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BOOK REVIEW

Diagenesis: a Quantitative Prospective. By Melvin Giles. Kluwer Academic Publishers, Dordrecht, The Netherlands, 1997, 526 p., US$225.00 (ISBN 0-7923-4814-1).

Diagenesis has evolved from largely descriptive petrography during the 1960s and early 1970s to modern studies integrating petrography, geochemistry of mineral and fluid phases and sophisticated computer models linking fluid, heat, and mass transfer with mineral changes in the rock. This book is a comprehensive treatment of the fundamental equations upon which many of these models are based. The emphasis is on basin-scale processes, and the examples are from hydrocarbon settings.

The book is comprised of 16 Chapters and three Appendices. The meat of the book resides in Chapters 2 through 14. Chapter 2 discusses the role of initial starting material and fluid-flow properties of the sediment at the time of deposition. Giles shows the importance of sea-level changes in mixing meteoric and marine porewater. This is an excellent chapter, as the author discusses variables that are many times forgotten when interpreting or modeling diagenesis.

Chapter 3 gives a critical view of studies relying only on petrographic observation in which separation of observation and interpretation is difficult. Chapter 4 shows that studies of modern aquifer systems can be used to infer scales and rates of mass transfer and diagenetic reactions from changes in fluid chemistry.

Chapter 5 is on statistical analysis of data (oddly out of place in the book), including regression analysis, relations between variables mostly applied to petrographic and petrophysical data. It is disappointing to see there is no mention of the propagation of errors associated with thermodynamic values or sensitivity analysis of modeling calculations. This would have been a good chapter in which to include such a discussion. Chapter 6 describes the power of simple mass-balance calculations in exploring diagenetic processes, with examples from petrography, fluid chemistry, and reaction-path modeling.

Chapters 7, 8 and 9 begin the heart of the text in giving a brief description of equilibrium thermodynamics (Chapter 7) and chemical kinetics (Chapter 8), and a comparison of what each has to offer (Chapter 9). Chapter 7 includes discussions of important topics such as changes in saturation state as a result of mixing fluids, ion complexing, and problems of assessing compositions of oil-field brines. The kinetics chapter gives a clear explanation of kinetics, and surface- *versus* transport-controlled processes. Chapter 9 argues for the local equilibrium during deep burial due to high rates of reaction.

Chapters 10 through 14 link heat, fluid, and mass-transport equations. In Chapter 10 (which constitutes 86% of the approximately 400 pages of text), Giles exhaustively develops the concepts behind porosity – depth loss curves, including the concepts of effective stress, compressibility of solids, and relations between effective stress and permeability. This chapter is interesting in showing a number of porosity – depth plots and describing various authors' attempts to quantify these relationships. Giles argues that, on a basin scale, porosity decreases systematically as a function of effective stress and temperature.

Chapter 11 is excellent in describing methods to reconstruct the time – temperature burial history of a basin. Here, Giles deals with such topics as missing section, transient thermal effects due to high rates of sedimentation, and estimating maturation of hydrocarbons. There is also an example of interpretation of K/Ar dates from North Sea illite. Chapter 12 describes the basic equations for various kinds of fluid-flow processes, including meteoric recharge into basins, compaction-driven flow (including effects of overpressure), and convection. Brief mention is made of the effects of faults and seismically driven flow of fluid, as well as effects of hydrocarbon emplacement.

Chapters 13 and 14 describe the basic equations to calculate mass transport and resulting water – rock interactions. Giles develops the equations for mass transport as a function of dispersion, pore-fluid velocity, rates of precipitation and dissolution of minerals, and changes in porosity. Reaction fronts are described that would theoretically occur in a quartz – H_2O system as a function of temperature, solution composition, grain size (surface area), and time. These chapters are especially instructive in showing the underlying assumptions and the power of quantitative methods.

In his concluding remarks (Chapter 15) on diagenesis at deep levels in sedimentary basins, Giles argues that there is a "race towards local thermodynamic equilibrium". He believes that this state is largely achieved at about 100°C. I think most would agree that this would be the case in relatively porous and permeable sedimentary rocks.

The level of the book is that of an advanced text most suited for graduate-level and professional researchers. Important references are listed, and although they are by no means comprehensive, they are sufficient to guide a reader into the topics. In some cases, I feel that they are out of date.The strength of the book lies in its geological perspective to quantifying diagenesis and bringing together most of the important concepts required to understand diagenetic modeling. This is refreshing because too many models are constructed without regard or assessment of geological reality.

Unfortunately, the book suffers from poor editing. Spelling errors, incorrect labels on equations, and lack of spaces between words are fairly common. In addition, figures are small and difficult to read, and in some cases, are poorly produced and "smudgy". Lack of tight editing is especially cause for concern considering the number of complex equations presented. Coverage of important topics is spotty. For example, little space is devoted to fluid flux along faults, and modeling episodic flow. The topic of permeability feedback in coupled flow – mass transport is described in less than 11 lines of text, yet this is one of the most difficult and crucial parameters that requires definition in a reactive transport model.

Additions to this book might include a discussion of what one is trying to accomplish from diagenetic modeling and the importance of good calibration datasets. The accuracy of a prediction will depend on whether we are interested in predicting basin-, reservoir-, or borehole-scale properties. Each case requires a different degree of resolution in the result. Predicting porosity on a basin scale might be satisfied with a much more general prediction than is appropriate on a reservoir-scale simulation.

Another point, which might have been developed more fully, involves the importance of representative subsurface datasets (partially discussed in the book), which are used to calibrate the models. Fluids, for example, are considerably changed just by the fact that a hole has been drilled into the formation. Also, these samples invariably represent fluid traps on some time scale, and the presence of hydrocarbons, which may interact with the fluid, is ubiquitous. Yet in many cases we rely on these fluid compositions to calibrate our models.

Fortunately, Giles does not hesitate to summarize what he believes are the important implications of the topic discussed in each chapter. His experience is based largely in a research lab of a major oil company, and as a result he has considerable insight into the nature and quality of subsurface data. Most chapters do not go into exhaustive depth on any given topic, but rather serve to expose the important equations and assumptions required to quantify diagenesis. Many applications, previously unpublished, come from Giles's experience in North Sea and Middle East. An important contribution of the book is his chapter-by-chapter discussion of the pitfalls of quantitative calculations.

Overall I enjoyed reading this book and would highly recommend it. The writing style is lucid, and the author makes his personal interpretations clear. The basic principles outlined here can be applied to a broad range of diagenetic problems. Unfortunately, the high price of the book may prevent many from buying it.

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