PREFACE

Mathematical astrophysics and mathematical geophysics have their own journals and conferences, where practitioners discuss mathematical formulations that come to grips with the physical processes of the cosmos and planet Earth. Mathematical petrophysics is by no means new. It started in 1942 with the publication of an equation: the Archie equation. Strictly speaking, there are two Archie equations. The first describes the resistivity of a rock filled with salt water. The second equation is concerned with the resistivity of hydrocarbon-bearing formations and proposed a prediction of hydrocarbon saturation. This quantitative outcome moved the vagueness of "log interpretation" to "log analysis" and was finally dignified with the name of "petrophysics" by Archie in 1950. The Archie equations are still used today, and the huge economic value of these and further developments is the principal reason why mathematical petrophysics is not an academic speciality. The consequences of poor mathematical decisions raise more than academic passions, because of potential losses of millions of dollars. Furthermore, the traditional differentiation between reservoir rocks and seals has recently crumbled with the emergence of resource plays, typified by tight porosities and minimal permeabilities. Consequently, mathematical petrophysicists continue to be challenged to propose new algorithms that characterize nontraditional targets as well as refining established methodologies to manage large but aging fields.

The idea of writing this book started with a discussion at an open-air banquet on the Stanford golf course at an IAMG conference. Further encouragement came at an SPWLA topical conference on "Computational Petrophysics" held in Ashville, North Carolina. The extraordinary power of modern computer environments to actualize complex petrophysical models was not disputed, and the ability of young petrophysicists to navigate their way through a labyrinth of software options was considered to be admirable. However, a model is a model, and as the eminent statistician George Box famously said, "All models are wrong; some models are useful." Consequently, the ability to reflect on the limitations and strengths of any petrophysical model is an important consideration. Classic default equations implemented within large software packages are often based on small data sets, and their historical development will be reviewed in this book. As an additional consideration, an equation that gave a reasonable solution in the Texas Gulf Coast may not necessarily perform so well in the steppes of Kazakhstan. So, the purpose of this book is to review mathematical

petrophysics ranging across microscopic to geographic scales from a perspective of strategic thinking rather than tactical cookbook recipes.

While reviewing a broad range of published petrophysical studies from around the world, a great proportion of the data sets analyzed in this book come from subsurface Kansas. In contrast with data from the Middle East, large numbers of these Midwest logs and core data sets are available in the public domain and can be downloaded from the Kansas Geological Survey website. The website also contains numerous petrophysical studies by Survey scientists, many of which I have cited. I have learned an extraordinary amount from my colleagues, past and present, in the Mathematical Geology and Energy Research sections, and my gratitude is reflected in my dedication of this book to them. My special thanks go to Jo Anne DeGraffenreid for her meticulous editing and John Davis for his technical critiques and advice over the period of this book project. However, any errors that remain are my responsibility. As a log petrophysicist, it has been my privilege to showcase the data supplied by the core petrophysicist maestro, Alan Byrnes, which have enriched and illuminated the wireline measurements. Finally, I owe special thanks to the Kansas Geological Survey as a stimulating and collegial institution for research, and to Survey directors, past and present, for their encouragement and support.

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