

CONTENTS

PREFACE	xiii
ACKNOWLEDGEMENTS	xv
ABOUT THE COMPANION WEBSITE	xvii
PART I: CARBONATE SEDIMENTOLOGY: AN OVERVIEW	1
1 CARBONATE ROCKS AND PLATFORMS	5
What are carbonate sedimentary rocks?	6
Why should we care about studying these rocks?	6
What is the scientific approach?	6
The carbonate continuum	7
How do carbonate sediments form?	9
Where are carbonates produced and where do they accumulate?	10
Tectonic settings and the nature of carbonate platforms	11
How do we study carbonate sediments and rocks?	14
Further reading	14
2 CARBONATE CHEMISTRY AND MINERALOGY	15
Introduction	16
Chemistry	16
Carbonate precipitation and dissolution in the ocean	19
Further reading	21
3 THE CARBONATE FACTORY	22
Introduction	23
Sediment production	23
Component modification	28
Karst and carbonate spring precipitates	36
Further reading	37

4	MARINE CARBONATE FACTORIES AND ROCK CLASSIFICATIONS	38
	Introduction	39
	Environmental controls	39
	Benthic marine factories	46
	Pelagic marine factories	47
	Limestone classification schemes	48
	Further reading	50
5	THE CARBONATE FACTORY: MICROBES AND ALGAE	51
	Introduction	52
	Microbes and carbonates	52
	Microbialites	52
	Modern <i>stromatolites</i>	54
	Calcimicrobes	60
	Calcareous algae	60
	Further reading	66
6	THE CARBONATE FACTORY: SINGLE CELLS AND SHELLS	67
	Introduction	68
	Single-cell microfossils	68
	Macrofossils	71
	Further reading	78
7	THE CARBONATE FACTORY: ECHINODERMS AND COLONIAL INVERTEBRATES	79
	Introduction	80
	Echinoderms	80
	Sponges	82
	Bryozoans	85
	Corals	89
	Further reading	93
	 PART II: CARBONATE DEPOSITIONAL SYSTEMS: AN OVERVIEW	 95
8	LACUSTRINE CARBONATES	99
	Introduction	100
	Modern lakes: Zonation and classification	100
	Controls on lake sedimentation	101
	Lake sedimentation	103
	Lacustrine microbialites	107
	Classification of ancient lake deposits	108
	Further reading	108
9	CARBONATE SPRINGS	110
	Introduction	111
	Spring systems	111
	Classification of springs	112
	Tufa, travertine, or sinter?	113
	Biota of spring systems	114
	Carbonate precipitation in spring systems	114
	Spring architecture	115
	Calcareous spring carbonate facies	117
	Further reading	122

10	WARM-WATER NERITIC CARBONATE DEPOSITIONAL SYSTEMS	123
	Introduction	124
	The carbonate factory	124
	Depositional systems	125
	Further reading	134
11	THE COOL-WATER NERITIC REALM	135
	Introduction	136
	The Carbonate Factory	136
	Depositional settings	139
	Warm-temperate carbonates	141
	Cool-temperate carbonates	144
	Cold-water, polar carbonate systems	144
	The rock record	145
	Further reading	148
12	MUDDY PERITIDAL CARBONATES	150
	Introduction	151
	Andros Island: The Bahamas	152
	Shark Bay: Western Australia	155
	The United Arab Emirates: Persian Gulf	156
	Stratigraphy	158
	The shallowing-upward peritidal cycle	158
	How do numerous peritidal cycles form?	160
	Temporal variations on the peritidal cycle theme	162
	Further reading	163
13	NERITIC CARBONATE TIDAL SAND BODIES	165
	Introduction	166
	Tides and tidal currents	166
	Tidal sand bodies	167
	Bahamian platform ooid sand bodies	169
	Types of Bahamian platform sand bodies	170
	Some examples of Bahamian sand bodies	171
	Inter-island tidal ooid sand bodies (tidal deltas)	173
	Platform interior Bahamian ooid sand bodies	174
	Carbonate ramp tidal ooid sand bodies	175
	Carbonate sand bodies in straits and seaways	175
	Carbonate sands in flooded incised valleys	176
	Carbonate sands in hypersaline basins	177
	The rock record of tidal ooid sands	177
	Ancient sand body geometries	178
	Further reading	178
14	MODERN REEFS	179
	Introduction	180
	The reef mosaic	180
	The coral reef growth window	182
	Shallow-water reefs	184
	Deep-water reefs	189
	Further reading	191

15	ANCIENT REEFS	192
	Introduction	193
	The ancient reef factory	193
	Microbes, calcimicrobes, and calcareous algae	194
	Internal cavities	195
	Lithification	195
	Boring and bioerosion	196
	Reef stratigraphic nomenclature	196
	The spectrum of ancient reefs	198
	Reefs	198
	Reef mounds	199
	Reef geohistory	202
	Reef rock classification	206
	Further reading	211
16	CARBONATE SLOPES	212
	Introduction	213
	Depositional bathymetry	213
	The deposits	213
	Contourites	217
	Slope types	219
	Temporal and spatial variability	220
	Further reading	222
17	DEEP-WATER PELAGIC CARBONATES	223
	Introduction	224
	Universal controls	224
	Depositional controls	225
	Universal attributes	226
	Old pelagic sediments	226
	Young pelagic sediments	228
	The pelagic factory	228
	Chalk	229
	Associated sediments	233
	Ocean anoxia	233
	Further reading	233
18	PRECAMBRIAN CARBONATES	234
	Introduction	235
	Precambrian carbonate systems	235
	The carbonate factory	235
	Reefs	242
	Further reading	246
19	CARBONATE SEQUENCE STRATIGRAPHY	247
	Introduction	248
	Carbonate sequence stratigraphy	249
	Shallow-water reef sequence stratigraphy	250
	Photozoan rimmed platforms	252
	Evaporites and siliciclastics	255
	Heterozoan unrimmed carbonate platforms	255
	Ramps	257

	Higher-order cycles (parasequences)	258
	Depositional cycles	259
	Further reading	259
20	THE TIME MACHINE	261
	Introduction	262
	Carbonates and plate tectonics	262
	Paleoclimate and paleoceanography	265
	Carbonates and the evolving biosphere	268
	Ocean acidification	271
	Further reading	271
	 PART III: CARBONATE DIAGENESIS: AN OVERVIEW	 273
21	THE PROCESSES AND ENVIRONMENTS OF DIAGENESIS	277
	Introduction to the processes	278
	Carbonate dissolution	278
	Carbonate precipitation	278
	The environments	281
	Synsedimentary marine diagenetic environment	282
	Meteoric diagenetic environment	282
	Burial diagenetic environment	284
	Dolomite and dolostone	285
	Further reading	285
22	ANALYTICAL METHODS	286
	Introduction	287
	Petrography	288
	X-ray diffraction analysis	291
	Scanning electron microscopy	292
	Electron microprobe analysis	294
	Chemical analyses	294
	Further reading	296
23	THE CHEMISTRY OF CARBONATE DIAGENESIS	297
	Introduction	298
	Trace elements and element ratios	298
	Stable isotopes	301
	Oxygen isotopes	301
	Carbon isotopes	303
	Stable isotope values for modern biogenic carbonates	304
	Carbonate stable isotope values through geologic time	305
	Strontium isotopes	307
	Further reading	309
24	LIMESTONE: THE SYNSEDIMENTARY MARINE DIAGENETIC ENVIRONMENT	311
	Introduction	312
	The setting	312
	Dissolution	312
	Precipitation	313
	Alteration	315

	Synsedimentary limestone	316
	Spatial distribution of early lithification	319
	Strandline diagenesis	320
	The rock record	322
	Isotopic composition of ancient marine cements	324
	Further reading	325
25	METEORIC DIAGENESIS OF YOUNG LIMESTONES	326
	Introduction	327
	Processes	327
	Cements and cementation	330
	Diagenesis of calcite sediments	333
	Importance of grain size	333
	Diagenesis in different meteoric settings	335
	Importance of climate	335
	How long does it take?	335
	The ultimate product	336
	Geochemistry	337
	Further reading	339
26	KARST AND WATER-CONTROLLED DIAGENESIS	341
	Introduction	342
	Surficial processes and products	342
	Surface karst facies	342
	Calcrete facies	346
	Subsurface karst facies	348
	Surface and subsurface carbonate geochemistry	355
	Further reading	356
27	BURIAL DIAGENESIS OF LIMESTONE	357
	Introduction	358
	The setting	358
	Controlling factors	358
	Processes and products	359
	Burial cementation	362
	Burial diagenetic models	365
	Paragenesis via cement stratigraphy	368
	Further reading	369
28	DOLOMITE AND DOLOMITIZATION	370
	Introduction	371
	Scientific approach	371
	Dolomite: the mineral	371
	Dolostone: the rock	373
	The limestone to dolostone transition	376
	Early diagenetic alteration of dolomite	376
	Dolomite geochemistry	380
	Further reading	382
29	DOLOMITIZATION PROCESSES AND SYNSEDIMENTARY DOLOMITE	383
	Introduction	384
	What limits dolomite formation?	384

	How to form extensive dolomite	385
	The different types of dolomite and dolostone	386
	Synsedimentary (authigenic) dolomite	386
	Further reading	390
30	SUBSURFACE DOLOMITIZATION AND DOLOSTONE PARAGENESIS	392
	Introduction	393
	Shallow-burial early-diagenetic dolomites	393
	Deep-burial late-diagenetic dolomites	396
	Synthesis	399
	Dolomite paragenesis	399
	Further reading	402
31	DIAGENESIS AND GEOHISTORY	403
	Introduction	404
	Eogenetic diagenesis	404
	Approach	406
	Lowstand systems tract	406
	Transgressive systems tract	408
	Highstand systems tract	410
	Post-eogenetic diagenesis	411
	Further reading	413
32	CARBONATE POROSITY	414
	Introduction	415
	Porosity	415
	Porosity measurement	415
	Permeability	416
	Types of porosity	416
	Porosity classification	421
	Porosity evolution through time	422
	Porosity and dolomitization	423
	The evolution of porosity	423
	Integration	425
	Further reading	426
	GLOSSARY	427
	INDEX	434