



## **Variogram analysis for sand and gravel deposit evaluation - implications for reserve definition**

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Geostatistical analysis of sand and gravel grading data has only rarely been used as part of the deposit evaluation process. These studies have generally indicated that while kriging provides some additional information in reserve assessments the quality of the drilling data is insufficient to justify such treatment and that the time and the cost of such analysis is not justified (Arthur 1994).

Simple and rapid variogram analysis however provides critical information on the variability of the deposits and, in particular, whether the deposit has been sufficiently drilled to define the changes in deposit geometry and quality. This is central to accurate extraction planning and the requirements of reserve definition under international reporting codes.

Variogram analysis has been undertaken on exploration drilling data gained from sand and gravel sites from a range of geological settings. These include fluvial, fluvio-glacial, glacial, Sherwood sandstone and Greensand deposits. In the UK fluvial deposits have been the preferred source of sand and gravel due to their low fines content, consistency and proximity to urban centres. Depletion of easily worked fluvial deposits and regional variation in availability has led to increasing exploitation of the more complex fluvio-glacial and glacial sources.

The standard practice of exploration involves drilling by flight auger, shell and auger and, more rarely, reverse circulation techniques supplemented by trial pitting. Typical borehole spacings are around 100m, but this ranges from 250m to approximately 75m depending on company practice and deposit characteristics. The variogram analysis reveals important insights into the sufficiency of this approach.

In the traditional fluvial deposits studied the 'ranges' defined by the variogram are

between 200 and 400m. Drill spacing should ideally be between 50% and 75% of this range for adequate definition of spatial quality variation, This suggests that drilling is adequate in these deposits. In the more complex glacial deposits however the variogram ranges are as low as 10m, and in almost all cases are less than 100m. The dimensional parameters of the deposits, e.g. thickness, have significantly longer ranges than the quality i.e. grading parameters, supporting anecdotal evidence from industrial experience that estimation of quantity (volume and tonnage) is generally more successful than the estimation of deposit quality.

These results suggest that in many cases, particularly for more complex deposits, the density of drilling used is insufficient to define continuity of the deposit quality. This raise an important question of corporate governance and whether these deposits can accurate be defined as proven reserves under international reporting codes.