GEOSTATISTICAL ASSOCIATION OF AUSTRALASIA

Newsletter 21 May-2004

Contact Addresses: PO Box 1719, West Perth WA, 6872.

Http:// www.gaa.org.au

OVERVIEW FROM THE PRESIDENT

Dear Colleagues,

Let me first thank you on behalf of the incoming 2004 committee for your continuing support and involvement with our association.

I have followed the GAA since its inception in 1996, and I am delighted that the association has grown and established itself as an important group that is recognized by other professional associations. Particularly in the last few years, the GAA has flourished, with many new members and a range of activities. I believe that in this past year the GAA was the most active geostatistical association in any part of the globe - not a small accomplishment. I attribute this to the efforts of a number of dedicated colleagues, including the past president Stella Searston. Stella has looked after the GAA in an outstanding way that I will find very hard to match. I would also like to mention the outstanding contributions of the 2003 committee members, the producers of the GAA's outstanding newsletter (in particular Jennette Binns), the people who keep the web page up and running (especially John Warner and John Henstrige) and several others who look after a variety of GAA activities. Associations like the GAA are able to provide a valuable service for their members due to the dedication, time and effort of people like the ones I have just mentioned. As an incoming president I feel fortunate that the GAA has so many outstanding and dedicated individuals in its ranks.

We are now looking forward to the next 12 months, aware that the GAA has an ongoing challenge to continue on its path of systematic growth and solid activities and initiatives that will meet the needs of our community today as well as tomorrow. I would like to note that the committee will be considering several topics and initiatives in the near future. A new update of our web site is being discussed, which would expand the availability of technical information (such as abstracts of published peer-reviewed technical journal papers in geostatistics), provide links to related web sites, ensure up-to-date information is available on relevant upcoming national and international events as well as their reviews, and so on.

Jennette Binns has worked brilliantly with Elsevier to produce the book reviews we regularly see in the newsletter. We would like to extend this type of interaction to other publishers such as Kluwer, Oxford and Springer. Our ability to disseminate high quality information is critical.

I would also like to suggest that we pursue further interactions with other professional associations, with the International Association for Mathematical Geology a likely first candidate. This will provide a broader link with our peers outside Australasia who share our technical interests. Some of the areas where closer links could be discussed include: updates on publications in the IAMG journals, information on and access to IAMG events, exchange of invited speakers/lectures (such as the one we have this year with Dr F. Agterberg, the 2004 IAMG Distinguished Lecturer), perhaps a joint GAA-IAMG meeting in the future.

On the actions front, in 2004 we have the International Symposium "Orebody Modelling and Strategic Mine Planning: Uncertainty and Risk Management". This will provide an excellent opportunity to promote the GAA and its interests to a majority of the mining-related professionals of the world. At the time of globalization, we are greatly assisted in this by the promotion and support for the event provided by the major mining institutes and associations, namely, AusIMM, SME, CIM and SAIMM (with a combined membership in excess of 30,000). As we can all appreciate, it is imperative in a competitive world that the significance of our field of work, geostatistics, continues to be appreciated by the mining industry. In 2004, we hope to expand the industry's recognition that this is a major part of mining technology, on a par with other technical disciplines used in mining. It is equally critical to show that our expertise encompasses, and in some cases leads, current developments in mining geostatistics, and that we have a strong capability to respond to current concerns and themes in the industry. These themes include modelling geological uncertainty, risk analysis, and the increasingly critical flow and integration of these technologies and methods to downstream mining. This Symposium has generated incredible international interest and enthusiasm, as well as mining company support, which are significant early indicators of a most outstanding event.

Turning to education, the committee will discuss the establishment of a postgraduate scholarship for studies in geostatistics, to be awarded to outstanding young individuals. This may start as a small incentive, largely an honorable recognition of academic excellence from the GAA, but hopefully in the longer run this will attract corporate support and more generous

funding. I am confident that in the initial stages we should be able to provide funds for the first two years from the proceeds of the 2004 International Symposium.

As a university professor, I would like to see further support for activities that enhance education in our field and in related broader disciplines. I believe that we all enthusiastically endorse the continuation of the excellent initiatives already introduced by the GAA, such as posters and displays at relevant conferences, more GAA talks (including outside the major cities), more information dissemination, and greater encouragement of the younger generation to join the profession.

Please join us to make the next 12 months a creative, constructive and rewarding period for the GAA. Thank you for your presence in the GAM, and thank you for your support of the GAA.

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OUTGOING PRESIDENT'S REPORT

Welcome to the 2004 AGM of the Geostats Association. I apologise for not being able to make the meeting in person - I was at the Kalgoorlie airport this morning, but all flights out of Kalgoorlie were cancelled due to bad weather.

No president is able to function without the support of a good committee. The 2003 committee was representative of the GAA's widely spaced membership, located in Townsville, Brisbane, Kalgoorlie, and Perth, together with one member being site-based. I would like to thank Ian Lipton, Roussos Dimitrakopoulos, Selina Broun, Simon Dominy, John Warner, Ute Mueller, Alan Miller, John Henstridge and Mark Noppé for their assistance throughout the year. In addition, I'd like to thank one of the best newsletter editors I've worked with, Jennette Binns, for her efforts during 2004.

The GAA started the year with the publication of the 1998 Beyond Ordinary Kriging symposium volume to CD, and posting of the abstracts to the website. John Warner and staff of Data Analysis Australia, who host our website, have done a great job in keeping the site relevant during the year.

Three newsletters were published, in May, September and December, and my thanks to all who contributed. One of the interesting features this year was the preparedness of two of our Life Members to summarise their experience, together with musings on the state of geostatistics at present. Andre Journel will be the next to comment, in the May edition. The GAA has been very fortunate that Prof. Clayton Deutsch and his students have been prepared to share papers with the GAA, for example the article on the hole effect.

Technical talks were held in Brisbane and Perth, including combined AusIMM and AIG joint technical talks.

The GAA sponsored an AIG student bursary during 2003, and to date, is still the only independent professional organisation to have donated.

The highlight of the year was the co-sponsoring of the Bendigo Mining Geology conference in November 2003. Committee member, Simon Dominy was co-convenor, while past president Mark Noppé chaired a four-paper session on geostatistical applications. As part of the program, the GAA prepared a poster display of about 10 posters that covered various aspects of geostatistics, including kriging, polygonal estimation, and recommended reading texts. These are to be posted to the website for free download.

And, finally, I would like to wish Roussos and the incoming committee all the best for 2004.

Stella Searston
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GEOLOGICAL AND GRADE RISK AT THE GOLDEN GIFT AND MAGDALA GOLD DEPOSITS STAWELL, VICTORIA, AUSTRALIA

By Scott Jackson, Dean Fredericksen, Mike Stewart, John Vann, Aongus Burke, Jon Dugdale and Olivier Bertoli

Scott Jackson, a Principal Geologist - Geostatistician with Quantitative Geoscience Pty Ltd kindly presented the AGM address, on Geological and Grade Risk at the Golden Gift and Magdala Gold Deposits Stawell, Victoria, Australia, a paper originally presented at the recent Mining Geology conference, co-sponsored by the GAA, in Bendigo. Attached, in case GAA members missed the original abstract published in an earlier newsletter, is the abstract of the talk.

ABSTRACT

The Golden Gift is a recently discovered deep deposit below the main operating areas of the Stawell Gold Mine. At an early stage of the project, diamond drilling was used to define the mineralisation on sections approximately 100 - 150m apart. The project economics were sensitive to both grade and tonnage. There were consequently two significant risks on resource quantification:

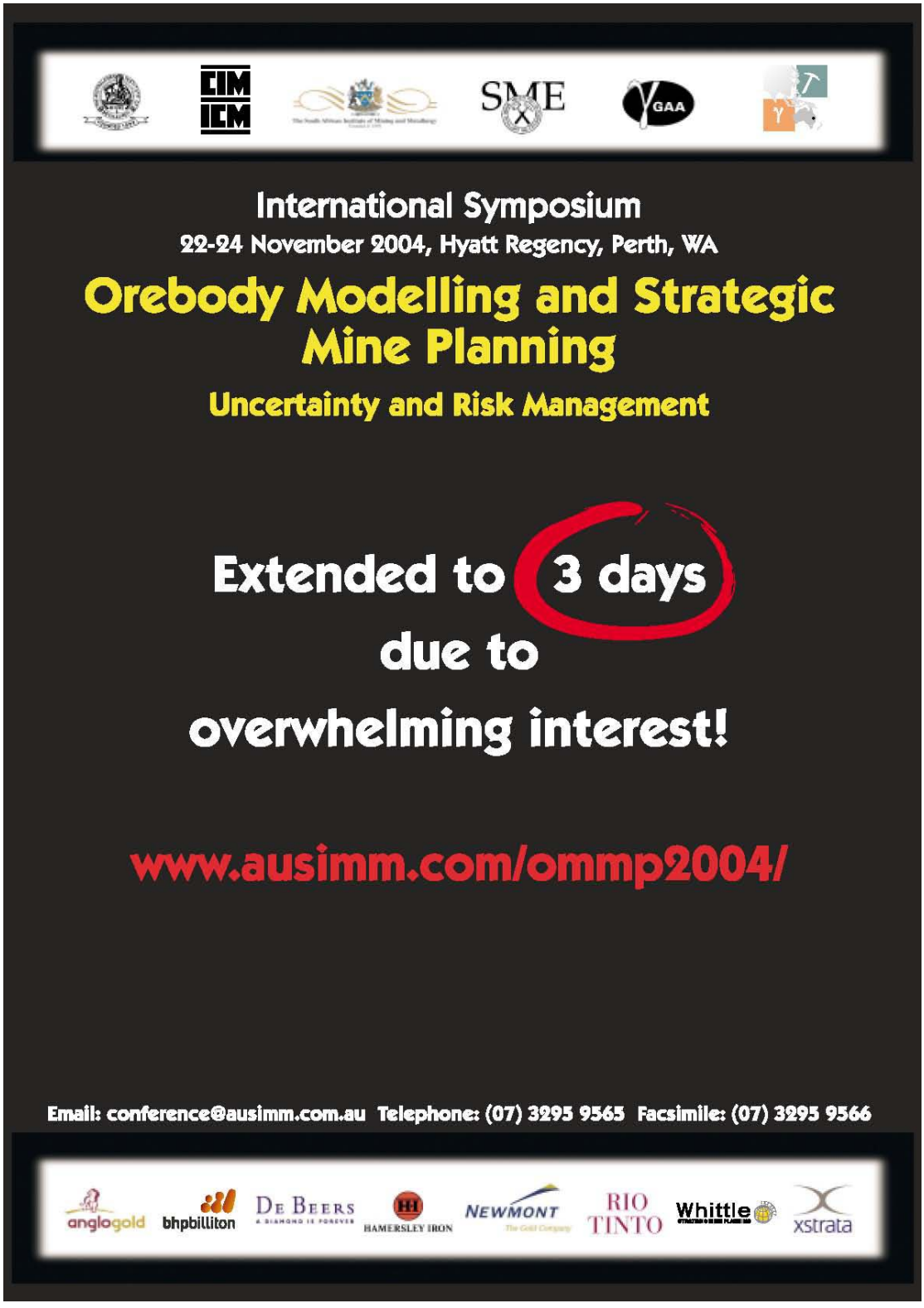
- risk on tonnage ('geological risk'); and
- risk on grade ('grade risk').

The degrees of freedom inherent in the geological model were considered to be potentially high because of wide drill spacing and likely structural complexity. To quantify geological risk three geologists familiar with Stawell mineralisation independently interpreted the deposit. This generated three plausible, different geological volume models.

Conditional simulation was then used to quantify grade risk. Conditional simulation requires the user to define input statistics (histogram and variogram model) and a geological envelope. Based on global mean grade of an ordered set of simulations, 'pessimistic', 'median' and 'optimistic' simulation cases were defined.

The result was a 3x3 risk matrix with geological risk (the three interpretations) on one axis and grade risk (also three cases) on the other axis. An interesting result was that geological and grade risk were of a similar order of magnitude. Therefore a risk analysis of grade by geostatistical methods within a fixed geological model is of limited value, especially if the drill spacing is wide. After completion of this study, with additional drilling, the geological degrees of freedom at Golden Gift reduced substantially. A second Golden Gift risk study used a refined geological model to build a set of simulations to be used in preliminary mine design.

A third simulation study in the deeper parts of the Magdala ore deposit, a well drilled part of the mine with production history, demonstrates that the geostatistical simulation method used at Golden Gift is a robust and useful tool to quantify grade risk.


International Symposium
22-24 November 2004, Hyatt Regency, Perth, WA
Orebody Modelling and Strategic Mine Planning
Uncertainty and Risk Management
Extended to 3 days
due to
overwhelming interest!
www.ausimm.com/ommp2004/
Email: conference@ausimm.com.au Telephone: (07) 3295 9565 Facsimile: (07) 3295 9566

DECLUSTERING AND DEBIASING

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Reproduced below with the kind permission of the University of Alberta, is the abstract, introduction and conclusion of an article on declustering and debiasing. The full text of the article, relevant diagrams and tables, is posted to the GAA website (www.gaa.org.au)

Abstract

Strategic project decisions are based on the distributions global variables, for example, total mineable resource, or recoverable oil volume. These global variables distributions are very sensitive to rock type proportions and the histograms of continuous variables. Representivity of the input one point statistics is important in all spatial models.
The process of assembling representative one point statistics is complicated by sample clustering and spatial bias in the data locations. Explanation is provided on the source of nonrepresentative sampling and the need for declustering and debiasing. This work addresses some key implementation details on declustering. Standard declustering is not always able to correct for sampling spatial bias. Two methods for correcting bias in the one point statistics: "trend modeling for debiasing" and "debiasing by qualitative data" are reviewed and demonstrated with a poly metallic data set.

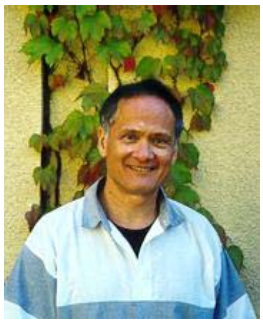
Introduction

Great computational effort is exerted to build realistic geostatistical simulation models. The goodness of these models is judged by their ability to reproduce input one-point statistics and continuity structures. Geostatistical techniques slavishly reproduce input lithofacies proportions and the histogram of petrophysical properties. There is very little intrinsic declustering or debiasing within geostatistical simulation algorithms. Geostatistical simulation always weights the input distribution. Gaussian simulation in particular ensures that the input distribution is approximately reproduced. Clustered sampling that misrepresents the proportions within specific bins, or spatial bias sampling that does not characterize the full range of the distribution, in the input distributions must be dealt with explicitly. The importance of representative input distributions must be evaluated with respect to the sensitivity of the response variable to clustering or bias in the input statistics. Simulated models are only an intermediate result. Management decisions focus on the results after the application of a transfer function. Declustering methods are commonly applied in an automated fashion. This work addresses the properties of a variety of declustering algorithms and methods of improving application. Issues such as working with anisotropy, within facies and with multiple variables are addressed. It is essential to understand the applicability and limitations of declustering algorithms since blindly applying declustering may be worse than working with the naïve statistics. Declustering is ineffective in cases with spatial bias. Debiasing tools such as "trend modeling for debiasing" and "debiasing by qualitative data" should be brought into common practice for the purpose of improving the inference of the one point statistic.

Conclusions

Nonrepresentative sampling is unavoidable in most geologic settings. Declustering techniques are widely used and are generally effective for correcting for nonrepresentative data. It is important to understand the appropriate methods and settings for the application of declustering. In settings where the underlying distribution has not been adequately sampled, declustering may not be adequate and debiasing is required. Debiasing relies on analogue information such as a trend in the primary variable or a well sampled secondary variable and a calibration. Two debiasing methods, trend modeling for debiasing and debiasing by qualitative data, have been demonstrated with a mining data set.

ANDRE JOURNEL HONORARY LIFE MEMBER



Andre Journel (geostatistician extraordinaire)

Andre Journel was born in French Indochina (now Vietnam) and spent his early life there and in the French colonies in Africa. He sees his life as having been strongly shaped by his being the son of a French engineer working in the French colonies.

Ask if he was attracted to science before becoming a mining engineer and Andre replies that he originally wanted to pursue a literary career. His parents, however, objected. He thus does a Science baccalaureate and enters the Ecole Des Mines in Nancy, with the intention of returning to the colonies.

At Nancy, he meets Professor Georges Matheron who is teaching probability, an encounter that will change Andre's life. He develops a passion for probabilities, earth sciences and … geostatistics. What he also mentions, when prompted, is his sporting endeavors–running 200 meters and 400 meters, some of it competitively.

While Matheron does not at first see much future in geostatistics, Andre enters the new discipline with the passion and faith that characterise the young intellectual milieu in the 1960s, namely, the French May of 1968. He is with Matheron when the "Centre De Recherche en Geostatistique" in Fontainebleau is created in 1969. He works hard there for the next nine years to become the youngest "Maitre de Recherches" and principal author of the book *Mining Geostatistics*.

After a year-long break traveling in a camping car in Central Africa, Andre is headed to work for a large company in Australia, when a second major event in his life happens. With his book *Mining Geostatistics* having a significant impact in the USA, Andre is invited to visit the prestigious Stanford University for three months. He is still there. At Stanford he finds the support he could not get in France. At Stanford, he created a research center with initial focus on the mining industry then changing in the mid 1980's to focus on the petroleum industry. At Stanford, Andre was awarded a Chair professorship in Earth Sciences.

Andre goes on to train a succession of students, striving to pass on to them his scientific vision that emphasizes "creative activity" over laborious endeavors. His view is that the USA is a country where such creativity is possible. He claims that "PhDs have to be springboards from which students learn to leave behind the accepted knowledge". He advises his students to use their intelligence, and not be constrained by the prevailing knowledge. In this respect, he says "many students have given up the Journel way", a fact that pleases him - he always wanted his students to live their life as creators and artists. And, Andre views himself as living like an artist with his family. He is optimistic about a future where 'geostatistics' will not be the way we perceive it today. He hopes to some day go back to his first passion: writing poetry. Andre remains truthful to his advice to others: "don't' be afraid, trust yourself".

BOOK REVIEWS

With lind permission of The Australian Geologist (GSA)

YANDAL GOLD PROVINCE: GEOSCIENCE AND EXPLORATION SUCCESS

Edited by: K. S. Ely, G. N. Phillips.2003, 219pp, ISBN 0-643-06968-2, CSIRO Exploration and Mining, Box 312, Clayton South, Vic. 3169. www.em.csiro.au

At first glance you groan inwardly and think "Oh God, not another self-laudatory booklet attempting to justify obscenely generous handouts from the taxpayer." And the Preface sure reinforces that view. But the opening chapter by Neil Phillips and Julian Vearncombe on its own justifies the purchase. Not since Roy Woodall was in full flight back in the 1980s have I read a better summary of what it takes to run a successful exploration programme. Given the great strides in technology since the 1980s, Phillips and Vearncombe have succinctly benchmarked the art of management and conduct of exploration in the current era. The claimed endowment of 400t of gold in the Yandal belt has been discovered at a cost of A$30/oz, which is a lot better than average, especially for a new province.

Tracing the events that led to the significant discoveries at Yandal in the 1990s, Phillips and Vearncombe point to the importance of integrating research into the process from the start. "Behind these successes was a combination of commitment to technical excellence, people, leadership, and an overall culture focused strongly towards discovery." So often we hear these phrases trotted out by CEOs and HR people with a complete lack of sincerity and an implementation which is totally the opposite! But in the case of Ed Eshuys and Joe Gutnick, they actually walked the walk and talked the talk. It must have been

tremendously inspirational, if exhausting, for the young geologists exposed to this culture, and many of them are listed in the acknowledgements (again an innovation!). Great Central Mines was fast on its feet: "…it was not unknown for project submission and Board approval on a Friday afternoon followed by project initiation the next Monday." And they could do it because " …from the outset there was an expectation that the results from up to 40 drill rigs would be plotted and ready for interpretation and planning next morning."

In the second chapter, Ravi Anand discusses the understanding of the regolith processes and landscape evolution that arose out of the intensive research at Yandal conducted chiefly by CRC-LEME. It's a traditional description, as the knowledge came from the study of over 50,000 drill holes. In other words, the research came well after discovery, rather than guiding the exploration process. I have a sneaking suspicion that Ed Eshuys would drill the shit out of anything that looked promising, so long as Joe was able to provide the funding. This recipe has been applied in many promising terranes by a number of companies, with a better-than-average success rate!

Chapter 3 is a useful overview of the geology of the Yandal province, with the focus on key controls on mineralisation. In 20 or so pages all of the important geological features are summarised, with a welcome absence of overly academic discussion. Overall, it turns out that the tectonic setting and ore controls in the Yandal belt are really no different from the other productive gold provinces in the Yilgarn Craton. The lack of any discussion on the geophysical signatures, particularly regional gravity and magnetic features, is a bit disappointing.

The remaining three chapters discuss the Jundee, Bronzewing and Darlot deposits respectively. The notable association of the mineralisation at Jundee with dacitic and granodioritic porphyry dykes is mentioned, but whether there is a genetic relationship between the dykes and gold mineralisation apparently remains an enigma.

Reflecting on the abundant information in this collection set me musing once again as to where you draw the line around a gold district or province. Is Jundee by itself a gold district (it contains over 70 major ore-bearing structures mined in 12 separate mines)? No, I prefer the philosophy inherent in this book: the district includes all the deposits from Jundee to Darlot, a stretch of over 200km. Compare the Carlin District, which is taken to include all the deposits from Rain in the south to Dee in the north, a distance exceeding 100km. The gold endowment in the Carlin Trend is more than 2,500t; at Yandal it exceeds 400t. The exploration at Yandal once again demonstrates the importance of viewing an entire district as the target, not individual deposits. Don't just peg only the first indication of mineralisation; whack tenements over the complete belt, and systematically explore the region as a whole.

So often when exploration managers justify focus on a particular deposit style by comparing endowments of, say, porphyry copper-gold deposits with orogenic gold deposits, they compare individual mines and conclude that your average porphyry is much more productive than your average orogenic gold deposit. An entirely different conclusion is reached if you compare district endowments.

Overall the book is good value at $35 (including delivery and GST). Order it direct from the CSIRO web site. In 219 pages it encapsulates all the important elements of this relatively new gold province. The compact size, less than 500g weight, and easy-flowing writing style means that it's the sort of book you could slip into productively during the 4 hours flying from the eastern states to Perth.

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FRACTALS AND CHAOS IN GEOLOGY AND GEOPHYSICS 2ND EDITION

By D. L. Turcotte 1997, 397pp, ISBN 0-521-56733-5. (Paperback) Cambridge University Press, Private Bag 31,Port Melbourne, Vic. 3207.egilmour@cambridge.edu.au Price: AUS$120.00 (Paperback)

In 1967, Benoit Mandelbrot introduced fractals in his pivotal paper, *How long is the coast of Britain?*. Six years earlier, the meteorologist Ed Lorenz discovered deterministic chaotic behaviour in the set of non-linear differential equations he was using to approximate thermal convection in a fluid layer. These two pillars of the theory of complex systems are built on earth-phenomena, yet, the earth sciences have been slow to adopt the application of fractals and chaos. This may be about to change. Donald Turcotte's second edition of *Fractals and Chaos in Geology and Geophysics* heralds that change.

Donald Turcotte is a Distinguished Professor in the Department of Geology at the University of California, Davis, and professor emeritus at the Department of Earth and Atmospheric Sciences at Cornell University. Originally an aeronautical engineer, it was during a sabbatical at Oxford in 1965 that a chance meeting with geologist Ron Oxburgh led to work on the problems of mantle convection, the pair writing landmark papers on the subject. It was, as Turcotte said, "… a collaboration between a geologist who didn't know anything about equations and an aerospace engineer who didn't–and doesn't–know one rock from another." In 1973 he joined the department of geological sciences at Cornell. Here he became interested in fractals when, in 1980, a graduate student Bob Smalley gave seminars convincing Turcotte of the relevance of fractals and scale-invariant statistics to problems in geology.

Since the first edition, published in 1992, Turcotte has increased the reference list from 160 to more

than 500 and he has written new chapters and sections: the fractal distribution of mineral deposits, geomorphology, wavelet analysis—indispensable for the study of potential field data—and renormalisation group methods—applied to fragmentation, permeability, and self-organised criticality. These are additional to the revised chapters on seismicity and tectonics, ore grade and tonnage, the chaotic behaviour of the mantle, and earth's magnetic field; all exemplars of the new mathematical tools being applied to earth sciences.

Because the study of fractals and chaos is unavoidably mathematical, there are necessary chapters, peppered with useful physical examples, dealing with theory: scale invariance, fractal sets and clustering, self-affine fractals, dynamical systems, logistic maps, and the Lorenz equations. Turcotte has resisted any temptation to be too clever and bombard the reader with a surfeit of mathematical theory. The level should suit anyone with basic undergraduate maths and physics, although you may want to brush up on the product rule, integration by parts, and derivation of the Gaussian distribution. Each chapter comes with a set of problems (answers in the back of the book, along with appendices on units, symbols, and definitions) should you wish to test your knowledge and understanding of a topic.

There are some minor items which mar an otherwise excellent work. Maybe they are quibbles, but I them found them irritating. The equations are not punctuated. Because equations are clauses, or sentences, it is standard practice to use stops to show context and clarify meaning. The practice should be followed, if for no other reason, to distinguish whether **!** is being used to denote a factorial or an exclamation mark. I would also prefer that the equations be centred rather than set flush left. *Data* is treated both as singular and plural. For the record, it is a plural but I would settle for consistency. I would also settle for the use of either kilometre or mile for a unit of distance, but not both—not in the same sentence. More attention by the publisher at editing would have helped.

The final chapter, *Where do we stand?* is where Turcotte shows some uncertainty whether fractals, chaos, and self-organised criticality are capable of providing adequate models of the complex systems studied in the earth sciences. Now, seven years after publication of the second edition, perhaps, the judgment can be made. I certainly hope that Donald Turcotte can find time to deliver us a third edition. If not, the second edition will have to stand as the landmark text.

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MODELLING IN NATURAL SCIENCES: DESIGN, VALIDATION AND CASE STUDIES

By T. Müller and H. Müller, 2003, 459pp,ISBN 3-540-00153-0 Springer-Verlag GmbH & Co.KG, Tiergartenstrasse 17, D-69121 Heildelberg, Germany. www.springer.de. Price: Hardcover US$89.95

The word "…Validation" in the title of this book really grabbed my attention. I have always been challenged by never really knowing how correct and/or appropriate the various geology, block, numerical and the odd physical models that I have used, created, reviewed and audited have been. Spatial sample-model comparisons, QQ plots, statistics (raw and declustered), jack-knifing and cross validation are all useful tools but as my first supervisor pointed out, "…the model is only as good as the next drill hole or cut". Having observed and even created the occasional model that passed all the formal tests but still looked fundamentally flawed, I was hoping that this book would provide some new ideas as well as some practical tools, especially with model validation. Tibor and Harmund Müller's, "MODELLING IN NATURAL SCIENCES: DESIGN, VALIDATION AND CASE STUDIES" provided some new ideas and certainly added considerable background and syntax to the concepts of scientific modelling, but unfortunately, offered little in the way of practical information. After reading the book several times, I cannot help but feel that to be fair, the inclusion of the word philosophy would have made for a more honest book title.

First impressions were that the book looked good and was well presented. The book packed a lot in to the 459 pages, being printed in a relatively small but very easy to read font and is divided in to two distinct sections. The first section consisted of the 11 chapters of discussion and references by Tibor Müller and Harmund Müller. The second section of the book consisted of 8 case studies by a variety of authors on a range of different modelling situations. Overall the book is well structured, building upon successive ideas and concepts with out making any large jumps of logic. The text frequently referenced either previously or yet to be covered concepts which tended to detract from the overall flow of ideas. There were few illustrations in the first section, which I found disappointing. I do believe that a picture is worth a thousand words and was glad to see the case studies in the second section of the book, were well illustrated.
Chapter 1 of the text by Tibor and Harmund Müller covered preliminary concepts of what models are with some very thought provoking examples. It also discussed the importance of knowing the purpose of the model prior to creating the model plan, an aspect that is often misunderstood by people who commission a model. Chapter 2 and 3 defined and outlined the process used with in the book and establishes the concepts that are to follow. Chapters 4, 5 and 6 discussed the processes involved with creating a model and introduced the idea of the modelling art, (best surmised as knowing what to leave out rather then what to include). Chapters 7, 8 and 9 then covered the principles of model quality, calibration, model iterations and tests. Chapter 10 then discussed the difference in opinion between two schools of thought on what the words verify and validate

represent in model testing and unfortunately, descended in to a high brow "he said, they said". Though the authors summed up the debate well and provided an agreeable closure on the subject, reading the chapter left me questioning the relevance of the discussion. The eleventh chapter contained suggestions for further reading and a very good bibliography on scientific modelling philosophy and concepts.

The text by Müller and Müller was verbose and lost some of the message in the language. Part of this may be an issue of translation of which there was some evidence and there is undoubtedly an element of this reviewer having little patience for esoteric discussions. Allowing for these factors, the authors still seemed to relish discussing the linguistic origins and nuances of words which often appeared irrelevant to the discussion and which made the text read like an academic treatise on the philosophy of scientific modelling. Discussions of semantics and literary meaning were interesting, but often diminished the impact of the discussion. What constitutes a model, the need to understand how the model will be used and what will be asked of it, plus many other important ideas and concepts are within this book and well covered, but were not effectively communicated to this reader. It was also disappointing that the book dealt with model documentation in a very cursory, almost incidental manner. I have observed numerous examples of re-work and knowledge loss within organisations due to reduced confidence or confusion about a model from inappropriate or inadequate model documentation. I had hoped that this book would discuss or assist formalising the issue, but it did not.

Having worked through the text, getting to the case studies was a welcomed change. Each case study emphasised different aspects of the modelling process, with each being well written and illustrated. It would have been useful to reference these case studies back to the text with some linking statement or note and provide some context for the first section by the two Müllers. The variety of issues and constraints from such varied subjects as astrophysics, hydrology, environmental chemistry, glass during melting, meteorology, chemical equilibria, hydrogen behaviour in nuclear reactors and palaeo-anthropology, together illustrated the modelling process very well and individually provided tremendous insight to problems facing other disciplines. Both the text and case studies are well referenced and the subject of modelling in natural science is very well researched making it is obvious that the subject of modelling is one that the two authors are passionate about.

The Springer-Verlag web site says the book was written for "…Scientists, researchers, lecturers, graduates; libraries" which covers just about everyone. This book is about the theory of scientific modelling and it does well to cover such a varied subject, thanks largely to the case studies. For people not familiar with modelling in science, this book introduces ideas and concepts behind scientific modelling but they are inefficiently communicated. To people who are comfortable using and creating models, this book will articulate some important ideas that are often taken for granted, even though you have to labour through the text. This not a good book for the casual reader, due to the frequent cross-referencing and the wordy text. I am however, glad to have read the book, as it is interesting and I recommend anyone involved with modelling in science to read it, as it will provide some context to the modelling process. I would not purchase this book outright, but I have located a copy of the book so that I know where to obtain a copy when I want to re-visit ideas. The case studies individually are a worthwhile read and as a collection, put many of the geological modelling issues in to perspective.

Kahan Cervoj
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MINE WASTES - CHARACTERIZATION, TREATMENT AND ENVIRONMENTAL IMPACTS

By Bernd Lottermoser, published by Springer, 2003

This book fills a significant gap in the readily available literature on the increasingly important topic of mine wastes. As our society places increasing emphasis on care for the environment, the Australian mineral industry has become a world leader in the management and rehabilitation of mining sites. However, there remain numerous environmentally damaging legacies of historic mining practices in Australia and of course untold examples overseas, especially in Third World and former Soviet Bloc countries. Consequently, there will be a continued, and increasing, requirement to have adequate knowledge and training on the issues of mines wastes and their environmental effects. Dr Lottermoser correctly states that there are many other books and reports that cover particular issues of mine wastes, but none readily encapsulate the breadth of topics that are dealt with in his book. This slim, reasonably inexpensive and well produced book provides an up-to-date, scientifically based and thorough reference for post-graduate students, exploration and mining geologists, geochemists and the broader environmental science and land management fields. As many of the latter people in statutory authorities and in industry have to deal with consequences resulting from mine wastes, the book can provide them with the necessary scientific (especially geochemical) background to understand the processes and seek viable solutions. Many university geoscience and environmental science courses in Australia and elsewhere have introduced some aspects of the environmental consequences of mining into their teaching curricula, so this concise, but detailed book is highly suited for teaching at senior undergraduate level, subject to students having a familiarity with the basics of inorganic chemistry. The contents of the book give a suitable adjunct to the teaching of ore deposit geology and a consideration of the environmental issues associated with resource exploitation.

The author has had many years of practical experience in Australia and Europe in research on mine wastes and related environmental issues

(e.g. sewage sludge, acid sulphate soils) and this has given the basis for the thorough coverage of waste characterisation (physical and chemical properties), the processes that occur in mine wastes, the environmental consequences and strategies for treatment and remediation. There are clear descriptions of all of these aspects and refreshingly, they are accompanied by the use of simple chemical equations and explanation of many metallurgical and hydrometallurgical processes that may give rise to waste products. As a person who appreciates mineralogy, I found the mineralogical descriptions of mine wastes and reaction products (e.g. mineral efflorescences and precipitates from acid mine drainage (AMD)) enthralling. The sensible predictive statements on the long term effects of AMD, cyanide wastes and the erosional stability of uranium-bearing and other tailings dams were very much appreciated.

Chapter 1 introduces the topic, giving definitions and some historic aspects of mine wastes and their environmental impacts. Chapter 2 provides considerable insight into sulphidic mine wastes, those dominantly associated with the metal-mining industry, but also associated with coal mining. Weathering and oxidation processes and resulting AMD of these wastes are well described as are methods of prediction, monitoring and control of acid generation and heavy metal liberation. Chapter 3 details the nature and chemistry of acid mine waters, and methods that can be used to treat them. The topic of tailings, covering the solid and liquid products commonly stored in tailings dams, is described in Chapter 4. Cyanide-bearing wastes that derive from the treatment of gold ores are dealt with in Chapter 5, along with clear description of the chemistry of cyanide and treatment options for these wastes. An excellent treatment of the unique situation of uranium ores and their treatments and wastes is the subject of Chapter 6. This chapter again has a solid chemical base but also includes necessary details of the principles of radioactivity and the radionuclides, and methods of mining and treatment of uranium ores. Chapter 7 displays a significant difference to other chapters in that it extends out from the "more familiar" aspects of metal mining and associated waste products into the fertiliser minerals arena, encompassing potash and phosphate ores. These materials are overall little-known by earth and environmental scientists.

Significant strengths of the book include the provision of useful tables and illustrations, topical case histories in all chapters (many of which are related to the direct experience of the author), valuable lists of resource materials, (including websites) that can be used to provide links to additional and related information, and concise summaries at the end of each chapter. There is a comprehensive reference list that will be of great relevance to many readers. The book has very few faults – I could only detect a few minor typographical errors. Perhaps the omission of any major discussion of the nature and behaviour of coal mine wastes could be criticised, as these can generate AMD, liberate heavy metals and metalloids, be subject to spontaneous combustion and have other physical attributes that cause problems. However, despite only cursory comments on coal mining, treatment and wastes, Dr Lottermoser's book will be a largely comprehensive and valuable resource on mine wastes for many years.

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NEW INSIGHTS INTO STRUCTURAL INTERPRETATION AND MODELLING

Edited by D.A. Nieuwland. 2003, 340 pp, ISBN 1-86239-131-9. Geological Society Special Publication No. 212, Published by the Geological Society Publishing House, Unit 7, Brassmill Lane, Bath UK BA1 3 JN. Fax: +44 1 225 442 836 or the Geological Society Bookstore: http://www.bookshop.geolsoc.org.uk. (Paperback) Price £80.00 (list price); £40.00 (GSL Member price).

This publication has emanated from a Geological Society of London conference of the same name and claims to present a balanced view of traditional structural geological investigations and present advances in the field of modelling. In the latter case, the book deals with developments in the fields of data acquisition processing and interpretation. It is these advances in the interrogation and modeling of data that the majority of papers focus on. Both of the complementary fields of modeling, namely analogue models using physical materials, and numerical models based on mathematical algorithms, are discussed.

The papers in the book have been collected with the intention of providing the reader with a comprehensive overview of state-of-the-art approaches and techniques in structural geological interpretation and modeling. The book starts with the papers based on interpretation of field-based datasets, with modelling-based papers dominating in the second half of the book.

Initial papers deal with such aspects as geometry and scaling properties of faults for modelling geofluid reservoirs, fault-horizon networks, stress inversion, shear-wave splitting, and the World Stress Map. Analogue model papers discuss such things as rift formation and extensional fault development. Numerical modelling papers discuss topics as varied as sedimentary basin formation, the integration of 3D stratigraphic information into basin evolution, extensional faulting, and the interplay between extensional and compressional deformation.

One thing that is only obvious after browsing the book is the focus of all of the papers on brittle deformation to the point of virtual exclusion of truly ductile processes. In this respect the title of the book is somewhat misleading, as the closest the papers come to dealing with ductile deformation is

that of thin-skinned tectonics in relation to thrusting. These comments are not meant to detract from the quality of the included papers. All of the papers are of the high scientific and editorial standard that we have come to expect from Geological Society Special Publications. Rather, the emphasis of the volume is much more restricted than indicated by the title.

In a pragmatic exploration sense the book will not find wide appeal. The papers focus almost entirely on the acquisition and interpretation of seismic data. In this sense the volume is very Euro-centric in that the models are developed largely in the context of northern hemisphere petroleum exploration. Any other geophysical data acquisition techniques and modelling/interpretation are absent. As such, there will be very little of use for the mineral explorationist.

Overall, the volume is of high quality but misleading in the breadth of topic suggested by the title. Its applicability external to academia and a small portion of the petroleum industry is limited.

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MOVING FORWARD FROM TRADITIONAL OPTIMIZATION: GRADE UNCERTAINTY AND RISK EFFECTS IN OPEN-PIT DESIGN

R. Dimitrakopoulos, C. T. Farrelly and M. Godoy.
Reproduced below, with permission, is the abstract of a paper originally presented at the Strategic Mine Planning conference held by the Australasian Institute of Mining and Metallurgy in Perth, Western Australia, from 26 to 29 March, 2001, and published in Trans. Instn Min. Metall. (Sect. A: Min. tech -nol.), 111, January-April 2002. The full text of the article, relevant diagrams and tables, is posted to the GAA website (www.gaa.org.au)

Abstract
An economic argument is presented for the incorporation of quantitative modelling of the uncertainty of grade, tonnage and geology into open-pit design and planning. Two new implementations of conditional simulation–the generalized sequential Gaussian simulation and direct block simulation–are outlined. An optimization study of a typical disseminated, low grade, epithermal, quartz breccia-type gold deposit is used to highlight the differences between the financial projections that may be obtained from a single orebody model and the range of outcomes produced when, for example, fifty deposit simulations are run. The effects on expectations of net present value, production cost per ounce, mill feed grade and ore tonnage are presented as examples and periods with a high risk of negative discounted cash flow are identified. Further integration of uncertainty into optimization algorithms will be needed to increase their efficacy.

CALENDAR OF EVENTS

2004 MAY 24-25
MINSANDS 5th ANNUAL MEETING Melbourne, Vic. **For Details:** www.ajmonline.com

2004 MAY 27-28
NQEM Exploration and Mining in Northern Queensland QLD branch of the AIG. **For Details:** www.aig.org.au

2004 JUNE 14-16
GOLD DEPOSIT WORKSHOP AT CODES. Hobart, Tas. **For Details:** www.codes.itas.edu.au

2004 AUGUST 20-28
32ND INTERNATIONAL GEOLOGICAL CONGRESS. International Union of Geological Sciences, Fortezza Da Basso, Italy. **For Details**: Chiara Manetti cmanetti@geo.unifi.it Website: www.32igc.org

2004 SEPTEMBER 19-20
SECOND EASTERN AUSTRALIAN BASINS SYMPOSIUM (PESA EABS 2). Adelaide Convention Centre. **For Details:** Barry Goldstein www.pesa.com.au or Goldstein.barry@saugov.sa.gov.au

2004 SEPTEMBER 19-22
8TH INERNATIONAL CONGRESS ON APPLIED MINERALOGY (ICAM 2004), Sao Paolo, Brazil. **For details**: www.icam2004.org

2004 SEPTEMBER 18-20
PACRIM 04: HI TECH AND WORLD COMPETITIVE - MINERAL SUCCESS STORIES AROUND THE PACIFIC RIM. Adelaide SA. **For Details:** www.ausimm.com.au

2004 SEPTEMBER 27 - OCTOBER 1
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2004 NOVEMBER 22-23
OREBODY MODELLING AND STRATEGIC MINE PLANNING - UNCERTAINTY AND RISK

MANAGEMENT. Perth WA **For Details:** www.ausimm.com.au

2005 FEBRUARY 28 - MARCH 2
SME ANNUAL MEETING AND EXHIBIT, Denver, Colorado. **For Details**: www.smenet.org

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