Clay is a commonly occurring porous material that is frequently used in engineering endeavors, but there are also other important porous materials, such as those used in some types of electrodes and as catalysts. Porous media should be examined giving due regard to both the physics and chemistry of the constituents. The purpose of this book is to present an approach that examines porous media from both these aspects, outlining a procedure that combines microscale (or even nanoscale) characteristics with macroscale behavior.

A fundamental outline of mechanics (or physics) and chemistry, including thermodynamics, is provided in Chap. 2, *Introduction to Continuum Mechanics*; Chap. 3, *Non-equilibrium Thermodynamics* and Chap. 4, *Virtual Work Equation, Variational Methods and Energy Principles*.

In Chap. 5, *Classical Theory of Diffusion and Seepage Problems in Porous Media* and Chap. 6, *Classical Theory of Consolidation for Saturated Porous Media* we review and re-organize the classical soil mechanics in terms of modern continuum mechanics; looking at the mass conservation law for a multi-component solution, we show that the diffusion field is strictly connected with the seepage field.

The central results for saturated porous media are given in the following chapters: In Chap. 7, *Introduction to Homogenization Analysis*, a one-dimensional (1D) elastic problem is used and the fundamental notion of the homogenization analysis (HA) is outlined, giving a unified procedure for treating a micro-inhomogeneous material, not only in the micro-domain but also in the macro-domain. In Chap. 8, *Homogenization Analysis and Permeability of Porous Media*, we use Stokes’ equation, and then apply the HA scheme to obtain the seepage equation together with the HA-based Darcy’s law. Using this procedure we can obtain the true velocity and pressure fields in the micro-domain. A relationship between the HA seepage theory and the conventional theory is discussed. Note that the distribution of water viscosity in the interlayer space between clay minerals is obtained using a molecular dynamics (MD) simulation. A diffusion problem in bentonite, including adsorption at the clay edges is discussed in Chap. 9, *Homogenization Analysis for Diffusion Problem in Porous Media*. The distribution of the diffusion coefficient in the micro-domain (i.e., the interlayer space between clay minerals) is calculated...
using MD, and the macroscale diffusivity obtained by HA is significantly similar to
that obtained experimentally. The purpose of Chap. 10, Long-term Consolidation of
Bentonite and Homogenization Analysis of the Flow Field, is to analyze the problem
of secondary consolidation of bentonite, which is frequently observed in long-term
experiments. This phenomenon was considered to be the result of time-dependent
deformation such as creep of the solid skeleton of bentonite. However, we show
that the secondary consolidation is caused by a non-homogeneous distribution of
permeability, which occurs as a result of a change in the crystalline structure during
the consolidation process. This result was verified by a series of X-ray diffraction
analyses, that continuously measured the crystalline structure at each point of a
bentonite specimen.

In the Appendices we outline the essential mathematics and classical thermody-
namics, including some chemistry. The section on thermodynamics is referred to in
Chap. 3.

We acknowledge our sincere gratitude to our wives, Maria and Sally. We are
indeed indebted to their dedication, collaboration and encouragement. We should
like also to thank Professor Katsuyuki Kawamura of Okayama University: The MD
results shown in the last three chapters are due to his work and excellent collabo-
ration. The first author expresses his deep gratitude to Professor Bogdan Raniecki
of the Polish Academy of Sciences, who introduced him to the greater realm of
mechanics. He is grateful to Dr. Kazumi Kitayama (Nuclear Waste Management
Organization of Japan; NUMO), Professor Masashi Nakano (Professor Emeritus
of University of Tokyo), Tokyo Electric Power Company (TEPCO), Japan Atomic
Energy Agency (JAEA) and NUMO: They have supported his research over many
years. Among others, he thanks Prof. Shunsuke Baba (Okayama University), Prof.
Kazushi Kimoto (Okayama University), Drs. Hiroyuki Umeki (JAEA) and Kozo
Sugihara (JAEA). The works in the last chapters were obtained by a collaboration
with his doctoral students. He is grateful to Dr. Naoki Fujii (Radioactive Waste
Management Funding and Research Center; RWMC), Professors Jian-Guo Wang
(University of Western Australia), Gyo-Cheol Jeong (Andong National University,
Korea), Yong-Seok Seo (Chungbuk National University, Korea), Drs. Byung-Gon
Chae (Korea Institute of Geoscience and Mineral Resources; KIGAM) and Jung-
Hae Choi (KIGAM). The second author wishes to thank the Max Plank Gesellschaft
for providing a Fellowship that enabled the initiation of this work and to McGill
University for research support in the form of the James McGill Professorship.
The research support provided by the Natural Sciences and Engineering Research
Council of Canada in the form of a Discovery Grant is also acknowledged. Finally,
the hospitality of Okayama University during his many visits to the Faculty of
Graduate School of Environmental Science is gratefully acknowledged. The authors
are indebted to Mrs. Sally Selvadurai, Assist-Ed Editorial Services, Montréal, QC,
Canada for her expert editing of the final manuscript.