Development of a best-practice mineral resource classification system for the De Beers group of companies

Z*: Sean Duggan, Andy Grills
De Beers: Johann Stiefenhofer, Malcolm Thurston
Overview

1. Classification of diamond deposits
2. Historical & current classification methodologies at De Beers
3. The De Beers mineral resource classification system (MRCS)
Some key characteristics of diamond deposits

• Particulate, generally highly variable and extremely low grade
• Complex in terms of estimation and classification
• Significant variability of parameters associated with estimating diamond deposits
• Representative sampling is difficult & costly
• Revenue estimation is critical - based on SFD & assortment models
• Exhibit high levels of uncertainty compared to other mineral deposits
Grade and Continuity
(modified after King 1983)

High Geological Continuity         Low

Proportion of Mineral

Diamond Placer Deposits
Disseminated Gold
Vein-hosted Gold
Vein-hosted Tin
Volcanic Lead, Zinc
Porphyry copper
Stratiform Lead, Zinc
Iron
Platinum
Coal
Kimberlites

average grade

homogeneity
Classifying diamond deposits

Average grade in ppm for a range of mines for different commodities

- Primary diamond deposits
- Diamond placers
- Au (O/P)
- Au (U/G)
- Ag
- Ni
- Cu
- Zn
- Al
- Mn
- Fe

ppm (log scale)

1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
Diamond deposit types

• Primary kimberlites
  • Pipes
  • Dykes, sills and fissures

• Secondary placers
  • Fluvial
  • Marine (raised beach, shallow & deep water)
  • Aeolian

• Tertiary deposits
  • Stockpiles
  • Tailings Mineral Resources (TMR’s)
Diamond deposits: key classification criteria

- **Geology**: the thinking behind the emplacement or deposition model
- **Grade**: data integrity, estimation methodology, process and validity of results
- **Volume**: 2D or 3D representation of the geological thinking
- **Revenue**: data integrity, SFD and assortment modelling and validity of results
- **Density**: data integrity, estimation methodology and process, and validity of results
De Beers classification pre 2004

• Non-quantitative methods, mostly undertaken by an estimator with input from project geologist(s)
• Diamond sections of JORC/SAMREC codes broadly followed
• Some debate within diamond fraternity, in particular defining and placing a value on the Inferred category (more difficult for diamond deposits to attain an Indicated level of confidence)
• Group Mineral Resource Manager accepted responsibility as the CP
Classification using scorecard

• Definition of the portion of deposit to be classified;
• Five main scorecards
  • geology, grade, volume, revenue & density
• Set of questions grouped into sub categories
  • e.g. data integrity, sample accuracy, estimation methodology
• Allocation of scores to all questions with answers justifying the score
• Reviewed by MRCC
• Ratified by MRCC Chairman
In 2004 De Beers identified the need for a single classification system for all operations.

- Appropriate governance in place
- Semi-quantitative method reflecting the uncertainty, i.e. a scorecard approach
- Classification Committee (MRCC) initiated
- Development of the MRCS
- 2015: Classification by CP utilising Windows based SQL scorecard (MRCS)
• Each year a CP is officially appointed for each operation
• CP for diamond resources and mineral reserves
• MRCC no longer utilised
• The CP uses the MRCS for classification and is responsible for finalising each classification
De Beers current classification methodology

• Preparation phase
  • deciding on the details of the deposit to be classified

• Step 1: Initial classification
  • project geologist: set up classification, complete scorecards

• Step 2: Operational review
  • MRM and peers of project geologist

• Step 3: Independent external review
  • recommendations only

• Step 4: Final approval/ratification
  • CP sign-off
Method of scoring

- Individual score assigned to each of 84 questions
- Assigned scores within each group of questions are averaged
- Average scores added to provide an overall score out of 100

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<tr>
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<th>Geology</th>
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</table>
**Method of scoring**

- **Classification limits were assigned as follows:**
  - 0-30 Deposit (excluded from the mineral resource)
  - 30-70 Inferred Mineral Resource
  - 70-90 Indicated Mineral Resource
  - 90-100 Measured Mineral Resource

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<td>80</td>
<td>90</td>
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</table>
Mineral Resource Classification System (MRCS)

Designed to simplify the process of mineral resource classification and ensure appropriate governance

All data and documents stored on Microsoft SQL Database

Central database and used over the De Beers intranet

Developed by Z* exclusively for De Beers
### De Beers MRCS: hierarchical structure

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>MINE/OPERATION</th>
<th>RESOURCE</th>
<th>GROUP</th>
<th>CLASSIFICATION</th>
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</table>
• Define the geology, e.g. kimberlite, fluvial placer, TMR, etc.
• Define the deposit type: primary, secondary, tertiary
• Upload documents, e.g. geology reports, estimation reports, etc.
• Resource name, date, user etc.
• The option to store and manage classifications according to criteria specified by the user
• Group classifications by year
• Geographical grouping
• Also enables comparative statistical analysis
• MRCS requires a name, a brief description and a dimension (3D or 2D and an option for including co-ordinates)
Creating a Classification

- Selection of appropriate area or volume of the deposit for classification
  - homogenous in terms of geology
  - density of information
  - grade considerations
- Classification name, user name, date, etc.
- Promoting classifications (locking)
- Permissions
Creating a Classification

Image of a classification creation interface with a form for inputting classification details.
Creating a Classification

SAMPLE INTEGRITY
(15 Points)

Question 6
Have accurate positioning surveys been conducted and utilised for each grade sampling technique?

Hint
Accurate locations for grade data is imperative. This applies to both:
(i) the surface coordinates of drillholes (collars), trench excavations or any grade sampling method; and
(ii) the downhole surveys of drillholes (GYRO survey preferred).

Answer
Collar surveyed for Schramm, holes assumed vertical, bulk-sample only per block centroid.

Confidence Level: 10  (Max: 15)
## ORA_K01 RAT North 17 MARCH 2014

### Classification
- **Classification**: ORA_K01 RAT North 17 MARCH 2014
- **Status**: Ratified
- **Locked**: True
- **Date Created**: 18 Mar 2014
- **Date Modified**: 16 Dec 2014
- **Classification Category**: HIGH INFERRED (60 - 69)

### Link Classification

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## Promote Classification

Classification: VEN_K2 600-800m Prelim - Copy

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**Please Note:**
You have 85 Questions that are unanswered.
# MRCS Comparative Analysis

## Companies
- De Beers Consolidated Mines

## Mines
- Cullinan Mine
- Jagersfontein Mine

## Resources
- Select Resources...

## Groups
- Select Groups...

## Date Group
- Post 2014

## Deposit Type
- Primary

## Geology
- Kimberlite
- Aeolian Placer
- Beach Placer
- Dyke
- Deep-Water Marine Placer

## Status
- Ratified

## Card
- Geology

## Category
- Knowledge Techniques

## Question
- Have applicable exploration techniques been utilised?

## Table

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<tr>
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### SUMMARY

**Operation:** Orapa  
**Resource:** A/K1 265 - 550 mbgl (AK/1 South Pipe)  
**Group:** Historical Data  
**Classification:** ORA_K01 RAT 17 MARCH 2014  
**Status:** Ratified  
**Report Date:** 11 May 2016

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Mineral Resource Classification Category: LOW INDICATED

Signed: 

Date:  

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De Beers  
Group of Companies  

Z*STAR
MRCS Performance

- Aims to review recent mining history on a specific operation, reconcile the mining results and re-assess the level of uncertainty associated with the mineral resource.
- Applied to limited volume adjacent to the recent mining.
- Ideally, undertaken every one or two years.
- Change in geology: face mapping, blast-hole chip sampling, field observations, etc.
- RsCR, RvCR, Rv$R
MRCS: Performance

Volume for Upgrade to Indicated based on the Reconciliation

Mined

High Inferred Resource

Waste

Kimberlite

Deposit
MRCS as a predictive tool

• Complete the classification by including assumptions about geology, sampling, estimation, etc.
• For example use MRCS to establish how best to achieve an Indicated level of confidence
• Planning capital projects on an annual basis or longer term
Conclusions

• MRCS is a user-friendly and flexible system and ensures that a robust record of the classification is correctly stored

• The De Beers classification method satisfies the key components of reporting codes
  • transparency, materiality, competence

• The scorecard approach has been applied to successfully produce numerous classifications

• MRCS provides De Beers with a best practice documented and justifiable classification for all types of diamond deposits
Thank You

Our diligence is your peace of mind