Mineral Resource Estimation An Introduction

Mineral Resource and Ore Reserve Estimation

This comprehensive textbook covers all major topics related to the utilization of mineral resources for human activities. It begins with general concepts like definitions of mineral resources, mineral resources and humans, recycling mineral resources, distribution of minerals resources across Earth, and international standards in mining, among others. Then it turns to a classification of mineral resources, covering the main types from a geological standpoint. The exploration of mineral resources is also treated, including geophysical methods of exploration, borehole geophysical logging, geochemical methods, drilling methods, and mineral deposit models in exploration. Further, the book addresses the evaluation of mineral resources, from sampling techniques to the economic evaluation of mining projects (i.e. types and density of sampling, mean grade definition and calculation, Sichel's estimator, evaluation methods - classical and geostatistical, economic evaluation - NPV, IRR, and PP, estimation of risk, and software for evaluating mineral resources). It subsequently describes key mineral resource exploitation methods (open pit and underground mining) and the mineral processing required to obtain saleable products (crushing, grinding, sizing, ore separation, and concentrate dewatering, also with some text devoted to tailings dams). Lastly, the book discusses the environmental impact of mining, covering all the aspects of this very important topic, from the description of diverse impacts to the environmental impact assessment (EIA), which is essential in modern mining projects.

Nature's Numbers

Applied Mineral Inventory Estimation presents a comprehensive applied approach to the estimation of mineral resources/reserves with particular emphasis on the geological basis of such estimations, the need for and maintenance of a high quality assay data base, the practical use of a comprehensive exploratory data evaluation, and the importance of a comprehensive geostatistical approach to the estimation methodology. Practical problems and real data are used throughout as illustrations; each chapter ends with a summary of practical concerns, a number of practical exercises and a short list of references for supplementary study. This textbook is suitable for any university or mining school that offers senior undergraduate and graduate student courses on mineral resource/reserve estimation. It will also be valuable for professional mining engineers, geological engineers and geologists working with mineral exploration and mining companies.

Minerals, Critical Minerals, and the U.S. Economy

The conferences on Applications for Computers and Operations Research in the Minerals Industry (APCOM) initially focused on the optimization of geostatistics and resource estimation. Several standard methods used in these fields were presented in the early days of APCOM. While geostatistics remains an important part, information technology has emerged, and nowadays APCOM not only focuses on geostatistics and resource estimation, but has broadened its horizon to Information and Communication Technology (ICT) in the mineral industry. Mining Goes Digital is a collection of 90 high quality, peer reviewed papers covering recent ICT-related developments in: - Geostatistics and Resource Estimation - Mine Planning - Scheduling and Dispatch - Mine Safety and Mine Operation - Internet of Things, Robotics - Emerging Technologies - Synergies from other industries - General aspects of Digital Transformation in Mining Mining Goes Digital will be of interest to professionals and academics involved or interested in the above-mentioned areas.

Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to Nuclear Fuel Resources - Selected Case Studies

This book contains selected contributions presented at the 10th International Geostatistics Congress held in Valencia from 5 to 9 September, 2016. This is a quadrennial congress that serves as the meeting point for any engineer, professional, practitioner or scientist working in geostatistics. The book contains carefully reviewed papers on geostatistical theory and applications in fields such as mining engineering, petroleum engineering, environmental science, hydrology, ecology, and other fields.

An Introduction to Cut-Off Grade Estimation

Geostatistics Valencia 2016
This book provides a wealth of geomathematical case history studies performed by the author during his career at the Ministry of Natural Resources Canada, Geological Survey of Canada (NRCan-GSC). Several of the techniques newly developed by the author and colleagues that are described in this book have become widely adopted, not only for further research by geomathematical colleagues, but by government organizations and industry worldwide. These include Weights-of-Evidence modelling, mineral resource estimation technology, trend surface analysis, automatic stratigraphic correlation and nonlinear geological exploration methods. The author has developed maximum likelihood methodology and spline-fitting techniques for the construction of the international numerical geologic timescale. He has introduced the application of new theory of fractals and multi fractals in the geostatistical evaluation of regional mineral resources and ore reserves and to study the spatial distribution of metals in rocks. The book also contains sections deemed important by the author but that have not been widely adopted because they require further research. These include the geometry of preferred orientations of contours and edge effects on maps, time series analysis of Quaternary retreating ice sheet related sedimentary data, estimation of first and last appearances of fossil taxa from frequency distributions of their observed first and last occurrences, tectonic reactivation along pre-existing schistosity planes in fold belts, use of the grouped jackknife method for bias reduction in geometrical extrapolations and new applications of the theory of permanent, volume-independent frequency distributions.

Computer Applications in Resource Estimation

Proceedings of the 28th International Symposium on Mine Planning and Equipment Selection - MPES 2019

As the importance and dependence of specific mineral commodities increase, so does concern about their supply. The United States is currently 100 percent reliant on foreign sources for 20 mineral commodities and imports the majority of its supply of more than 50 mineral commodities. Mineral commodities that have important uses and face potential supply disruption are critical to American economic and national security. However, a mineral commodity's importance and the nature of its supply chain can change with time, a mineral commodity that may not have been considered critical 25 years ago may be critical today, and one considered critical today may not be so in the future. The U.S. Geological Survey has produced this volume to describe a select group of mineral commodities currently critical to our economy and security. For each mineral commodity covered, the authors provide a comprehensive look at (1) the commodity's use; (2) the geology and global distribution of the mineral deposit types that account for the present and possible future supply of the commodity; (3) the current status of production, reserves, and resources in the United States and globally; and (4) environmental considerations related to the commodity's production from different types of mineral deposits. The volume describes U.S. critical mineral resources in a global context, for no country can be self-sufficient for all its mineral commodity needs, and the United States will always rely on global mineral commodity supply chains. This volume provides the scientific understanding of critical mineral resources required for informed decision making by those responsible for ensuring that the United States has a secure and sustainable supply of mineral commodities.

Mining goes Digital

An Introduction to Cut-off Grade Estimation examines one of the most important calculations in the mining industry. Cut-off grades are essential to determining the economic feasibility and mine life of a project. Increased cut-off grades can reduce political risks by ensuring higher financial returns over a shorter period of time. Conversely, lower cut-off grades may increase project life with longer economic benefits to shareowners, employees, and local communities. Cut-off grades also impact reported reserves, which are closely monitored by stock exchanges and regulatory agencies. Author Dr. Jean-Michel Rendu, an internationally recognized expert in the management, estimation, audit, and public reporting of mineral resources, provides practical insights into this critical variable. YouCOOL learn about minimum cut-off grades, as well as those for deposits containing multiple valuable minerals. Dr. Rendu explains which costs should be included in cut-off grade calculations and considerations when planning open pit, underground, and block and panel caving operations. He shows how to optimize a copper mining project by changing grind size, and demonstrates the relationship between deposit modeling, ore control, and cut-off grades.

Energy and Mineral Resource Systems

Governance of the World's Mineral Resources: Beyond the Foreseeable Future provides in-depth information on the geological scarcity of mineral resources. The book demonstrates the urgent need to implement sustainable utilization of mineral resources, in order to ensure that these resources will be sufficiently available for future generations too. The availability of resources, especially for modern technologies, is an increasingly important issue. Some key mineral resources are so geologically scarce that their availability for future generations may not only become substantially less, but also much less affordable than for the current generation unless timely measures are taken. This book provides detailed data and calculations of the availability of mineral resources. The book elaborates on whether and how it is possible to keep providing sufficient mineral resources to a growing world population, and for how long. The book details also how and for how much time it will be possible for all countries, worldwide, to achieve and maintain service delivery of raw materials to their population at levels equivalent to those in developed countries in 2020. Governance of the World's Mineral Resources: Beyond the Foreseeable Future is therefore an important source of knowledge for postgraduates, academics and researchers in the fields of environmental science, sustainability, and geology, as well as anyone in the field of mining and economics who need to account for sustainable provision of mineral resources. Provides a thorough overview of all considerations related to a sustainable production rate of mineral resources Comprehensively details scarce mineral resources and describes their applications, worldwide in-use stock increases, and sustainable production rates Covers all aspects of a sustainable production rate of mineral resources, detailing the current challenges and possible global solutions, both technically and from a policy point of view Includes detailed studies of thirteen different scarce mineral resources and extensive quantitative data from recent studies and in-depth research

Advances in Spatio-Temporal Analysis

Geostatistical Ore Reserve Estimation

Originally published in 1976, this study was undertaken to fill a gap in knowledge about non-fuel resources and the advantages and disadvantages of specific methodologies of analysing material modelling. Mineral Materials Modeling examines the influence of factors such as raw material price and availability, technological aspects and related environmental questions in relation to both economic and mathematical models. The results are particularly helpful in terms of forecasting, policy development and decision-making about mineral materials as well as assessing the usefulness of different types of model. This title will be of interest to students of Environmental Studies as well as policy makers
and professionals.

Availability of U.S. Chromium Resources

Progress in Geomathematics

Quantitative Methods for the Appraisal of Mineral Resources

Quantitative resource assessment methods play an increasing role in exploration for petroleum, water and minerals. This volume presents an international review on the state-of-the-art of the computerized methodology in resource exploration. The papers taken from those presented at the symposium are classified to either techniques, i.e., trend analysis; classification techniques; geostatistics; image analysis; expert systems/artificial intelligence; inventories; tomography and others, or to resources, i.e., petroleum, water, metals and non-metals.

Mineral Resources Off the Northeastern Coast of the United States

I'd Like to Be OK with MIK, UC?

Essentials of Mineral Exploration and Evaluation offers a thorough overview of methods used in mineral exploration campaigns, evaluation, reporting and economic assessment processes. Fully illustrated to cover the state-of-the-art exploration techniques and evaluation of mineral assets being practiced globally, this up-to-date reference offers balanced coverage of the latest knowledge and current global trends in successful mineral exploration and evaluation. From mineral deposits, to remote sensing, to sampling and analysis, Essentials of Mineral Exploration and Evaluation offers an extensive look at this rapidly changing field. Covers the complete spectrum of all aspects of ore deposits and mining them, providing a "one-stop shop" for experts and students Presents the most up-to-date information on developments and methods in all areas of mineral exploration Includes chapters on application of GIS, statistics, and geostatistics in mineral exploration and evaluation Includes case studies to enhance practical application of concepts

Mineral Resource Potential and Geology of the San Juan National Forest, Colorado

The Handbook of Natural Resource and Energy Economics examines the current theory and sample current application methods for natural resource and energy economics. This third volume deals primarily with non-renewable resources. It analyzes the economics of energy and minerals, and includes chapters on the economics of environmental policy. The Handbook provides a source, reference and teaching supplement for use by professional researchers and advanced graduate students. The surveys summarize not only received results but also newer developments from recent journal articles and discussion papers.

Geomathematics: Theoretical Foundations, Applications and Future Developments

The conference is organized by the Department of Mining Engineering and Metallurgy of the National University of Athens, Greece and its purpose is to promote technology transfer and identify future courses of action in research and development via the Internet. The topics covered include applications in a wide spectrum of mining related fields: Mineral exploration; Orebody modelling; Mine planning and operations; Mine equipment; Rock mechanics; Mine safety and training; Reclamation and environmental issues; Mineral processing. The complete proceedings are published on a CD-ROM with an accompanying book which contains the full texts of keynote papers and the abstracts (including full title, author's names and e-mail addresses as well as a keyword index) of all papers.

Applied Mineral Inventory Estimation

Quantitative Mineral Resource Assessments

Mineral Trends and Forecasts

An Introduction to Cut-off Grade Estimation examines one of the most important calculations in the mining industry. Cut-off grades are essential to determining the economic feasibility and mine life of a project. Profitability and socioeconomic impact of mining operations are influenced by the choice of cut-off grades. Cut-off grades play a key role in estimating mineral reserves that can be publicly reported. This new edition is easier to read and of greater practical interest to practitioners. The relationship between optimization of net present value, capacity constraints, and opportunity cost is explained in greater detail. A new section discusses blending strategies, which play a critical role in an increasing number of mining operations. Author Jean-Michel Rendu, an internationally recognized expert in the management, estimation, and public reporting of mineral resources, provides practical insights. As a manager in major mining companies, a consultant, and an educator, Rendu has acquired considerable experience in all aspects of mining engineering, experience that was incorporated into this publication.

The Art and Science of Resource Estimation

In order to really see the forest, what's the best way to count the trees? Understanding how the economy interacts with the environment has important implications for policy, regulatory, and business decisions. How should our national economic accounts recognize the increasing interest in and importance of the environment? Nature's Numbers responds to concerns about how the United States should make these measurements. The book recommends how to incorporate environmental and other non-market measures into the nation's income and product accounts. The panel explores alternative approaches to environmental accounting, including those used in other countries, and addresses thorny issues such as how to measure the stocks of natural resources and how to value non-market activities and assets. Specific applications to subsoil minerals, forests, and clean air show how the general principles can be applied. The analysis and insights provided in
this book will be of interest to economists, policymakers, environmental advocates, economics faculty, businesses based on natural resources, and managers concerned with the role of the environment in our economic affairs.

**Handbook of Natural Resource and Energy**

This book provides a detailed overview of the operational principles of modern mining geology, which are presented as a good mix of theory and practice, allowing use by a broad range of specialists, from students to lecturers and experienced geologists. The book includes comprehensive descriptions of mining geology techniques, including conventional methods and new approaches. The attributes presented in the book can be used as a reference and as a guide by mining industry specialists developing mining projects and for optimizing mining geology procedures. Applications of the methods are explained using case studies and are facilitated by the computer scripts added to the book as Electronic Supplementary Material.

**Information Technologies in the Minerals Industry**

**Geomathematics: Theoretical Foundations, Applications and Future Developments**

Mineral resource estimation has changed considerably in the past 25 years; geostatistical techniques have become commonplace and continue to evolve; computational horsepower has revolutionized all facets of numerical modeling; mining and processing operations are often larger; and uncertainty quantification is becoming standard practice. Recent books focus on historical methods or details of geostatistical theory. So there is a growing need to collect and synthesize the practice of modern mineral resource estimation into a book for undergraduate students, beginning graduate students, and young geologists and engineers. It is especially fruitful that this book is written by authors with years of relevant experience performing mineral resource estimation and with years of relevant teaching experience. This comprehensive textbook and reference fills this need.

**Applied Mining Geology**

Developments in Geomathematics, 2: Geostatistical Ore Reserve Estimation focuses on the methodologies, processes, and principles involved in geostatistical ore reserve estimation, including the use of variogram, sampling, theoretical models, and variances and covariances. The publication first takes a look at elementary statistical theory and applications; contribution of distributions to mineral reserves problems; and evaluation of methods used in ore reserve calculations. Concerns cover estimation problems during a mine life, origin and credentials of geostatistics, precision of a sampling campaign and prediction of the effect of further sampling, exercises on grade-tonnage curves, theoretical models of distributions, and computational remarks on variances and covariances. The text then examines variogram and the practice of variogram modeling. Discussions focus on solving problems in one dimension, linear combinations and average values, theoretical models of isotropic variograms, the variogram as a geological features descriptor, and the variogram as the fundamental function in error computations. The manuscript ponders on statistical problems in sample preparation, orebody modeling, grade-tonnage curves, ore-waste selection, and planning problems, the practice of kriging, and the effective computation of block variances. The text is a valuable source of data for researchers interested in geostatistical ore reserve estimation.

**Mineral Resource Estimation**

Celebrating Frits Agterberg's half-century of publication activity in geomatics, this volume's 28 timely papers, written by his friends and colleagues, treat a variety of subjects of current interest, many of them also studied by Frits, including: spatial analysis in mineral resource assessment, quantitative stratigraphy, nonlinear multifractal models, compositional data analysis, time series analysis, image analysis, and geostatistics. Professor Agterberg published his first paper as a graduate student in 1958 and has since produced (and continues to publish) a steady stream of research papers on a wide variety of subjects of interest to geomathematical practitioners. Most of the papers included here address methodology and feature practical case studies, so that the book likely has broad appeal to those interested in mathematical geosciences, both to academic researchers seeking a comprehensive overview and also to practitioners of geomathematical approaches in industry.

**Mineral Policy Mining Law and Development 2nd Ed**

This book is an introduction to the energy and resources systems that influence all of our lives.

**Introduction to Mineralogy and Petrology**

**An Introduction to Cut-off Grade Estimation, Second Edition**

Critiquing approaches to estimating mineral resources for the mining industry by comparing methods, parameters and strategies.

**U.S. Geological Survey Professional Paper**

This book provides a wealth of geomathematical case history studies performed by the author during his career at the Ministry of Natural Resources Canada, Geological Survey of Canada (NRCan-GSC). Several of the techniques newly developed by the author and colleagues that are described in this book have become widely adopted, not only for further research by geomathematical colleagues, but by government organizations and industry worldwide. These include Weights-of-Evidence modelling, mineral resource estimation technology, trend surface analysis, automatic stratigraphic correlation and nonlinear geochemical exploration methods. The author has developed maximum likelihood methodology and spline-fitting techniques for the construction of the international numerical geologic timescale. He has introduced the application of new theory of fractals and multi fractals in the geostatistical evaluation of regional mineral resources and ore reserves and to study the spatial distribution of metals in rocks. The book also contains sections deemed important by the author but that have not been widely adopted because they require further research. These include the geometry of preferred orientations of contours and edge effects on maps, time series analysis of Quaternary retreating ice sheet related sedimentary data, estimation of first and last appearances of fossil taxa from
frequency distributions of their observed first and last occurrences, tectonic reactivation along pre-existing schistosity planes in fold belts, use of the grouped jackknife method for bias reduction in geometrical extrapolations and new applications of the theory of permanent, volume-independent frequency distributions.

Governance of The World’s Mineral Resources

This conference proceedings presents the research papers in the field of mine planning and mining equipment including themes such as mine automation, rock mechanics, drilling, blasting, tunnelling and excavation engineering. The papers presents the recent advancement and the application of a range of technologies in the field of mining industry. It is of interest to the professionals who practice in mineral industry including but not limited to engineers, consultants, managers, academics, scientist, and government staff.

Mineral Trends and Forecasts

Developments in Geographic Information Technology have raised the expectations of users. A static map is no longer enough; there is now demand for a dynamic representation. Time is of great importance when operating on real world geographical phenomena, especially when these are dynamic. Researchers in the field of Temporal Geographical Information Systems (TGIS) have been developing methods of incorporating time into geographical information systems. Spatio-temporal analysis embodies spatial modelling, spatio-temporal modelling and spatial reasoning and data mining. Advances in Spatio-Temporal Analysis contributes to the field of spatio-temporal analysis, presenting innovative ideas and examples that reflect current progress and achievements.

Critical Mineral Resources of the United States

Introduction to Mineralogy and Petrology presents the essentials of both disciplines through an approach accessible to industry professionals, academic researchers, and students. Mineralogy and petrology stand as the backbone of the geosciences. Detailed knowledge of minerals and rocks and the processes of formation and association are essential for practicing professionals and advanced students. This book is designed as an accessible, step-by-step guide to exploring, retaining, and implementing the core concepts of mineral and hydrocarbon exploration, mining, and extraction. Each topic is fully supported by working examples, diagrams and full-color images. The inclusion of petroleum, gas, metallic deposits and economic aspects enhance the book’s value as a practical reference for mineralogy and petrology.

Critical Mineral Resources of the United States

Authored by two of the world’s premier experts, this book is a must for any young professional, researcher, or student looking for a thorough and inclusive guide to mineralogy and petrology in a single source. Authored by two of the world’s experts in mineralogy and petrology, who have more than 70 years of experience in research and instruction combined Addresses the full scope of the core concepts of mineralogy and petrology, including crystal structure, formation and grouping of minerals and soils, definition, origin, structure and classification of igneous, sedimentary and metamorphic rocks Features more than 150 figures, illustrations, and color photographs to vividly explore the fundamental principles of mineralogy and petrology Offers a holistic approach to both subjects, beginning with the formation of geologic structures followed by the hosting of mineral deposits and concluding with the exploration and extraction of lucrative, usable products to improve the health of global economies

Statistical Evaluations in Exploration for Mineral Deposits

Minerals are part of virtually every product we use. Common examples include copper used in electrical wiring and titanium used to make airplane frames and paint pigments. The Information Age has ushered in a number of new mineral uses in a number of products including cell phones (e.g., tantalum) and liquid crystal displays (e.g., indium). For some minerals, such as the platinum group metals used to make catalytic converters in cars, there is no substitute. If the supply of any given mineral were to become restricted, consumers and sectors of the U.S. economy could be significantly affected. Risks to minerals supplies can include a sudden increase in demand or the possibility that natural ores can be exhausted or become too difficult to extract. Minerals are more vulnerable to supply restrictions if they come from a limited number of mines, mining companies, or nations. Baseline information on minerals is currently collected at the federal level, but no established methodology has existed to identify potentially critical minerals. This book develops such a methodology and suggests an enhanced federal initiative to collect and analyze the additional data needed to support this type of tool.

Mineral Resources

"Informed decisions concerning undiscovered mineral resources cannot be made without an understanding of the technological, environmental, or economic difficulties that might be encountered. Quantitative Mineral Resource Assessments: An Integrated Approach offers a modern quantitative assessment that explicates the diverse factors that affect mineral-related decisions, so that potential consequences can be more easily assessed, uncertainty and risk reduced, and courses of action determined without bias. The integrated approach focuses on three assessment parts and the models that support them and is designed so that consequences of alternative courses of action can be examined with respect to land use, exploration, or mineral-resource development. Drawing upon newly developed deposit density models, frequency distributions, and previously unpublished experiments, the book provides an essential and practical approach for making critical decisions." "Written for governmental and industrial policy makers, managers of exploration, planners of regional development, and similar decision makers, the book brings together for the first time the widely scattered literature on the subject. It also captures the necessary ingredients of the diverse disciplines of economic geology, statistics, mineral economics, and geology that are an integral part of quantitative mineral resource assessments. With this wealth of information, the book will serve not only as a guide for professionals but also as a comprehensive reference for those studying or researching mineral resources."--BOOK JACKET.

Mineral Resource Potential of the Stillwater Complex and Adjacent Rocks in the Northern Part of the Mount Wood and Mount Douglas Quadrangles, Southwestern Montana

This publication includes eight case studies that demonstrate the classification of uranium or thorium resources at different scales, with examples in Argentina, Brazil, China, India, Malawi, Niger and the USA. To test the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) to Nuclear Fuel Resources. UNFC-2009, which has been developed by the UNECE Expert Group on Resource Classification, is applicable to all extractive activities worldwide with work underway to broaden application to encompass renewable energy as well as injection projects for the geological storage of carbon dioxide. Guidelines, described here, were prepared for the application of UNFC-2009 to nuclear fuel resources. They will assist those responsible for finding,
classifying, quantifying, financing, permitting, mining, and processing these minerals such that they are fit to enter the nuclear fuel cycle. They must be used in conjunction with the most recent release of UNFC-2009. The eight case studies demonstrate that UNFC-2009 can be applied to nuclear fuel resources and that the Bridging Document and Guidelines are both workable documents, providing a practical basis for application.

Essentials of Mineral Exploration and Evaluation

Statistical evaluations of exploration data are the basis for decisions to be made at various stages of an exploration project. In contrast to other geostatistical books, Statistical Evaluations in Exploration for Mineral Deposits focuses not only on theory, but examples are also given, frequently originating from experience in mineral exploration by the author who worked worldwide for a mining company. Together with its companion volume, Economic Evaluations in Exploration, the book illustrates methods used in exploration campaigns and mining activities. It is intended as a vademecum for geologists who are forced to make quick decisions regarding an exploration project. It also addresses scientists and students involved in teaching or in mineral economic evaluations, recommendations or decisions.

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