



Two Dimension (2D) Estimation and Application of Accumulations

Introduction

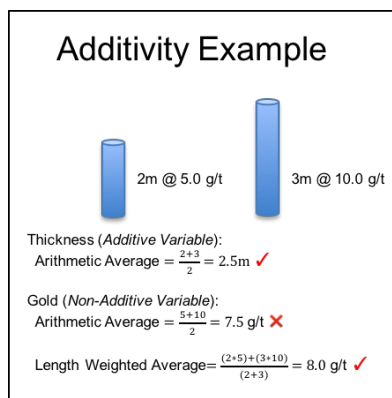
Selecting an appropriate estimation methodology for a mineral deposit is not an arbitrary decision. This decision should be based on the geological and mineralisation characteristics, as well as the envisaged mining methodology. Narrow lode deposits are generally tabular in form, with the strike and down dip continuity significantly larger than the across strike continuity. Narrow lode deposits are often sampled on geological intervals of varying length or support, which is problematic if the deposit is being estimated with three-dimensional (3D) estimation techniques.

Two-dimensional (2D) geostatistical estimation techniques are well suited to narrow lode deposits where no mining selectivity is possible across the width of the lode. 2D methods account for the different sample lengths/supports by estimating an 'accumulation' variable, which is defined as the product of the measured grade and the thickness of the lode. The final estimated grade is defined as the ratio between the estimated accumulation and the estimated thickness.

2D estimation techniques may not be optimal for all narrow lode deposits and are dependent on the sample support, relationship between grade and thickness/density, envisaged mining selectivity and experience of the resource geologist. In order to decide whether or not 2D estimation is suitable for your deposit, the important concept of 'additivity' first needs to be understood.

Additivity

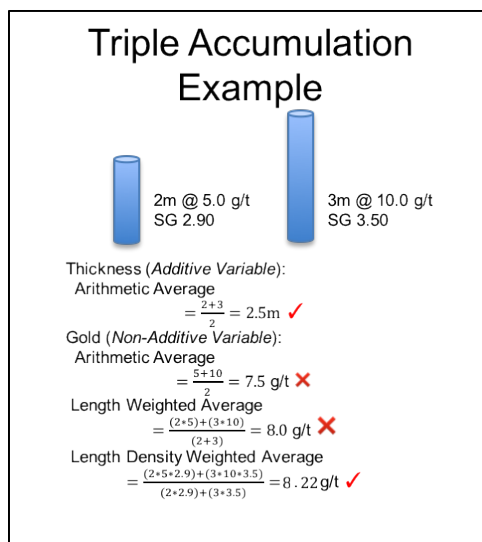
The additivity of a variable is best illustrated with a simple example. Here we have two drill intercepts that have sampled a narrow lode for gold grade:



Here we can see that the arithmetic mean of the gold grade is not the correct measure of the average grade in the volume represented by the two samples. The grades must be weighted by the length of the

intercepts in order to ensure they are additive. Essentially, this amounts to a volume-weighting of the grades to produce a proxy for metal content in each sample.

In some instances, variable density will also make a grade variable non-additive, since units of grade measurement typically involve expressing the amount of metal per unit of mass (eg. g/t, wt% etc.). In such a case the grade should be weighted not only by the length/thickness (ie. volume) but by the product of thickness and density (ie. tonnage):



The product of grade and thickness (and density) is additive and is called an accumulation variable.

$$accum(x) = grade(x) * thickness(x)$$

OR

$$accum(x) = grade(x) * thickness(x) * density(x)$$

Block Grade Estimation

The accumulation variable is typically interpolated into blocks using Ordinary Kriging (OK), as is the thickness or the density weighted thickness. Both variables are estimated using the same interpolation parameters in order to ensure consistency. The intercepts are projected onto a suitable 2D plane for the estimation. A final block grade is back-calculated by dividing the estimated accumulation by the estimated thickness or density weighted thickness as follows:

$$\text{Block Grade} = \frac{[\text{grade}(x) * \text{thickness}(x) * \text{density}(x)]^{OK}}{[\text{thickness}(x) * \text{density}(x)]^{OK}}$$

OR

$$\text{Block Grade} = \frac{[\text{grade}(x) * \text{thickness}(x) * \text{density}(x)]^{OK}}{[\text{thickness}(x) * \text{density}(x)]^{OK}}$$

An estimate for density can also be undertaken:

$$\text{Block Density} = \frac{[\text{thickness}(x) * \text{density}(x)]^{OK}}{[\text{thickness}(x)]^{OK}}$$

Advantages of the 2D Accumulation Methodology

The 2D estimation methodology offers a number of significant advantages over 3D methods in many narrow lode deposits:

- A single composite is created across the lode eliminating the problem of determining an appropriate downhole composite length;
- Simplifies undulating reef geometry onto a 2D plane allowing improved directional variography and simplified search strategies;
- Estimation block size can be chosen independently from volume model requirements. Estimation block sizes can be tailored on the basis of data spacing rather than compromising the estimation block size due to volume definition requirements. This reduces over-smoothing and conditional bias introduced by estimating into small blocks relative to data spacing (Vann, 2003);
- Longitudinal presentations of modelled reef attributes such as grade, thickness and reef attitude, can assist with resource classification and engineering design. Calculated fields such as grade x thickness x \$ can be easily presented and reported.
- Mining parameters such as variable dilution and minimum mining widths are easily applied.
- Models estimated using a 2D projection approach can be transferred back into a 3D real world environment upon completion.

Cube's Experience and Capabilities

Cube Consulting has extensive experience and skills in geostatistical estimation; Cube's geostatisticians frequently apply the 2D methods described here to suitable narrow lode deposits.

Further Reading

- Armstrong, M. 1998, Basic Linear Geostatistics.
- Bertoli, O., M. Job, J. Vann, and S. Dunham, 2003, Two-Dimensional Geostatistical Methods—Theory, Practice and a Case Study from the 1A Shoot Nickel Deposit, Leinster, Western Australia: 5th International Mining Geology Conference.
- Vann, J., S. Jackson, and O. Bertoli, 2003, Quantitative kriging neighbourhood analysis for the mining geologist—a description of the method with worked case examples: Proceedings Fifth International Mine Geology Conference.

Additional information can be found in the following:

- Coupland, T., D. Sims, V. Singh, R. Benton, D. Wardiman, and T. Carr, 2009, Understanding Geological Variability and Quantifying Resource Risk at the Kencana Underground Gold Mine, Indonesia, in : 18 p. p. 1–18.
- DAGBERT, M., 2001, Comments on “The Estimation of Mineralized Veins: A Comparative Study of Direct and Indirect Approaches,” by D. Marcotte and A. Boucher: Exploration and Mining Geology.
- Fowler, A., and C. Davis, 2011, Quantifying uncertainty in a narrow Vein deposit – An Example from the Augusta Au-Sb Mine in central Victoria, Australia: 8th International Mining Geology Conference, p. 307–318.
- Journel, A., J. 1978 Mining Geostatitics.
- Roy, D., S. D. Butt, and P. K. Frempong, n.d., Geology and Geostatistical resource estimation for the Poura narrow-vein gold deposit: CIM Bulletin.