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Third Annual Report of the Centre for Computational Geostatistics

MARCH 2001

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Introduction

Last year's report was introduced with a discussion on extrapolating trends. Much to my dismay, the oil price and commodity prices in general have not grown as anticipated. Nevertheless, prices have remained stable and companies are still doing business. CCG has done the same; there are 10% more papers than last year at a leaner, more efficient, average length of 15.5 pages. There are many exciting new ideas related to heterogeneity modeling, uncertainty quantification, and decision making.

Extrapolating the commodity market has grown too dangerous for me. I've decided to stick with statistical inference. The key to statistical inference is choosing a stationary population and selecting relevant analogues to aid inference. There seems to be a clear analogue between our research deliverables and cash commodities such as oil and/or mineral products. A cash commodity must meet three basic conditions:

1. It has to be standardized and must be in a basic, raw, unprocessed state (there are futures contracts on wheat, but not on flour). This seems applicable. The research ideas and procedures developed by CCG are of standard high quality. Our work is in a raw unprocessed state; we leave commercial development to the sponsors that support our work.

2. Commodities must have an adequate shelf life. This is certainly applicable to the research deliverables of CCG. We continue to develop new and exciting ideas, but many ideas from the first two years are still fresh and have yet to see full implementation.

3. The commodity's price must fluctuate enough to create uncertainty, which means both risk and potential profit. There is uncertainty, risk, and potential profit in the sound application of the geostatistical tools developed by CCG.

That third basic condition is a bit of a stretch. Perhaps the analogue is not so clear. Seems like I better stick to geostatistics.

The CCG research group consists of nine graduate students and myself. Some students will graduate this year, one or two new students will be brought in, and I'm considering a replacement postdoctoral scholar. Research continues in two main directions: *data integration* and *decision making in presence of uncertainty*. As promised, research remains focused toward petroleum reservoir characterization with interesting diversification into related subjects of mining and agriculture. The cross-fertilization of ideas from different disciplines is important to me. CCG develops the commodity of standardized long shelf-life tools and techniques to deal with uncertainty.

An important hallmark of the CCG is close contact with industry and research into problems of practical importance. A number of the papers in this report are the result of collaboration with industry. Chevron has provided extra funding above CCG sponsorship levels to focus the work of myself and Dr. YuLong Xie on the important subject of direct geostatistical simulation on unstructured grids. Some important research results have come out of this work. These novel results will be the "seeds" for future research and development in this area. Member companies will be contacted about involvement in extending this work

even further. The research of Bora Oz and Hanh Nguyen on size scaling and gridding issues relate to this new research direction of *populating unstructured grids.*

Secondary data are important in geostatistics. Sequential Gaussian simulation remains the standard tool for such data integration because of its relative simplicity and robustness. The two most common approaches to integrate secondary data are with (1) locally varying mean, or (2) collocated cokriging. A significant problem with both of these techniques is variance inflation, that is, the variance of the resulting simulated values is too high because of an inappropriate decision of stationarity or an artifact of choosing a single secondary data in presence of many. Ty Faechner and Stefan Zanon have worked with me on a self-healing procedure for dynamic correction of the simulated values. This method will see much practical application.

Oy Leuangthong has more completely developed the stepwise conditional transformation procedure. This method promises to greatly simplify the integration of secondary data, which may make it unnecessary to use the self-healing algorithm. It is nice to have a choice. One choice that people avoid is using the cyclic hole effect variogram model. Michael Pyrcz gives us the whole story on the hole effect model. The integration of production data is another critical aspect of secondary data; Zulfiquar Reza will present his latest results.

The CCG attempts to avoid duplication with other research groups. André and SCRF have done some work on iterative methods for integration of multipoint statistics. Julián Ortiz C. at CCG has also done some work in this area. The research avenues we have opened up with "runs" and hierarchical indicator simulation are truly original. Just because we avoid duplication does not mean we avoid developing superior ideas to old problems (this is where I would add a smiley face if I was typing an e-mail).

Geostatistical modeling leads to a quantitative model of uncertainty. Then, we are faced with making decisions in presence of the uncertainty we just quantified. How do we deal with the multiple realizations provided by geostatistics? Karl Norrena has been focusing his research on this challenge.

The application of geostatistics to real problems is of the utmost importance. At first glance, the newcomer to CCG may question the practicality of our research. I vigorously defend the practicality of everything we do *and* the widespread practical applicability to different areas of application. Of course, I should probably visit with you and discuss this claim of practicality and applicability.

Now that the research team at CCG is more mature, I plan on visiting CCG member companies and extending CCG membership. Recent members are AngloAmerican, Pan-Canadian, and Petrobras; welcome! A reciprocal arrangement has been made with the gOcad group; they are members of CCG and we are members of gOcad. I look forward to leveraging our research using the strong computational background of the gOcad consortia. Support for the Centre for Computational Geostatistics remains modest. Nevertheless, I hope you share my pride in this year's research results. Thank you for your support.

Clayton V. Deutsch

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CCG Staff / Researchers / Students

Following are people at the University of Alberta who are affiliated with the Centre for Computational Geostatistics. There are numerous contacts in member companies who contributed in significant ways to the results presented in this report. They are prominantly acknowledged in the author lists of each paper.

Clayton V. Deutsch: Associate Professor of Civil & Environmental Engineering and Director of CCG

Ty Faechner: Ph.D. student working on application of geostatistics and risk-qualified decision making to agricultural problems

Oy Leuangthong: Ph.D. student working on multivariate geostatistical methods

Hanh Nguyen: M.Sc. student working on the interaction of heterogeneity and grid discretization effects

Karl P. Norrena: Ph.D. student working on decision making in the presence of uncertainty and application of optimization techniques for geostatistical modeling

Julián Ortiz C.: Ph.D. student working on multiple point statistics for geologically-realistic models and improved models of uncertainty

Bora Oz: Ph.D. student working on scaling relationships in presence of complex geologic structures

Michael J. Pyrcz: Ph.D. student working on application of geostatistics

Zulfiquar A. Reza: Ph.D. student working on the integration of historical production data in geostatistical reservoir models

YuLong Xie: postdoctoral fellow who left CCG in November to take a position at Pacific Northwest Labs

Stefan Zanon: M.Sc. student working on the integration of secondary data and improved Gaussian simulation techniques