Digger for Open Pit Grade Control

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Digger is a computer program written in "C" for the design of optimum dig lines constrained by a minimum mining width for open pit grade control. The dig lines are optimum in the sense that the objective is to maximize profit for a given minimum mining width. For example, given a map of ore types at the resolution of individual ore control model (OCM) blocks, an optimum set of dig lines minimizes the misclassification of individual OCM blocks by the dig line polygons, and thereby maximizes profit. Note that the dig line designs provided by Digger are actually minable – that is, their design is constrained by a minimum mining width (MMW).

Why Digger?

- Revenue Increase
  Dig line misclassification errors are usually very costly. For example, given 35 dollar rock, the loss of a single 600 tonne OCM block sent to the dump exceeds 20 thousand dollars. Similarly waste blocks may be classified as mill feed and so on. In fact, given N ore types in a single blast, the number of possible misclassification types is N^2-N. For example, given 4 ore types, there are 12 different ways blocks may be misclassified by dig lines in a single blast. And the bad news is that none of these misclassification errors cancel one another. The total dollars lost simply accumulate with each misclassified block. For instance, at 35 dollar rock the dollars lost by a dozen or more 600 tonne mill feed blocks located within a few waste dig line polygons exceeds a quarter million dollars! Over the course of a single year, misclassification losses may exceed several million dollars! Digger minimizes these losses.

  Digger is currently being used by Newmont Mining Corp, Barrick Gold, Freeport McMoRan, MMG, and IAM Gold. Test cases and demonstrations at these properties show in situ net revenue increases ranging between 2% and 7%.

Comments from Industry

"*We implemented Digger in 2008 and it has been an integral part of our operation since. The added efficiency and confidence in ore delineation Digger offers has helped us remain productive in a challenging mining environment. We are excited to see what benefits will emerge from Digger 2015*". Senior Mine Geologist, Bald Mountain, Barrick Gold Corporation.

Digger Features

- Constrained Optimization
  Digger seeks to design dig lines that minimize the dollar loss associated with the dig line misclassification of ore types for a given minimum mining width. For example, equation (1) illustrates a simple loss function for calculating the cost of misclassifying a single tonne of ore.

$$\$_{\text{Loss}} = (\$_m * Z_i * R_i - C_i) - (\$_m * Z_i * R_j - C_j) \quad (1)$$

where:
$\$_m$ = metal price in dollars
Z_i = an OCM block with grade Z and ore type "i".
R_i = the recovery rate for recovery process "i".
R_j = the recovery rate for recovery process "j".
C_i = mining and processing costs per tonne for recovery process "i".
C_j = mining and processing costs per tonne for recovery process "j".
"i" and "j" denote ore type and corresponding recovery process.

Dig lines designed by Digger minimize the dollar loss given by equation (1) for a given MMW constraint thereby maximizing the potential net revenue of material available for mining.

- Deposit Customization
  No two ore deposits are the same. For example, ore type definitions vary from one deposit to another. However, given metallurgical and mineralogical constraints, ore type definitions, cutoff grades, costs and other information relevant to the definition of ore types, Digger can be customized to work with any deposit. Digger has been successfully implemented in deposits with as many as 7 ore types including waste, but if necessary, Digger can be configured to work with more than 7.
  For day to day use, user input includes variables such as ore type names, cutoff grades, ore type recovery functions, target tonnage, metal price, OCM block size, MMW, digging direction, specific gravity and other variables as required.

- Minimum Mining Width
  Digger enables one to quickly evaluate various MMWs and cutoff grades. The benefits of different MMWs or cutoff grades can be evaluated in a few minutes enabling the selection of a dig line set that best satisfies current short term mine plan targets or changes in the local patterns of mineral continuity as mining progresses through the deposit. This is not possible with manually designed dig lines. The numerous calculations required within a few seconds are too complex for manual design. Figures 1, 2, and 3 illustrate three sets of dig lines constrained by different minimum mining widths. The grey blocks around the border of Figures 1, 2, and 3 are fringe blocks. They do away with dig line discontinuities at the edge of the current blast but are not part of the current blast.

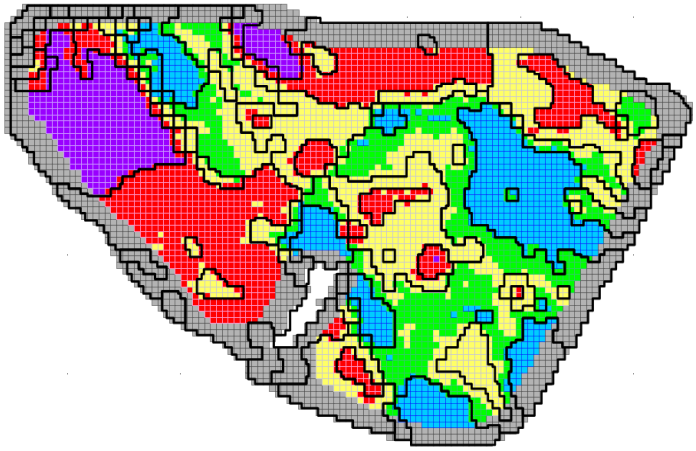

Figure 1: Minimum mining width is 2 blocks

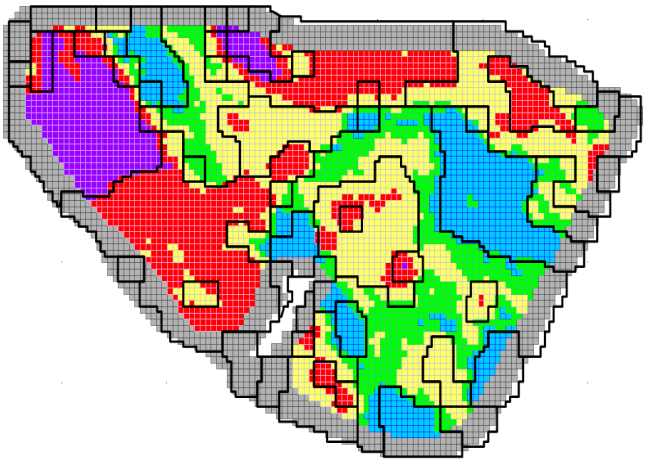

Figure 2: Minimum mining width is 4 blocks

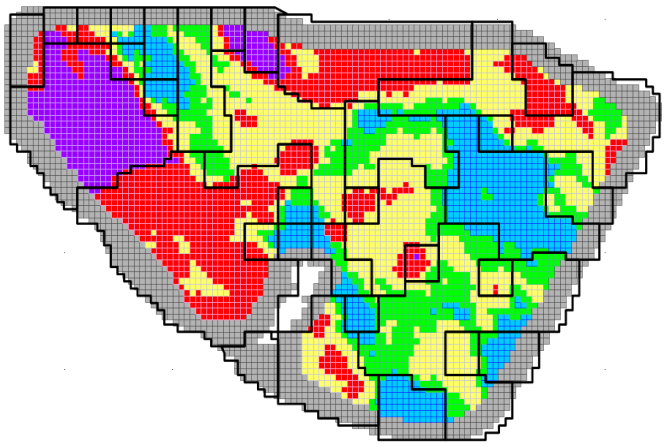

Figure 3: Minimum mining width is 6 blocks

- Digging Direction
  The benefits of various digging directions are also easily determined in a few minutes. This feature may be particularly useful where linear patterns of mineralization are incongruent with the X and Y axes of the local coordinate system or where the digging direction is constrained by a mine plan or pit design such as the orientation of a pit bench. Figures 4 and 5 illustrate dig line designs for two different digging directions.

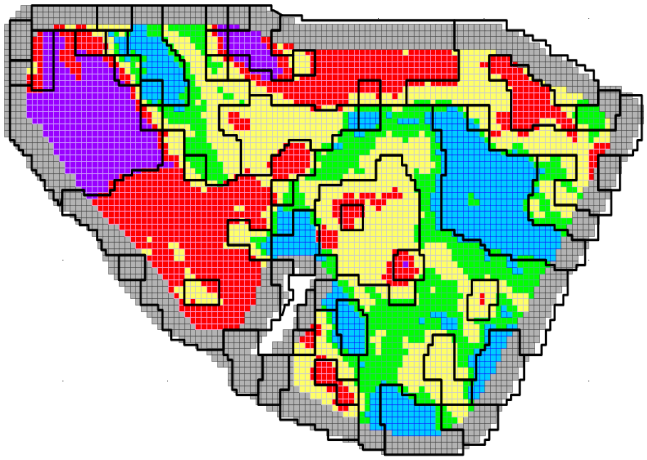

Figure 4: Digging Azimuth = 360 degrees. MMW = 4 blocks

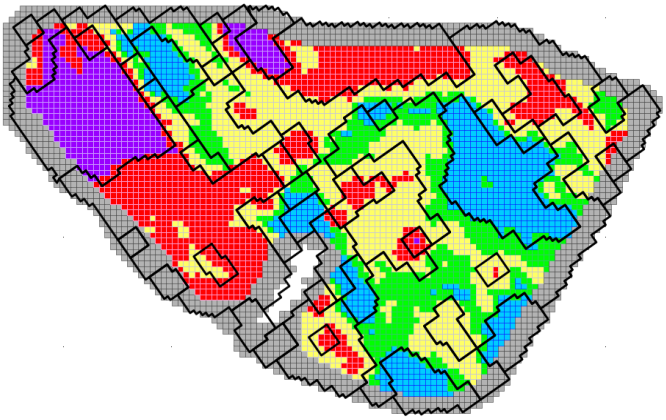

Figure 5: Digging Azimuth = 325 degrees. MMW = 4 blocks

- Target Tonnages
  One of the unique features of Digger is "Target Tonnage". This feature is useful where the mine must deliver sufficient mill feed tonnage from the current short term mine plan to insure the mill will have adequate tonnages of material to process each day. To use this feature, one simply specifies the required "Target Tonnage" in the input control file. If the initial set of dig lines designed by Digger contains fewer mill feed tonnes than the Target Tonnage, Digger will iteratively redesign the dig lines until the mill feed target tonnage is met. Digger accomplishes this by including OCM blocks from other ore types within the mill feed dig line polygons. Only the highest grade blocks are selected from other ore types and re-classified as mill feed. Thus, the final dig line design together with temporary stock piles, enable the short term mine planners to schedule sufficient material to meet the daily mill feed requirement at the highest possible grade.

- Immediate Summaries
  Digger provides immediate summaries for each dig line design as an aid to evaluate various design options. For example, dig line designs constrained by various minimum mining widths and/or digging directions can be computed in a matter of minutes. Comparative statistics for each design include:
  - Minimum mining width
  - Digging direction
  - Dig line tonnes and grade for each ore type
  - The percentage of each misclassified ore type within the dig line polygons.
  - Total in situ net revenue of minable material.

- Simplicity
  Digger is a very easy program to use. Simply provide Digger with a BlastID, a minimum mining width, and a digging direction, select the "RUN" button and you will have a set of optimized dig lines in probably less than two minutes.

  Digger works with MineSight, Vulcan, and Gems through Python scripts. Python takes care of downloading the subset of the ore control block model for processing and the uploading of the optimized dig lines into your ore control module whether it be Minesight, Vulcan, or Gems. This approach insures the grade control engineer has control over the final dig line design sent to the mine. If your grade control software is something other than MineSight, Vulcan or Gems, Digger can likely be made to work with it as well.

  Imagine increasing the bottom line by thousands of dollars with a simple "mouse click". You can have all of this without additional samples, equipment, or personnel – just a simple computer program. Call 650-369-7069 or send email to ed@isaaks.com