

# Introduction to the Numerical Modeling of Groundwater and Geothermal Systems: Fundamentals of Mass, Energy and Solute Transport in Poroelastic Rocks (Multiphysics Modeling)

*By Jochen Bundschuh, Mario César Suárez A.*

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This book provides an introduction to the scientific fundamentals of groundwater and geothermal systems. In a simple and didactic manner the different water and energy problems existing in deformable porous rocks are explained as well as the corresponding theories and the mathematical and numerical tools that lead to modeling and solving them. This approach provides the reader with a thorough understanding of the basic physical laws of thermoporoelastic rocks, the partial differential equations representing these laws and the principal numerical methods, which allow finding approximate solutions of the corresponding mathematical models. The book also presents the form in which specific useful models can be generated and solved. The text is introductory in the sense that it explains basic themes of the systems mentioned in three areas: engineering, physics and mathematics. All the laws and equations introduced in this book are formulated carefully based on fundamental physical principles. This way, the reader will understand the key importance of mathematics applied to all the subjects. Simple models are emphasized and solved with numerous examples. For more sophisticated and advanced models the numerical techniques are described and developed carefully.

This book will serve as a synoptic compendium of the fundamentals of fluid, solute and heat transport, applicable to all types of subsurface systems, ranging from shallow aquifers down to deep geothermal reservoirs.

The book will prove to be a useful textbook to senior undergraduate and graduate students, postgraduates, professional geologists and geophysicists, engineers, mathematicians and others working in the vital areas of groundwater and geothermal resources.

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## **Editorial Review**

### About the Author

Prof. Dr. Jochen Bundschuh (1960, Germany), finished his Ph.D. on numerical modeling of heat transport in aquifers in Tübingen in 1990. He is working in international academic and technical co-operation in different fields of geothermics, hydrogeology and integrated water resources management and connected disciplines, including the water-related economic, social, health, and political aspects. He spent many years in various different countries like: Paraguay, Argentina, Brazil, Uruguay, Brazil, Mexico, Bolivia, Costa Rica, Honduras, Guatemala, Panama, Pakistan, India, Bangladesh, Middle East, Tunisia and South Africa.

From 2001 to 2008 he worked within the framework of the German governmental cooperation (Integrated Expert Programme of CIM; GTZ/BA) as advisor in mission to Costa Rica at the ICE Instituto Costarricense de Electricidad). In 2005 he was appointed affiliate professor at the Royal Institute of Technology, Stockholm, Sweden.

Since June 2009 he is teaching and researching renewable energies, in particular geothermics, at the University of Applied Sciences in Karlsruhe

Prof. Bundschuh is an editor of the book "Geothermal Energy Resources for Developing Countries" (2002), "Natural Arsenic in Groundwater" (2005), principal editor of the 2-volume work: "Central America: Geology, Resources and Hazards" (2007), "Groundwater for Sustainable Development" (2008), Natural Arsenic in the Groundwater of Latin America" (2008). He is co-author of the book "Low Enthalpy Geothermal Resources for Power Generation" (2008) and Series Editor of the book series: "Multiphysics Modeling" and the book series "Arsenic in the Environment", all published by CRC Press/ Balkema - Taylor & Francis group.

*Prof. Ph.D. Mario César Suárez Arriaga* (Mexico City, 1950) studied Physics and Mathematics at the National Autonomous University of Mexico (UNAM), and Applied Mathematics and Mechanics at the universities of Toulouse III and Paris VI, France (1981). He obtained his PhD in Petroleum & Geothermal Engineering at the Faculty of Engineering-UNAM (2000).

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He was co-author of the book "Stories from a Heated Earth: Our Geothermal Heritage", published by the Geothermal Resources Council and IGA (1999). He is editor of the book series "Multiphysics Modeling" and volume 1 in the series: "Numerical Modeling of Coupled Phenomena in Science and Engineering", published by CRC Press/Balkema - Taylor & Francis Group.

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