

Progress in Geomathematics

Bearbeitet von
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1. Auflage 2008. Buch. xvi, 554 S. Hardcover

ISBN 978 3 540 69495 3

Format (B x L): 15,5 x 23,5 cm

Gewicht: 1116 g

Weitere Fachgebiete > EDV, Informatik > Informationsverarbeitung >
Computeranwendungen in Geistes- und Sozialwissenschaften

Zu Inhaltsverzeichnis

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Introduction

Graeme F. Bonham-Carter and Qiuming Cheng

Keywords Festschrift · fractal · quantitative stratigraphy · compositional data · mineral resource assessment · time series · geostatistics

This volume is composed of a series of papers written by colleagues and friends of Frederik (Frits) P. Agterberg – a Festschrift. All the papers were contributed in response to invitations to potential contributors, sent out in late 2006. First drafts were mostly complete by July 2007, and it has taken a further year to complete reviews and revisions for a publication date in time for the International Geological Congress in Oslo, August 2008.

The book consists of 28 (plus 2 introductory) papers by a total of 58 authors, the majority from Canada and USA, but including authors from 12 other countries. The papers cover a diverse range of topics in geomathematics, such as fractal and multifractal modelling, quantitative stratigraphic analysis, compositional data analysis, mineral resource assessment, time series analysis and geostatistics. The diversity of subject matter and the multi-nationality of authors reflect Frits' own broad interests within geomathematics, and the international make-up of his colleagues and friends. Following this introduction, we provide information about Frits Agterberg's career and his many achievements, including his close links with the International Association for Mathematical Geology (IAMG) since its founding in 1968.

Deciding the running order of these papers was not straightforward, because although some papers are naturally linked to others, many are not easily grouped. The subject matter of the book depends only on the current research interests of the contributors and no themes (beyond some geomathematical content) were prescribed in

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advance. The running order of the papers is, therefore, not always logically consistent, being based on a blend of methodology and application.

We begin with three papers about advances and applications of compositional data analysis to geochemical data. Following on the earlier work by Felix Chayes and John Aitchison, Vera Pawlowsky and colleagues have made significant theoretical and applied advances that have raised the awareness of the problem to many. The first 2 papers (Buccianti and Pawlowski; Mateu-Fugueras et al.) provide new material on applications and methodology. Then Drew et al.'s contribution provides an application of logratio transforms to coal data, confirming the importance of evaluating compositional data in coordinates that remove the closure effect.

The next four papers are loosely grouped as being about problems in geophysics. Ute Herzfeld gives an overview of the methodology and application of her geo-statistical characterization approach applied to map the texture and morphology of various surfaces, particularly sea floor and ice, both sea ice and glaciers. The following paper by Mayer and Herzfeld is a recent application of the methodology to a Greenland glacier. T. Shoji provides an example of applying 3-D variograms to rainfall data, in order to model the spatial and temporal continuity of this phenomenon. Many will be familiar with the work on multifractals and nonlinear dynamics by Shaun Lovejoy and colleagues. Here Lovejoy et al. extend this approach to rock density and surface gravity. They provide theory and application that allows for vertical anisotropy, clearly important in a stratified Earth.

The following seven papers are clustered under the heading of mineral exploration. Cheng discusses how hydrothermal mineral deposits can be regarded as end products of nonlinear processes that can be modelled as fractals and multifractals. He uses a case study to illustrate how spatial evidence (from geochemistry, structures etc.) can be processed with nonlinear models to reveal singularities in the data that indicate the presence of deposits. Harris et al. provide an application of integration of spatial datasets to evaluate mineral potential in an area of Canada's Northwest Territories proposed as an extension to an already existing National Park. Singer and Menzie explore the problem of estimating the number of undiscovered mineral deposits in an area. Raines demonstrates the bifractal nature of various mineral deposit types, and discusses how this property could be used to estimate the number of undiscovered deposits. Thiart and de Wit show that mineral deposit patterns are distinctly different in older crust that has been remobilized in Pan African belts compared to those in juvenile crust of Neoproterozoic age. Fabbri and Chung argue that mineral (or landslide) potential maps calculated by integrating information from spatial data layers are in a metric that should be regarded as a rank order only, and that blind tests using quantile-type prediction indices should be used to evaluate such spatial prediction models. Coburn et al. use a simulation approach to model strip transect sampling, and although their immediate concern is to find buried ordnance, the methodology has wide application, including its use in oil and mineral exploration.

The next five papers are about the application of mathematical methods in paleontology and stratigraphy. Gradstein et al. discuss the use of the RASC and CASC software (developed over many years by Agterberg, Gradstein and others) to improve the resolution of stratigraphic correlation. Zhou Di illustrates the

same methodology applied to data from the Pearl River Mouth Basin, in which a biozonation was developed and applied for correlation of well data. Brower demonstrates how Euclidean distances between landmarks (followed by a singular value decomposition) provide a useful tool for geometric morphometrics in paleontology. Reyment et al. apply a discriminant analysis (on compositional data transformed to overcome closure) to show that some species of radiolarians react differently from season to season, whereas others may be less affected by environmental conditions.

Statistical methods applied to sedimentary and stratigraphic data are exemplified by four papers. Doveton shows how a lithologic transition probability matrix can be transformed to a mean first-passage time matrix that provides a metric useful for characterizing differences between stratigraphic sections. Deutsch discusses the beta distribution for modelling the shape of the scale-dependent multivariate distribution of facies proportions. Olea et al. provide a case study of cokriging to generate a porosity map in an area of the Baltic Sea, using densely sampled bathymetry and grain size measurements as proxy variables. Merriam and Davis use Watson's U^2 statistic to compare structural directions amongst a wide variety of data sources from Kansas.

There are three papers on time series analysis. Prokopf and El Bilali use a cross-wavelet approach to model CO_2 time series from plant cuticle measurements, and temperature from δO^{18} data, for the last 290 my, focussing particularly on the influence of nonstationarities introduced by stratigraphic uncertainties. Reyment examines the volcanic history in an area of Japan using cross-correlations between the magnitudes of A-type earthquakes and depth of events for three periods from 1983 to 2005. Data from harbors on the Baltic Sea illustrate an example of producing sea level measurements from which local variations have been separated, yet with the sea level components in the correct phase at desired locations (Robinson).

The final two papers by Ian Lerche do not seem to cluster with others, so we have put them together at the end of the book—they are last but definitely not least (and we should also mention that these papers were submitted first, at least six months before any others!) They are both good examples of simulation models of an imaginative type, one dealing with strategies to divert flood water to old mine sites, the other about how one can investigate a “Christmas parking lot problem” from the merchant's perspective.

Many of the papers in the book, at the suggestion of the publisher, appeared in recent issues of *Mathematical Geosciences* and *Natural Resources Research*, and now are “reprinted” here, although it must be stressed that they were all written for the book, without exception. By appearing also in these journals, the papers involved benefit from a wider circulation and greater availability (particularly online) than would be possible in the book alone. This in no way detracts from the ‘specialness’ of the book, because the contributors all wrote their papers to honour our friend and colleague Frederik P. Agterberg.

We are very grateful for the time and effort by our many reviewers: Thomas Axel, Geoff Bohling, Fred Bookstein, Antonella Buccianti, John Carranza, Mark Coolbaugh, Roger Cooper, John Davis, Carlos Roberto de Souza Filho, Clayton Deutsch, Juan José Egozcue, Neil Fordyce, Bob Garrett, Michael Goodchild, Felix

Gradstein, Ralf Greve, Pablo Gumiel, John Harbaugh, Jeff Harris, Ute Herzfeld, Mike Hohn, Jerry Jensen, André Journal, Subhash Lele, Gang Liu, Dan Merriam, Mark Mihalasky, Don Myers, Vesa Nykanen, James Ogg, Margaret Oliver, Javier Palarea-Albaladejo, Tim Patterson, Vera Pawlowski-Glahn, Andreas Prokopf, Gary Raines, Joe Robinson, Peter Sadler, Michael Schulz, Bill Sharp, Don Singer, Paul Switzer, John Tipper and Danny Wright.