From The President

Dear Colleagues,

I and several other GAA members were fortunate enough to attend the Mine Geologist Workshop in Townsville recently. Of particular interest amongst a very diverse set of presentations was the brief description of the successful implementation of conditional simulation for grade control at Ravenswood gold mine. Sequential indicator simulation is used, together with structural mapping, as a tool for the delineation of ore and waste. Dean Collett, Planning and Resources Manager at Ravenswood, estimates that the system increased profitability by about 1 to 2%. When you consider that the operation realised profits of the order of $90 Million over the last 6 years, the simulation system certainly paid for itself many times over.

Simulation is sure to feature prominently in the forthcoming GAA symposium on Quantifying Risk and Error. You should by now have received the initial advertisement and call for papers for this event. There is a lot of excellent work being undertaken in this area and the symposium will be a great platform for sharing some practical experiences as well as presenting new ideas and directions for research. Your committee is eagerly awaiting being swamped with abstracts but don't forget that they are required by October 15th at the latest!

The date for the Symposium is likely to be the 22nd March 2002. Symposium registration fees will be kept as low as possible in order to encourage the widest participation. They will also be structured in favour of current financial members of the GAA, so if you have not yet paid your 2001-2002 membership fee, let me encourage you, once again, to do so!

The two previous symposia were highly regarded by those who were able to attend. After a little rummaging in boxes and hard drives we have been able to compile copies of the volume of papers from the 1998 symposium on the theme of 'Beyond Ordinary Kriging'. These copies are now available for a mere $60 for GAA members and $70 for non-members, plus $15 postage and packaging, or you can purchase over the counter from the AMF bookshop in West Perth. The presentations from the International Symposium on Geostatistical Simulations in the Mining Industry are also available on CD, from the GAA, for $50 for GAA members and $60 for non-members, plus $15 postage and packaging. Please send your cheques or gold bullion to The GAA, PO Box 1719, West Perth, Australia 6872.

Sjoerd Duim has been collecting links to Internet sites that may be of interest to GAA members. As well as the Russell Crowe fan club and Pamela Anderson trivia sites there are plenty of useful resources on the web. If you have any other favourite sites with a geostatistical flavour that you would like to recommend, please email Sjoerd. (sjoerd.duim@minproc.com.au). The GAA web site is kindly hosted and maintained by John Atkinson at Confed Computer Services. You will currently find it at www.confed.com.au/gaa, until our chosen domain name (gaa.org.au) is pointed in the correct direction. Don't try www.gaa.com.au unless you want the Galvanisers Association of Australia.

The Committee would like to thank Jennette Binns for volunteering to be the editor of this GAA newsletter. Jennette is on the look out for material for the next newsletter. Perhaps you have read a book with a geostatistics flavour? Why not do us all a favour and tell us in a review whether you found it useful? Please send your reviews, technical tips, suggestions, questions, and geostatistical trivia to Jennette at minstat@bigpond.com.

Until next time, may all your errors be minimised.

Ian Lipton
GAA President 2001-2002
International Mining Consultants

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Symposium on Quantifying Risk and Error

Theme: The Geostatistical Association of Australasia is hosting a symposium on the theme of **Quantifying Risk and Error** in March 2002. This topic is increasingly the focus of industry and research, as businesses seek to manage risk and provide greater returns for all stakeholders. The theme of the symposium is deliberately broad and contributions are sought from professionals involved in fields such as mining, resource estimation, petroleum, geotechnical engineering, environmental sciences, biological sciences etc. Case histories and papers describing practical applications are welcome.

The aim of the symposium is to promote discussion on alternative methods of estimating risk, current applications, challenges and future trends. The symposium will provide an excellent opportunity to exchange ideas and experience and to discuss some of the practical new developments in this field.

Call for Papers: Abstracts should be submitted to the GAA as soon as possible and no later than **15th October 2001**. Full drafts of papers should be submitted by **30th November 2001**. Poster presentations may also be accepted. Those wishing to submit poster presentations should provide an outline of the presentation by **15th October**.

Sponsorships and an exhibition area will provide an important marketing opportunity for progressive companies and institutions. Dates, venue and fees will be advised shortly.

Expressions of interest and abstracts should be directed to Stella Searston, GAA Secretary, PO Box 1719, West Perth, Australia 6872 or email bateleur@omen.com.au

Geostatistics Around the Bend - a talk by Michel Dagbert

The GAA, in association with the Joint Institutes (AusIMM, AIG, BEDG) is pleased to announce the following technical meeting:

PLEASE NOTE REVISED DATE

**Monday October 1st, 5:15 for 6:15pm
The Theodore Club
333 Adelaide Street,
Brisbane
Cost: $6 plus cash bar (includes finger food)**

Presented by **Michel Dagbert** Geostat Systems International Inc. Montreal, Canada

Abstract: With the widespread use of general mining packages, resources of "thin" deposits (veins, seams, layers.) are modelled using a 3D gridded block framework which is at the core of most of those packages. Obviously, those models use "thin" blocks and tend to interpolate the grade of each of them searching for samples in neighbour intercepts with a "flat" ellipsoid with a short radius perpendicular to the "average plane" of the deposit. Unfortunately those deposits are seldom "flat" and they often exhibit even slight change of dip and azimuth angles. As a result, more often than not, blocks in-between intercepts are not interpolated with the right samples e.g. the grade of a block in the footwall of the deposit maybe derived from samples in the hangingwall. In extreme cases, a block is not estimated at all because with its average orientation and flatness, the ellipsoid fails to pick any samples in existing neighbour intercepts because of some local bend. In the past, resources of those deposits used to be derived using 2D models (polygons, contours or grid) with interpolated average intercept grade and thickness at points on a long horizontal or vertical projection plane. The sample search problems described above do not happen in 2D but those models do not give a position in 3D space for interpolated data nor do they show grade variation from footwall to hangingwall of a deposit. The purpose of this talk is first to present real life examples of problems and limitations associated with standard 3D and 2D models in thin deposits and then to present tentative ad-hoc solutions which amount to spatial transformation or change of coordinates. In some cases, geostatistics can orientate the choice of the right transformation but at the same time, those transformations raise some geostatistical questions about the real support size of a sample in such deposits.

Geostatistics at Edith Cowan University.

ECU currently has two full-time staff with a teaching and research involvement in geostatistics: Associate Professor Lyn Bloom and Dr Ute Mueller. In addition, there are at present five research students (one PhD student, one Masters student and three honours). Current research at ECU concerns the use of wavelets in geostatistical simulation, the modelling of soil and water pH and salinity data, sampling design and the modelling of categorical data.

The study on soil and water pH is linked to the modelling of salinity data. It is a study that uses data coming from the Western Australian Wheat Belt and techniques developed through it should be of benefit for the quantification of the extent and spread of salinity.

The use of wavelets in simulation may be of benefit for the simulation of phenomena with sharp edges. Of particular interest to us is the conditioning of a wavelet-based algorithm. This study is of a theoretical nature and only test data sets for which the exhaustive data are known are used at this stage. Sampling design impacts strongly on the exploration cost. In the study on sampling we are comparing a traditional drilling design consisting of a wide-spaced grid with a cluster of narrow-spaced drill-holes against one with a wide-spaced grid together with narrow-spaced crosses. The study is based on nickel data from a Western Australian deposit.

The modelling of categorical data is based on kriging for the categorical indicators. A number of different decision criteria will be tested to allocate categories to the grid nodes, these include maximum likelihood and Soares' allocation scheme. The study uses lithology data from a gold deposit.

For more information, contact Lyn Bloom (l.bloom@ecu.edu.au) or Ute Mueller (u.mueller@ecu.edu.au)

Empowering our lean, mean, mining industry teams.

THE DILEMMA
Are you and your mining team in control of your operation's current and future direction? Does your current lean geology – mining-processing – management team 'connect' to get the most from your personnel and mineral resources? Do they have time and skills or experience?

Many mining companies have invested heavily in management information systems in an attempt to cope with increasing flows of information and shrinking workforces. Some companies have recognised that their technical data has not been adequately catered for in these systems and have introduced integrated mine planning systems to try and address this shortcoming.

However, the successful application of these systems depends entirely on the people who support and use them. Obvious? It is surprising, actually frightening, how commonly the importance of the people around these systems is forgotten.

Today's mining teams are generally so stretched to cope with daily operational requirements that insufficient attention is given to optimal and innovative forward planning. If this is the case, then we are in severe danger of simply following rather than leading the rest of market. And if we are not in control and leading the way, then we are unlikely to be in a position to grow and succeed in our sector, particularly not when measuring up against non-mining investment alternatives.

THE DANGER SIGNALS
One of the first signs of an over-stretched team is evident in poor communication, not only between disciplines, but even between members within the same company section! Sure, information may be dispersed, but is it understood? Do others really listen? Do they care, or more particularly, do they have the time to care? If this is the case between the people on the team, what hope is there for the mining and management information systems we are relying on in this new age? What does this mean when trying to make the right decisions? And don't think this malaise is confined to small companies – it's not!

THE SOLUTIONS
While the symptoms of poor inter-disciplinary co-operation are probably obvious at any project meeting, it takes a pro-active manager to act to address the problem. It is unlikely that these problems can be solved

internally – otherwise why would they exist in the first place? Calling in communication consultants may be an option, although technical and professional staff are often anti such initiatives.

So what other solutions are there? Mining companies frequently call upon mining consultants to assist or carry out those functions or studies which they are either not equipped to do, or which their staff have no time to complete. While this solves a short-term requirement, it does not fulfil the need for the company to work better and smarter now or in the future.

AN ALTERNATIVE

An alternative technical solution may be found in mentoring, facilitation and skill-sharing exercises and workshops. These may either be incidental to a specific technical consulting project, or specifically requested to address 'gaps' identified by a company's management. These engagements may be intra-disciplinary, but there are also advantages to hold these across interrelated disciplines. Experience shows that such facilitation can produce exceptional results. The participants, whether part of a formal workshop or incidental facilitation, or as individuals or groups, can become more motivated, better equipped and generally more valuable company members. The benefit of this resulting rejuvenation to the participating company is immense.

If your human resource is not working together optimally, chances are neither is the management of your mineral resource. The time to fix that is now!

Monograph 23 Mineral Resource and Ore Reserve Estimation The AusIMM Guide to Good Practice
Edited by: A.C. Edwards
ISBN 1 875776 80 X

Looking for some light bedtime reading?   Well, you may have to look elsewhere but the AusIMM's Monograph 23 is an essential read for all Mineral Resource – Ore Reserve estimation practitioners.   This monograph is an attempt to produce a set of illustrative papers to accompany the JORC Code.   The AusIMM says it is a first attempt.   Let's hope that this is a forerunner to yet more good quality information.   Many of our GAA members have made significant contributions to its production and they should be congratulated for their dedication to promotion of good practice in the mining industry.

The book consists of 79 papers representing a cross section of those collected at the **Towards 2000 AusIMM Mineral Resource and Ore Reserve Estimation Seminars** held between 1997 and 1999. All have been updated. A full list of papers presented at these seminars and a copy of the JORC code are contained in Appendices of the monograph.

The book is thematic and follows through from start to finish the process of producing an Ore Reserve estimation (of course, it is never actually finished). The themes are:

- **Exploration and Data Collection** - The Resource Database

- **Geological Interpretation and Modelling**

- **Statistical Analysis, Mineral Resource Estimation, Classification and Reporting**

- **Modifying Factors** (Mining, Metallurgical, Economic, Marketing, Legal, Environmental, Social and Government)

- Risk and Sensitivity Assessment of **Ore Reserve Estimation, Classification and Reporting**

- Monitoring the Resource and Reserve **Grade Control, Production and Reconciliation**

- **Iterations of Technical, Financial and Risk Assessments**

Naturally there is much in this volume related to Geostatistics.   The main points for geostatisticians include: be familiar with the database, its weaknesses and strengths; use good geology and geometry in the estimation method; pay attention to likely scenarios for

mining when modelling the resource; don't put blind faith in a computer software program; one estimation method is not appropriate for all deposits; communicate, communicate, communicate; and, use your common sense. This list is expanded in the Monograph - and although most of us already know about these practices, it is good to be reminded.

The Monograph is available as Hardcopy or CD-ROM. To purchase both, AusIMM members pay $165.00 inclusive of GST, or $150.00 if you are a non-Australian resident. If you just wish to purchase the Hardcopy or the CD then the cost is $99.00 including GST, or $90.00 if you are a non-Australian resident. Other rates apply if you are a non-member or student.

More information and order forms can be obtained from:
http://www.ausimm.com.au/publications/books/monographs.asp

Jennette Binns, minstat@bigpond.com

Negative Kriging Weights

Have you ever puzzled over why kriging weights are sometimes negative? This question and answer from the AI-Geostats list provides a neat explanation of the subject.

Question: I have recently carried out ordinary kriging for an ore reserve estimation exercise (using GSLIB), and noted that a very few of the grade estimates are negative (always a very small number e.g. 0.002 ppm). I have been able to trace this back to negative kriging weights, and would like some confirmation of my understanding of how this occurs.

My understanding is that samples lying close to the block centroids being estimated receive a high weighting, and samples further away receive a lower weighting. However, if the sample search neighbourhood is very large, and since the sum of the weights must equal 1, the samples lying furthest away from the centroid/s are assigned a very small negative weight, in order for the closer samples to maintain their higher weighting, and for the sum of the weights to equal 1.

Is my understanding of this "compensation" correct? Why wouldn't the weights for the furthest samples be calculated by subtracting the weighting of the closer samples from 1, instead of compensating using negative weights afterwards?

Answer (1): Kriging weights are produced by a set of equations, which minimise the variance of the estimation error. All of the weights are determined simultaneously and negative weights can be produced in the solution of the kriging equations. The condition on the weights is that they sum to 1, not that they have to be positive. Negative weights are usually an indication that your data is clustered or that our search radius is larger than it need be. Some packages will eliminate the samples with negative weights and then re-solve the kriging equations without them. Of course, you may have to go round a few times as there is no guarantee that the new set won't have negative weights ....

Isobel Clark, http:/uk.geocities.com/drisobelclark

Answer (2): Kriging, in it's native state, does not ensure positivity of the weights or the estimates. The methodology does not 'know' that such and such a variable (eg concentrations in ppm or permeability in md) has to be positive. For the most part this is a good thing. Consider the 'picture' below. We are trying to estimate elevation on the top of the 'hill' using the 6 data points - marked with a * - that are on the flanks. A reasonable estimate would be given by the + (If the diagram gets screwed up - then the + is at a slightly higher elevation that any of the data - as we expect since we are estimating the top of the hill).

Now kriging does this by assigning weights to all 6 points - as you suggest the nearer ones to the point to be estimated will have high positive weights and in this case the furthest will have negative weights. The weights need to be negative in this case to get the estimate at the top of the hill higher than any of the data points. You can see this - because the highest possible estimate that you can get using positive weights only is equal to the highest data point (when a weight of one is applied to it and zero to all the other points).

So, to enable kriging to get estimates that are higher than the maximum data point (or lower than the minimum) you need to have negative weights. It is the variogram that determines just

how large those negative weights are to be (based on the degree of continuity of the variable at hand).

                                            +
                            *   *

                    *   *

            *   *

If you really dislike your negative estimates you could change your variogram slightly (Add a small nugget effect / Reduce the range of the variogram /Don't use Gaussian models or other variogram with quadratic behaviour at the origin. These are 3 methods that will usually help to improve matters for you). If you object to modifying your variogram you could try 'positive kriging'. There were a couple of papers by Olivier Dubrule on this subject in the mid 80's in Mathematical Geology (there may be more recent stuff by others - I don't know - and I don't have the exact reference to Olivier's papers). However this is fairly heavy duty stuff from a computer resource perspective - so unless it is a real concern or they become too large I would be tempted to live with the small negative estimates and just correct them to zero.

I have just 'grabbed' some references for this stuff from the web at Melanie Wall's site http://www.biostat.umn.edu/~melanie/ - I neither endorse nor condemn any of them as I don't know them (with the exception of Barnes - which I can't remember but I think predate the Dubrule papers).

Herzfeld, U.C. (1987) "A Note on Programs Performing Kriging with Non-negative Weights" Mathematical Geology Vol 21 391-393.
Szidarovsky, F., Baafi, E. Y., and Kim, Y.C., (1987) "Kriging Without Negative Weights" Mathematical Geology Vol 19 549-559.
Baafi, E.Y., and Szidarovsky, F. (1986) "On nonnegative weights of linear kriging estimation" Mining Engineering 437-442.
Barnes, R.J. and Johnson, T.B. (1984) "Positive Kriging" Geostatistics for Natural Resources Characterization, Part 1 eds. G. Verly et al. 231-244.

Colin Daly, Roxar Ltd

Answer (3): Good reasons can be presented to accept negative weights, principally that they provide unbiased estimates particularly in zones where grades change rapidly. It is worth considering just why we have a reluctance to use negative kriging weights. I can identify two that are based on good principles.

The first is that negative weights can lead to negative grade estimates. This is more likely to occur when the distribution of grades is highly skewed and generally low, as occurs with gold. While the estimates may be generated by a process that is unbiased, a value of zero is obviously a better estimate for those points. However to change the negative estimates to zero introduces an overall upward bias to grades. Sometimes this can be overcome by modelling the logarithms of grades - this will always give positive estimates of grade but involves other adjustments that are correct only if the data has a log-normal distribution.

The second is that negative weights are just one sign of weights that vary considerably. To achieve the most precise estimates the weights would ideally be all equal and departure from this lowers precision. Hence negative weights are a warning sign.

Neither of these reasons provide an overwhelming reason to never permit negative weights but they do illustrate the care that is always required.

John Henstridge, Data Analysis Australia

GAA People on the Move

Snowden Mining Industry Consultants have recently had the following personal changes:

MARK NOPPE has relocated from Perth to run the new Snowden office in Brisbane,

STEVE POTTER has moved from Perth to run the Resource Division for Snowden's Johannesburg office,

IVOR JONES has joined the Resource Division in Perth from WMC's Leinster Operation,

MARK MURPHY has joined the Resource Division in Perth from Anaconda, and

STEFAN MUJDRICA joins the Resource Division in Brisbane in September from Normandy Mining's Adelaide office.

Golder MRT changes:
ANDREW WEEKS has joined Golders MRT in Perth.

ROB STEWART has left Pan Australian Resources in Brisbane and has joined Golders MRT in Perth.

MIREK WOZGA has joined Golders MRT in Perth.

BIELIN SHI has completed his post-doctoral studies at Edith Cowan University and has joined Golders MRT in Perth.

IAN LIPTON has left Golder MRT and has joined **International Mining Consultants** in Brisbane.

SRK changes:
LOUIS VOORTMAN has left Anaconda and has joined SRK in Perth. JAN DE VISSER has left Global Mining Services and has joined SRK in Perth. PAUL HODKIEWICZ will complete his doctorate at the University of Western Australia and will soon join SRK in Perth.

JOHN VANN, SCOTT JACKSON, and OLIVIER BERTOLI have left SRK in Perth and have set up **Quantitative Geoscience**, based in Fremantle, WA.

MIKE SPERINCK has joined **Resource Service Group** in Perth from RandGold in South Africa.

MICHAEL ANDREW has transferred to the head office of **Normandy Mining** in Adelaide.

SCOTT DUNHAM has left Australian Mining Consultants and has joined **WMC** at Leinster Nickel Operations as Geology Manager.

MICHAEL ERICKSON has transferred to **PacMin's** Tarmoola operation as Chief Geologist

Membership Fees

Thank you to all those who have renewed their membership fees for 2001-2002. Your continued support provides the foundation for an interesting program of meetings and the Symposium on Quantifying Risk and Error that will be held in Perth in 2002. Symposium fees will be structured favourably for GAA members to ensure that you get maximum value from your membership.

The current fees are:

- Ordinary Member $35,
- Associate Member $15,
- Student Member $5.

If you are unsure of your membership category, please check our web site or email John Warner (rj_warner@hotmail.com).

If you have not already done so, please play your part in the development of geostatistics in the region by becoming a financial member of the GAA. The GAA has a bright future and your committee would like you to be a part of it!

Workshop on Spatial Data Usability

This workshop may be a bit far away for most of us but the background statement throws up some interesting ideas and questions. If anyone is in the Netherlands at the right time, they might like to drop in for a session or two!

November 19-20, 2001,
Center for Geo-Information,
Wageningen UR, The Netherlands
Organized by: Prof. Dr. A.K. Bregt,
Dr M. Wachowicz and Dr G.J. Hunter

BACKGROUND

Almost 150 years ago a London doctor combined maps of cholera deaths and water pumps to discover the source of a deadly epidemic, and the case has since become an acclaimed use of spatial analysis taught to generations of geography students worldwide. Moving forward to the present day, data mining techniques are now radically changing the way supermarkets think about product placement within their stores, and telephone customers are moving away from their traditional "YellowPages" directories and turning instead to enhanced "YellowMap" products. While these are all very positive examples, on the other hand a recent UK government hearing into the establishment of an underground radioactive waste repository determined not to proceed with this major project after the results of groundwater hydrology modelling were rejected because they could not be validated. While each of these cases involves the application of spatial data, more importantly they demonstrate either extremely high or low degrees of data "usability", which in turn results in very positive or negative economic, social, environmental or scientific impacts. Our interest here lies in understanding exactly what distinguishes these cases from others. Is it the correct choice of data, models and algorithms for a given application, is it simply a matter of data quality, is it the "interestingness" or "unexpectedness" of the data (as knowledge discovers would say), or is it the integration of data and adding of value that produces these extreme examples? Clearly, with a better understanding of data usability we might be able to increase the number of "successes" and reduce the "failures" in the application of spatial data. Accordingly, we invite participants to attend this workshop on usability and to consider the following core questions:

What do we mean by "usability"?
Why is usability important?
What are the characteristics of spatial data usability?
What are the research problems to be solved in spatial data usability?
What should the research priorities be?

FIRST CALL FOR PARTICIPATION

All interested participants are invited to submit an abstract (1-page maximum) by email to the contact address below. Abstracts should include a title and the author's name, address and contact details. Abstracts will form the basis for a short presentation by each participant at the workshop. Presenters are not required to submit a full paper. There is no charge for attending the workshop and participants are responsible for organizing their own travel and accommodation, however the availability of lower-cost university accommodation in Wageningen is currently being investigated.

Further Information:
Monica Wachowicz
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