CSA Global
Mining Industry Consultants

Categorical Simulation applied during Feasibility Studies – A case Example

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Introduction

Context

- Geostatistics most often associated with grade and tonnage estimation for mineralisation
- Feasibility studies require numerous additional inputs to be modelled, but often form an afterthought to the production of a Mineral Resource
- Not necessarily given the same level of rigour as modelling “the good stuff”
- It’s is critical to understand the impact of these additional parameters to a level that will support life of mine planning

Introduction

Estimation v Simulation

- Estimation (Inverse Distance, Various Flavours of Kriging etc…) are deterministic. Given the available data, designed to give you the single best estimate at a particular point.
- Simulation designed to quantify variability. Is *probabilistic*; foregoing the “best estimate” at any given point, to better quantify the potential variability / reliability of the assigned value for a given location

Simulation

- Just like estimation (ID, kriging) simulation comes in a few flavours:
- Common application – grade simulation. Multiple scenarios of possible grades for any given block.
- Useful for looking at profit / tonnage sensitivity, assessing “best” and “worst” case scenarios
- Based on simulation of a continuous distribution (eg. grade data that can assume any value between min and max)

Introduction

Simulation cont'd

- Other methods of simulation also exist;
  - Truncated Gaussian (±Plurigaussian)
  - Multiple Point
  - Indicator Simulation
- Indicator Simulation is the one of interest
- Similar to Indicator Kriging; Concerned with simulation of indicator data (0 / 1)
- Applied to continuous data – defines probability of exceeding (or not exceeding) the value at which the indicator threshold has been set. (ie. Probability of exceeding a cutoff grade)
- Good for assessing sensitivities to cutoff grade changes

Introduction

Categorical Simulation

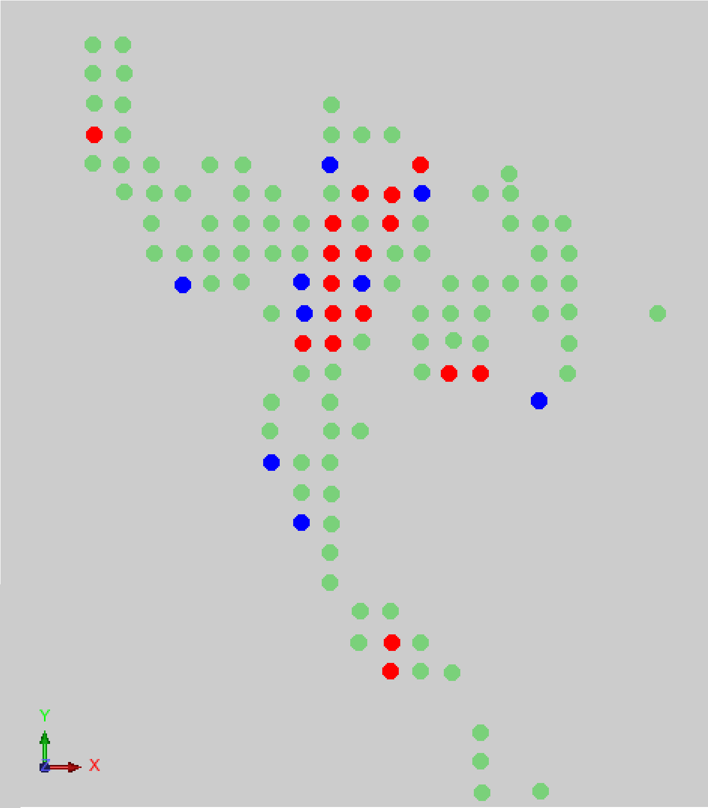
- Particular variant of Indicator Simulation
- Rather than grade thresholds, indicators represent belonging to a given category (rock type, domain, etc…)
- Categories are mutually exclusive
- Useful for assessing likely distributions and tonnages of rock type
- Also useful for reviewing confidence in rock type assignation

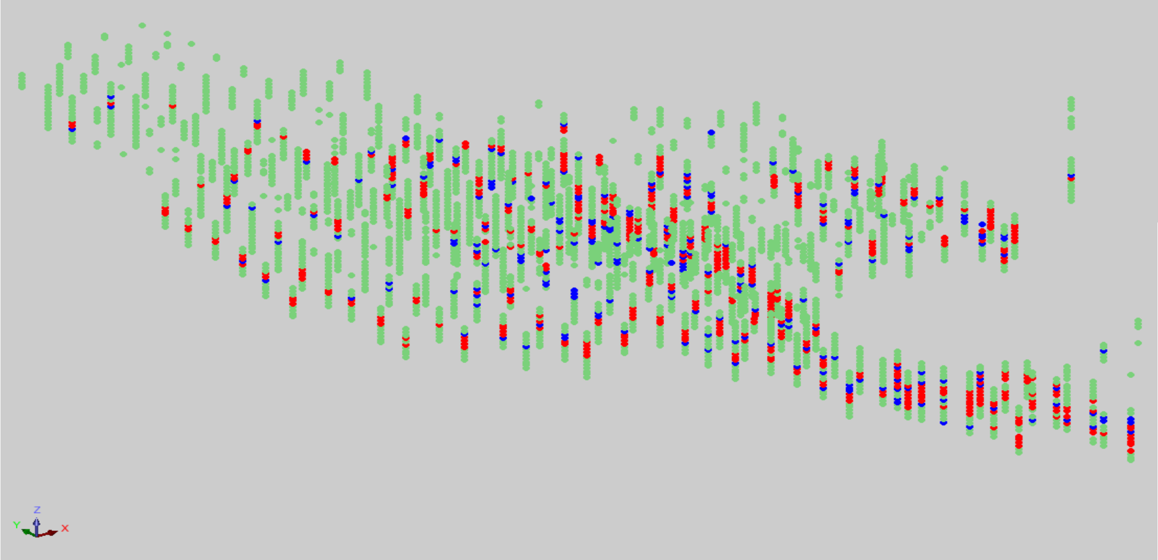
A Little Bit of Theory…

Categorical Simulation

Implementation

- Categories defined:
  - Rocktype
  - Soiltype
  - Stratigraphic Horizon
  - Domain
  - Acid Generating Class etc…





Categorical Simulation

Implementation

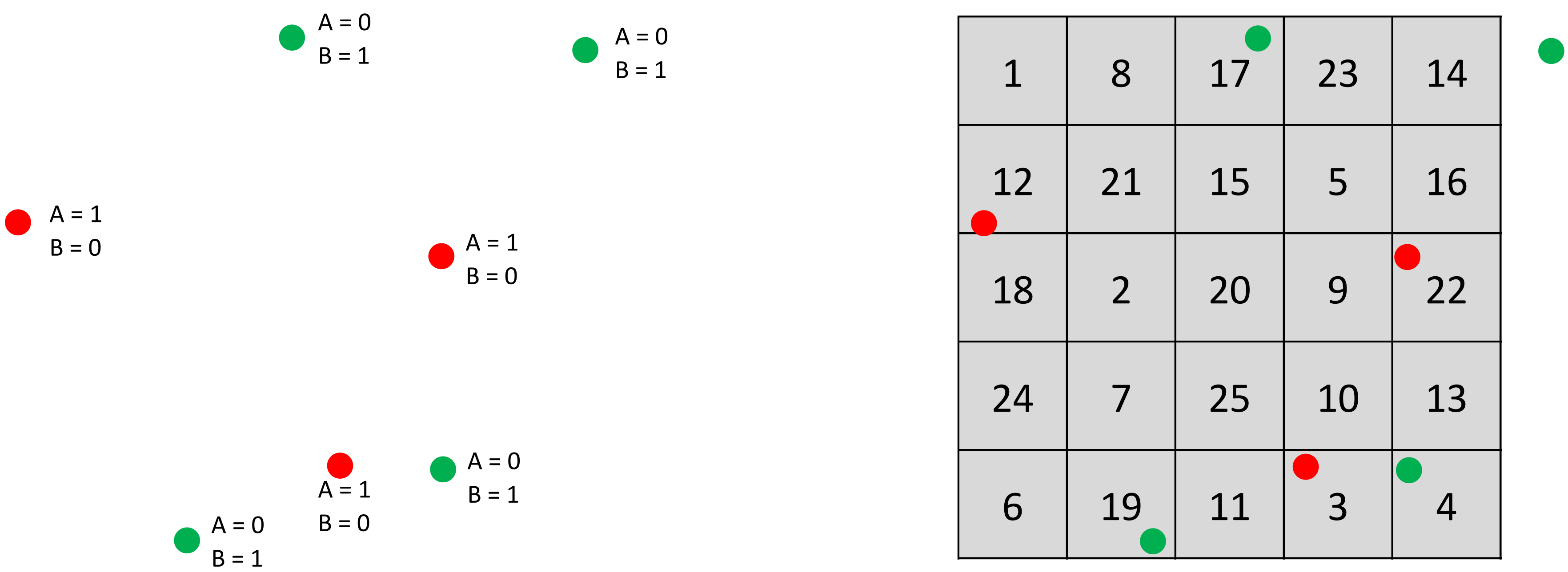
- Indicators calculated for *each* definition of category
  - Indicators are mutually exclusive; belonging to one rock type means exclusion to all other rock type categories.
- A random path is defined, visiting each block / node in a model once only
- Each set of indicators is kriged at each node
  - Gives probability of each rocktype occurring at estimated location
- A categorical CDF is built for each block from individual category probabilities

Categorical Simulation

Implementation

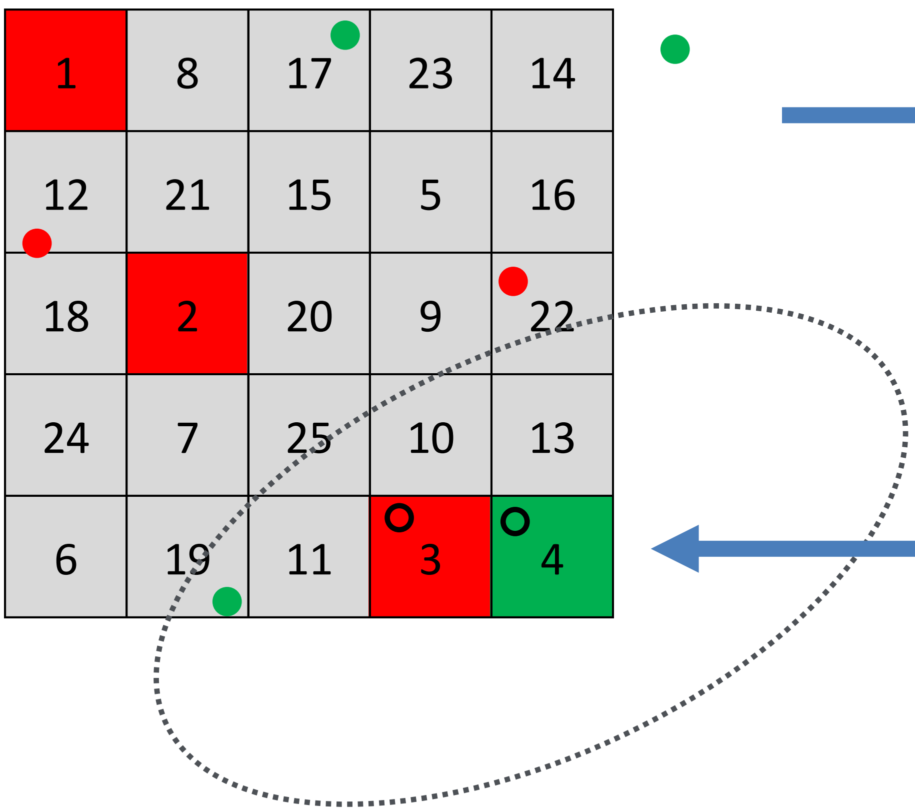
- Monte Carlo method is used to randomly draw a value between 0 and 1
- Category corresponding to that value on CDF is assigned to that block.
- Repeat n times (usually 100)

Implementation



Categorical Simulation

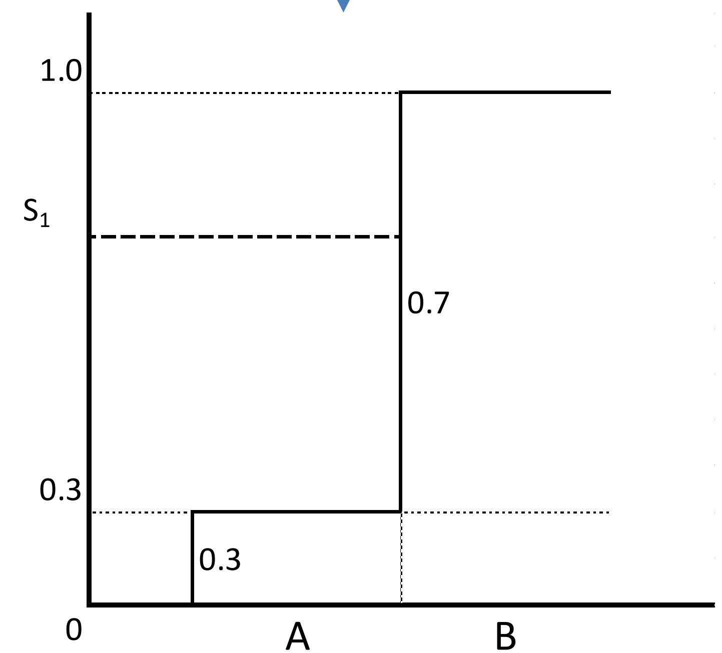
Implementation



At Block 4:

A* = 0.3

B* = 0.7



Do for every block, repeat *n* (100) times

Case Example – Simulation of Acid Forming Potential

Case Example

Base Metal Deposit (VMS)

- Currently undergoing Feasibility Study
- Environmentally Sensitive Area
- Real Estate is Valuable!
- Separate dumps required for particular waste categories
- Preliminary assessments no longer appropriate
    - Methods of calculation biased
    - No spatial distribution of waste categories
    - Rick assessment / mitigation not easily quantified

Case Example

Original Method

- Selected samples taken from limited number of drillholes
- Acid forming potential calculated through bench scale testwork
- Samples of varying supports
- Simple numerical proportion of sample within each category extrapolated to tonnages within preliminary pit optimisations

Case Example

Original Method - Limitations

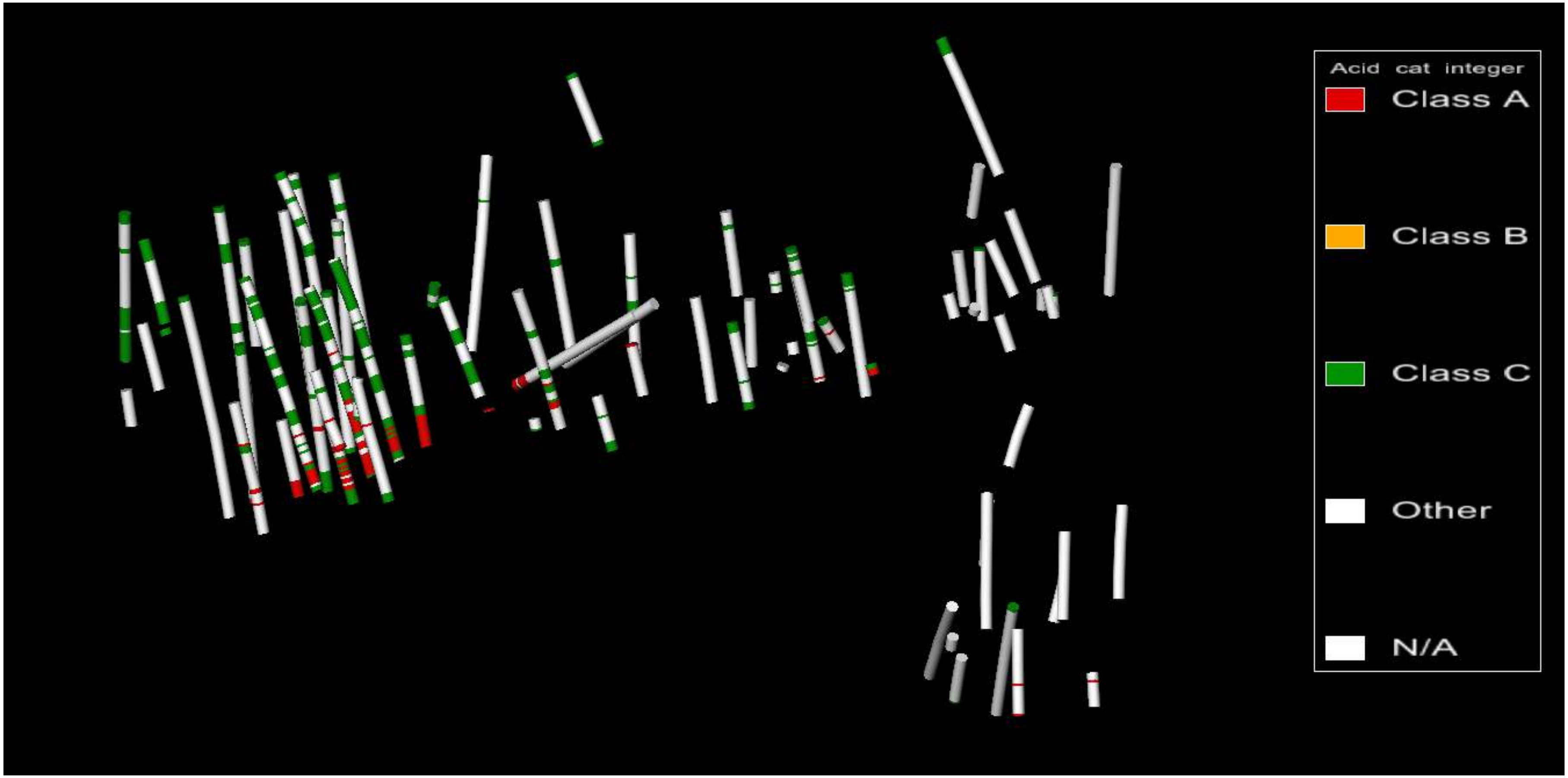
- Equal weighting given to each sample regardless of length / volume
- Spatial distribution each category unavailable
- “What if?” not possible to answer

Case Example

Categorical Simulation

- Take formula developed from initial testwork – determine Acid Forming Potential category for every sample with suitable assay data in database
- Composite downhole to uniform support of 2m – using modal proportions of each category within composite interval

Categorical Simulation



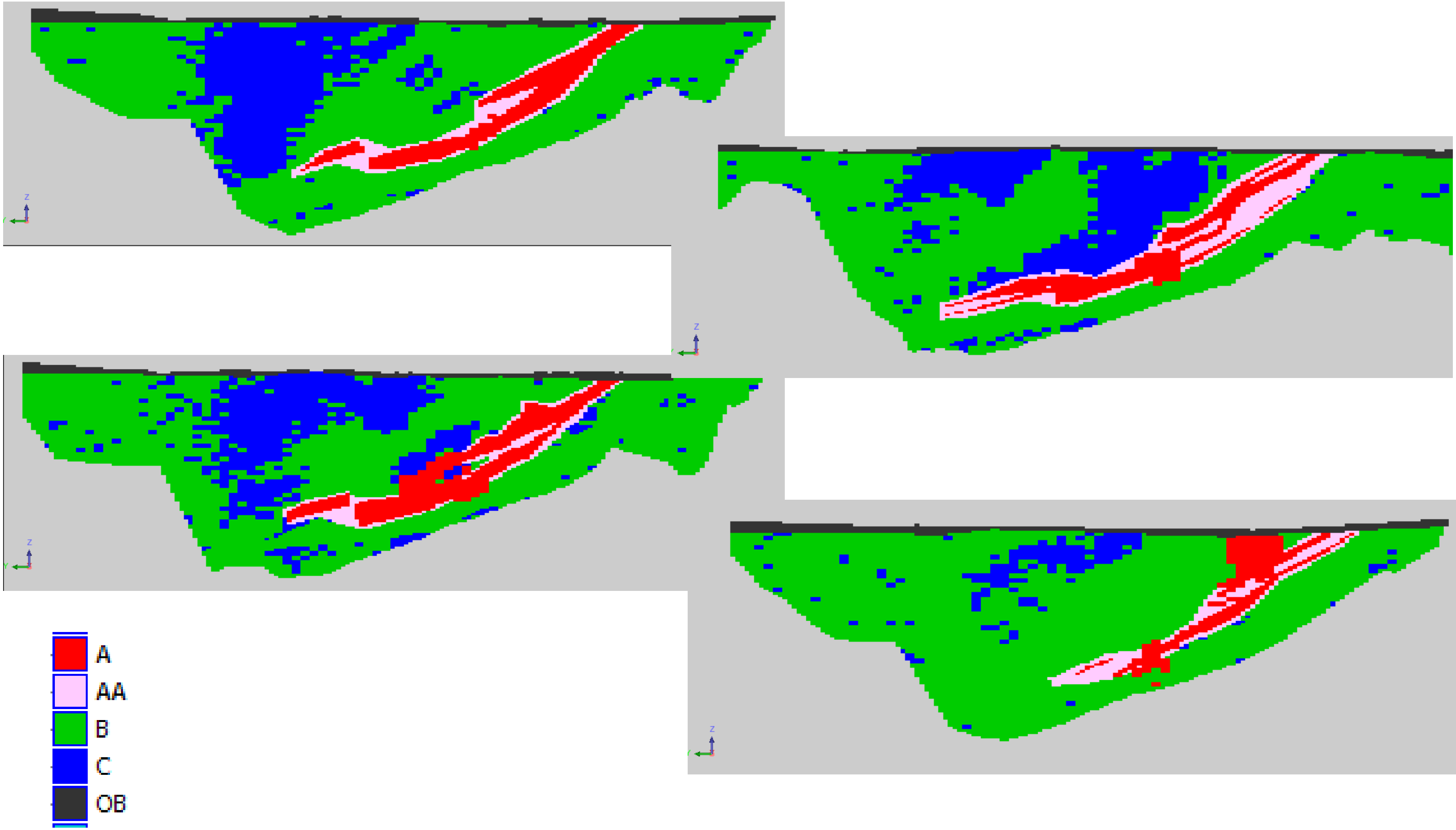
Case Example

Categorical Simulation

- For conservatism – anything with Py logged as a mineralogical component also put into Class B
- Simulation Run
- Calculate Most Probable Category and assign
- Post processing (force coding some lithology units into higher classes)

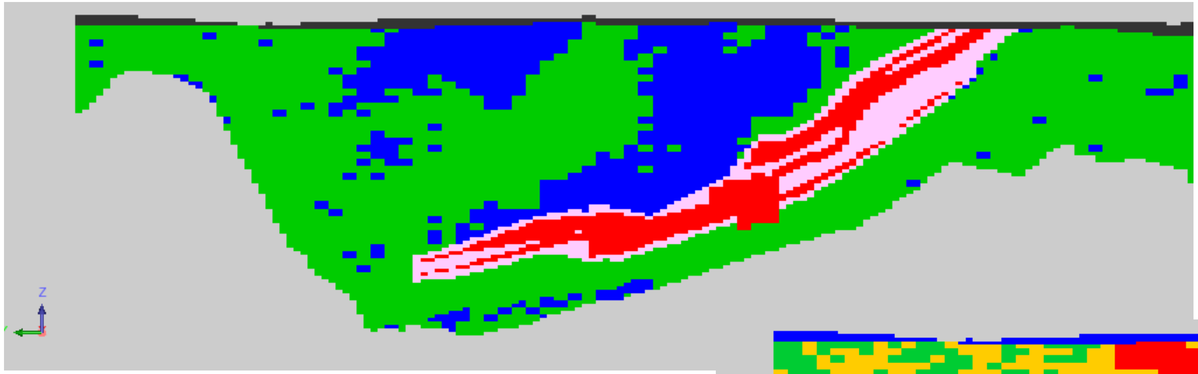
Case Example

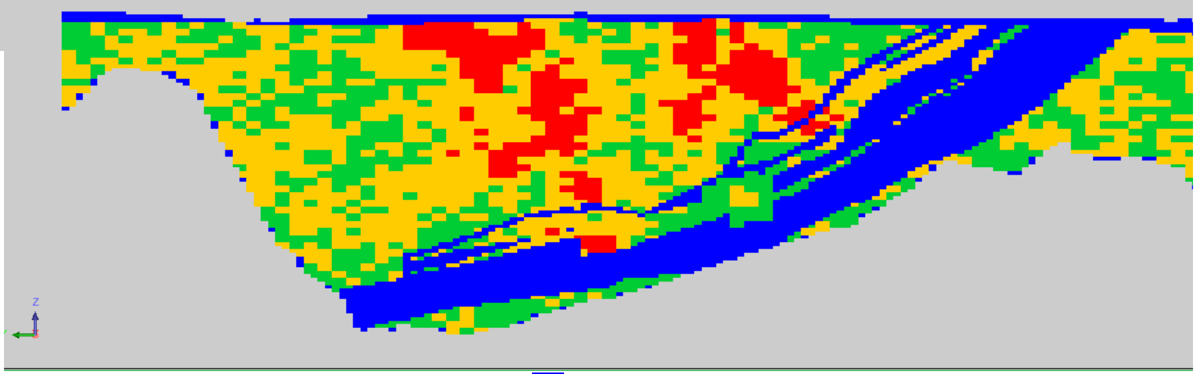
Categorical Simulation

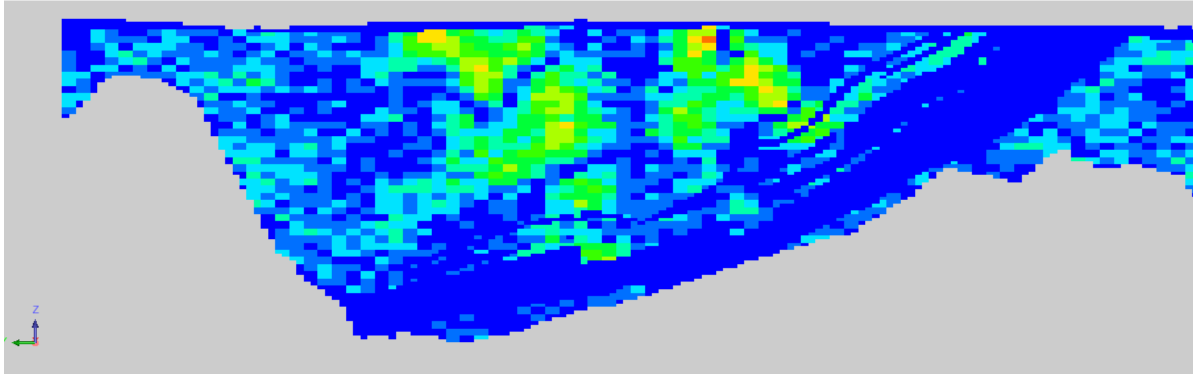


Case Example

Categorical Simulation







Extra Stuff

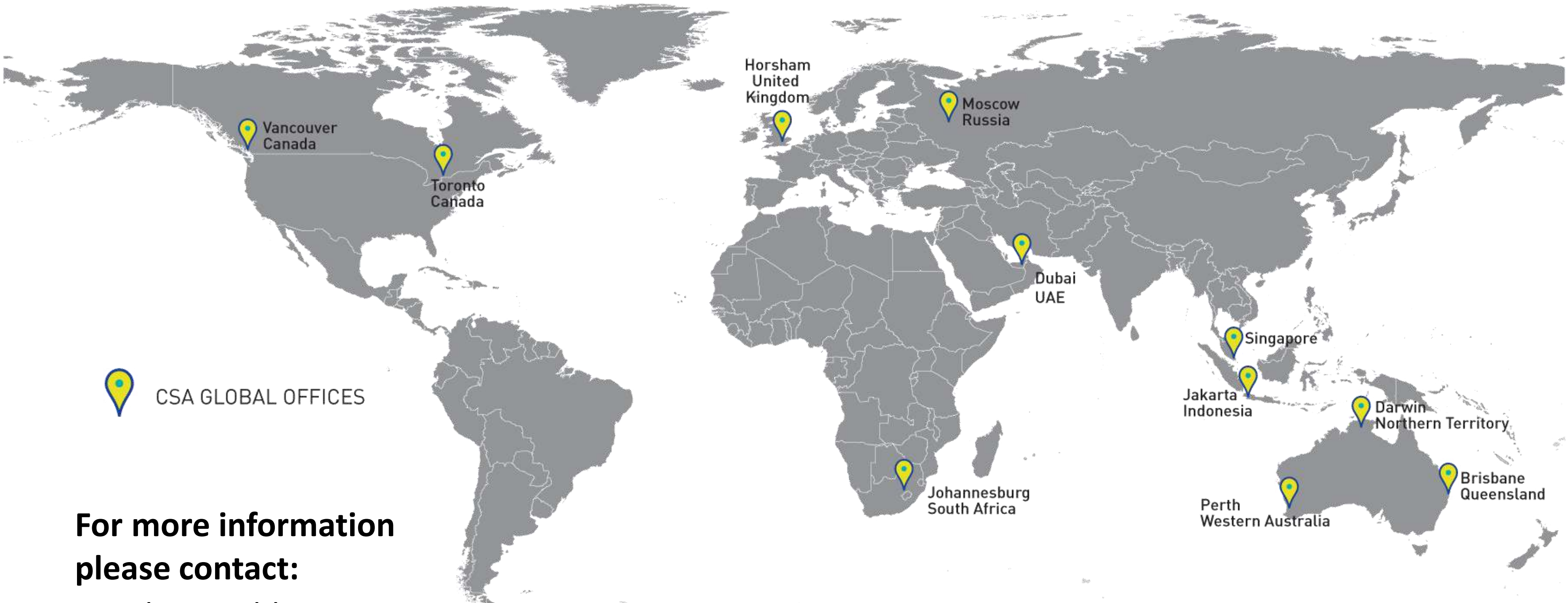
Other possibilities

- Soares Correction
  - Can help make simulation more realistic in comparison to input data
  - Relies on specific assumptions
- Domain modelling / Domain validation
- Accessory element domaining

Review Geology

Summary Thoughts

- Geostatistics not just for Mineral Resource estimation
- Categorical Simulation useful for situations where a project is advanced, but density of data not necessarily appropriate
- Offers not only "an answer" but also highlights areas of uncertainty
- Maximises ability to specifically target follow up work…
- Which minimizes the volume of work potentially required



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