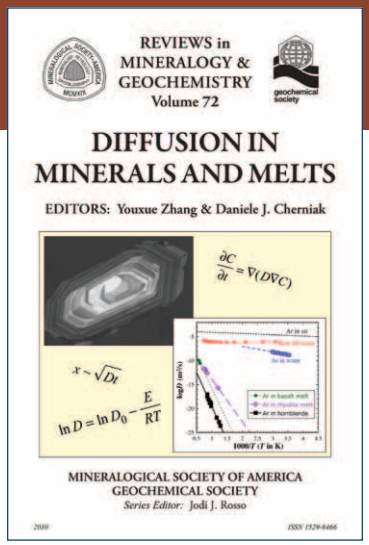
DIFFUSION IN MINERALS AND MELTS[2]



Diffusion in Minerals and Melts is volume 72 in the popular Reviews in Mineralogy & Geochemistry series of the Mineralogical Society of America and the Geochemical Society. It continues the series' successful tradition of collecting review articles on topics with a common theme written by top experts in the field. Like most other books in the series, *Diffusion in Minerals and Melts* is rooted in a short course, this one organized by the book's two editors, Youxue Zhang and Daniele Cherniak, and held just prior to the 2010 Fall Meeting of the American Geophysical Union.

The goal of this volume is an ambitious one. As they state in their introductory chapter, the editors sought to "compile, compare, evaluate and assess diffusion data … for all elements in minerals and natural melts (and glasses)" with the aim of helping readers "to understand the basics of diffusion and applications to geological problems." An explosion of interest in the kinetics of geological systems over the last decade or two has stimulated great demand for high-quality diffusion data, leading to a wealth of new experimental results. Along with those results have come important advances in theoretical approaches to the treatment of diffusion data, and increasingly diverse and widespread geological applications. The attempt made in this volume to corral and evaluate the abundant new data and novel concepts that have emerged in recent years is therefore challenging, but timely.

With 23 chapters and 26 authors, and with hundreds of figures and thousands of references, the 1038 pages in this book allow an extensive treatment of the subject matter. In fact, the potential exists for a reader to be overwhelmed by the sheer breadth of topics and their complexity, but the volume is obviously intended more as an occasional reference than as a treatise to be read cover to cover. Most persons drawn to the book will likely have immediate interests focused on only a subset of the wide-ranging menu of choices, and the overall organization of the volume and its careful internal subdivision of individual chapters should make it possible for such readers to zero in quickly on relevant topics.

The volume opens with three introductory chapters of general interest on theory, new experimental methods, and analytical techniques. These are followed by five lengthy chapters on diffusion in melts and glasses and ten mostly shorter chapters on diffusion in minerals. Four additional chapters cover trends in diffusion data for minerals, diffusion in polycrystalline materials, computational approaches, and geological applications.

The discussion of diffusion theory that opens the book is concise yet wide-ranging. It mirrors treatments of fundamental ideas available elsewhere but connects strongly to geological examples. The following chapter on experimental methods highlights "non-traditional and emerging" techniques and eschews description of older classical approaches, although those are covered to some degree in later chapters. The section on analytical techniques might have been improved by de-emphasizing discussion of the instrumental and analytical details (information that is easily available elsewhere in more complete and useful forms) and accentuating instead the specific utility of each technique in the determination of diffusivities. In some instances, examples from the literature are indeed provided to illustrate the application of these techniques to diffusion studies; if that had been done in all cases, it would have added further value to the chapter.

The treatment of diffusion in silicate melts encompasses three extensive data compilations: one for H, C, and O components; one for noble gases; and one of extraordinary breadth for essentially all other major, minor, and trace elements for which data exist on diffusion in silicate melts. These compilations are complemented by an exposition of the theory of multicomponent diffusion in melts, with illustrative experimental results and geological applications, and by a largely theoretical analysis of models for self-diffusion in silicate melts. This segment of the book does not shy away from addressing the essential complexity of diffusion in melts, and it defines clearly the current boundaries of our understanding.

The daunting task of creating a comprehensive compilation of diffusion data for minerals is tackled in a set of chapters that first address diffusion of hydrogen, oxygen, and noble gases across a wide suite of minerals, and then consider diffusion of cations (and a few other species) in a large number of mineral groups, each taken in turn. These chapters assemble most or all of the available diffusion data for the elements and minerals covered. The assessment and evaluation of those data, however, are uneven: whereas some chapters carefully compare, contrast, and appraise the assembled results, others simply compile them and offer little in the way of detailed examination of their value.

The concluding chapters include (1) an original and thought-provoking overview that seeks to uncover general trends in diffusion data for minerals, (2) a synoptic analysis of grain-boundary diffusion in polycrystalline materials, (3) an enlightening survey of methods and results obtained from computational approaches, and (4) a brief and thus highly selective summary of common applications of diffusion data to geologic problems.

The shortcomings of this volume are few. More attention could have been given to linking experimentally measured rates and trends to nanoscale processes and mechanisms, in order to illuminate the underlying causes of observed variations in diffusivities; this is done to some degree in the chapters on computational models of diffusion and on self-diffusion in melts, and it is touched on in a few other instances, but an overall lack is felt elsewhere. One modest topical omission is a treatment of intergranular diffusion in fluid-mediated systems: the chapter on grain-boundary diffusion in polycrystalline materials focuses almost exclusively on anhydrous systems, leaving unaddressed the important process of intergranular diffusive transport in common metamorphic environments. Finally, review volumes such as this present rare opportunities to assess the current state of the art and to point the way forward, directing new research in the most fruitful directions. Although a few individual chapters address this issue effectively, more commonly, the opportunity was missed.

Overall, this volume is a substantive addition to the reference literature, in keeping with past successes in the series. The editors largely achieved their goal of gathering together the voluminous but widely dispersed data on diffusion in geological materials, and they have also made progress toward assessing those data critically and placing them in the context of their geological applications. These achievements, when combined with the low price of the volume—especially considering the discount available to members of the Mineralogical Society of America, the Geochemical Society, and allied groups—should earn it a place on the bookshelf of any student or researcher enthused by diffusion in geological materials.

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2 Zhang Y, Cherniak DJ (eds) (2010) Diffusion in Minerals and Melts. Reviews in Mineralogy & Geochemistry 72, Mineralogical Society of America, Chantilly, VA, 1038 pp, ISBN 978-0-939950-86-7, $50 (25% discount for MSA. GS, and CMS members)