

Contents

Part I: Primary Structures and Textures	
Introduction	3
Depositional Environments	4
Physical Parameters	7
General Information	7
Inorganic Primary Sedimentary Structures	7
Hydrodynamic Factors and Bedforms in Water	8
Flow Regime	8
Lower Flow Regime	8
Transition Regime	9
Upper Flow Regime	9
Bedforms	9
Plane Bed without Movement	10
Small Ripples	10
Megaripples	10
Plane Bed with Sediment Movement	10
Antidunes	10
Rate of Migration of Bedforms	10
Bedforms, Stream Power, and Water Depth	11
Current and Wave Ripples	14
General Information	14
Description of Ripple Marks	14
Internal Structure of a Ripple	15
Pattern of Flow over a Lee Face of a Small Ripple, Megaripple, and “Microdeltas”	17
Zone of No Diffusion	17
Zone of Mixing	18
Zone of Backflow	18
Development of Lamination in the Lee Face	19
Variables Controlling the Shape and Slope of Foreset	
Laminae	21
Velocity and Bed Shear Stress	21
Influence of Depth Ratio	21
Sediment Type	21
Causes for the Production of Foreset Laminae of Varying Composition	21
Sediment Movement in Symmetrical Wave Ripples	22
Sediment Movement in Asymmetrical Wave Ripples	23
Wave Ripples	24
Symmetrical Wave Ripples	24
Asymmetrical Wave Ripples	25
Current Ripples	29
Small-Current Ripples	29
Straight-Crested Small Ripples	30
Undulatory Small Ripples	31
Lingoid Small Ripples	31
Rhomboid Small Ripples	32
Megaripples	34
Straight-Crested Megaripples	35

Undulatory Megaripples	35
Lunate Megaripples	35
Lingoid Megaripples	36
Rhomboid Megaripples	37
Giant Ripples	37
Antidunes	39
Combined Current/Wave Ripples	40
Longitudinal Combined Current/Wave Ripples	40
Transverse Combined Current/Wave Ripples	41
Isolated Ripples	41
Wind Ripples	42
Movement of Sand in a Wind Regime	42
Wind Sand Ripples	42
Wind Granule Ripples	44
Tables for the Identification of Ripples	44
Distribution of Ripples in Various Depositional Environments	46
Surface Markings and Imprints	48
Mud and Sand Volcanoes and Other Similar Features	48
Clastic Dykes	49
Mud Cracks	50
Frost and Ice Cracks	51
Raindrop Imprints	51
Foam Impressions	52
Crystal Imprints and Casts	54
Water Level Marks	55
Primary Current Lineation	55
Wrinkle Marks	56
Antiripples (Adhesion Ripples)	56
Bubble Sand Structure and Other Bubble Cavities	57
Swash Marks	58
Rill Marks	58
Tooth-Shaped Rill Marks	59
Comb-Shaped Rill Marks	59
Fringy Rill Marks	59
Conical Rill Marks	59
Branching Rill Marks	59
Meandering Rill Marks	59
Bifurcating Rill Marks	60
Rill Marks with Accumulation Tongues	60
Scour-and-Fill Structures	62
Channels	62
Scour Marks	64
Flute Marks	64
Transverse Scour Marks	65
Flute Rill Marks	66
Longitudinal Furrows and Ridges	66
Triangular Marks Tapering Down-Current	68
Pillow-like Scour Marks	68
Tool Marks	69
Stationary Tool Marks	69
Obstacle Marks	70
Moving Tool Marks	70
Groove Marks	71
Chevron Marks	72
Prod Marks	73
Bounce Marks	73
Brush Marks	73

Skip and Roll Marks	74
Penecontemporaneous Deformation Structures	75
Load Structures	75
Ball- and Pillow-Structure	77
Convolute Bedding	78
Slump Structures	79
Bedding	82
General Information	82
Cross-bedding	84
Small-ripple Bedding	87
Megaripple Bedding	87
Wave-ripple Bedding	89
Longitudinal Cross-bedding	89
Channel-fill Cross-bedding	91
Antidune Cross-bedding	92
Microdelta Cross-bedding	92
Beach and Longshore Bar Cross-bedding	93
Sand Dune Cross-bedding	94
Sand-Drift Cross-bedding	95
Scour-and-Fill Cross-bedding	95
Climbing-ripple Lamination	95
Flaser and Lenticular Bedding	97
Ripple Bedding with Flasers	98
Flaser Bedding	98
Wavy Bedding	99
Lenticular Bedding	100
Graded Bedding	103
Evenly Laminated Sand and Horizontal Bedding	105
Coarsely Interlayered Bedding	107
Thinly Interlayered Bedding (Rhythmites)	108
Thinly Laminated Mud	112
Homogeneous Bedding	112
Sediment Grain Parameters	114
General Information	114
Grain Size	114
Grain Size Distribution	114
Suspension Transport	117
Saltation Transport	117
Rolling Transport	117
Shape and Roundness of Sediment Grains	119
Shape and Roundness of Gravel	119
Shape and Roundness of Sand	121
Surface Texture of Sediment Grains	123
Primary Fabric or Grain Orientation	126
Orientation of Pebbles	126
Orientation of Sand Grains	127
Orientation of Clay Particles	127
Orientation of Organic Remains	128
Chemical and Mineralogical Parameters	131
Oxidation-Reduction Potential (Eh)	131
Acidity-Alkalinity	131
Salinity	131
Temperature	131
Index Minerals	132
Color	132
Trace Elements	133
Biological Parameters	134
General Information	134

Hard Skeletal Parts	134
Bioturbation Structures	138
Surface Lebensspuren	140
Internal Lebensspuren	141
Dwelling Structures	141
Characterizing of Environments by Lebensspuren	143
Fecal Pellets	150
Environmental Reconstructions	154

Part II: Modern Environments

Introduction	159
General Information	159
Importance of Sequence in Environmental Reconstruction	160
Glacial Environment	164
General Information	164
Geomorphology of Glaciers	164
Glacial Flow	166
Glacial Erosion	167
Glacial Transport	169
Glacial Deposit	170
Eskers	171
Kames	174
Small-Delta Deposits	175
Glacial Lake Deposits	177
Sandur Deposits	177
Interglacial Deposits	179
Evidences of Glacial Activity	180
Grain Size Characteristics of Glacial Deposits	180
Wind Activity in Outwash Plains	181
Ancient Sediments of Glacial Environments	182
Desert Environments	183
General Information	183
Erosion and Sedimentation Processes in the Desert	185
Deposits of Desert Environments	186
Hamada Deposits	186
Serir Deposits	188
Desert Lake and Inland Sebkha Deposits	189
Wadi Deposits	191
Aeolian Sand Deposits	195
Sand Drifts and Sand Shadows	195
Gozes	196
Sand Sheets	196
Sand Dunes	196
Internal Structure of Sand Dunes	197
Horizontal Bedding	197
Cross-Bedding	197
The Lower Bounding Surfaces	198
Other Bedding Types	199
Sand Dune Types	200
Barchan Dunes	200
Seif Dunes	200
Transverse Dunes	201
Parabolic Dunes	202
Dome-shaped Dunes	205
Star Dunes	205

Reversing Dunes	205
Dikaka	208
Interdune Areas	209
Dust or Loess Deposits	210
Grain-size Characteristics of Aeolian Sand Deposits	210
Identification of the Desert Environment in Ancient Sediments	211
Wind-deposited Sands	212
Water-deposited Sediments	212
Criterion for the Recognition of Subaerial Exposure of Water-laid Sediments	212
Ancient Deposits of the Desert Environments	212
Lake Environment	213
General Information	213
Clastic Lake Deposits	213
Lake Geneva	214
Delta Foreslope Outside the Channel and the Fan	215
Central Plain	215
Lateral Slope	215
Channel Bottom	216
Central Fan	216
Marginal Part of the Fan	216
Sublacustrine Natural Levees	216
Lake Constance	216
Rhine River Delta in Lake Constance	219
Ripple Bedding	219
Graded Bedding	219
Thinly Interlayered Bedding	220
Laminated Bedding	220
Diffuse Bedding	221
Bioturbation Structures	221
Bubble Cavities and Plant Remains.	221
Distribution of Sedimentary Structures in the Delta	
Body	222
Delta Topset Deposit	222
Delta Foreset Deposit	222
Delta Bottomset Deposits	222
The Life in the Lakes	222
Chemical Precipitates in Lakes	223
Examples of Ancient Lake Deposits	223
Fluvial Environment	225
General Information	225
Channel Pattern	225
Straight Channels	226
Braided Channels	227
Meandering Channels	228
Form of a Channel and Fluvial Processes	228
Fluvial Environments and Their Deposits	229
Channel Lag Deposits	231
Point Bar Deposits	231
Channel Bar and Braided River Deposits	238
Natural Levee Deposits	244
Crevasse-Splay Deposits	246
Channel-fill Deposits (Cut-off Channels and Lakes)	248
Flood Basin Deposits	250
Flood Plain Deposits	252
Alluvial Fan Deposits	253
Fluvial Associations	258

Alluvial Fan Association	258
Flood Plain Association	259
Coastal Plain-Delta Association	259
Some General Remarks	259
Role of Aeolian Sediments in Fluvial Deposits	261
Grain-size Characteristics of Fluvial Sediments	262
Ancient Fluvial Deposits	263
Deltaic Environment	264
General Information	264
The Structure of a Delta	264
Topset Deposits	265
Foreset Deposits	265
Bottomset Deposits	265
Marginal Deposits	266
Subenvironments of a Delta	266
Subenvironments of Subaerial Topset Deposits	266
Subaqueous Topset Deposits and Their Environments	268
Distributary Channel	269
Subaqueous Levees	269
Distributary Mouth Bar	269
Distal Bar	269
Interdistributary Bay	269
Deltaic Sand Bodies	270
Delta Front Sheet Sand	270
Bar Finger Sand	271
Prodelta Environment	273
Shelf-mud Environment (Delta Bottomset)	273
Development of Repetitive Lateral and Vertical Sequences in a Delta System	273
Examples of Ancient Deposits of the Delta Environment	279
The Coast	280
Introduction	280
The Coast: Definition and Classification	280
Coastal Sand	281
Geomorphology of Coastal Sand (Beach)	285
Beach Dynamics and Sediment Transport	286
Coastal Sand Dunes	289
Beach Ridges and Cheniers	291
Beach Ridges of the Coast of Nayarit, Mexico	293
Chenier Plain of Southwestern Texas	295
Washover Fans	298
Backshore	299
Foreshore	301
Shoreface	304
The Shelf	306
Hydrodynamic Conditions on the Continental Shelf	306
Transition Zone	307
Shelf Sediments	308
Examples of Beach-Shelf Profiles from Modern Environments	311
Introduction	311
Beach Sand—Shelf Mud Profile, Gulf of Gaeta, Medi- terranean Sea, Italy	311
Channels and Sand Bars (Shoals)—Channels and Sand Tongues, North Sea	315
The Channels and Sand Bars (Shoals) of the Outer Jade, North Sea	315
Sand Tongues (Shoals) and Channels in the Region of Nordergründe, North Sea	318

Profile of the Büsum: Coastal Sand – Transition Zone –	
Shelf Mud with Storm Sand Layers	322
Coastal Sand	322
Transition Zone	323
Shelf Mud with Storm Sand Layers	323
Galveston Island	326
Beach Profile of a High-energy Coast	330
Beach-Shelf Profile, Sapelo Island, Georgia, USA	332
Introduction	332
Distribution of Sedimentary Structures	333
Distribution of Fauna	340
Distribution of Trace Fossils	341
Summary	341
Sand Deposits on the Continental Shelf	342
Sand Ribbons	342
Giant Ripples	343
Tidal Current Ridges	343
Examples of Ancient Sand Deposits of the Shelf	346
Examples of Ancient Coastal Sand and Shelf Sediments	346
Coastal Lagoons	350
General Information	350
Distribution of Sediment and Sedimentary Structures	351
Example of a Modern Coastal Lagoon	352
Barrier Beach	352
Barrier and Sand Bar	352
Tidal Delta and Algal-bound Sand Flats	353
Tidal Channels	353
Lagoonal Bottom (Subtidal Pond)	353
Gullies (Tidal Creeks)	353
Intertidal Zone	354
Barren Zone	354
Marsh	354
Salt Pans	354
Examples of Ancient Lagoonal Sediments	354
Tidal Flats	355
General Information	355
Physiography and Morphology	356
Type of Bedding in Tidal Flat Sediments	358
Bioturbation and Fauna	359
Tidal Channels	363
Surface Structures	366
Horizontal and Vertical Sequences of Tidal Flat Deposits	370
Diagnostic Features of Tidal Flat Deposits	371
Ancient Tidal Flat Deposits	371
Continental Margin, Slope and Ocean Basin	373
General Information	373
Major Units of Continental Margins	373
Tectonic or Erosional Type of Continental Margin .	375
Depositional Continental Margins	375
Submarine Canyons and Fan Valleys	377
Transport System in the Continental Shelf, Margin and Ocean Basins	378
Fluvial Mixed Transport and Separation of Sand and Lutum (Mud)	379
Transport and Deposition of Sand	380
Low-velocity, Low-density Turbidity Currents	380
High-density, High-velocity Turbidity Currents	382

Turbidite Deposits	383
Large-scale Gravity Slide and Slump Deposits	387
Pebby Mudstone Deposits	388
Contour Currents	388
Deposition in Submarine Canyons	390
Deposition in the Deep-sea Fan Region	391
Examples of Ancient Deep-sea Fan and Fan Valley Deposits	393
Deep-sea Sediments	394
Brown Clay (Red Clay)	395
Globigerina Ooze	395
Radiolarian Ooze	395
Diatom Ooze	395
Pteropod Ooze	395
Diagenetic (Hydrogenous) Deposits	395
Manganese Nodules	395
Current Markings and Related Sedimentary Structures in the Deep-sea Sediments	396
Bedding and Bioturbation Structures in the Bottom Samples of Deep-Sea Sediment off the East African Coast	400
Distribution of Sediments	400
Red Deep-Sea Clay	400
Globigerina Ooze	401
Zoophycos	401
Pyritic Burrows	403
Burrows with Thick Walls	404
Nonoriented Burrows	404
Green-colored Streaks	404
Graded Bedding	404
Foraminiferal Sand	404
Olive-gray Mud	404
Biogenic Carbonate Sand	404
Continental Slope, Rise and Abyssal Plain of the Gulf of Mexico	404
General Information	404
Sedimentary Structures in the Sediments of the Gulf of Mexico	405
Thin Bedding and Lamination	405
Turbidite Layers	405
Load Structures	406
Muddy Conglomerate Layers	406
Primary Homogeneous Layers	406
Burrows	406
Mottling	406
Mycelia	406
Shells and Shell Fragments	406
Distribution of Sedimentary Structures over Physio- graphic Provinces	407
Sedimentation in the Deeper Parts of the Adjacent Seas	407
Varve-like Thinly Interlayered Bedding	407
Alternating Bedding of Fine Sand, Silt/Clay	407
Primary Homogeneous Bedding	408
Strongly Bioturbated Layers	408
Turbidite-like Intercalations	408
Concluding Remarks	411
References	413
Subject Index	435