

# Managing Mineral Resource Risk

*Erik C. Ronald*  
*SRK Consulting (U.S.), Inc.*  
*Denver, CO*

**SMART**  **MINING**

*Resources for a Connected World*

**SME**

2019 SME ANNUAL  
CONFERENCE & EXPO



CMA 121st NATIONAL WESTERN  
MINING CONFERENCE

 **srk** consulting

# What is Mineral Resource Risk?

- “A **Mineral Resource** is a concentration or occurrence of solid material of economic interest in or on the Earth’s crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction” (CIM, 2014)
- “...The **location, quantity, grade (or quality), continuity and other geological characteristics** of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated, and Measured categories. (JORC, 2012)

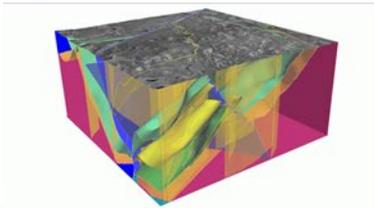
# Inherent Uncertainty and Risk

- Mineral Resources and Mining inherently risky
- Subjectivity – “known, estimated, or interpreted”.
- Additionally...
  - lack of studies, economics, recoveries, title, environment, community, etc.



# Why Manage Mineral Resource Risk?

- Mineral Resources are the foundation of Reserves, Mine Plan, & Business plan;
- 40% of projects have problems with grade estimates and 24% with tonnage estimates (CMMI, 1998);
- Shareholders, BOD, and external stakeholders require assurances on reported technical information supporting Mineral Resources (and Reserves);
- Producing companies commonly focus on short-term value – long-term value treated as expense;
- Resource uncertainty and errors remain a major source of economic failure in the mining industry!



# “We Manage Just Fine”

- Many companies running lean on technical expertise, resources (hours), and internal assurance;
- Internal company standards for reviews/audits rarely question dogma or owners;
- Industry guidance (CIM) is good but relies on the expertise of the QP for quality and appropriateness of technical evaluation;
- General ignorance of technical details in management;

## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

(chemical, observational, physical, etc)

# Data Risks

- Garbage in = Garbage out
- Change in personnel, logging styles, assay suites;
- Data locations, Assay, Quality, Type, Material...
- Subjective geological interpretation;
- Deleterious attributes;

Total Metal = (volume) x (density) x (grade)

Value = (geologic knowledge) x (tonnage factor) x (assay quality)

Lost value = (geologic complexity) x (assumed density) x (poor estimation)

# Data Risk Management

- Know your data!
- Database management, security, and regular validity checks;
- Documentation on included and excluded data, why decision was made either way;
- Quality Control program covering all aspects, not just assay QA/QC;
- Holistic view of data (structure, geochem, geophys, met...) – Experienced staff reviewing and understanding.

## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

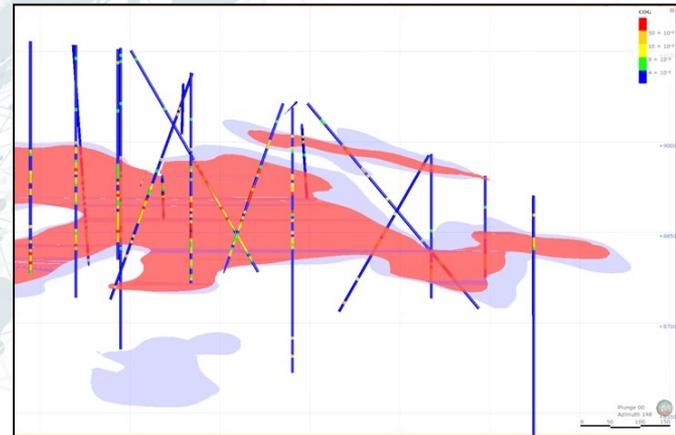
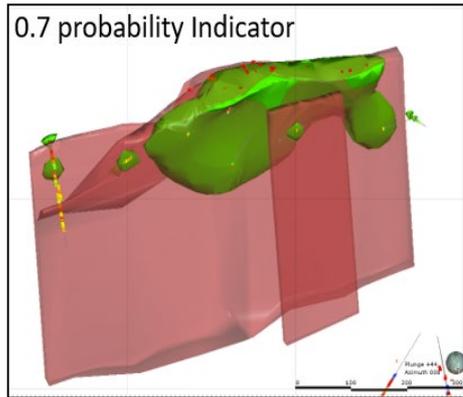
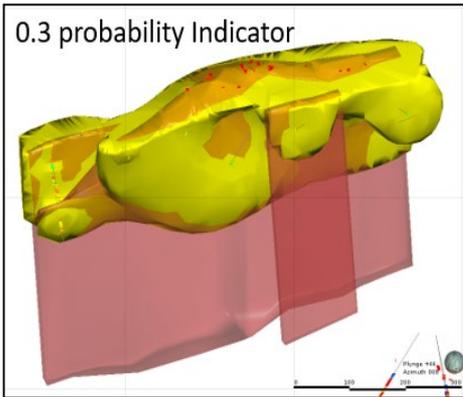
(chemical, observational, physical, etc)

# Interpretation Risk

- Geological and Domain interpretation of volumes can be largest risk to Mineral Resources;
- How well-understood is mineralization?
- Complex ore bodies?
- Grade shell use to constrain estimation of high-grade?
  - Leapblobs created by inexperienced users?
  - Overly optimistic volumes by exploration personnel?
  - Overly pessimistic volumes by mining personnel?

# Interpretation Risk Management

- Alternative versions created?
- Quantified risk assessment through probability?
- Semi-Quantitative through implicit modeling?



## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

(chemical, observational, physical, etc)

# Tonnage Risks

- Density often the forgotten critical factor;
- Errors rarely considered or quantified;
- Complex lithology, alteration, and mineralization;
- Appropriate testing methodology:
  - Friable material, competent rock, clays, voids...
- Sample size and scale: bulk samples, core, chips, etc.
- Minor differences in big volumes can drastically change Mineral Resources!

# Tonnage Risk Management

- Geometallurgical / Physical characterization of deposit;
- Multiple methods of testing;
- Use of operational data;
- Ensure data population is appropriate for variability;
- Don't "set it and forget it"

## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

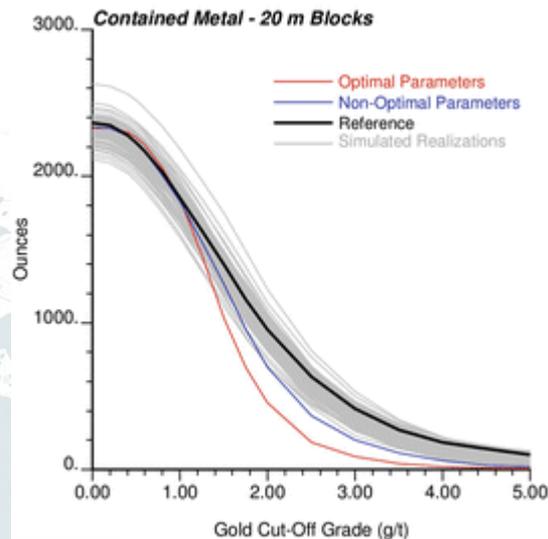
Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

(chemical, observational, physical, etc)

# Estimation Risk

- Either overly simplified or unnecessarily complex;
- Inexperienced staff;
- Incorrect anisotropy due to software;
- Blowing grade where it shouldn't be;
- Overly restrictive capping – lost metal;
- Over smoothing – mean grade.



Nowak & Leuangthong, 2017

# Estimation Risk Management

- Experienced personnel overseeing estimate;
- Does estimation parameter and geology align?
- Model validations;
- Alternative estimation methods trialed;
- Quantitative risk assessment through probability?
- Reconciliation!

## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

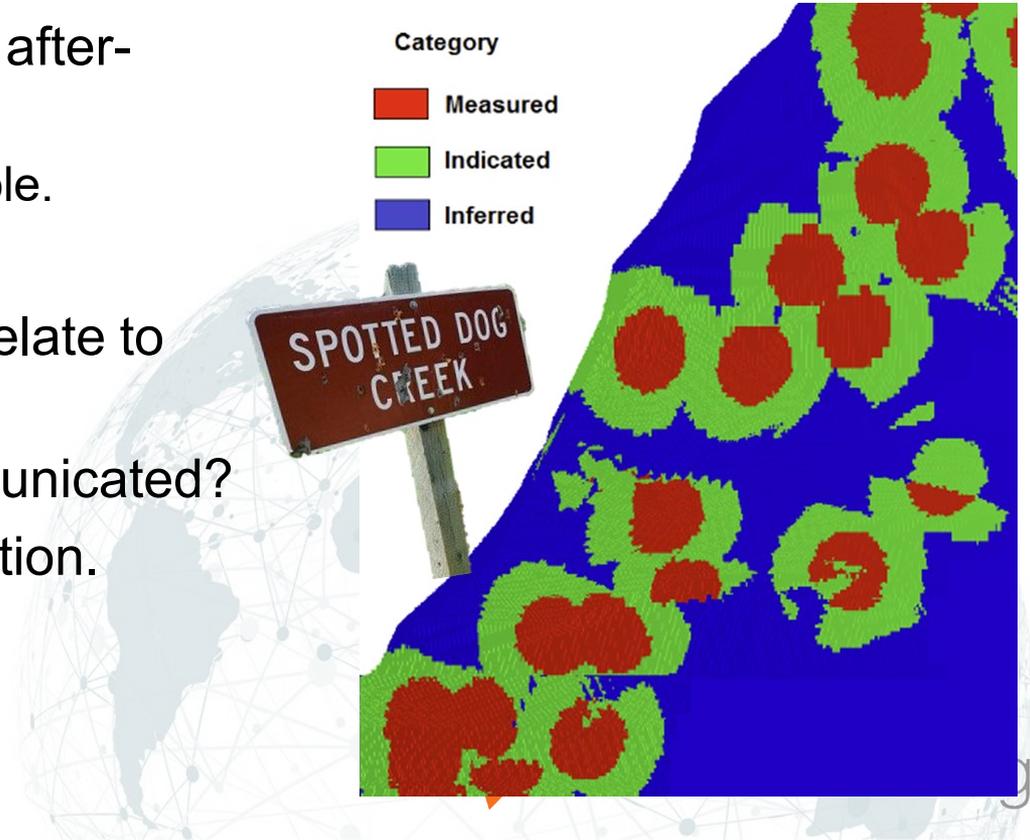
Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

(chemical, observational, physical, etc)

# Classification Risk

- Often over-simplified and an after-thought;
  - Pitfalls of distance to drill hole.
- Spotted dog!
- Does classification truly correlate to Mineral Resource risk?
- How is short-term risk communicated?
- Ulterior motives to Classification.



# Classification Risk Management

- Holistic and long-term view;
- Reconciliation by category;
- Probability of quarterly grade & tonnes?
  - i.e. 90% probability of quarterly GT within 10% prediction
- Use of estimation quality, subjective rankings, and priority data;
- QP decision, not management!

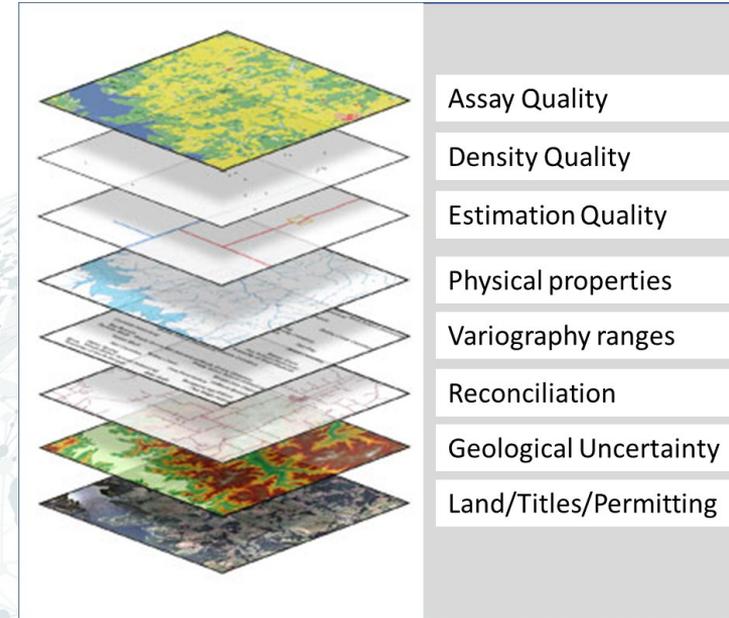


Image modified after ESRI - <http://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/an-overview-of-geodatabase-design.htm>

## Documentation

### Geology/Domains

Understanding of geological complexity, structure, rock types, alteration, mineralization, domains, spatial relationships, etc.

### Tonnage

Density domains, variations in density across deposit, waste characterization, voids, friability, material properties.

### Estimation

Exploratory data analysis, domains, spatial continuity, neighborhood analysis, estimation methodology, outliers, composite size, block size, anisotropy, etc.

### Classification

Confidence in data and interpretations, interpolations distances, quality of estimates, production history, ore body variability, continuity of above cut-off grade, etc.

## Data

(chemical, observational, physical, etc)

# Documentation

- “If it’s not documented, it didn’t happen”
- Updated, clear, and thorough to provide proof and process descriptions;
- Allows improved auditing and identify issues;
- Must be regularly updated and reflect what “really happens”;
- Not just a cook book!

# System Process Risk Management

- Corporate established system that documents process of calculation Mineral Resources is key;
  - Paper trail on what was done, why, and by who;
  - Responsible individuals or roles clearly identified;
  - Auditable and repeatable;
  - Doesn't rely on single person or external expertise;
- Can be easily reviewed by peers or external reviewer for comment and validity.

# Corporate Risk Management

- Management of risk central to the business...is it a focus of BoD and C-suite?
- Alignment of risk to business plan?
- Who's responsibility and accountable for MinRes Risk?
  - CEO, QP, or site geologist?

# Internal v. External Reviews

- Internal review can be tricky!
  - Authority and Knowledge required
  - Challenge dogma
- Who's accountable for results?
- External and independent
  - Sufficient time, experience, and knowledge
  - Paranoid and accusatory culture
  - Fresh eyes and Good Practices

# Importance of Peer Review

- Peer reviews are one of the most important internal tasks that can be completed in Mineral Resource Assurance;
- True Peer-to-Peer (P2P) is key. When performed under guise of supervisor or senior review, honesty can be lost;
- Requires competence in technical areas of review;
- Findings, recommendations, and follow-up work documented;

# Independent Health Checks & Review

- Process should not necessarily be viewed as an audit or review on staff competence;
- “Health checks” commonly used to assess state of a process, staff experience, and process robustness;
- Opportunities typically result with many value-added projects generated from Health Checks;
- Combination of internal and external personnel typically works best for in-house knowledge and independence.

# Common Audit Findings

- Siloed communications within organizational structures;
- Poor documentation of process or outdated paradigms;
- Gaps in resources or skill sets;
- Not enough focus on fundamentals;
- Opportunities for increased confidence, additional ore body knowledge, or unrealized value;
- Testing of historic dogma or assumptions.

# Summary

- Mining and Mineral Resources can be a risky business!
- A process of internal assurances and external audits can provide value to ID risks before they become lost \$\$\$;
- Hard to do!
- Documentation and Peer Review and great (and cheap) assurance systems;
- Must have champion at C-suite / BoD level for success.