

Porous Media

Fluid Transport and Pore Structure

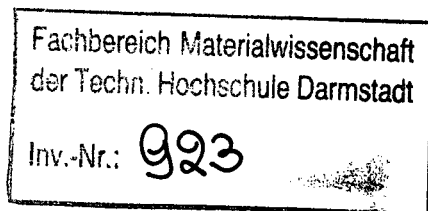
SECOND EDITION

F. A. L. DULLIEN

*Department of Chemical Engineering
University of Waterloo
Waterloo, Ontario, Canada*



ACADEMIC PRESS, INC.
Harcourt Brace Jovanovich, Publishers
San Diego New York Boston
London Sydney Tokyo Toronto



Contents

<i>Preface</i>	<i>ix</i>
<i>List of Symbols</i>	<i>xi</i>
Introduction	1
1 Pore Structure	
1.1 Macroscopic Pore Structure Parameters	6
1.2 Microscopic Pore Structure Parameters	20
1.3 Pore Structure of Some Important Materials	78
1.4 Field Level Characterization of Porous Media	91
References	110
2 Capillarity in Porous Media	
2.1 Surface between Two Fluids	118
2.2 Capillary Equilibrium in Three-Phase Systems	122
2.3 Capillary Pressure	128
2.4 Irreversible Effects in Quasi-Static Capillary Displacement	163
2.5 Pore Structure Models	167
References	232

3 Single-Phase Transport Phenomena in Porous Media

3.1	Introduction	237
3.2	Phenomenological Flow Models	240
3.3	Permeability Models Based on Conduit Flow	254
3.4	Flow of Gases and Diffusion in Porous Media	288
3.5	Non-Newtonian Flow in Porous Media	297
3.6	Anisotropic Permeability	303
3.7	Resistivity (Formation) Factor	306
3.8	The Tortuosity Tensor	311
	References	313

4 Selected Operations Involving Transport of a Single Fluid Phase through a Porous Medium

4.1	Deep Filtration	319
4.2	Mass Transfer through Membranes	322
4.3	Gel Chromatography	329
	References	331

5 Multiphase Flow of Immiscible Fluids in Porous Media

5.1	Introduction	333
5.2	Macroscopic (Phenomenological) Description of Flow	338
5.3	Immiscible Displacement	380
	References	478

6 Miscible Displacement and Dispersion

6.1	Introduction	487
6.2	Dispersion in a Capillary	488
6.3	Hydrodynamic Dispersion (Miscible Displacement) in Porous Media	501
	References	562

Index