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BOOK REVIEW

Methods and applications in petroleum and mineral exploration and engineering geology (1st edn)

Said Gaci, Olga Hachay and Orietta Nicolis
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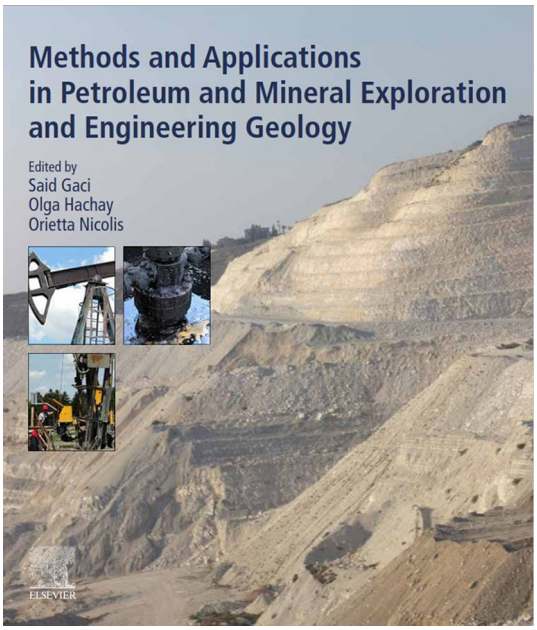
Reviewed by Arkoprovo Biswas

Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221 005, India.
e-mail: arkoprovo.geo@bhu.ac.in arkoprovo@gmail.com



Exploration of natural reserves such as petroleum and minerals, and the geological engineering problems are of great importance to the society. There is still so much that we do not understand and much more to learn. In this context, an interdisciplinary approach for the undiscovered reserves of oil, gas, and minerals is the need of the hour. With the availability of numerous theoretical methods, data processing, modelling, and data resolution, than never before, today umpteen opportunities and choices lie before for geoscientists. Analogous to the dynamic surface of our Mother Earth, the information, data availability, and novel techniques for learning are also developing quickly. Considering the fact, this book bridges the knowledge gap in the fields of earth science and engineering. Novel methods and techniques for the exploration of natural resources and the application of geological, geophysical, geochemical, and other mathematical and statistical techniques with comprehensive case studies are the hallmarks of the book. This book is the 1st volume edited by Drs. Said Gaci, Olga Hachay, and Orietta Nicolis and published by Elsevier Science. The book runs into 396 pages and was contributed by 16 authors around the world. The book editors have organized the chapters into three different sections. The first section concerns the topic of petroleum exploration, and it comprises 13 chapters. The second section is devoted to mineral exploration with six chapters, and the final section concentrates on engineering geology, comprising six chapters. Every section starts with a brief review of the chapters presented by the Book editors. Chapter 1 describes the review of the chapters presented on petroleum exploration. This chapter is categorized into three sections, namely geochemistry studies, unconventional reservoirs, and finally with the new technologies developed for petroleum exploration.

Chapter 2 deals with the study of microseeps, which act as a pathfinder and regional filtering tool

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in petroleum exploration. In this chapter, the authors have discussed surface geochemistry that can help the probability of success. It offers valuable information about the presence or absence of hydrocarbons on the strata. It may not be always an effective tool, but can be helpful in conjunction with subsurface data such as seismic methods.

Chapter 3 bring forth an application of multiproxy data such as stable carbon isotope, total organic carbon (TOC), and degree of pyritization (DOP) which can be used to delineate the stratigraphic and paleoenvironmental reconstruction for Desmoinesian and Atokan sediments in the Denver and Cherokee basins in the Mid-Continent USA.

Chapter 4 provides a comprehensive review of the application of current geophysical methods for shale gas exploration. In this chapter, authors have described the latest techniques for data acquisition, data processing and interpretation with application in the Barnett shale reservoir.

Chapter 5 deals with the case study for enhanced oil recovery from a low-temperature hydrothermal unconventional carbonate reservoir which was discovered in 2012. Many issues were discussed in this chapter and the unsuitability of implementing waterflooding where the subsurface reservoirs are highly fractured and categorized.

Chapter 6 gives an insight into the analysis of drilling and production data which offers a negative reservoir characteristic because of the presence of water compared to oil and gas. This also delimits the knowledge of the stratigraphy and reservoir properties of the carbonate reservoirs, and the unavailability of sufficient data determines the practicability of the resource play before drilling a well.

Chapter 7 presents the application of seismic acoustic emission (AE) in a porous geological medium under mechanical loading by acoustic action. The authors studied the AE arising from the core samples from reservoirs and also from boreholes. AE is the wide-scale amplitude and frequency, and discrete spectra of signals similar to oscillations of nonlinearly coupled oscillators have been observed. The spectra have a distinct physical appearance for each type of rock. Investigating these emission processes can assist as a consistent source of evidence on the filtration–capacitive properties of productive reservoirs of fractured porous kinds of rocks.

Chapter 8 provides an overview of the application of shear waves in understanding and characterizing hydrocarbon reservoirs around the world. A historical overview of the shear wave technology, the basic and fundamental concept behind the shear wave technology and its applications for hydrocarbon discovery and reservoir characterization is illustrated with worldwide data and the benefits of this technique.

Chapter 9 bring forth the delineation of low-velocity zones (LVZ) at a deeper crystalline crust using seismic studies and presents a novel thermodynamic mechanism for their formation. The chapter gives an idea about the presence of a potential regional methane trap of thermobaric type and the process for the formation in the LVZ, suitable migration and localization of organic methane. A model mechanism has been constructed based on the seismic cross-section, geothermal data, and petrophysical properties of high pressure and temperatures.

Chapter 10 gives an insight into the estimation of oil-source thickness productivity from the thermal influences of magmatic intrusions on the maturation of the organic matter. A numerical algorithm is presented for solving the problem of developed convection in two-dimensional and three-dimensional models of the porous medium and the efficient operating conditions can be computed for different structures for oil-bearing reservoirs.

Chapter 11 presents an idea of the empirical mode decomposition (EMD) technique for the prediction of the velocity well logs in a petroleum reservoir. The idea behind this work is to forecast the S-wave velocity (Vs) log from the P-wave velocity (Vp) log with the help of a supervised learning model, the multiple layer perceptron artificial neural network (MLP ANN). The predicted Vs values at different depths were delineated from the input logs derived from using other decomposition techniques such as empirical mode decomposition (EMD), ensemble empirical mode decomposition (EEMD), and complete ensemble empirical mode decomposition (CEEMD) combined with the Hölderian regularity-based fine-to-coarse reconstruction (HR-FCR) algorithm. Finally, the results suggest that the combination of CEEMD and HR-FCR algorithm provides an efficient tool for predicting S-wave velocity in complex geological settings.

Chapter 12 provides an improved study on the two-dimensional bi-dimensional empirical mode decomposition (2D EMD) technique to derive the seismic attribute data. The results from this study show that the expressive attributes, explicitly

instantaneous Hilbert spectral amplitude attributes, that lead to the computed intrinsic mode functions (IMFs) help detect the light hydrocarbon traps that cannot be recognized by the conventional attributes.

Chapter 13 presents an application of multifractal methods to define the scaling properties of well logs. The study shows that the investigation of the local singular behaviour of data by using multifractal and fractal techniques can provide additional information to understand the reservoir properties.

Chapter 14 describes the brief idea about the non-invasive studies and methods for mineral exploration. Different geophysical methods from ground to airborne techniques were applied for mineral exploration, mathematical and statistical procedures to delineate the specific structure/features of ore deposits.

Chapter 15 presents the application of deep seismic sounding and reflected wave methods in the modification of common depth point data, together with the earthquake seismology and geological data collected over 40 years from Fennoscandian Shield. 3D seismic-geological models were created for the first time, which shows crystalline crust has developed a block-hierarchic structure with no obstinate seismic boundaries in it all over the shield. Moho discontinuity is determined from the structural heterogeneities and variation in the crustal thickness. Regional positive and negative magnetic fields replicate the patterns of petrologic, geochemical, and metallogeny processes. The presence of ore deposits was controlled by hydrothermal circulation with mantle- and crustal-derived composition.

Chapter 16 presents the data related to the investigation of the phenomenon of magneto-acoustic emission (MAE) on magnetite rock samples of various deposits. Qualitative correlation of the MAE curve with the crystallographic and textural parameters was studied. Different MAE signals are associated with varying types of magnetite from different ore deposits. The study is an attempt to relate the parameters of MAE to the petrophysical properties of different rocks and also the crystal structure.

Chapter 17 gives an idea of characterizing the anisotropies present in a radioactive source from airborne gamma-ray data using bidimensional empirical mode decomposition (EMD). The method presents a new approach to exploit the spectrometric data for naturally occurring radioactive elements. The 2D-EMD results show that it is a powerful tool for prominence and detecting anomalies for mineral exploration studies.

Chapter 18 presents statistical analysis for finding the geological fault to identify the mineral deposits. It uses the box-counting method to estimate the fractality in fault images. It is proved to be an efficient tool to relate fractal analysis of fault systems for the identification of mineral deposits.

Chapter 19 brings forth a preliminary idea of analyzing multispectral drone images using 2D wavelet transform and multifractal analysis for the detection of heterogeneities in the rocks. The fractal and multifractal spectra are different in each image. The work needs more images for such research, and machine learning techniques will be applied for the demarcation and classification of mineral deposits.

Chapter 20 describes a brief overview of the different geophysical and geotechnical methods for the monitoring process. The chapter covers an idea about the rock massif hierarchic heterogeneity by its deep mining using explosions, reasons for the manifestation of earthquakes source explosion, different hardware/software devices used to study the dynamic characteristics of seismic data for building constructions, tidal motion monitoring in hydroelectric power plant, and the use of CSEM for defining the geotechnical parameters.

Chapter 21 deals with the development of mathematical models from the use of active and passive geophysical monitoring data. It also gives an overview of the development of an inverse algorithm for 2-D diffraction of a linear polarized elastic transversal wave for n-layered media with hierarchic elastic inclusions. Mathematical derivations are presented for such work.

Chapter 22 presents the possible causes of the manifestation of earthquakes of explosive types and the dynamics of the state, its structure, and the phenomenon of self-organization in rock shock mines.

Chapter 23 describes the application of different hardware and software for the study of seismic dynamics for engineering structures. It also addresses the state of a multifaceted geological environment that has possible instability and the ability to rearrange the hierarchy of the structure with significant external impact. The method is based on the development of a 3D planshet method of electromagnetic induction studies in the frequency-geometric version, constructed on the one

hand, on a software-implemented system for interpretation of 3D variable electromagnetic fields.

Chapter 24 presents the influence of tidal activity in the unstable massif near the Toktogul Hydroelectric Power Plant, Kyrgyzstan. The study shows that the manifestation of earth tides should be considered for assessing and predicting the stability of landslide collapse in mountain slopes. It is also recommended for the strengthening of tidal deformation as it could give an indirect quantification for the measurement of instability.

Chapter 25 highlights the new methods of understanding the geomechanical and geoelectrical parameters from the control source electromagnetic method (CSEM) for the dynamic stability of rock massif. The basic concept about the CSEM and the model development of the subsurface geoelectrical data is presented. The results showed that the general state of the area was poor, and the estimated parameters helped to understand the geodynamic state of the rock massif.

Overall, the book provides an insight into the new application and development of various techniques for oil and mineral exploration and engineering geology problems. The book also provides fundamental ideas from geochemistry, geophysics, geotechnical methods, model development, statistical and mathematical techniques for understanding the various methods applied for such studies. The main highlights of the book which are likely to secure a place for it in the libraries of the university, research institutes as well as exploration industries include: (i) an appropriate balance of basics and fundamental theory of newly developed technologies with essential case studies; (ii) various applications, usability and significance in different domains; (iii) cautious addition of chapters with thorough reviews for each section and applications to various problems; (iv) eloquent yet efficient style of writing, excellent quality and high-class illustrations further augment the understanding of concepts. The edited book is an excellent compilation of the latest developments in the field, backed up by compendium of updated references, and proper fundamentals which would benefit the researchers, academicians, as well as industry personnel.

Corresponding editor: N V Chalapathi Rao