Foreword

Danie Krige

Through his work and exposure to the data and information received while working for the Government Mining Engineer's office in the early 1950s, as well as his methods of comparing sampling information and derived block values by means of regression, Danie Krige became a leader in the field of mineral resource estimation, out of which the science and methods of geostatistics were developed. The *Danie Krige Commemorative Volume* was designed to attract contributions from local and international geostatisticians, practitioners, researchers, and academia in the field of geostatistics with the intention of honouring Danie Krige, who passed away in March 2013, for his work and the impetus it provided in stimulating the creation of new knowledge and improved mineral extraction.

The Southern African Institute of Mining and Metallurgy (SAIMM) has now published three issues of their *Journal* that carry research papers and case studies covering a wide range of topics in the discipline of geostatistics. The first call for papers went out in mid-May 2013, with the first issue containing twelve research papers being published in March 2014, and the second issue, in August 2014, containing fourteen papers. This, the third issue contains eight papers. In total there are 35 papers in the three issues, submitted by 83 authors representing 17 countries including Australia, Brazil, Canada, Chile, China, France, Germany, Ghana, Ireland, Namibia, Peru, Poland, Russia, Scotland, South Africa, Spain, and the USA. This is a remarkable response, for which the Southern African Institute of Mining and Metallurgy and the organizers of the Commemorative Volume are truly grateful.

The foreword to the first and second issues of the *Danie Krige Commemorative Volume* was designed to emphasize the growth and development of the science of geostatistics in the period 1945 to 2005 by numbering the publications of Danie Krige and Georges Matheron. It is not certain that 'number of publications' is an acceptable metric by which to measure the growth of a science or discipline, but is a useful, easy-to-do exercise if the information is readily available. This investigation leaned heavily on a document prepared by Patricia Sheahan (1988) in which she lists 315 publications in the field of geostatistics in the period 1951 to 1988. Within this period Matheron and Kleingeld (1987) identified three phases in the development of aspects of geostatistics, the first being the period 1945–1965, when linear geostatistics was developed, and the second being the period 1966–1974, when interest in nonlinear geostatistics grew. They also describe how and when the terms 'géostatistique' and 'kriging' for 'the mathematical process of assigning grade to individual points or mining blocks' was introduced. The third period, from 1975 onwards, was characterized by the development of more complex geostatistical techniques. The last record by Sheahan (1988) is 133 publications in 1987, but beyond this date it is difficult to quantify the growth and development of the discipline of geostatistics in terms of geostatistically related publications. Global interest in geostatistics and the numbers of publications around the discipline grew exponentially after 1987, and without considerable effort it would be impossible to fairly and comprehensively name the most influential contributors and practitioners.

Although many theoreticians and practitioners of geostatistics have worked across multiple generations, the changes in the discipline from generation to generation are noteworthy. The first generation, including Krige and Matheron and others, launched the characterization of regionalized variables with sound theory and practice. They clearly understood the rich and infinite complexity of geological processes at all scales. The combination of this complexity and widely spaced drilling leads to inevitable uncertainty and defies precise calculation, yet they saw the potential value that could be achieved by a rigorous mathematical statistical approach applied within a sound conceptual geological model. There

Foreword

Danie Krige

was appreciation for the partly structured and partly random nature of mineral deposits. Krige and Matheron pioneered the quantification of spatial correlation, the calculation of optimal local estimates, and an appreciation for the influence of scale/support of different data types and of different mining methods.

For the most part, the second generation was a hardy and strong-minded group. They took the theory of geostatistics around the world and vigorously developed novel solutions to a wide variety of practical applications. They saw the inevitable rise of computing machinery and the potential for more than simply mimicking what we could do by hand. The computation of optimum local estimates with variograms was understood as the foundation of geostatistics, but computationally challenging applications, including simulation and multivariate approaches, were developed.

The third generation is irreverent in many respects. They pay little attention to old debates and schools of thought. There are few that believe in a universal random function approach; this generation will readily develop and adopt custom tools for different deposit types. There is little argument for an absolute best. Debates over conditional bias and other issues have lost momentum as we appreciate there can be no single best estimate suited to all purposes. The absolute belief in a richly complex geological reality frozen in time and space has not diminished, but there is a greater maturity about the inevitable uncertainty and the acceptability of different modelling approaches and models.

Future generations will surely appreciate the rich complexity of geology and the interaction with mining resource and reserve calculations. Krige and Matheron adapted core mathematical principles to these calculations. Significant efforts are being devoted to 'big data', data mining, and predictive analytics. Future generations of geostatisticians will adapt some of the most sophisticated techniques to our problems. It is also likely that, finally, a truly probabilistic view will be adopted where uncertainty is always quantified and always carried through the decision-making process. Massively multivariate modelling of intrinsic grade variables, geomechanical rock properties, and metallurgical properties will become commonplace for the real-time optimization of mining activities. Danie Krige would not even recognize much of what is done, but he would rest easy when he recognized the best practice application of kriging at the heart of many of the techniques.

The importance of the three issues of the SAIMM Journal that together constitute the *Danie Krige Commemorative Volume* is that they document the important strides made in improving and optimizing the determination of available grades and tonnages in deposits and the evaluation of mineral resources and recoverable reserves. This in turn translates into improved quality and optimized evaluation of the metal and mineral content of ore deposits, reduced risk for mining investments, quantification of the risks associated with the evaluations, and generally improved extraction of the Earth's natural resources. The combined outcome is improved 'geovalue', the returns to mining companies and shareholders. For this reason the forthcoming Danie Krige Geostatistical Conference, due to be held in South Africa in August 2015, has the title '*Geostatistical Geovalue — Rewards and Returns for Spatial Modelling*'

R.C.A. Minnitt
C.V. Deutsch