Geostatistics or voodoo science?

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Guest Column

The objective of mineral exploration is to find ore deposits, and to estimate grades and contents in an unbiased manner and with a reliable, realistic and affordable degree of precision. The term "unbiased" implies that the estimated grade and content of an ore deposit are statistically identical to its unknown true grade and content. A bias or systematic error in the measurement chain distorts the metal grade and content of an ore deposit.

Kriged variances are mathematically invalid and are useless for porphyry deposits, meaningless for stratabound deposits and even dangerous for gold deposits.

Author M. David cautions that his book, "Geostatistical Ore Reserve Estimation," is not for professional statisticians and correctly predicts that they will find many unqualified statements.

Kriging attempts to make a few drill holes go a long way. It creates ore grade values in domains where grades and variances cannot possibly be estimated with a realistic degree of confidence, and where discontinuities in mineralization are bound to occur. Thus kriging tends to inflate expectations for the continuity of mineralization between measured data points with often devastating consequences.

Covariances and kriged variances dominate geostatistics. Yet dependencies and degrees of freedom, concepts even more fundamental than variances, seem irrelevant to the geostatistical theorist. Perhaps, not surprisingly, the geostatistical theorist likes to fit spherical, exponential or linear models to the variance terms for ordered data sets. After all, continuous functions that obscure mundane matters such as dependencies and degrees of freedom most effectively, make a fitting choice!

Some geostatisticians seem cautiously concerned. For example, M. Armstrong and N. Champigny, (*CIM Bulletin*, March 1989), display smooth plots of kriged variances plunging to zero in chaotic domains. The authors caution in the abstract that "the oversmoothed estimates should not be used for calculating recoverable reserves" which is quite understandable. Kriged variances converge to zero exponentially so that only a few fabricated data points are required to generate suspiciously low variances in small blocks. Zero variances, which permit perfectly precise grade predictions, even geostatisticians find hard to believe.

In another paper, David, too, displays his fondness for smoothing in "Grade control problem dilution and geostatistics: choosing the required quality and number of samples for grade control" he shows how to predict recoveries and grades by entering differences between estimated variances and kriged variances into smoothing relationships that some computer programs so conveniently provide.

The estimated and kriged variances turned out to be statistically identical which implies that their differences are random numbers. Applying mathematical analysis, or just a little smoothing, to that class of random numbers is an exercise in futility and a typical example of voodoo statistics of the worst kind. Nonetheless, recoveries are predicted with one decimal point and grades with two.

Kriged variances inflate expectations for the continuity of mineralization between measured data points, and cannot possibly deliver the reliable and realistic precision estimates that ore reserves demand. However, a technique that replaces a bulldozer's crooked blade with a surgeon's scalpel has already been developed and published.

The "grade-squared partition technique" merges Matheronian basics with the conventional block design and proven statistical techniques that take full advantage of the additive property of variances for grades and contents. Not only does it provide reliable and realistic precision estimates but it is also an effective tool to optimize exploration programs. It would allow geologists to apply statistical tests and techniques in a spreadsheet environment on laptops and portables in the field, and combine geological interpsetations and applied statistics most effectively.

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