GEOCHEMICAL KINETICS[1]

In the chemistry world, many good textbooks cover the fields of chemical kinetics and diffusion. These include numerous modern texts, as well as various older classics and their updated versions, such as Laidler's *Chemical Kinetics*. But in the geochemical world, the choice is rather sparser: Lasaga's well-known text, *Kinetic Theory in the Earth Sciences*, published a decade ago by Princeton University Press, and now *Geochemical Kinetics* by Youxue Zhang, published in 2008, also by Princeton University Press, and the subject of this review.

The book's target audience is graduate students and advanced undergraduate students. The author states that his intention is to "emphasize the 'geo' aspect of geochemical kinetics and to de-emphasize some chemical aspects."

The five chapters comprise an introduction and overview, as well as treatments of homogeneous and heterogeneous reactions, mass transfer, and inverse problems in which past conditions may be inferred from present-day kinetic observations. The "Overview" chapter introduces the reader to the essentials required to delve deeper into the subject, such as the reaction rate law and constant, reaction order, the Arrhenius equation, collision and transition state theory with simple applications to heat and mass transfer, Fick's law and diffusion during cooling, and aspects of geochronology and geothermometry. This is all presented clearly and succinctly and prepares the reader for what is to come. Chapter 2, titled "Kinetics of Homogeneous Reactions," introduces some specific derivations in "boxes" separated from the text. I think that this is an excellent idea. For example, the formulation of a reversible reaction subjected to a defined cooling history is presented in a box and keyed into a description of the error function in appendix 2. The author's choice of examples is imaginative, and we are treated to a diversity of discussions, including the kinetics of nuclear hydrogen burning, the decomposition of ozone and the ozone hole, and the nature of the glass transition.

Chapter 3, "Mass Transfer: Diffusion and Flow," deserves special mention. Anyone who has taken the effort to come to terms with the mathematical treatments of nonequilibrium phenomena, as presented so elegantly by Carslaw and Jaeger (1959) and De Groot and Mazur (1962), will appreciate the challenge of attempting to synthesize the essence of these concepts without getting bogged down in the details of the mathematics. But the mathematical methods must be considered because they provide the *modus operandi* with which the problems may be considered. The author has done an excellent

job in this, given the aim of the book and audience for whom it is intended. Again, he has included interesting examples, such as the formation of Liesegang rings, sorption and desorption effects, and ionic conductivity, to support and illustrate the concepts being discussed.

Chapter 4 considers heterogeneous reaction kinetics, with an extensive section entitled "Dissolution, Melting or Growth." For those of you without the slightest interest in kinetics but with a keen enthusiasm for certain fizzy beverages, there is something here for you, as Zhang also presents an erudite discussion of bubble vesiculation in champagne and Guinness beer. The final chapter considers what the author terms "Inverse Problems," and deals extensively with kinetic aspects of geochronology, thermochronology, and geospeedometry; it includes, for example, a detailed mathematical treatment of diffusive loss upon cooling and radiogenic growth.

The strength of any specialized textbook is often partially defined by the research interests and in-depth knowledge of the author. In the present case, the numerous and informed discussions of many aspects of silicate melts, magmas, and glasses, as well as crystal growth, crystallization, and diffusion in melt and mineral systems, makes this book even more interesting. The extensive and rigorous kinetic treatment of isotope decay systems is also thorough and well done. If I have any criticism of the subject matter, it would be that there is almost no discussion in the book of the kinetics of ambient-temperature, silicate mineral–aqueous solution reactivity, or mineral dissolution–precipitation reactions in aqueous systems, despite the availability of a considerable volume of literature. This is an important and fast-expanding research area, with fundamental applications to our understanding of weathering chemistry, natural CO_2 sequestration, and climate change. This is not meant to be a major criticism but should perhaps be addressed if a later edition is contemplated sometime in the future.

In summary, this is a very good textbook, which I would recommend to anyone wanting to be informed about the kinetic aspects of geochemistry. The book is well organized and well written—Professor Zhang's English style makes it easy to read. Interesting sets of carefully thought-out problems at the end of each chapter contribute to making this an excellent introductory text, one that may be used in teaching. The book is remarkably free of errors, which is impressive given the extensive mathematical formulation throughout. The publisher is also to be commended for the easy-to-read font size and the clarity and simplicity of the figures. This book has a nice "feel" about it.

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REFERENCES

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1 Zhang Y (2008) Geochemical Kinetics. Princeton University Press, Princeton, NJ, 656 pp, US$70