# Resource Classification Index

*by Abdullah Arik*

## Introduction

Over the past decades, a number of resource/reserve classification codes have been developed to standardize the classification principles and reporting guidelines in the mineral industry. These codes or principles can be found in the bulletins of different agencies and institutes. The basic concepts of the resource and reserve reporting guidelines revolve mainly around geological assurance, technical factors, and economic viability.

The classification of resources and reserves must conform to the standard codes of reporting. However, the specific classification scheme or practice utilized is up to the practitioner, as long as he or she uses acceptable criteria to satisfy both the regulatory authority and the internal company planning needs.

## Popular Classification Criteria

The two most popular criteria for classifying the resources are the traditional measure of "Distance" to the nearest drill hole and the Geostatistical classification approach based on the distribution of kriging variance.

In its simplest form, the "Distance" classification is based on the distance from the centroid of the block to be interpolated to the nearest sample used in the interpolation. In the kriging variance method, the cumulative probability (cdf) or the histogram of the kriging variance is used to categorize the resources.

## An Alternative Measure for Resource Classification

The existing resource classification methodologies have some advantageous points and they more or less provide the necessary tools for the practitioners to use. Yet they all have one common shortcoming. They fail to incorporate and use all the information or criteria available in the resource classification scheme.

Therefore, a resource classification methodology based on an index is suggested. This index will be referred to as the "Resource Classification Index" and will take into account the local variation, the spatial data configuration around the block being estimated, as well as the traditional distance measures, and any other information that is considered important (Arik 2002).

## Resource Classification Index

The "Resource Classification Index" (RCI) can have several components. Its major component is the "Combined Variance" ($\sigma^2_{cv}$). This variance is a combination of the kriging variance and the variance of the weighted average block value based on the data values used (Arik 1999a). The advantage of this variance is that it is not only a function of the spatial distribution and configuration of data points, but also is a function of the variability of the samples used in the block estimation.

### *Combined Variance*

In an ordinary kriging program, the first component of $\sigma^2_{cv}$, the kriging variance ($\sigma^2_k$), is already computed. We compute the second component of $\sigma^2_{cv}$, the local variance of the weighted average ($\sigma^2_w$) as follows:

$$\sigma^2_w = \Sigma w^2_i * (Z_0 - z_i)^2 \qquad i = 1, n \quad (n>1) \quad \text{[Eq. 1]}$$

where n is the number of data used, $w_i$ are the weights corresponding to each datum, $Z_0$ is the block estimate, and $z_i$ are the data values. If there is only one datum, $\sigma^2_w$ is set to $\sigma^2_k$.

The Combined Variance ($\sigma^2_{cv}$) is then calculated as follows (Arik 1999b):

$$\sigma^2_{cv} = \sqrt{(\sigma^2_k * \sigma^2_w)} \qquad \text{[Eq. 2]}$$

### *Resource Classification Index*

To classify the resources into measured, indicated, and inferred categories, the use of a Resource Classification Index (RCI) is suggested as follows:

$$RCI = \sqrt{(\sigma_{cv} / m_k)} * C \qquad (m_k > 0) \qquad \text{[Eq. 3]}$$

where $\sigma_{cv}$ is the square root of the Combined Variance, $m_k$ is the block grade computed from kriging, and C is a calibration factor.

The Calibration Factor (C) depends on which criteria we would like to include in the computation of the Resource Classification Index. Each component of this factor is optional, and other components can be added, as appropriate. The following Calibration Factor (C) is only a suggestion:

$$C = \exp^d / (\exp^n * \exp^q * \exp^t) \qquad \text{[Eq. 4]}$$

The superscripts of the exponents in the above equation are as follows:

d = Dist/Dismax

n = Nused/Nmax

q = Nquad/4 or Noctant/8

t = Nddh/Nused

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These variables are explained in detail in, *Arik, 2002*. The advantage of the calibration factor is that it could be modified and customized for each deposit depending on the weight that must be given to certain measures.

## Application to a Gold Deposit

A study was performed on a gold deposit. A minimum of 3 and a maximum of 16 composites were used for the interpolation of the blocks with 3 maximum composites from each individual drill hole. Furthermore, a quadrant search was applied with maximum of 4 composites per quadrant.

During the kriging interpolation, the kriged grade (AUK), standard deviation of kriging variance (KSTD), and standard deviation of Combined Variance (CSTD) were computed and stored in each block. The number of composites used for the blocks (NUSED), the distance to the nearest composite (DIST), and the number of quadrants with data (NQUAD) were also stored into the model blocks.

### *Classifications Based on DIST and KSTD Variables*

In this deposit, 50 and 90 feet were used to classify the resources into Measured, Indicated, and Inferred categories. Based on DIST, cdf calculated using the values from the model, these values correspond approximately to 50 and 95 percentiles.

Similarly for kriging variance, the KSTD values corresponding to the 50 and 95 percentiles were determined using KSTD cdf and used for the classification purposes.

### *Classification Based on RCI Variable*

The Resource Classification Index was computed for each block using a Calibration factor, C, as follows:

$$C = \exp^{d} / (\exp^{n} * \exp^{q}) \qquad \text{[Eq. 5]}$$

In this equation, d = Dist/50, n=Nused/16, and q=Nquad/4 were used. In order to classify the resources based on the Resource Classification Index, the RCI values corresponding to the 50 and 95 percentiles were determined.

## Review of the Results

Table 1 summarizes the "Measured+Indicated" resources classified at 0.01 gold cutoff based on three different criteria used in this study. The table reports the tonnage and the average grade of blocks from each methodology. For purposes of comparison, it also reports the average distance to the closest composite, the average number of composites used in the interpolation (NCOMP), and the average standard deviation of kriging variance (KSTD).

Since the Measured, Indicated and Inferred categories are based on the 50 and 95 percentiles, the tonnages in each category from different methodologies had to be the same. However, as a result of not being able to pick the 50 and 95 percentiles precisely, there are some small tonnage differences. These differences will be ignored in the comparison of the results since they are not critical.

Figures 1, 2, and 3 display the plan views of resource categories based on DIST, KSTD, and RCI variables, respectively, on a portion of 4280 bench. This particular portion of the bench has relatively high-grade gold intercepts, but no outliers. Through the visual comparisons, one can see that the views from DIST and RCI variables are similar to each other with some exceptions. The Measured category blocks in RCI classification are more continuous whereas DIST classification resulted in choppiness as the drilling density increased. KSTD classification, on the other hand, gives a different view, with most of the blocks included in the Indicated category.

Since we used a Calibration Factor in our RCI calculation to give more weight to the DIST variable, obtaining comparable results to the DIST classification method in the "Measured+Indicated" category was not surprising. However, knowing to have incorporated all the variables of interest in our classification scheme and then come up with sensible results was reassuring. That is one of the obvious strengths of the RCI approach.

*Table 1 Measured+Indicated resources at a 0.01 cutoff using three different methods.*

| Method | K-Tons | Ave. Grade | Ave. Distance | Ave. NCOMP | Ave. KSTD |
|---|---|---|---|---|---|
| DIST | 253,744 | .0262 | 47.09 | 9.13 | .0371 |
| KSTD | 253,421 | .0259 | 48.62 | 9.06 | .0358 |
| RCI | 253,628 | .0265 | 47.23 | 9.19 | .0368 |

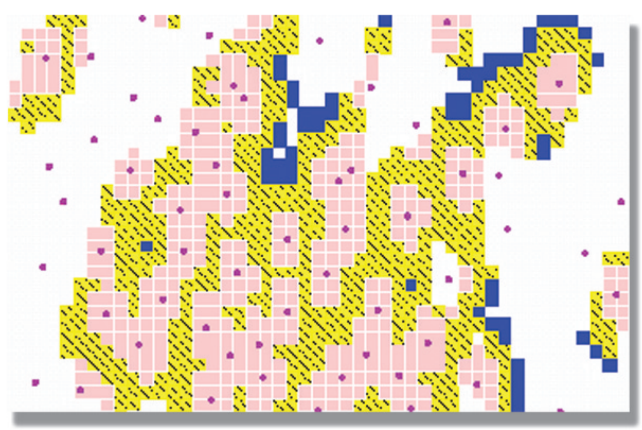

*Fig. 1 Resource categories at a 0.01 cutoff using DIST variable on Bench 4280.*

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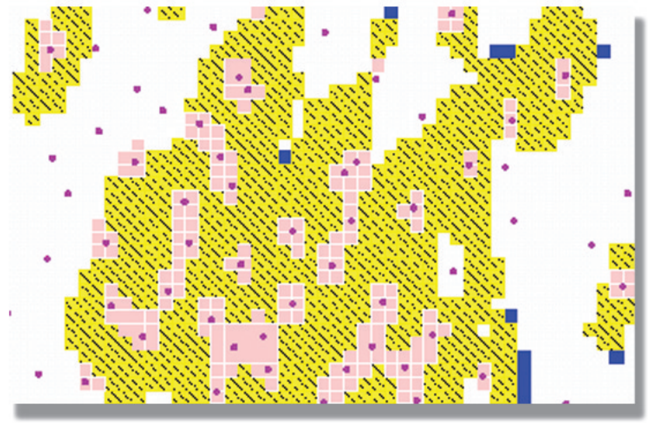

*Fig. 2 Resource categories at a 0.01 cutoff using KSTD variable on Bench 4280.*

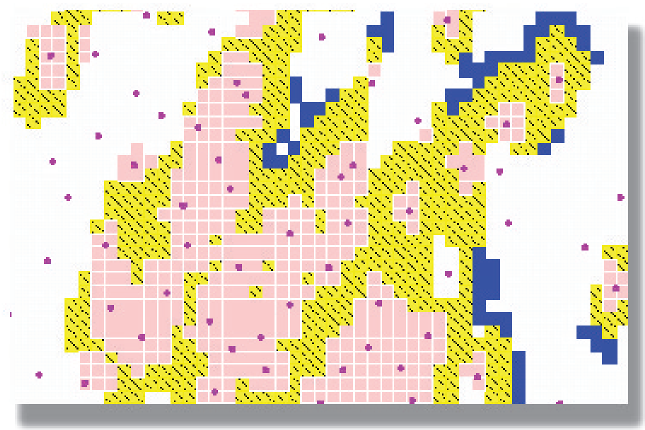

*Fig. 3 Resource categories at a 0.01 cutoff using RCI variable on Bench 4280.*

Legend for Figs. 1-3:
- Pink blocks – Measured Ore
- Dashed Yellow blocks – Indicated Ore
- Blue blocks – Inferred Ore
- White blocks – Below 0.01 Cutoff
- Big dots – Drillhole intercepts

## Conclusions

The Resource Classification Index (RCI) can be an effective tool for classifying resources or reserves into specific categories for reporting. The main advantage of this index is that it combines several desirable classification measures into one. Furthermore, with the use of a customized Calibration Factor, it can be practically suited to different deposits.

Another nice property of RCI is that, like the coefficient of variation that can be used to compare different distributions, it can be helpful to compare the estimations in different parts of the deposit. Generally, relatively high RCI values in parts of the deposit are an indication of insufficient drilling, the presence of high local variations, or the existence of marginal ore. Furthermore, the distribution of the calculated Combined Variance in the deposit is extremely useful to study in itself even if the Resource Classification Index is not used.

## References

Arik, A., 1999a, “An Alternative Approach to Resource Classification,” APCOM Proceedings, Computer Applications in the Mineral Industries, Colorado School of Mines, pp. 45-53.

Arik, A., 1999b, “Uncertainty, Confidence Intervals and Resource Categorization: A Combined Variance Approach,” Proceedings, ISGSM Symposium, Perth, Australia.

Arik, A., 2002, “Comparison of Resource Classification Methodologies With a New Approach,” APCOM Proceedings, Computer Applications in the Mineral Industries, Phoenix, pp. 57-64.

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