

Contents

PART I																	
Principles		1															
Chapter 1																	
Origin, Classification, and Occurrence of Sedimentary Rocks		3															
1.1 <i>Introduction</i>	3																
1.2 <i>Origin and Classification of Sedimentary Rocks</i>	4																
1.3 <i>Distribution of Sedimentary Rocks in Space and Time</i>	7																
1.4 <i>Recycling of Sedimentary Rocks</i>	9																
1.5 <i>Tectonic Setting of Sediment Accumulation</i>	11																
<i>Introduction</i>	11	/ <i>Geosynclines and Tectonics</i>	12	/ <i>Plate Tectonics and Seafloor Spreading</i>	12	/ <i>Interior Basins, Intracontinental Rifts, and Aulacogens</i>	13	/ <i>Passive Continental Margin Settings</i>	18	/ <i>Ocean Basins and Rises</i>	21	/ <i>Subduction-related Settings</i>	22	/ <i>Strike-Slip/Transform Fault Settings</i>	23	/ <i>Collision-Related Settings</i>	26
1.6 <i>Study of Sedimentary Rocks</i>	27																
<i>Field Study</i>	27	/ <i>Laboratory Study</i>	29	/ <i>Basin Analysis</i>	30												
PART II																	
Siliciclastic Sedimentary Rocks		33															
Chapter 2																	
Sedimentary Textures		35															
2.1 <i>Introduction</i>	35																
2.2 <i>Grain Size</i>	36																
<i>Grain-size Scales</i>	36	/ <i>Measuring Grain Size</i>	36	/ <i>Reducing and Displaying Grain-size Data</i>	40	/ <i>Significance of Grain-size Data</i>	44										

Contents

2.3	Grain Shape	48
<i>Methods of Expressing Shape</i> 48 / <i>Particle Form</i> 48 / <i>Particle Roundness</i> 50 / <i>Significance of Form and Roundness</i> 52 / <i>Other Methods for Analyzing and Quantifying Two-dimensional Particle Shape</i> 52 / <i>SEM Analysis of Grain Surface Texture</i> 60 / <i>Concept of Textural Maturity</i> 65 / <i>Fabric</i> 66		
2.4	Porosity and Permeability	72
<i>General Statement</i> 72 / <i>Porosity</i> 74 / <i>Permeability</i> 75		

Chapter 3
Sedimentary Structures

79

3.1	Introduction	78
3.2	Major Kinds of Sedimentary Structures	79
3.3	Bedding and Bedforms	79
<i>Nature of Bedding</i> 79 / <i>Laminated Bedding</i> 81 / <i>Graded Bedding</i> 83 / <i>Massive Bedding</i> 85 / <i>Cross-bedding</i> 86 / <i>Ripple Cross-lamination</i> 90 / <i>Flaser and Lenticular Bedding</i> 91 / <i>Hummocky Cross-stratification</i> 93 / <i>Ripple Marks</i> 95		
3.4	Irregular Stratification	99
<i>General Statement</i> 99 / <i>Deformation Structures</i> 99 / <i>Erosion Structures: Channels and Scour-and-fill Structures</i> 105 / <i>Biogenic Structures: Stromatolitic Bedding</i> 105		
3.5	Bedding-Plane Markings	107
<i>Markings Generated by Erosion and Deposition</i> 107 / <i>Sole Markings Generated by Deformation: Load Casts</i> 111 / <i>Markings Generated by Organisms: Trace Fossils</i> 112 / <i>Bedding-plane Markings of Miscellaneous Origin</i> 116		
3.6	Other Structures	119
<i>Sandstone Dikes and Sills</i> 119 / <i>Structures of Secondary Origin</i> 119		
3.7	Methods for Studying Sedimentary Structures	124

Chapter 4
Sandstones: Composition

126

4.1	Introduction	126
4.2	Particle Composition	127
<i>Detrital Constituents</i> 127 / <i>Authigenic Minerals</i> 146 / <i>Framework Grains vs. Matrix and Cement</i> 153		
4.3	Chemical Composition	157
<i>Significance</i> 157 / <i>Expressing Chemical Composition</i> 158 / <i>Relation of Chemical Composition to Mineralogy</i> 158		
4.4	Relationship of Particle and Chemical Composition to Grain Size	160

Chapter 5	
Sandstones: Classification and Petrography	162
5.1 <i>Introduction</i>	162
5.2 <i>Classification of Epiclastic Sandstone</i>	163
Parameters for Classification	163 / Problems in Selecting Classification
Parameters	163 / Classification Choices
5.3 <i>Petrography and Chemistry of Epiclastic Sandstones</i>	167
Major Petrographic Divisions	167 / Quartz Arenites
Arenites	177 / Lithic Arenites
5.4 <i>Volcaniclastic Sandstones</i>	197
Introduction	197 / Processes That Form Volcaniclastic Rocks
Volcaniclastic Deposits	199
5.5 <i>Miscellaneous Sandstones</i>	208
Chapter 6	
Conglomerates	210
6.1 <i>Introduction</i>	210
6.2 <i>Definition of Conglomerates, Breccias, and Intraformational Conglomerates</i>	211
6.3 <i>Composition of Epiclastic Conglomerates and Diamictites</i>	214
Composition of Framework Clasts	214 / Composition of Matrix and Cements
6.4 <i>Texture</i>	217
Matrix Content and Fabric Support	217 / Clast Shape and Orientation
6.5 <i>Structures in Conglomerates</i>	217
6.6 <i>Descriptive Classification of Conglomerates and Diamictites</i>	218
General Statement	218 / Classification by Relative Clast Stability
Clast Lithology	219 / Classification by Clast Size
6.7 <i>Occurrence of Quartzose and Petromict Conglomerates (and Diamictites)</i>	221
General Statement	221 / Quartzose Conglomerates
Clasts	221 / Petromict Conglomerates
6.8 <i>Depositional Environments and Characteristic Properties of Conglomerates (and Diamictites)</i>	224
6.9 <i>Distinguishing Characteristics of Conglomerates and Diamictites Classified by Depositional Process</i>	229
General Statement	229 / Conglomerates Deposited by Fluid Flow
Clasts	230 / Conglomerates and Diamictites Deposited by Ice Flow
Clasts	247 / Conglomerates and Diamictites Deposited by Sediment Gravity Flows
Clasts	250
6.10 <i>Volcaniclastic Conglomerates and Breccias</i>	259

Chapter 7	261					
Shales						
7.1 <i>Introduction</i>	261					
7.2 <i>Methods of Study</i>	262					
7.3 <i>Physical Characteristics of Shales</i>	263					
<i>Texture</i>	263 / <i>Sedimentary Structures</i>	275				
7.4 <i>Composition</i>	279					
<i>Mineralogy</i>	279 / <i>Chemical Composition</i>	290 / <i>Organic Content</i>	294			
7.5 <i>Color of Shales</i>	297					
7.6 <i>Classification of Shales</i>	298					
<i>Introduction</i>	298 / <i>Shale Classification Mainly on the Basis of Texture and Structure</i>	298 / <i>Shale Classification Based in Part on Mineralogy</i>	298			
7.7 <i>Distribution and Significance of Shales</i>	300					
<i>Occurrences</i>	300 / <i>Environments of Shale Deposition</i>	301 / <i>Significance of Shale Occurrence</i>	302			
7.8 <i>Examples</i>	302					
Chapter 8	304					
Provenance of Siliciclastic Sedimentary Rocks						
8.1 <i>Introduction</i>	304					
8.2 <i>Tools for Provenance Analysis</i>	305					
<i>General Statement</i>	305 / <i>Composition of Detrital Constituents</i>	305 / <i>Textures and Structures</i>	307 / <i>Thickness and Volume of Siliciclastic Units</i>	307 / <i>Paleomagnetism</i>	308 / <i>Facies Relationships</i>	308
8.3 <i>Locating Source Areas</i>	308					
<i>Paleocurrent Analysis</i>	308 / <i>Mapping Attribute or Scalar Properties</i>	309 / <i>Studies of Paleomagnetism</i>	311			
8.4 <i>Factors That Affect the Composition of Siliciclastic Sedimentary Rocks and Provenance Interpretation</i>	311					
<i>General Statement</i>	311 / <i>Effects of Climate and Relief</i>	311 / <i>Effect of Sediment Transport</i>	312 / <i>Effects of the Depositional Environment</i>	312 / <i>Effects of Diagenesis</i>	313	
8.5 <i>Provenance of Sandstones</i>	313					
<i>Interpreting Source-rock Lithology</i>	313 / <i>Interpreting Tectonic Provenance</i>	334 / <i>Interpreting Climate and Relief of Source Areas</i>	343			
8.6 <i>Provenance of Conglomerates</i>	346					
<i>General Statement</i>	346 / <i>Interpreting Source-rock Lithology from Conglomerates</i>	348 / <i>Interpreting Tectonic Setting from Conglomerates</i>	350			
8.7 <i>Provenance of Shales</i>	352					

Chapter 9	
Diagenesis of Sandstones and Shales	353
9.1	Introduction 353
9.2	Diagenetic Stages and Regimes 354
9.3	Biologic and Physical Diagenesis 356
	<i>Bioturbation 356 / Compaction 356</i>
9.4	Biochemical and Chemical Diagenesis 364
	<i>General Statement 364 / Diagenetic Reactions in the Eogenetic Zone 365 / Diagenetic Reactions in the Mesogenetic Zone 370 / Diagenetic Reactions in the Telogenetic Zone 376</i>
9.5	Major Chemical Diagenetic Processes 378
	<i>Cementation and Porosity Reduction 378 / Dissolution and Porosity Enhancement 391 / Replacement 394 / Recrystallization and Inversion 399 / Clay Mineral Authigenesis 401 / Zeolite Authigenesis 404 / Oxidation of Ferromagnesian Grains 406 / Ages of Diagenetic Events 407</i>
9.6	Diagenesis of Organic Matter and Hydrocarbon Generation 408

PART III

Carbonate Sedimentary Rocks	409
Chapter 10	
Limestones	411
10.1	Introduction 411
10.2	Mineralogy 412
	<i>Principal Carbonate Groups 412 / Ion Substitution in Carbonate Minerals 413 / Identification of Carbonate Minerals 413 / Mineralogy of Carbonate-secreting Organisms 416 / Noncarbonate Components 416</i>
10.3	Chemical and Isotope Composition 416
	<i>Elemental Composition 416 / Stable Isotope Composition 418 / Stable Isotope Composition of Carbonate Sediments and Fossils 421 / Radiogenic Isotopes in Carbonate Rocks 422</i>
10.4	Major Components of Limestones 423
	<i>General Statement 423 / Carbonate Grains 423 / Microcrystalline Carbonate (Lime Mud) 437 / Sparry Calcite 446</i>
10.5	Classification of Carbonate Rocks 450
	<i>Available Classifications 450 / Folk Classification (1962) 450 / Dunham's Classification (1962) 452 / Classification of Mixed Carbonate and Siliciclastic Sediments 455</i>
10.6	Structures and Textures in Limestones 455
	<i>Structures Common to Siliciclastic Rocks 455 / Special Structures 455</i>

Contents

10.7 Carbonate Microfacies and Marine Depositional Environments	465					
<i>Microfacies Analysis</i>	<i>465 / Standard Microfacies Types</i>	<i>466 / Facies Belts and Depositional Environments</i>	<i>467 / Depositional Environments and Compositional Maturity of Limestones</i>	<i>471 / Chemistry of Marine Carbonate Deposition</i>	<i>474</i>	
10.8 Nonmarine Carbonates	477					
<i>Introduction</i>	<i>477 / Lacustrine Carbonates</i>	<i>477 / Carbonates in Rivers, Streams, and Springs</i>	<i>478 / Speleothem (Cave) Carbonates</i>	<i>480 / Caliche (Calcrete) Carbonates</i>	<i>480 / Eolian Carbonates</i>	<i>483</i>
Chapter 11						
Dolomites						
11.1 Introduction	484					
11.2 Mineralogy of Dolomites	485					
<i>Stoichiometric vs. Nonstoichiometric Dolomite</i>	<i>485 / Identifying Dolomite in Thin Section</i>	<i>486</i>				
11.3 Dolomite Textures	487					
11.4 Spheroidal Dolomite	491					
11.5 Zoned Dolomite	492					
11.6 Mottled and Zebra Structure	494					
11.7 Origin of Dolomite	494					
<i>The Dolomite Problem</i>	<i>494 / Origin of Penecontemporaneous Dolomite</i>					
<i>496 / Subsurface (Later-stage) Dolomitization</i>	<i>504 / Discussion and Summary</i>	<i>511</i>				
Chapter 12						
Diagenesis of Carbonate Rocks						
12.1 Introduction	514					
12.2 Regimes of Carbonate Diagenesis	515					
12.3 Diagenesis on the Seafloor	516					
<i>Biogenic Processes</i>	<i>516 / Carbonate Cementation and Dissolution</i>	<i>517 / Marine Neomorphism</i>	<i>525</i>			
12.4 Diagenesis in the Meteoric Environment	527					
<i>Geochemical Constraints</i>	<i>527 / Diagenesis in the Vadose Zone</i>	<i>528 / Diagenesis in the Phreatic Zone</i>	<i>530 / Diagenesis in the Mixing Zone</i>			
<i>532 / Diagenesis in the Telogenetic Meteoric Environment</i>	<i>533 / Isotope Geochemistry and Trace-Element Composition of Carbonates in the Meteoric Zone</i>	<i>534</i>				
12.5 Diagenesis in the Deep-burial Environment	537					
<i>Introduction</i>	<i>537 / Factors Influencing Burial Diagenesis</i>	<i>537 / Diagenetic Processes in the Deep-burial Environment</i>	<i>539</i>			
12.6 Evolution of Porosity in Carbonate Rocks	558					
<i>Introduction</i>	<i>558 / Classification and Origin of Carbonate Porosity</i>	<i>558 / Changes in Carbonate Porosity with Burial</i>	<i>560</i>			

PART IV**Other Chemical/Biochemical Sedimentary Rocks
and Carbonaceous Sedimentary Rocks****563*****Chapter 13******Evaporites, Cherts, Iron-rich Sedimentary
Rocks, and Phosphorites*****565****13.1 Introduction 565****13.2 Evaporites 566**

Introduction 566 / Composition 567 / Classification of Evaporites 571 / Deposition of Evaporites 575 / Diagenesis of Evaporites 580 / Ancient Evaporite Deposits 582

13.3 Siliceous Sedimentary Rocks (Cherts) 583

Introduction 583 / Mineralogy and Texture 584 / Chemical Composition 585 / Principal Kinds of Cherts 586 / Deposition of Chert 589 / Diagenesis of Chert 594 / Replacement Chert 594 / Ancient Cherts 596

13.4 Iron-rich Sedimentary Rocks 598

Introduction 598 / Principal Kinds of Iron-rich Sedimentary Rocks 599 / Iron Formations 601 / Ironstones 609 / Iron-rich Shales 609 / Miscellaneous Iron-rich Deposits 612 / Origin of Iron-rich Sedimentary Rocks 612

13.5 Sedimentary Phosphorites 618

Introduction 618 / Occurrence and Distribution 619 / Composition of Phosphorites 621 / Petrography of Phosphates 622 / Principal Kinds of Phosphate Deposits 624 / Deposition of Phosphorites 626

Chapter 14***Carbonaceous Sedimentary Rocks*****631****14.1 Introduction 631****14.2 Characteristics of Organic Matter in Carbonaceous Sedimentary
Rocks 632**

Principal Kinds of Organic Matter 632 / Chemical Structure of Kerogen 633 / Elemental Chemistry of Organic Matter 634 / Stable Isotope Chemistry 635

14.3 Major Kinds of Carbonaceous Sedimentary Rock 636

General Statement 636 / Coals 637 / Oil Shale 646 / Petroleum 651 / Solid Hydrocarbons 675

References**661*****Author Index*****695*****Subject Index*****703**