# Journal Comment

## Danie Krige Geostatistical Conference 2015

One might ask what benefit the Danie Krige Geostatistical Conference imparted to the delegates. Principally, it drew us together and confirmed again the importance of the work being done in the field of geostatistics. A significant concern over the past decade and a half has been the declining numbers of local geostatistics practitioners and the need for ongoing education of the geostatistical fraternity. Unfortunately, there are many geostatisticians working in South Africa who have become 'transparent' to the professional institutions in that they are not affiliated in any way. All participants at the Conference were urged to enrol as members of the Southern African Institute of Mining and Metallurgy (SAIMM), and the Geostatistical Association of Southern Africa (GASA).

Papers published in this issue of the Journal arose from the Proceedings of the Danie Krige Geostatistical Conference, which in turn was based on submissions of original geostatistical research presented in the Danie Krige Commemorative Volume. The intention for the Danie Krige Geostatistical Conference was to provide the authors of papers in the Commemorative Volume with a platform from which to present their research. However, most of the twenty-two papers contained in the Proceedings were original items of research that relate to, or are extensions of, work published in the Commemorative Volume. The international call for papers in honour of Professor Krige through the SAIMM resulted in three issues of the Journal, published in March 2014, in August 2014, and in January 2015, and included 35 papers submitted by 83 authors from 17 countries around the world. The theme of the Danie Krige Geostatistical Conference, '*Geostatistical Geovalue - Rewards and Returns for Spatial Modelling*', highlighted the role of geostatistics in optimizing financial returns from mineral extraction by minimizing uncertainty. 'Geovalue' refers to the capitalized value of the Earth's primary natural resources, and only the diligent and correct application of geostatistics can maximize this value. The Conference went a long way in presenting new and innovative ways to improve 'geovalue', but it is felt necessary to briefly explain the history underlying the development of geostatistics.

In 1644 Descartes used a method, later to be referred to as the Voronoi diagram after the Ukrainian mathematician Georgy Voronoy (1868–1908), in a strictly geometric or polygonal method of estimation; a similar method employs what are known as Thiessen polygons. Others who investigated spatial variability include Bertil Matern (1917–2007), a Swedish statistician whose research applied to forestry, and Lev Gandin (1921–1997), a Russian mathematician whose work centred on climatology and the best way to average scattered meteorological data to give a spatial average. Georges Matheron (1930–2000), who knew of the work of Matern and Gandin, drew heavily on the work done by Andrey Kolmogorov (1903–1987), a Russian mathematician who made significant contributions to the mathematics of probability theory as well as other areas. Matheron, intrigued by the pioneering work of Danie Krige and Herbert Sichel in the late 1940s and early 1950s on topics specific to mining and mineral resource evaluation, went on to formalize Krige's evaluation methods at Ecole des Mines de Paris in Fontainebleau, France. It was Krige's work in particular that became known as geostatistics, and the technique for estimating values at unsampled localities using nearby samples that Matheron referred to as *'kriging'*. Evidence presented by Noel Cressie indicates that both Georges Matheron and Lev Gandin independently developed ordinary kriging as we know it today.

What was particularly important in the advancement of geostatistics and the spreading of this idea through industry as an estimation technique in mineral resource evaluation was the parallel development of computing technology. Computing power grew quickly from its inception in the late 1940s and early 1950s, without which the science of geostatistics would simply not have been possible. In addition, a growing range of software for application to geostatistical problems also found a place on the stage. The application of geostatistics grew not only in mining- and mineral resource-related problems, but also in soil science, meteorology, environmental science, the oil and gas industries, and more recently in ecology and image analysis.

The simple concepts lying at the foundations of geostatistics need some air-time lest readers relegate the contents of this volume to paths less well trodden. Krige's main aim was to convince South African mining engineers in particular to use multiple regressions to predict the grade of mining blocks from the huge amount of assay values that had already been collected. Spatial modelling and the need to predict point or block estimates in space from surrounding data has given rise to what is today known as geostatistics. This is a significant break from classical statistics, which demands that data values be both random and independent. Geostatistics has taken a more pragmatic view, with its fundamental premise being that while data values may be random, they are not independent of one another. Closer sample values will be more similar than those farther apart. If one imagines a point in space for which you would like to estimate a value (or grade) from surrounding samples, one could simply calculate their average and assign it as the estimate. If the concept of spatial dependence between variables is allowed to ferment, the next logical step would be to weight the contributions of local data values to the estimate based on their distance away from the point being estimated; nearer data points contribute a greater proportion of their value to the estimate than points further away. Hence, inverse distance estimation – a weighted linear combination of nearby sample values. Immediately, questions arise about the nature, validity, and confidence one might place in the estimate produced in this way. What confidence do we have in the

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estimate? Is it a single point estimate or only one value from a probability distribution; is the inverse distance function appropriate; how many samples should we use; what is the maximum distance for including samples in the estimate; what should we do if the samples are clustered; how do we manage anisotropy; how do we deal with outliers; what is the data from a skewed distribution; how do we manage the regression effect; and how will the estimate change if we consider an area or volume rather than a point estimate? Almost half these questions can be answered by resorting to the standard geostatistical approach, which is to use a variogram, a graph which shows how the variance of the difference between data points changes as the distance between them increases. Georges Matheron succeeded in answering the balance of the questions by developing the concepts of ordinary kriging for the mining industry.

It is now sixteen years since the last significant geostatistical conference, Geostats 2000, which was held in South Africa. The length of time between geostatistical conferences rang a note of concern amongst all delegates and acted as a reminder that we should be in regular contact to share ideas. The Danie Krige Geostatistical Conference provided geostatisticians with just such an opportunity and I trust that the momentum for good quality research generated by this Conference will be carried into the future.

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