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LETTERS TO THE EDITOR

Geostatistics credible

The editorial "Challenging Geostatistics" (*T.N.M.*, Sept. 28-Oct. 4/98) contains many statements and implications with which I disagree. I restrict my comments here to the title and the general aim of the editorial to "re-open" the debate as to the validity of geostatistics. Questions raised in the past regarding the viability of geostatistics as a resource/reserve estimation procedure are highly technical, and it is unlikely that different points of view will be resolved in the pages of *The Northern Miner*. In response to the *Miner's* challenge, a summary of the principal criticisms of geostatistics, and responses to them, follows.

To begin with, it is important to appreciate that geostatistics is a subject dealing with spatial correlations of a variable. Among its wide range of applications — including forestry, fisheries, hydrogeology and soil science — mining is but one field. Within the mining industry, geostatistics has found extensive applications both in resource/ reserve estimation and in simulating grade distributions in mineral deposits as an aid to mine/mill planning. These applications are widely documented in established textbooks and traditional technical or scientific publications, most of which have been peer-reviewed. An extensive global community of consultants, including many highly regarded Canadian firms and individuals, has been selling geostatistical services for more than a quarter of a century. It is through such public examination, critical review and practical applica-

tions that the subject has evolved from concepts described initially by Professor G. Matheron in the 1950s and 1960s to the much more extensive arsenal of tools now available and in use globally.

Thus, the subject has undergone 40 years of scrutiny by applied and theoretical scientists and a myriad of mining practitioners, quite apart from the multitude of users in fields other than mining. As a result of this scrutiny, a very small group of professionals has raised questions about certain aspects of geostatistics, matters that have been well-publicized and discussed in both peer-reviewed and non-reviewed literature. These are real concerns that have been the subjects of public discussion, which has led to improvements in the understanding and application of geostatistics. Consider some of the principal questions that have been publicized, in the *International Journal of Mathematical Geology* and elsewhere, regarding mining geostatistics. As with many subjects, extreme differences in viewpoints and in styles of argument have led to acerbic commentary on both sides.

Philip and Watson have critiqued geostatistics in an extensive article and appear to disagree with the theoretical basis of the subject and just about everything that geostatistics purports to accomplish. Consider the matters that they emphasize. Their concern about the weakness of ordinary kriging in the face of outlier values has led to the

Geostatistics widely used

use and development of alternative techniques such as multiple-indicator kriging and restricted kriging. Criticism in this case has led to improvements in geostatistical procedures for dealing with outliers. Note that non-geostatistical methods have the identical problem of how to treat outlier values, and this matter has not been addressed by proponents of these methods. Philip and Watson's concern that the estimation variance of a block grade, for example, is a global variance rather than a local variance is a matter of fact that does not render kriging invalid. Their philosophical comments about geostatistics not being a theory are not of immediate concern to practitioners but will remain a topic of debate among those more theoretically inclined.

Shurtz also complains vociferously about geostatistics. One of his widely publicized concerns relates to the peculiar distribution of weights in the common case where strings of data, such as samples along a drill hole, are used to make point or block estimates by ordinary kriging. The problem that arises is that members of a string farthest from the point/block being estimated have the highest weights. A detailed study of this topic by Deutsch indicates that the problem arises in ordinary kriging where the mean of the data field is unknown; the problem can be minimized in a variety of ways, including the use of

a simple kriging procedure. Open discussion in this case has led to an understanding of the phenomenon leading to the criticism, as well as suggesting ways of minimizing or avoiding the problem.

Jan Merks's principal complaint against geostatistics seems to be that "degrees of freedom" are not taken into account by geostatistical procedures. There is a substantial school of thought among geostatisticians that the concept of degrees of freedom breaks down in matters of spatial correlation. Unfortunately, Merks's tirade against geostatistics is heavy on verbal abuse and short on theoretical support. His complaints are not documented in detail and generally are not available for thorough scrutiny and evaluation, as normally is deemed necessary in the discrediting of one technique or the acceptance of another.

There are many methods of resource/reserve estimation. Some are geostatistical in nature (ordinary kriging, simple kriging, multiple-indicator kriging), while other are traditional or empirical methods (method of sections, polygonal, inverse distance weighting). Any one method might or might not be appropriate in a particular case. Moreover, any method can be applied inappropriately, particularly if it is not well-understood by the user.

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