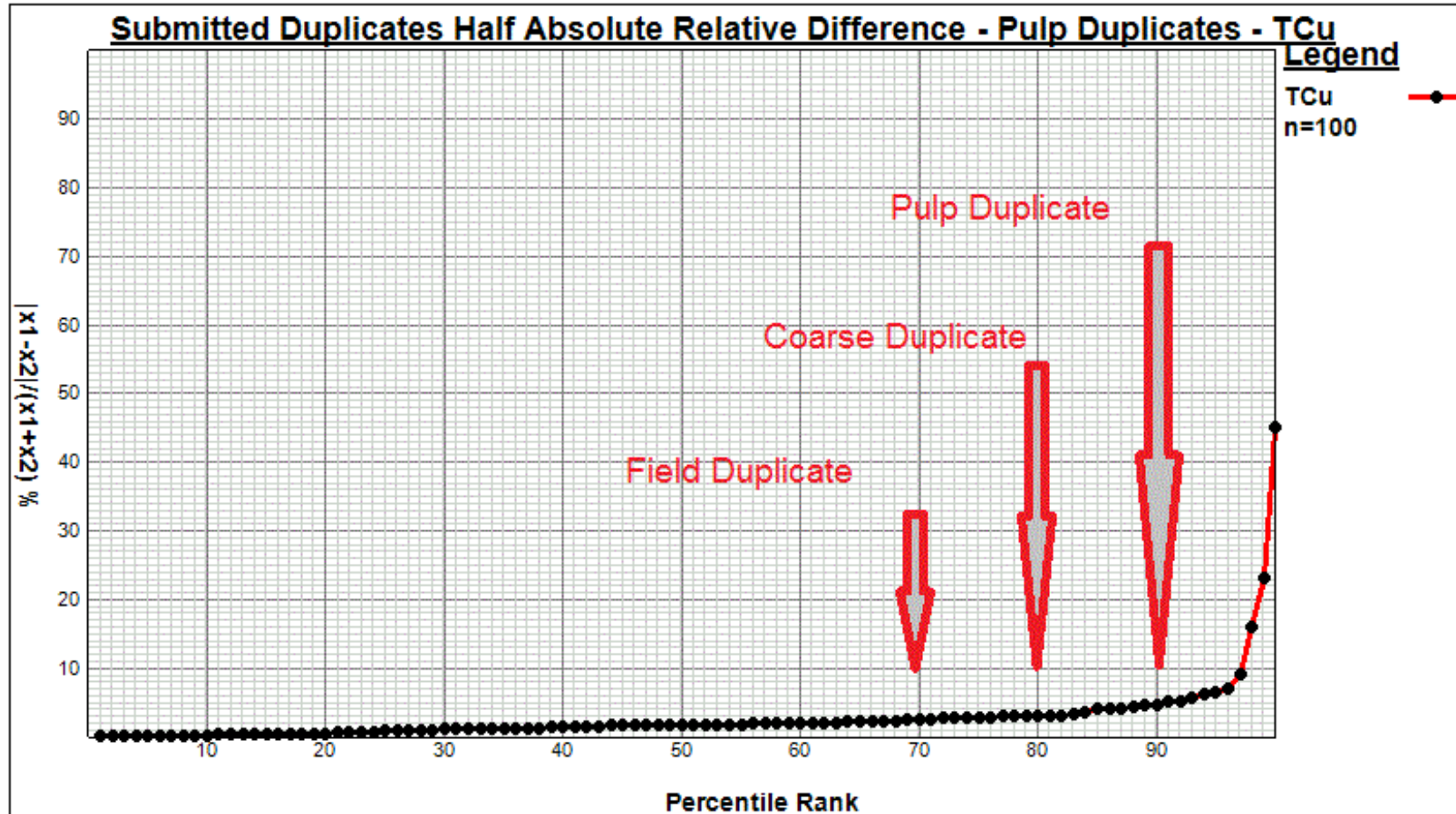
Quantitatively reflect errors of different grades



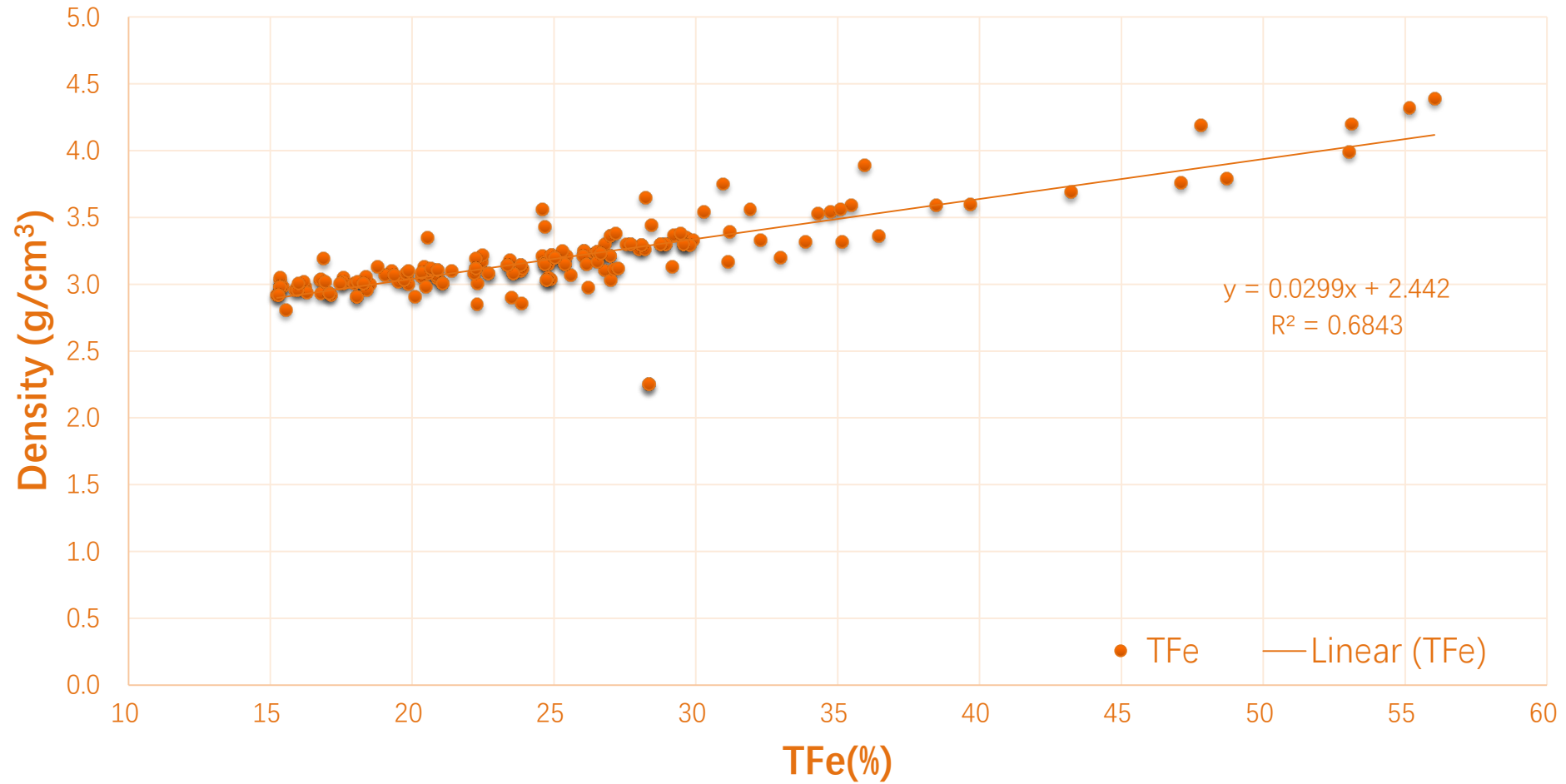


# Duplicate Performance – HARD Plot

$$\text{Half Absolute Relative Difference} = |x_1 - x_2| / (x_1 + x_2)$$



# Analysis of Bulk Density Sample





## Mineral Resource Estimation Risk Assessment

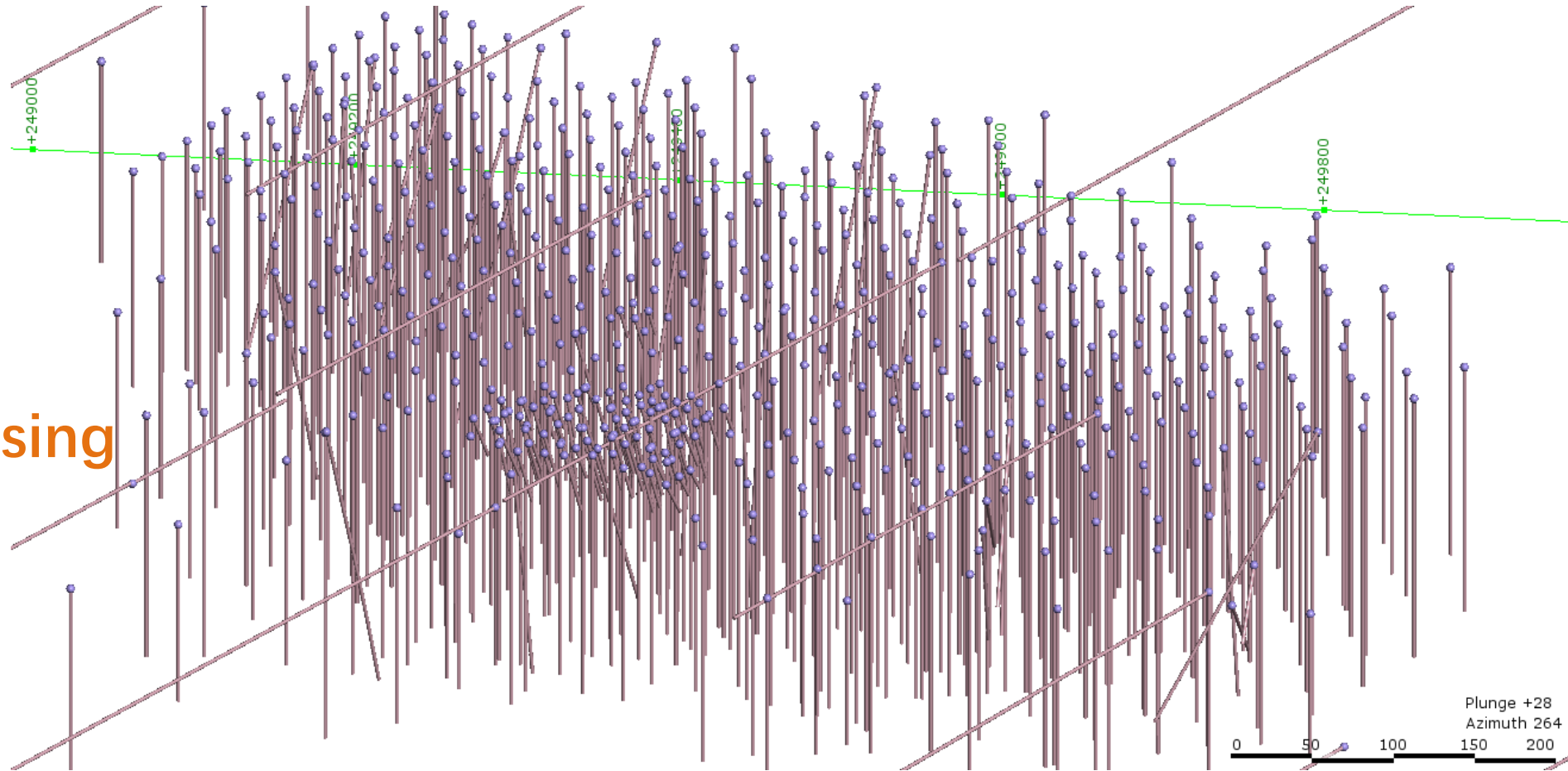
- Data Processing
- Delineation of Orebody
- Method Assessment



# Representation of Data

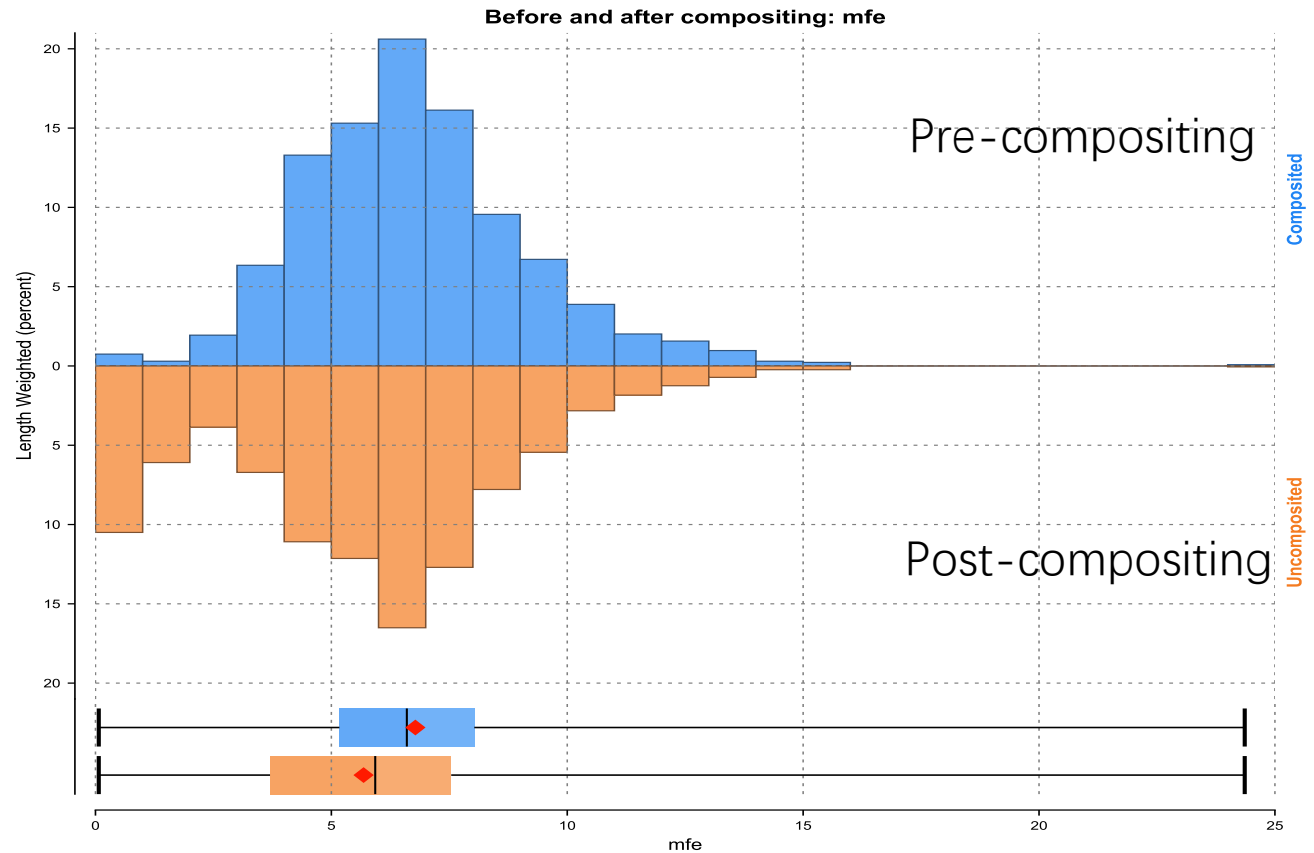
Sample Length  
Exploration Density

- Data Preprocessing

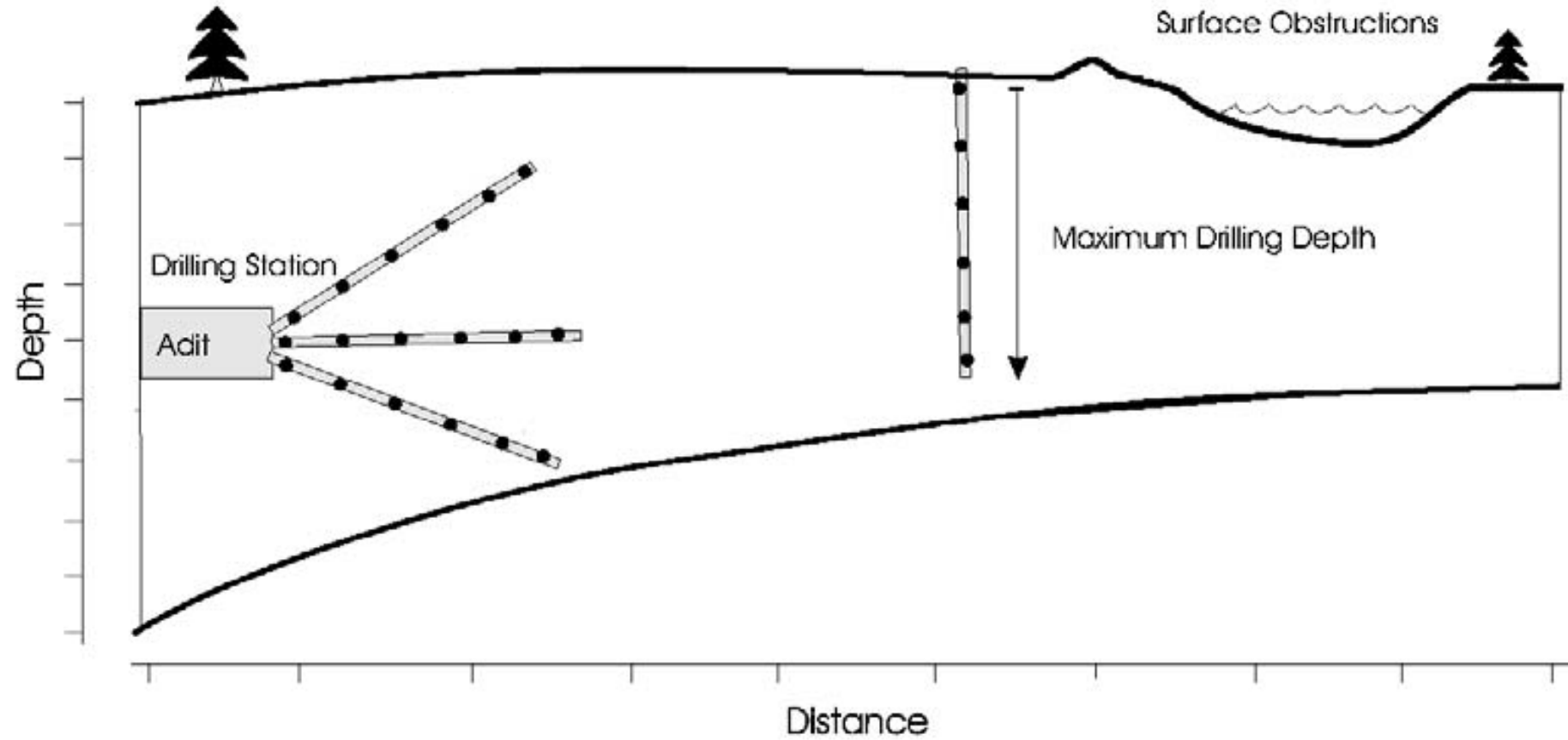


# Compositing

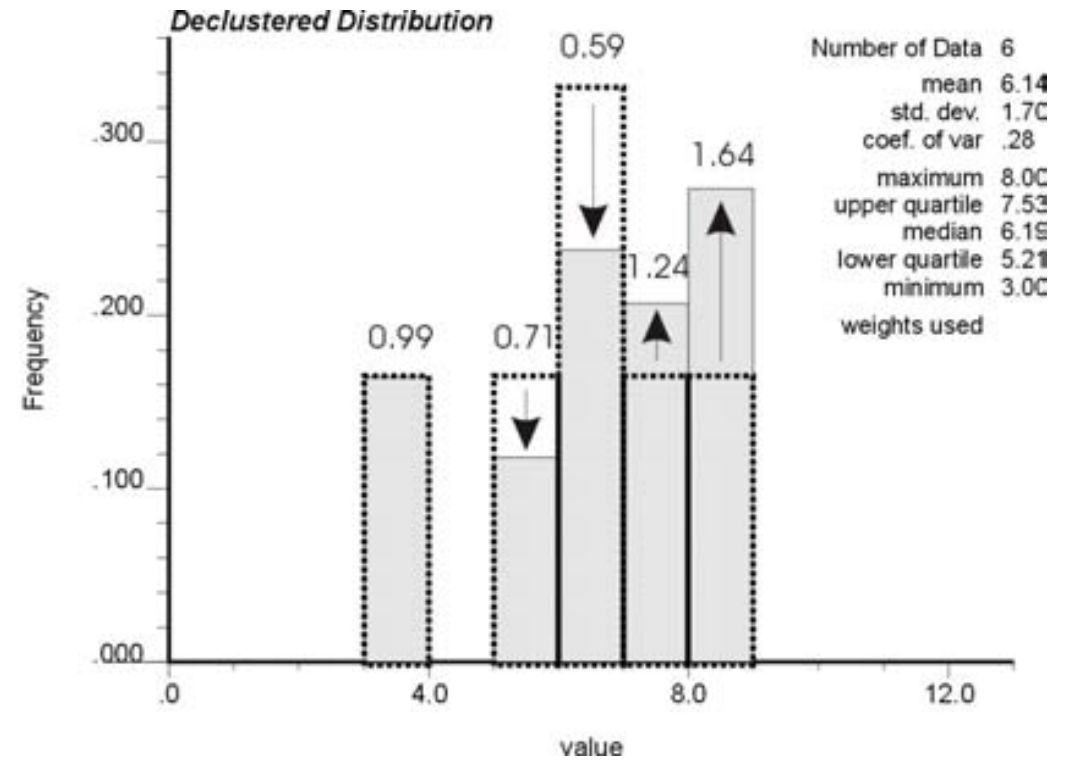
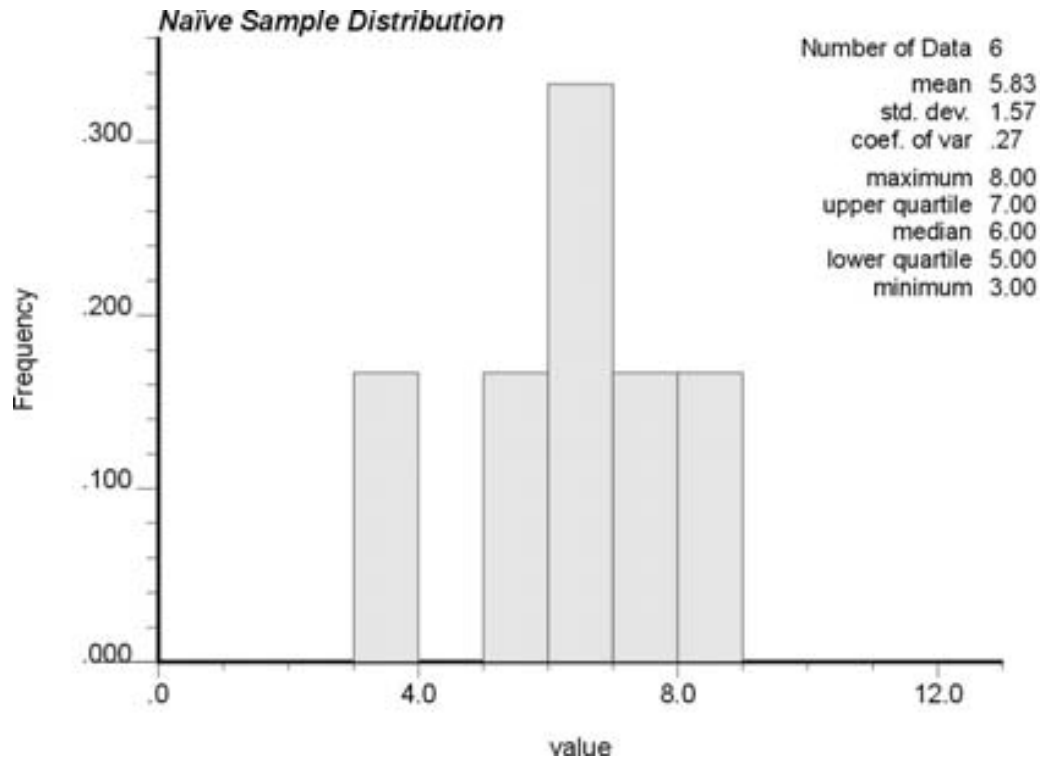
Different sampling lengths will lead to different weights for each sample and possible different analyte statistics



# Clustering



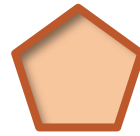
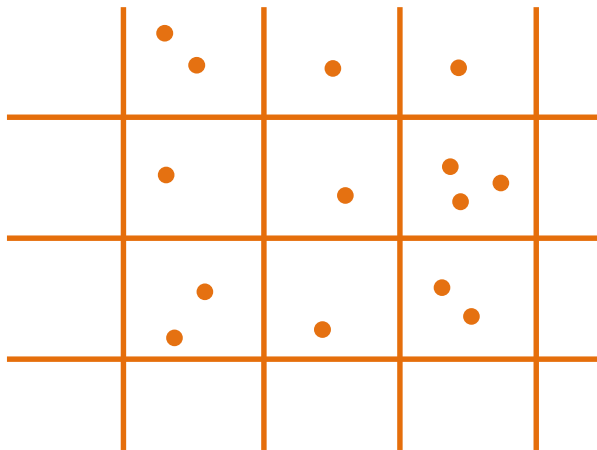
# Declustering



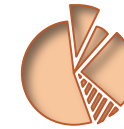
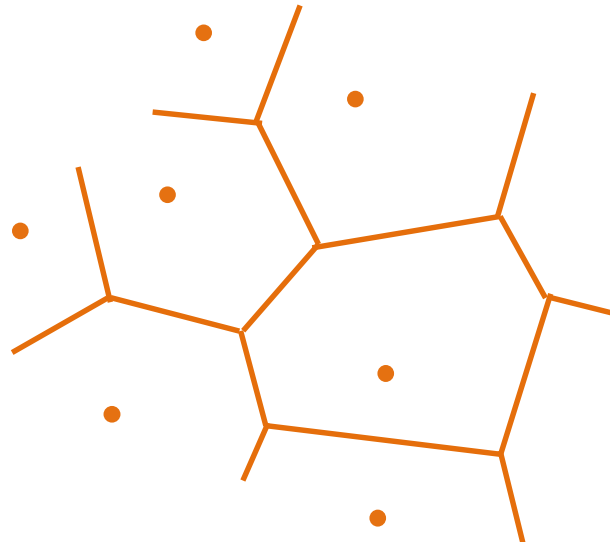
# Declustering Method



**Cell Method**



**Polygon Method**



**Kriging Weight Method**



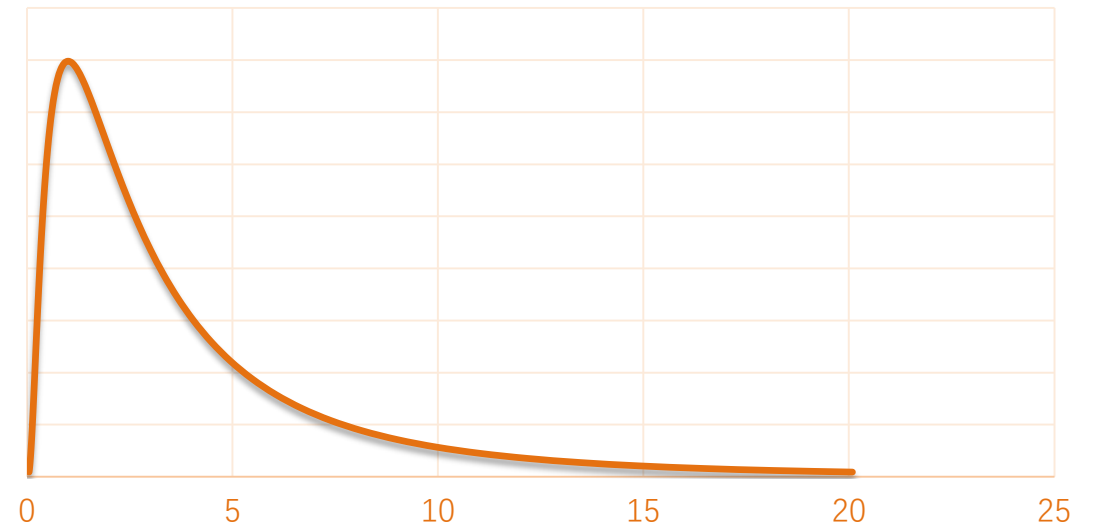
# Basic Statistical Analysis of Data

Core: Data Distribution

Normal Distribution

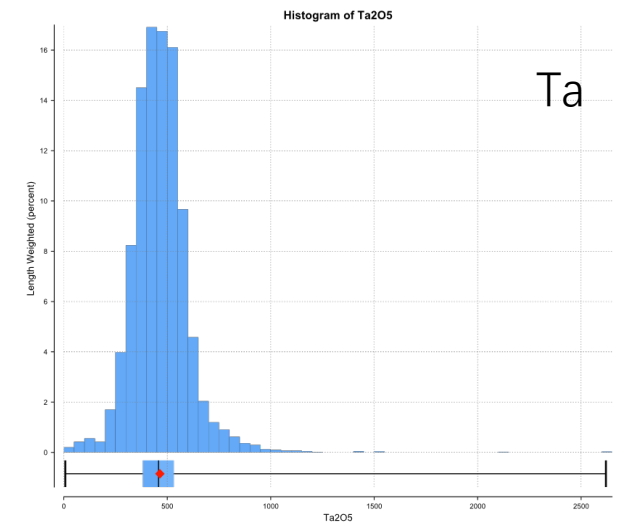
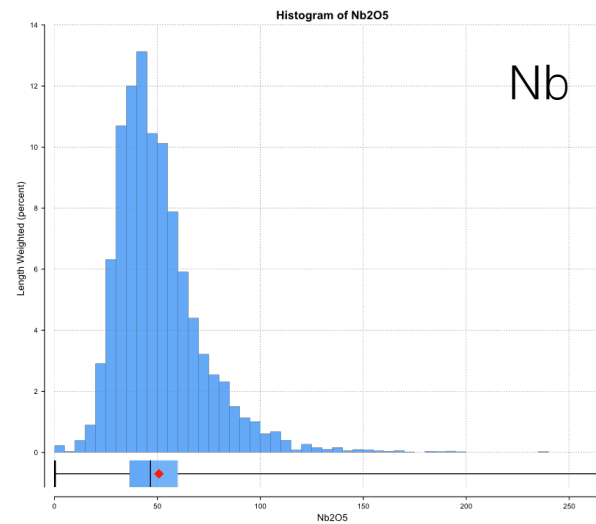
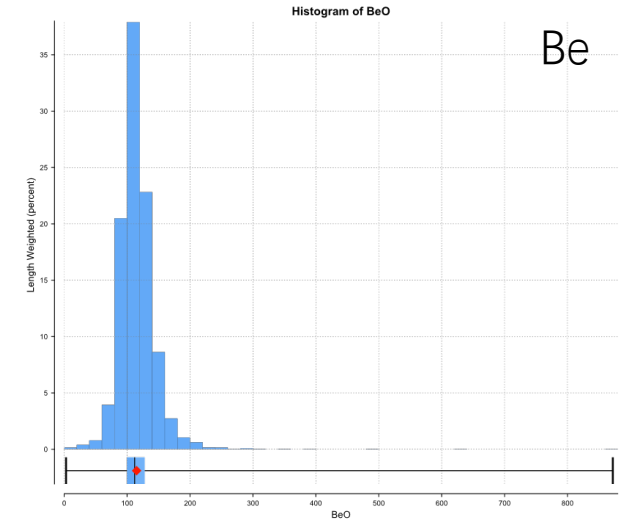
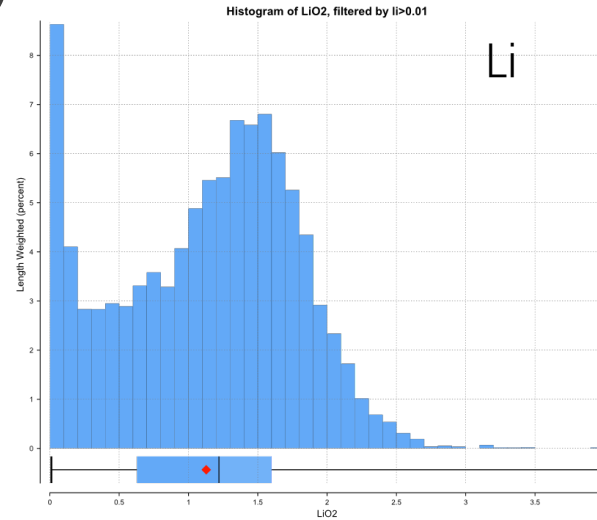


Lognormal Distribution

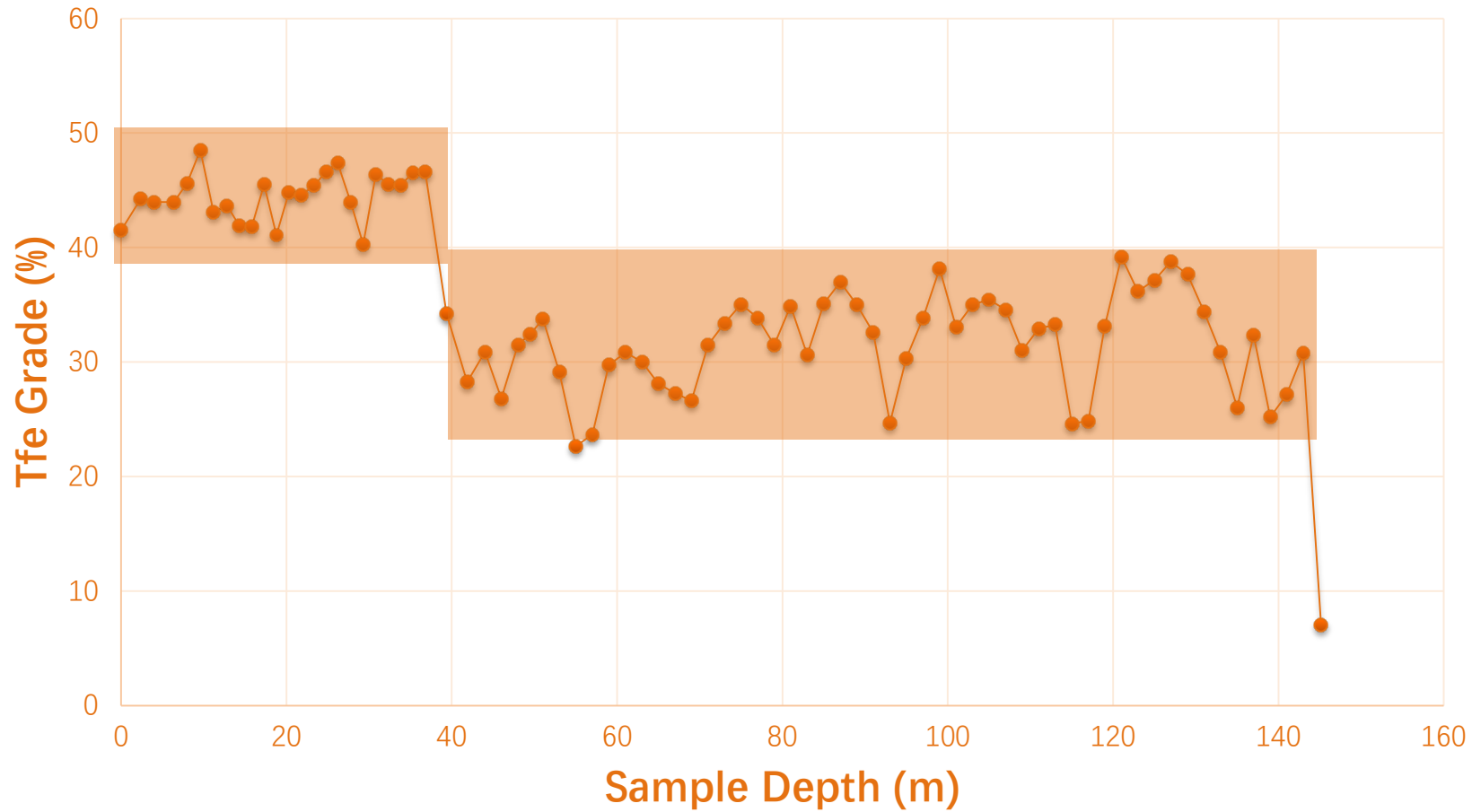


# Basic Statistical Analysis of Data

Analysis of elements can help us understand the mineralization background to a certain extent



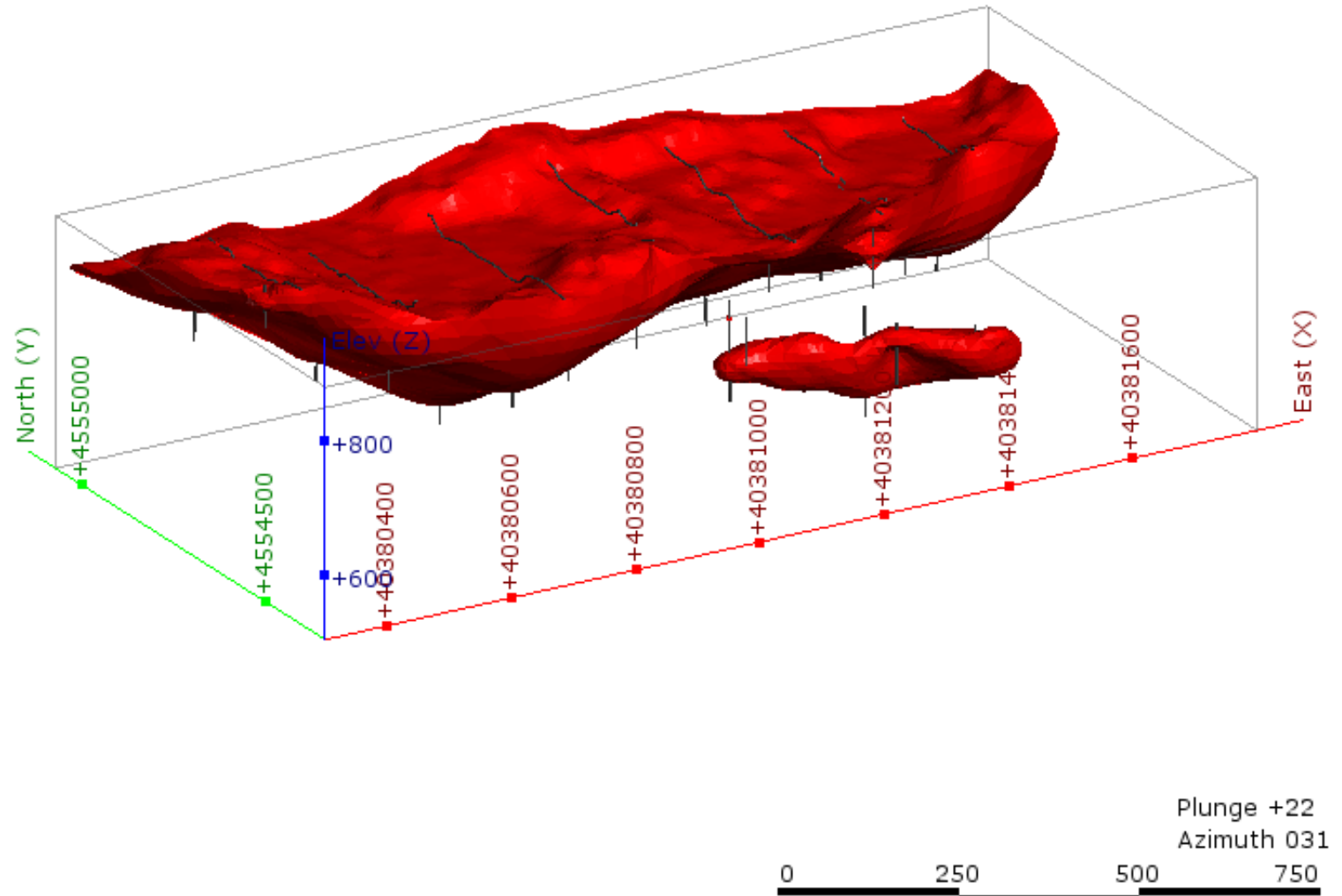
# Basic Statistical Analysis of Data



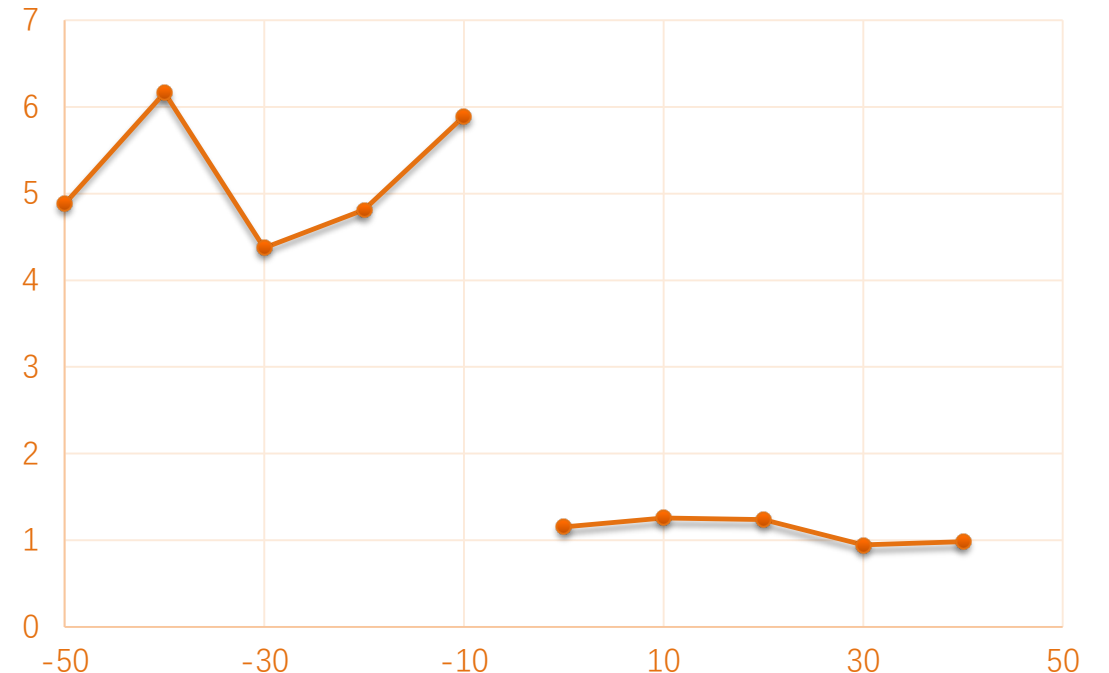
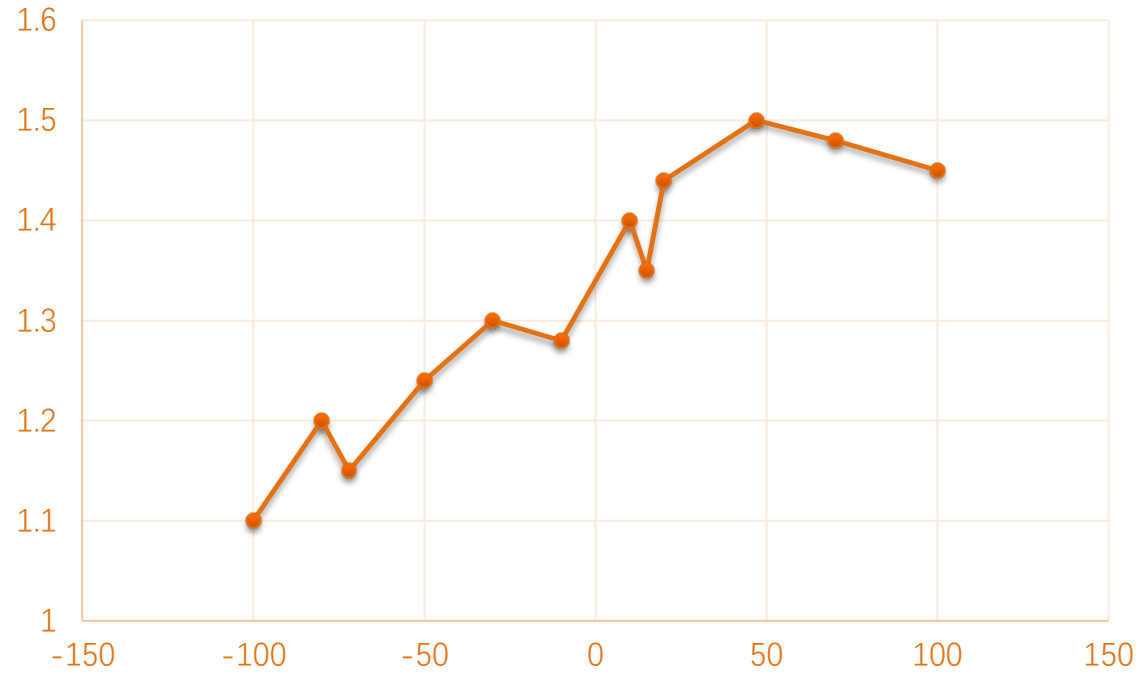
# Delineation of Geological Bodies

Definition of Orebody

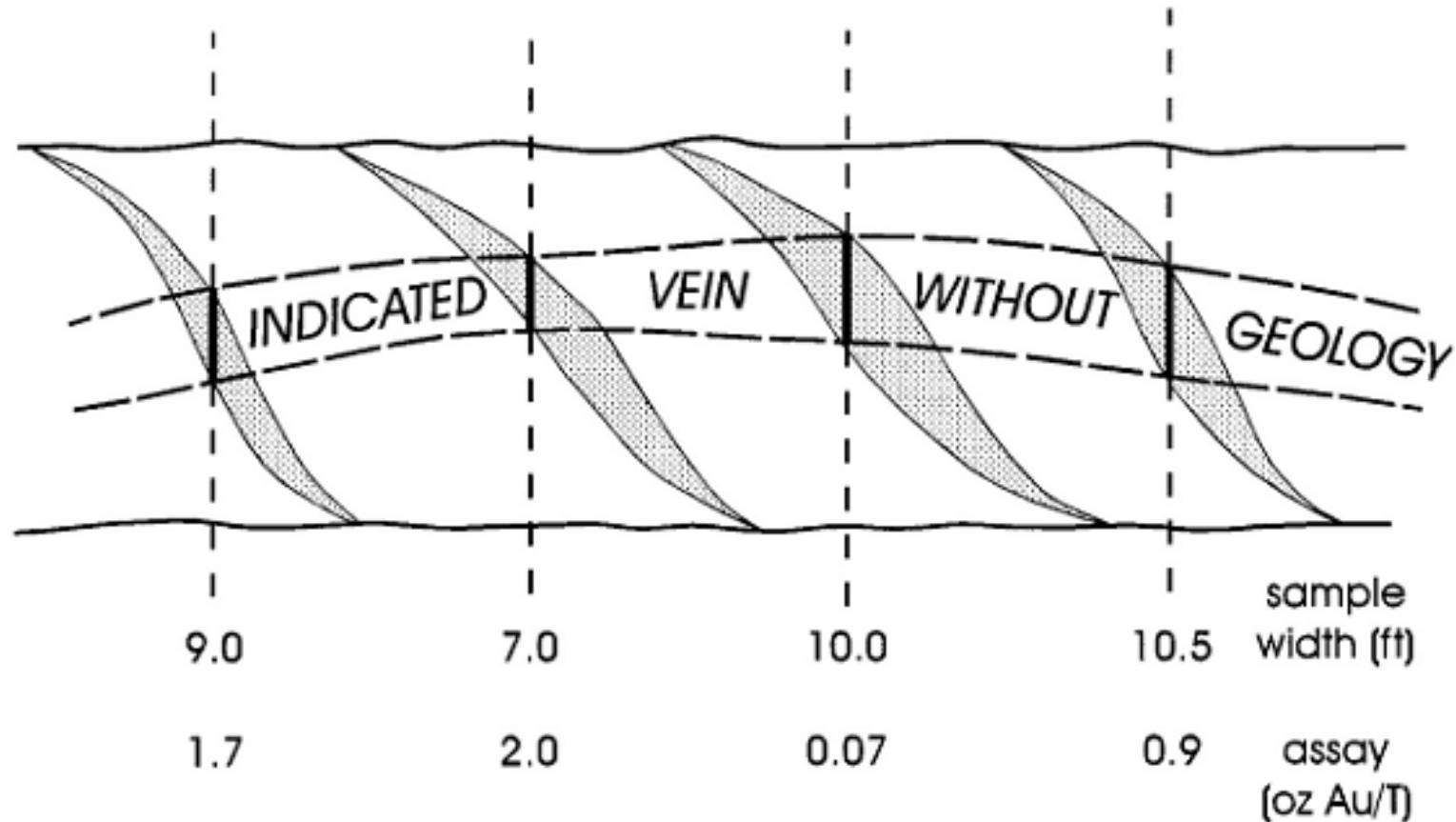
Geological Modelling



# Cutoff Type - Grade Continuity



# Geological Continuity



Source from Alastair J. Sinclair (2004)

# Related Concept of Geostatistics

**Statistics:** Study the distribution of samples (mean, variance, etc.)

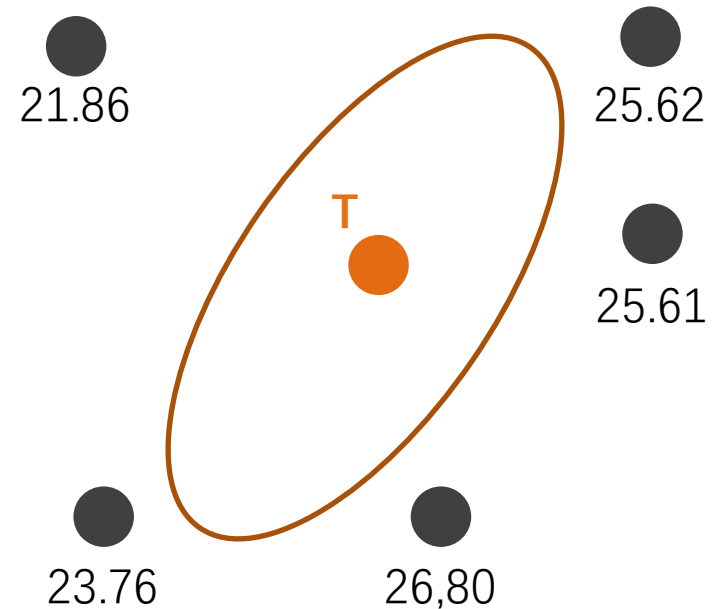
**Geostatistics:** Study the spatial distribution pattern of samples

**Assumption:**

- Random process
- Normal distribution
- Stationarity

**Regionalized Variable:** Variables showing a certain spatial distribution

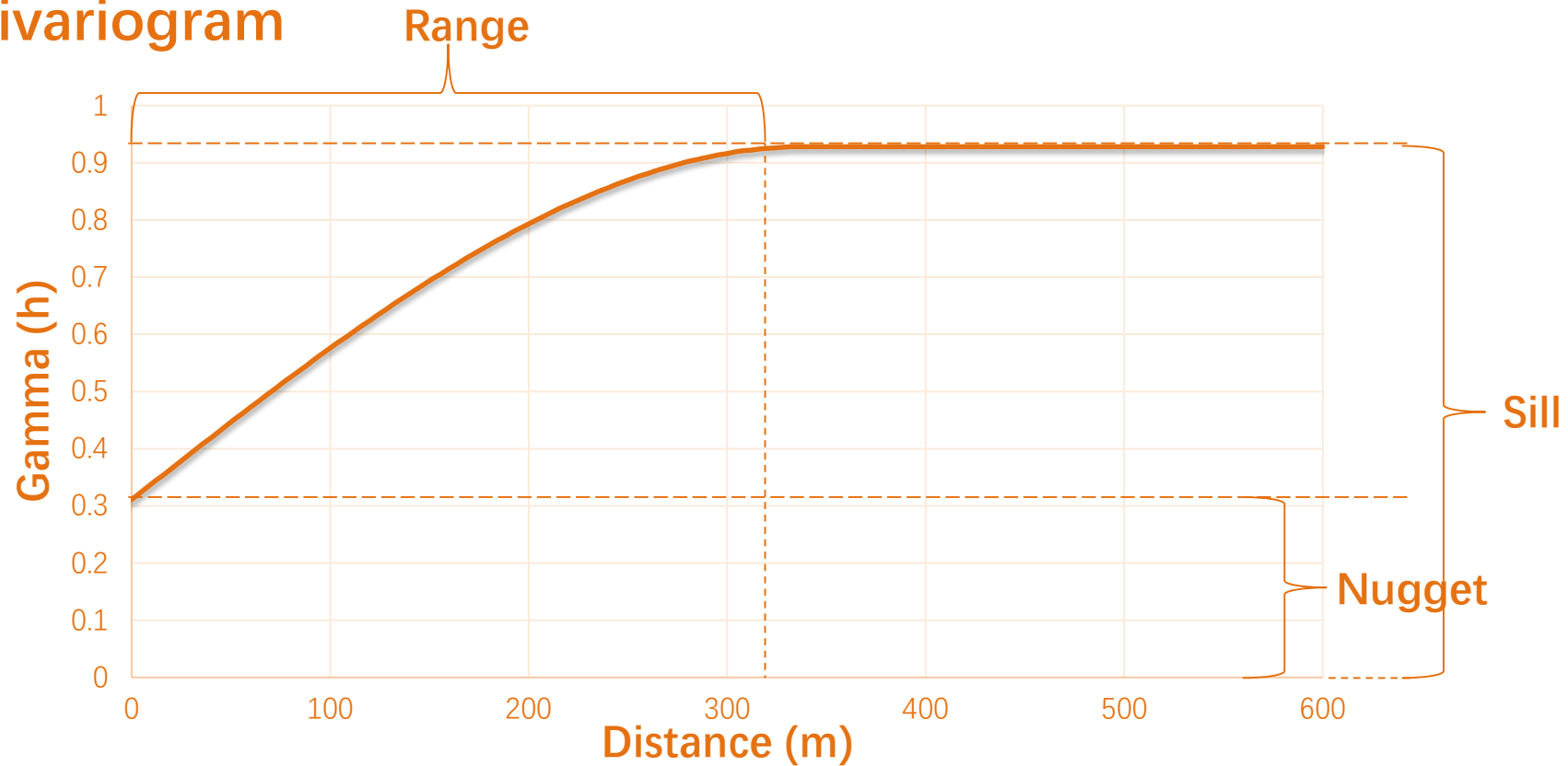
- Random
- Structural



# Related Concept of Geostatistics

**Variogram:** Analyze sample variation over distance

**Semivariogram**

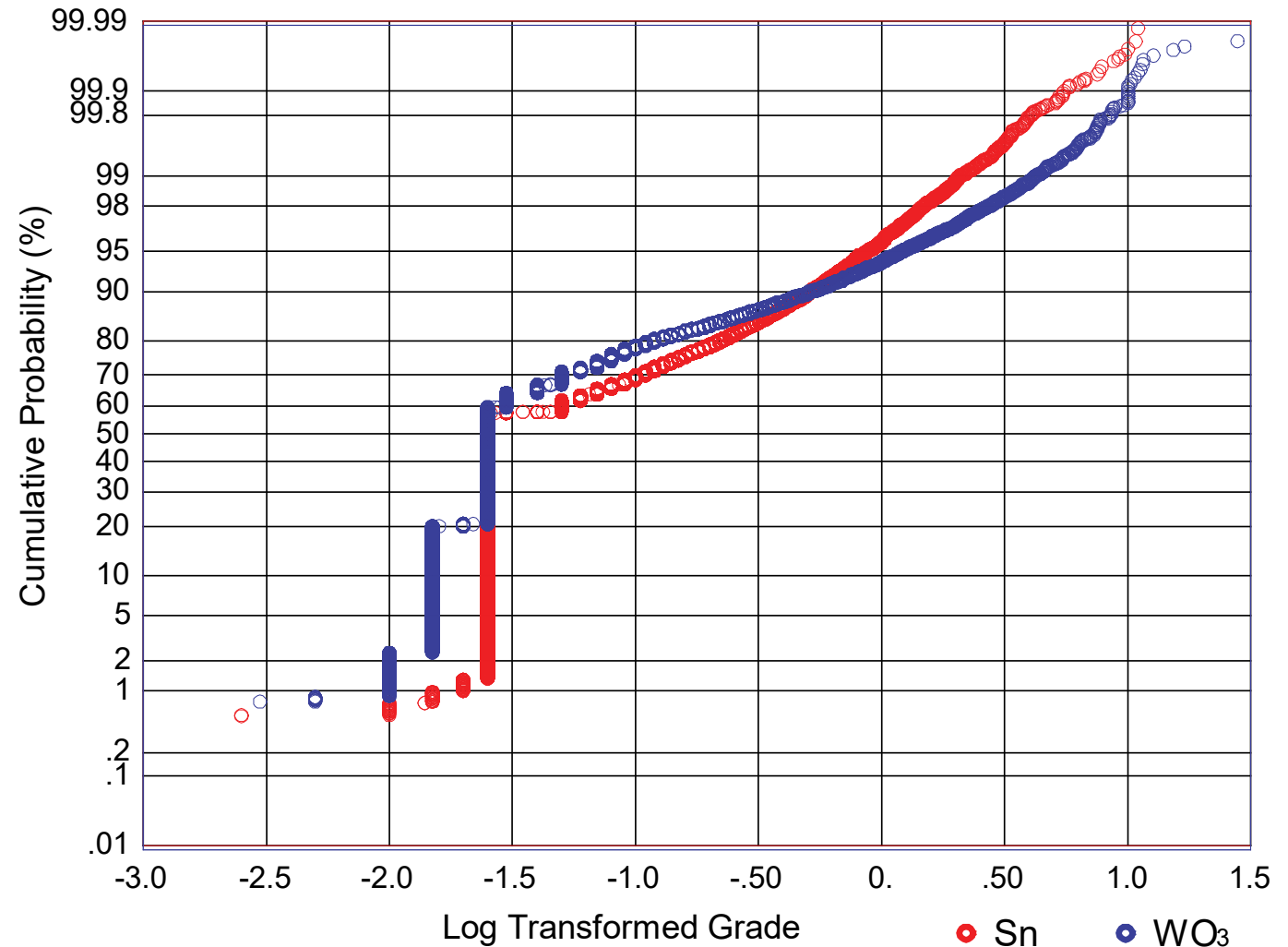




# Selection of Outliner

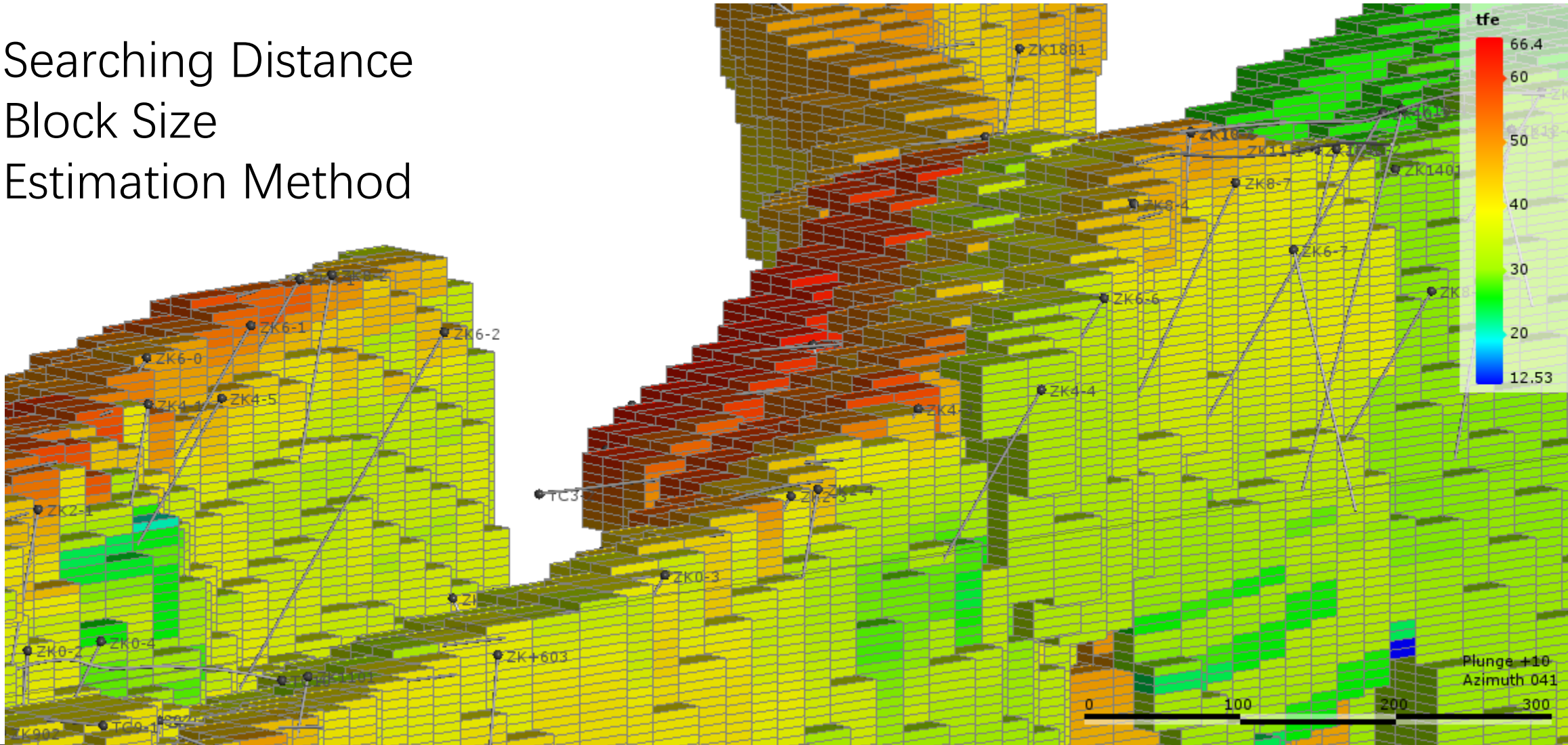
According to the mean and standard deviation (eg: 3 times standard deviation is less than 0.15%)

Based on cumulative probability curve

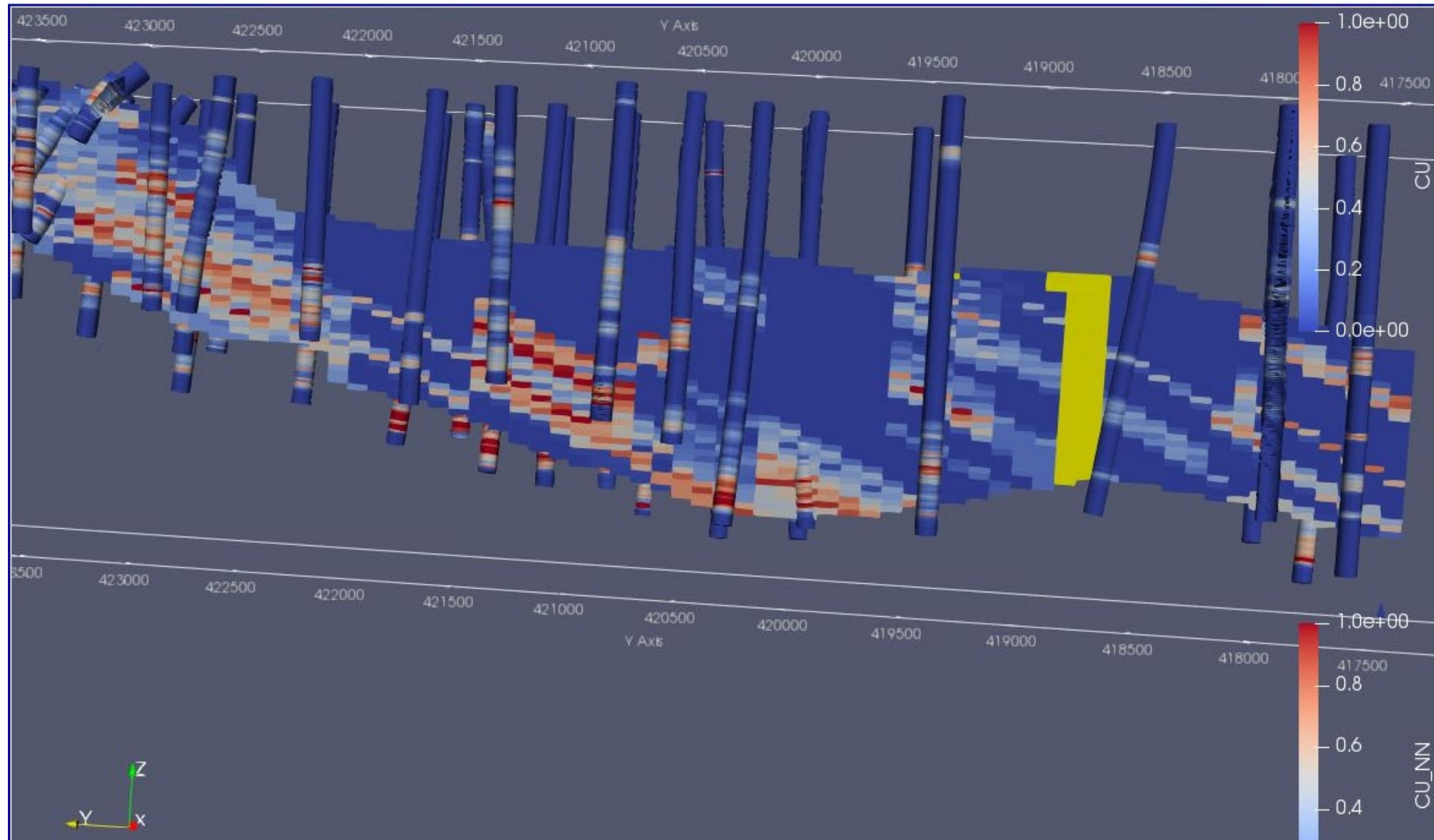


# Grade Estimation in Orebody

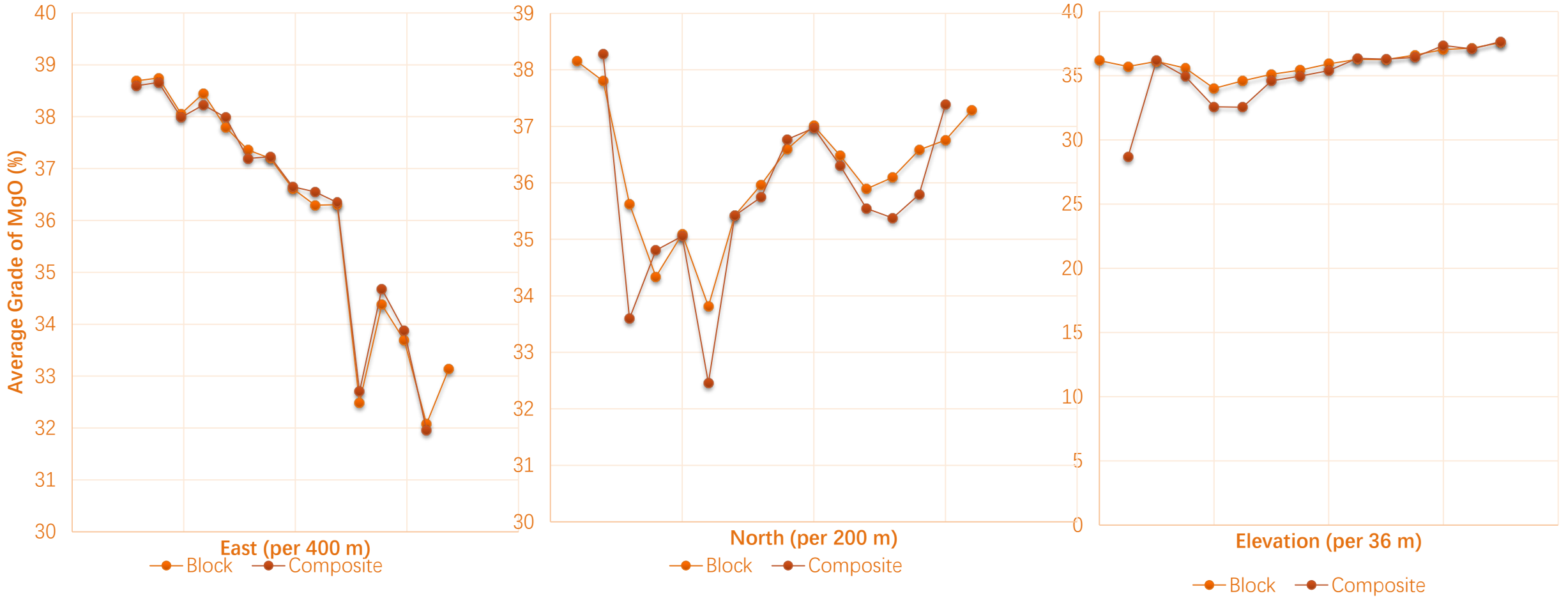
Searching Distance  
Block Size  
Estimation Method



# Verification of Grade Estimation

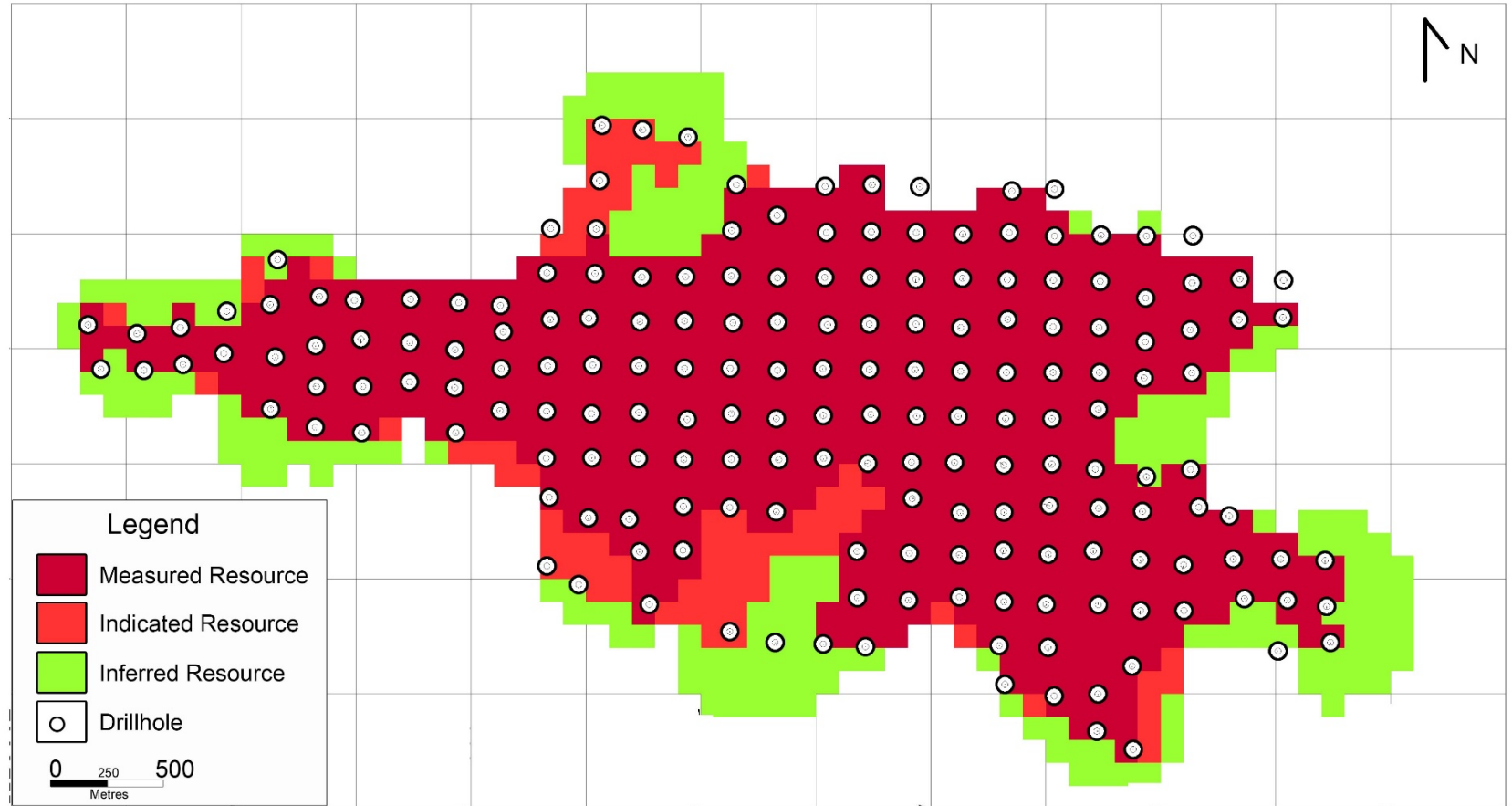


# Verification of Grade Estimation - Swath Plot

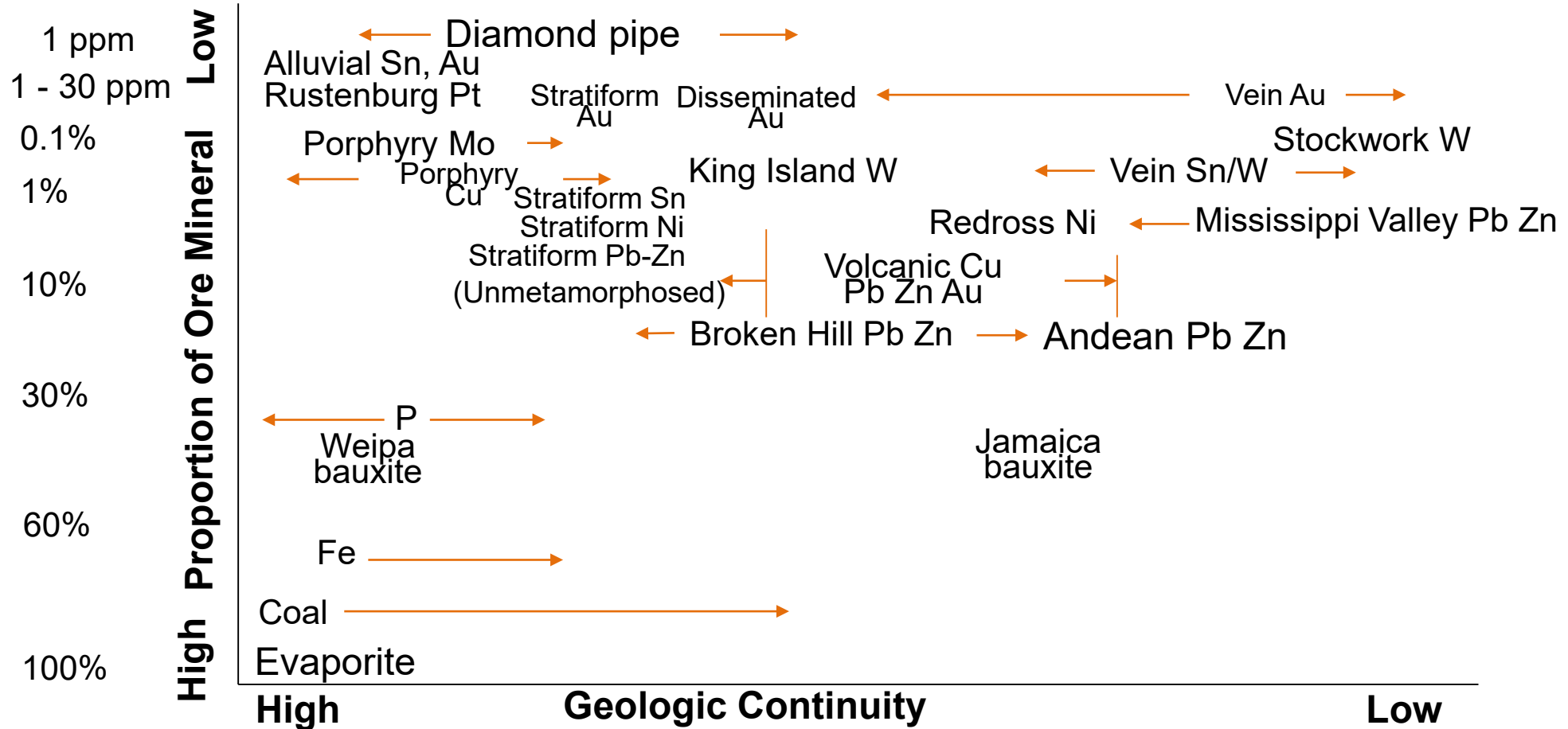


# Resource Classification

How to classify is not specified in JORC.



# Geological Continuity



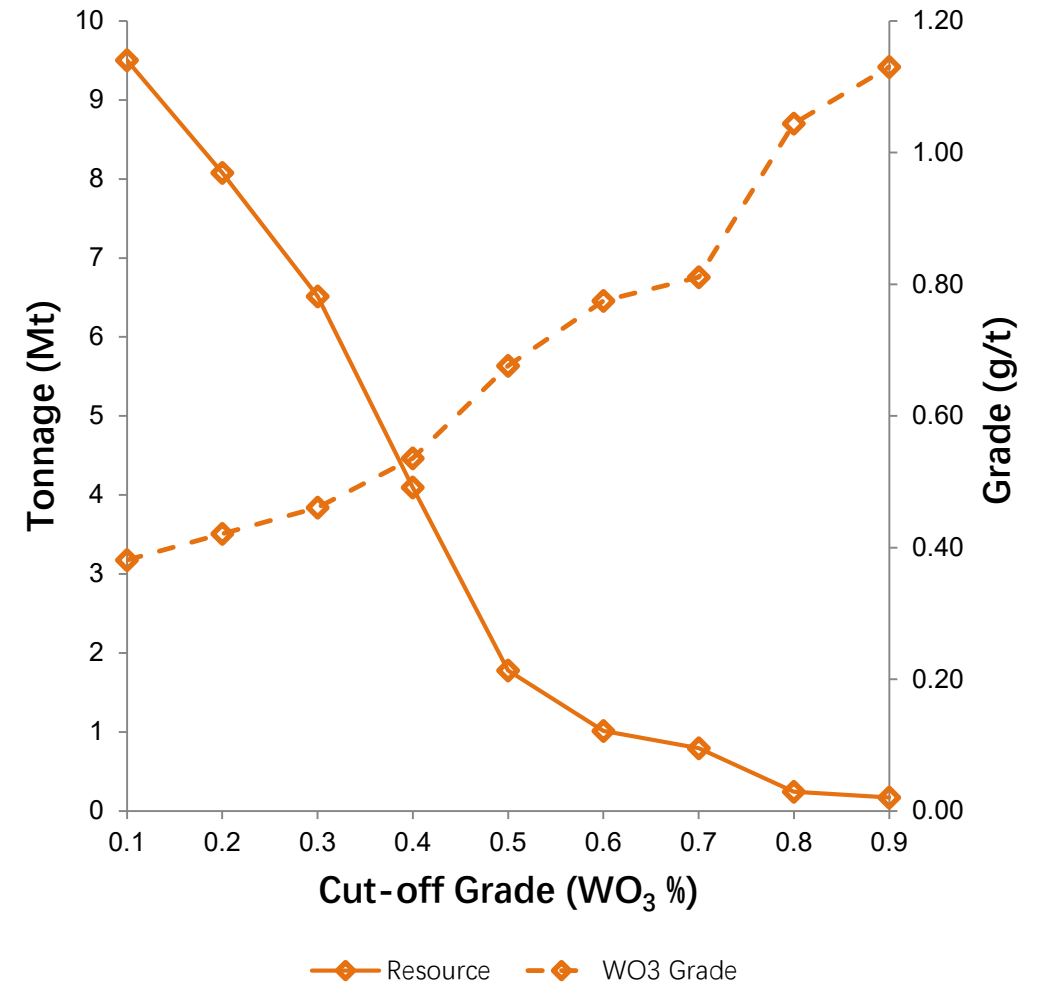
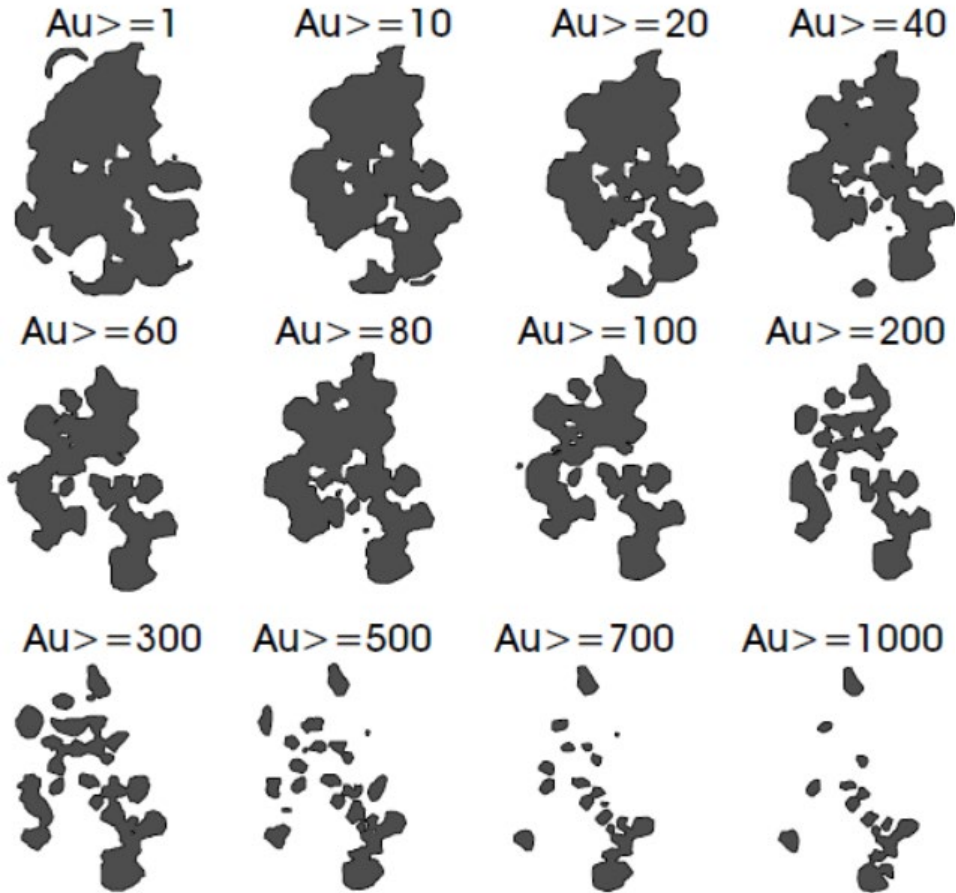
Redrawn from King et al. (1982)

# Selection of Cutoff Grade

a *cutoff grade* is a grade below which the value of contained metal/mineral in a volume of rock does not meet certain specified economic requirements.

$$CoG = \frac{Cost_{per\ ore/t} \times Grade_{concentrate}}{Price_{incl.Tax} / (1 + Tax) \times Recovery\ Rate \times (1 - Dilution\ Rate)}$$

# Sensitivity Analysis



Source from Alastair J. Sinclair 2004



Thank you!

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