PINCOCK Perspectives

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CALENDAR

- ***Mineral Exploration Roundup 2007***
  January 29 – February 1, 2007
  The Westin Bayshore
  Vancouver, B.C., Canada
  e-mail: roundup@amebc.ca

- ***Mining Investment 07 - Indaba***
  February 6 – 8, 2007
  Cape Town International Convention Centre
  Cape Town, South Africa
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- ***Austmine 2007 Conference and Exhibition***
  February 12 – 13, 2007
  Burswood Entertainment Complex
  Perth, WA, Australia
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- ***2007 SME Annual Meeting and Exhibit***
  February 25 – 28, 2007
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- ***Asia Mining Congress 2007***
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  Grand Hyatt
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  e-mail: joan.ong@terrapinn.com

- ***Mining World Russia 2007***
  April 25 – 27, 2007
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Does This Geologic Resource Model Make Any Sense?

Introduction

Computerized geologic resource modeling is a specialized skill, which is part science, part art, and at times complete garbage. This is a dangerous combination. The errors of a faulty model will propagate all the way through the economic analysis of a mining operation, straight to the bottom line. Therefore, geologists, engineers, metallurgists, investors, CFOs, CEOs, and all the rest have a vested interest in resource modeling. Ideally each of these individuals would have sufficient skills to look over a given model and be able to answer the question: Is this reasonable? Yet, too often the only one who has looked over the resource model is the same person who created it. When editing the text of a report, a fresh set of eyes can spot typos and other blunders a lot better than the author and the same is true for modeling. This article is designed as a guide for conducting reality checks on geologic resource models. While this is not a playbook for a detailed audit, it will arm the reader with tips on spotting gross errors.

Before beginning a review of a geologic resource model, we should first have a basic understanding of how these types of models are constructed and of their purpose. A resource model is an interpretation of the location, size, shape, and grade of a deposit and the surrounding waste material. This interpretation is based on information derived from drill holes such as geologic contacts, rock types, structures, assays, geophysical logs, and density measurements. The modeler, who starts with an empty chunk of three dimensional (3-D) space on the computer screen, will bring this drill hole information into that space just as it exists in the real world. The modeler will then begin to divide the 3-D space into zones representing different rock types, different zones of mineralization, or perhaps the hanging wall and footwall of a fault. Additionally, topographic data will be used to divide the 3-D space into an above ground (air) zone and a below ground (rock) zone. The boundaries of these zones are typically 3-D wireframe surfaces and solids or a series of polylines. At this point the location, size, and shape of the deposit are loosely defined. To refine these and determine grade it will be necessary to develop a block model.

When developing a block model, the modeler will take the same 3-D space he has been working with and divide it into a matrix of small blocks usually of equal size. These blocks will hold bits of information about the small portion of 3-D space it encompasses. This information should include the type of rock, the average density, grade, and resource classification (measured, indicated, or inferred). There are different ways for determining what value a block will hold. For instance, the rock type of a block might be assigned based on the zone it falls in from the previous wireframe work. Block values such as grade are typically assigned based on some weighted averaging scheme using the surrounding drill hole grade values.

Block sizes vary from model to model. To give the reader a point of reference, a typical block size is about 25 percent of the average drill hole spacing for the X and Y dimensions, and equal to the projected mine bench height for the Z direction. For example, if a given deposit was drilled on 100 meter centers and the general idea was to open pit mine the deposit using 10 meter benches, the block size used for modeling would be 25 by 25 by 10 meters in the X, Y, and Z dimensions, respectively. Again this is just a general rule of thumb, not stone cold fact.

Conducting the Review

Again, geologic resource modeling is a specialized skill. It should be noted that a great deal of that specialization is a simple matter of software know-how. The modeling packages available today are powerful, versatile, and inherently complex. Just importing drill hole data can be a daunting task. The good news is that this software know-how is not a prerequisite for validating model results. The tools one needs to conduct the type of reality checks that are the subject of this article are the model documentation detailing the modeling methods and, if not already included in the documentation, a few sections through different parts of the model and some basic statistics of the values in the block model and those in the drill holes.

Sections

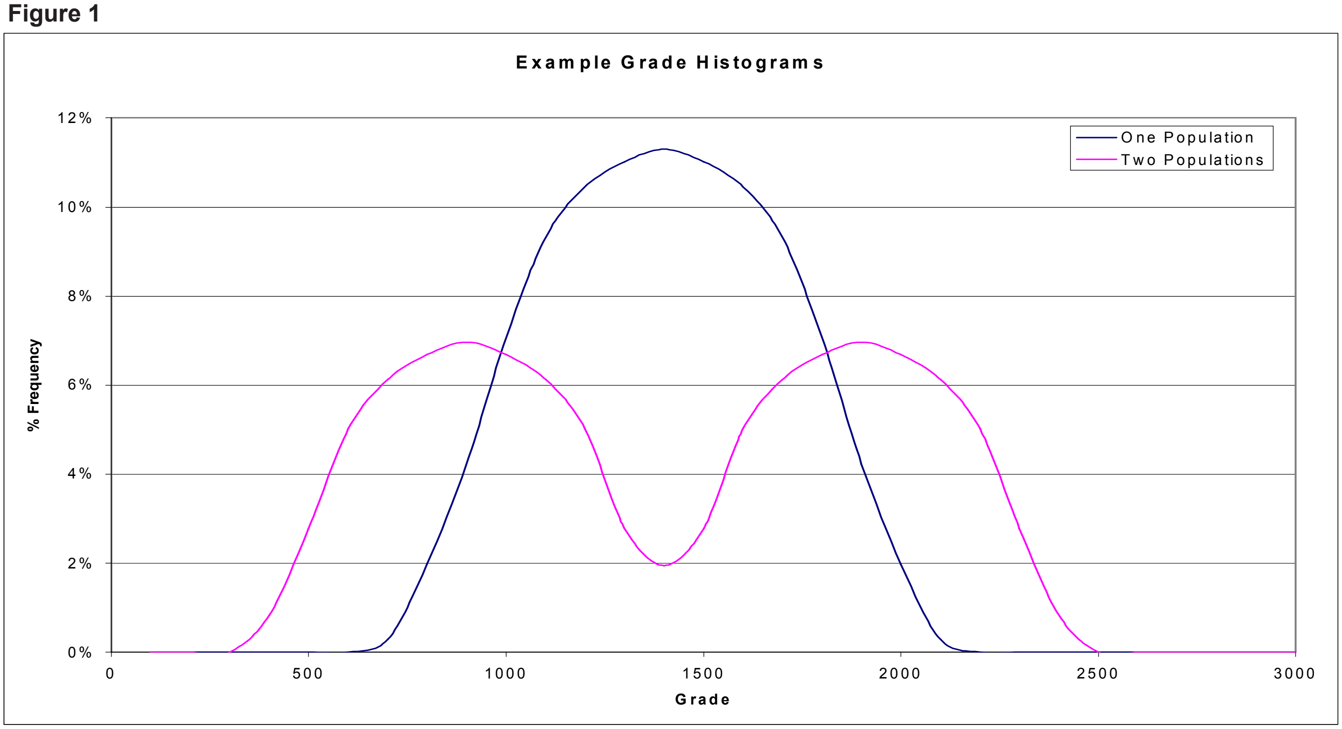
Sections are narrow slices of the model space. While they can be generated in any orientation, vertical and horizontal are the most common. For our purposes, these sections should display drill hole locations, color coded drill hole and block values (such as grade, density, and rock type), and lines indicating the location of important boundaries (such as geologic contacts and topography). When comparing block values and drill hole values, it is best to have a separate set of sections for each value. Trying to compare block grades against drill hole grades on a section that also includes densities and rock types can get confusing.

While studying sections, ask the following questions:

1) *Do the drill hole collars match-up with the topography?*

   It is a simple question, but one that could expose a serious problem in the model. If the collars and topography aren't matching, it

Figure 1



might indicate a busted survey or an error in importing the data. Either way the spatial integrity of all data and results are in question. Here are three legitimate reasons the answer to this question might be no: a) the hole was drilled from existing underground workings, b) between the time the hole was drilled and the time of the topographic survey the ground was disturbed, and c) the terrain is very steep and the hole is far enough from the section centerline that it appears the collar elevation is in error.

2) *Do the air blocks have appropriate values?*

All blocks above topography are air blocks. Air blocks should have densities of zero for obvious reasons. The same is true for the grade values of air blocks. One can make the argument that an air block with a positive grade value is not a problem as long as the density of that block is zero. Such a block would not contribute to the tonnage and grade of the resource estimate due to this zero density value. However, interpolating grade into the air is not common practice and may indicate that block grade interpolation did not occur as intended.

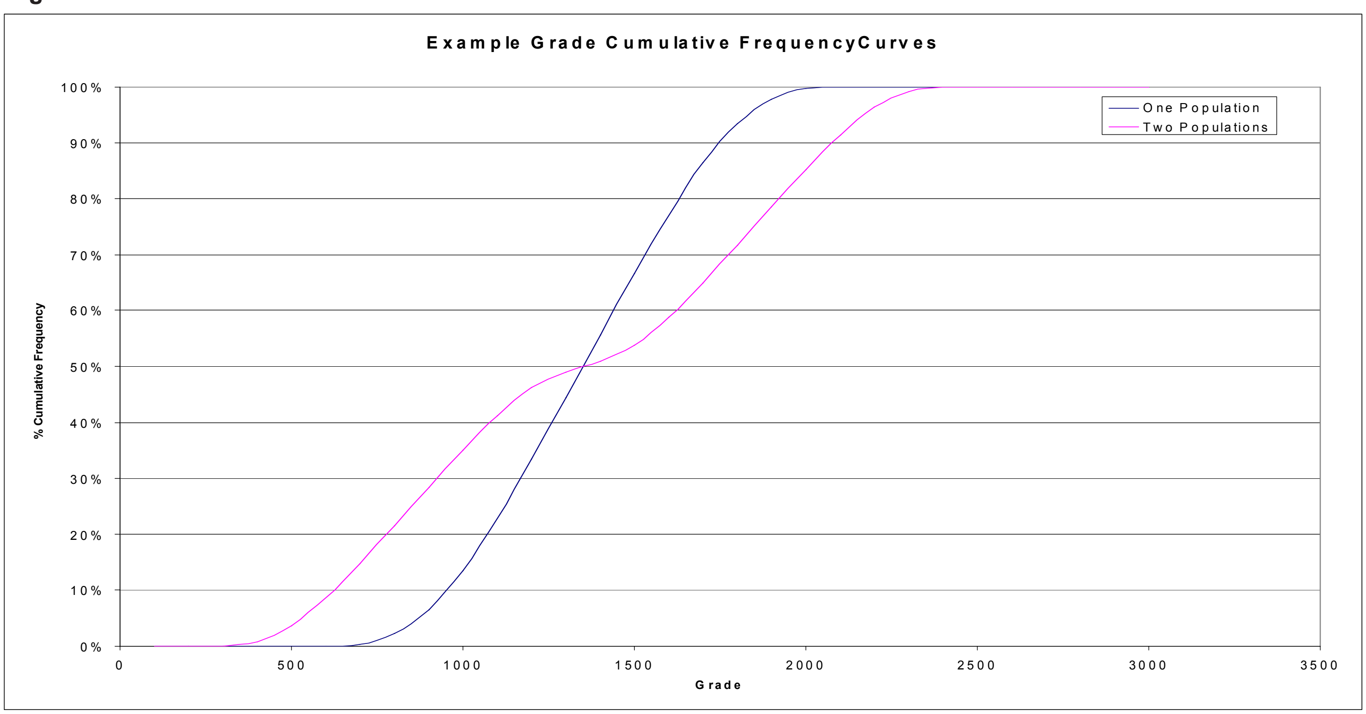
3) *Do all blocks below the topography have a density greater than zero?*

A block without density will not contribute tonnes or grade to a resource estimate. Just as important, such a block will not contribute to the mining cost during the pit optimization analyses to be conducted down stream. It is not uncommon to see block models where only blocks that received a grade value also received a density value as well. However, this is a problem when it comes time to determine the economic viability of the deposit where knowing the total tonnes of waste to be moved is as important as knowing the total tonnes of ore to be recovered.

4) *How far does grade extend from the drill holes?*

This question brings us to a slippery slope that could lead into the shadowy world of geostatistics. While such discussions are necessary for a detailed audit, they are beyond the scope of this article. Instead, observe the distance between a block with an interpolated grade value and the nearest drill holes. This distance should be less than or equal to the maximum search distances cited in the model documentation. This exercise is simply to help verify that grade interpolation has followed the plan.

Figure 2



5) *Do the block values fairly represent the drill hole values?*

This is where having blocks and drill hole intervals color coded based on value is really helpful. If a drill hole encounters a layer of limestone, the surrounding blocks should have been assigned the limestone rock type. If a drill hole encounters a low grade zone, the surrounding blocks should have similar low grade values. The same goes for density.

Basic Statistics

Comparing block grades against drill hole grades in section, as described above, is an important qualitative check. To get a more quantitative comparison we must delve into some statistics. This analysis focuses on the means and the overall shapes (as displayed on a histogram or cumulative frequency curve) of the block grade distribution and the drill hole grade distribution.

When dealing with drill hole grade distributions, you may encounter the term "declustered". It is often true that exploration drilling programs sink fewer holes in low grade areas of a deposit than in the high grade areas. As a result, basic stats run on the assays from these holes will be biased towards higher grades. Geostatistics offers a method for mitigating this affect. This method is called declustering. If statistics for the declustered drill hole data are available, use those. If not, take a second look at some of the sections to see if the drill hole spacing in some areas is denser than others. You may be able to get away with using the unaltered drill hole statistics if the holes are generally evenly spaced. Otherwise, this comparison will yield misleading results.

While comparing the drill hole grade statistics with the block grade statistics, ask the following questions:

1) *Are the means close to the same value?*

They should be. Just how close is a difficult question to answer especially if the distributions are highly skewed. Keep an eye out for anything absurd.

2) *Do the distributions have similarly shaped histograms/cumulative frequency curves?*

While never identical, the general shape of the block grade distribution should reflect that of the drill holes. Some deposits may show multiple populations within their drill hole grade data. On a histogram this will present itself as two or more peaks rather than one. Instead of a smooth cumulative frequency curve, multiple populations will cause the curve to deflect. See Figure 1 for examples of this. If multiple populations exist in the drill hole data, expect to see them in the blocks as well.

Note: Blocks sizes are usually a lot larger than sample sizes. As a result, the spread of the block grade distribution will be tighter than that of the drill hole grades (Tip: impress your friends by referring to this as the Volume-Variance Relationship). For block grade distributions, expect to see narrower peaks on the histograms and steeper slopes on the cumulative frequency curves.

Summary

Generating geologic resource models is not an easy task. Wrestling with huge amounts of data, making sense of geostatistics, and just getting the software to behave as intended can play havoc on a modeler's ability to think clearly. Consequently, there is a great deal of value in having a fresh set of eyes look over the model results seeking evidence of gross errors. Fortunately, one does not need to possess any specialized skills to determine if the model results are reasonable. Certainly full technical audits are important. Yet, armed with a few sections, some basic statistics, and a little common sense, anyone can spot a major modeling blunder.

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