

## Contents

Preface, ix

### **Writing a Rosetta stone: insights into continental-margin sedimentary processes and strata, 1**

*Charles A. Nittrouer, James A. Austin Jr, Michael E. Field, Joseph H. Kravitz, James P.M. Syvitski and Patricia L. Wiberg*

Introduction, 1

The boundary conditions, 2

The common threads, 3

Eel River (California) continental margin, 3

New Jersey continental margin, 6

Sediment delivery, 7

General considerations, 7

Delivery of Eel margin sediment, 9

Sediment alteration, 11

General considerations, 11

Alteration of Eel margin sediment, 13

Sediment dispersal system, 15

General considerations, 15

Eel margin sediment dispersal system, 17

Seabed failure, 19

General considerations, 19

Eel margin failure, 21

Gravity flows, 23

General considerations, 23

Eel margin gravity flows, 26

Margin morphology, 26

General considerations, 26

New Jersey margin morphology, 29

Eel margin morphology, 31

Margin stratigraphy, 31

General considerations, 31

New Jersey margin stratigraphy, 33

Eel margin stratigraphy, 35

Conclusions, 37

Acknowledgements, 38

References, 38

### **Sediment delivery to the seabed on continental margins, 49**

*Paul S. Hill, Jason M. Fox, John S. Crockett, Kristian J. Curran, Carl T. Friedrichs, W. Rockwell Geyer, Timothy G. Milligan, Andrea S. Ogston, Pere Puig, Malcolm E. Scully, Peter A. Traykovski and Robert A. Wheatcroft*

Introduction, 49

Review of previous work, 52

Early conceptual models, 52

Sediment loss from discharge plumes, 54

Advective transport in river plumes, 56

Bottom-boundary-layer transport of flood sediment, 59

Summary of past research, 60

Sediment delivery to the Eel margin, 61

Site description, 61

Observational programme, 61

Results, 63

Fate of missing sediment, 86

Summary and conclusion, 92

Summary of strataform sediment delivery, 92

Questions for future research, 92

Acknowledgements, 94

Nomenclature, 94

References, 94

### **Post-depositional alteration and preservation of sedimentary strata, 101**

*Robert A. Wheatcroft, Patricia L. Wiberg, Clark R. Alexander, Samuel J. Bentley, David E. Drake, Courtney K. Harris and Andrea S. Ogston*

Introduction and scope, 101

Consolidation, 104

Theoretical framework, 106

Observations, 108

Physical alteration, 111

Fluid forcing, 111

Bed properties, 116

Deposition, 124

Biological alteration, 125

Alteration of key dynamical bed properties, 125

Bioturbation, 129

Biogenic sedimentary structures, 136

Preservation, 137

Controlling parameters, 138

Dissipation times, 141

The key role of episodic sedimentation, 142

Summary, 144

Acknowledgements, 147

Nomenclature, 147

References, 148

## **Oceanic dispersal and accumulation of river sediment, 157**

*Christopher K. Sommerfield, Andrea S. Ogston, Beth L. Mullenbach, David E. Drake, Clark R. Alexander, Charles A. Nittrouer, Jeffrey C. Borgeld, Robert A. Wheatcroft, and Elana L. Leithold*

- Introduction, 157
  - Margin sediment dispersal systems:
    - a Holocene perspective, 158
    - Research background, 161
- Quantifying sedimentary processes, 162
  - Suspended-sediment transport, 162
  - Sediment deposition and accumulation, 164
- The northern California margin, 167
  - Previous work and insight, 167
- Sediment production and coastal delivery, 169
  - Tectonics and sediment yield, 169
  - Hydroclimatology and recorded streamflow, 171
  - Floods, land use and sediment delivery, 173
  - Coastal ocean circulation, 175
- Sediment transport and accumulation, 176
  - Mechanisms of sediment transport, 178
  - Dynamic trapping mechanisms, 183
  - Static trapping mechanisms, 183
- Sedimentation patterns and rates, 186
  - Sedimentary event deposition, 186
  - Centennial to millennial accumulation, 190
  - Latest Holocene sedimentary record, 194
  - Accumulation rates and stratigraphic completeness, 197
- Sediment budgets of dispersal systems, 199
  - Development of sediment budgets, 199
  - Eel margin sediment budget, 201
- Conclusions, 203
- Acknowledgements, 204
- Nomenclature, 204
- References, 205

## **Submarine mass movements on continental margins, 213**

*Homa J. Lee, Jacques Locat, Priscilla Desgagnés, Jeffrey D. Parsons, Brian G. McAdoo, Daniel L. Orange, Pere Puig, Florence L. Wong, Peter Dartnell and Eric Boulanger*

- Introduction, 213
- Historic development of understanding, 214

- Classification, 215
- Environments, 216
  - Fjords, 216
    - Active river deltas on the continental shelf, 217
    - Submarine canyon-fan systems, 218
    - The open continental slope, 219
- Statistics of submarine landslides, 219
- Mechanics of slope failure, 221
  - Driving stress, 221
  - Resisting stress (strength), 221
  - Slope stability analysis, 224
- Pore-water pressure, 224
- Sediment mobilization and strength loss, 226
- Triggers, 228
  - Sediment accumulation, 228
  - Erosion, 228
  - Earthquakes, 228
  - Volcanoes, 231
  - Waves, 233
  - Gas and gas hydrates, 233
  - Groundwater seepage, 234
  - Diapirism, 234
  - Human activity, 234
- Contributions to submarine landslide research from the strataform program, 235
  - 'Humboldt Slide' controversy, 236
  - Liquefaction failures in Eel Canyon, 247
  - Gas charging and pore pressures, 248
  - Development of shear strength and rheology in marine sediment, 249
  - Submarine landslide geomorphology, 256
  - Regional mapping of landslide susceptibility, 259
- Summary, 261
  - Overall occurrence and triggers, 261
  - Controversies, 264
  - Importance of the liquidity index, 265
  - Pore pressures and the development of anomalously weak sediment, 265
  - Development of anomalously high strength, 265
  - Slope stability analysis and regional assessment of landslide susceptibility, 265
    - An important contribution, 265
- Acknowledgements, 265
- Nomenclature, 265
- References, 267

**The mechanics of marine sediment****gravity flows, 275**

*Jeffrey D. Parsons, Carl T. Friedrichs, Peter A. Traykovski, David Mohrig, Jasim Imran, James P.M. Syvitski, Gary Parker, Pere Puig, James L. Buttle and Marcello H. García*

Introduction, 275

Turbidity currents, 278

Basic mechanics, 279

Frontal dynamics, 283

Turbidity-current fans, 285

Channelization and channel processes, 289

Observations of turbidity currents, 294

Debris flows, 295

Basic mechanics, 296

Hydroplaning, 299

Advances in analytical and numerical solutions, 302

Observations of submarine debris flows, 303

Wave-supported sediment gravity flows, 305

Wave-boundary-layer mechanics, 305

Wave-supported sediment gravity flows and the role of buoyancy, 306

Vertical distribution of momentum and sediment concentration, 309

Observations of wave-supported sediment gravity flows, 315

Origin and transformation of sediment gravity flows, 320

Failure-induced formation, 320

Wave/tide-induced formation, 322

Direct formation from river loading, 323

Linkages between phenomena, 325

Conclusions, 327

Acknowledgements, 328

List of nomenclature, 328

References, 330

**Seascape evolution on clastic continental shelves and slopes, 339**

*Lincoln F. Pratson, Charles A. Nittrouer, Patricia L. Wiberg, Michael S. Steckler, John B. Swenson, David A. Cacchione, Jeffery A. Karson, A. Bradley Murray, Matthew A. Wolinsky, Thomas P. Gerber, Beth L. Mullenbach, Glenn A. Spinelli, Craig S. Fulthorpe, Damian B. O'Grady, Gary Parker, Neal W. Driscoll, Robert L. Burger, Christopher Paola, Daniel L. Orange, Michael E. Field, Carl T. Friedrichs and Juan J. Fedele*

Introduction, 340

From bathymetry to seascape evolution, 340

Scope of paper, 341

Background, 341

Physiographic definitions, 341

Historical interest in and importance of the continental shelf and slope, 341

Processes governing shelf width and slope relief, 342

Plate tectonics and the stair-step shape of continental margins, 342

First-order effects of thermal subsidence and tectonic uplift, 344

Second-order effects of isostasy, compaction and faulting, 345

Added effects of faulting, 347

Processes that form the shelf profile, 348

Rivers, deltas and growth of the coastal plain, 348

Bedload deposition, sediment plumes and clinoforms, 351

The impacts of waves and currents on the shelf and shoreface profile, 353

Subaqueous deltas and wave-supported sediment gravity flows, 356

Independent movements of the shoreline and shelf break, 357

Shelf evolution during sea-level change, 359

Processes that act to limit the slope of the continental slope, 362

Seafloor failure and submarine groundwater flow, 362

Bottom shear from internal waves, 364

Turbidity-current erosion and deposition, 365

Processes that create submarine canyons and slope gullies, 366

Turbidity currents versus seafloor failure in forming submarine canyons, 366

Turbidity currents versus seafloor failure in forming slope gullies, 370

Future research, 372

Acknowledgments, 373

References, 373

### **The long-term stratigraphic record on continental margins, 381**

*Gregory S. Mountain, Robert L. Burger, Heike Delius, Craig S. Fulthorpe, James A. Austin, David S. Goldberg, Michael S. Steckler, Cecilia M. McHugh, Kenneth G. Miller, Donald H. Monteverde, Daniel L. Orange and Lincoln F. Pratson*

#### Introduction, 381

Distinguishing time-scales, 382

The importance of the long-term record, 382

Long-term geochronology: dating continental-margin records, 383

#### Analysing the long-term record, 383

Basin-wide surfaces and long-term processes, 383

Tools for accessing the long-term record, 387

#### The Eel River Basin, 390

Tectonism – a major control of sediment distribution and preservation, 390

Offshore stratigraphy – local variations of governing processes, 398

Stratigraphic modelling, 412

#### The New Jersey margin, 415

Cenozoic sedimentation on a passive margin, 415

Pleistocene sequences, 425

The last eustatic cycle and its preserved record, 432

New Jersey submarine canyons, 436

Stratigraphic modelling, 439

#### Summary, 444

The long-term record: its challenges and rewards, 444

The Eel River Basin: difficulties in recognizing eustatic control, 445

The New Jersey margin: eustatic imprint, with complications, 446

The long-term record – where next?, 448

Acknowledgements, 448

References, 449

### **Prediction of margin stratigraphy, 459**

*James P.M. Syvitski, Lincoln F. Pratson, Patricia L. Wiberg, Michael S. Steckler, Marcelo H. Garcia, W. Rockwell Geyer, Courtney K. Harris, Eric W.H. Hutton, Jasim Imran, Homa J. Lee, Mark D. Morehead and Gary Parker*

#### Introduction, 459

#### Component sed-strat modules, 462

River flux, 462

Surface plumes from rivers, 467

Hyperpycnal flow from rivers, 471

Shelf boundary-layer sediment transport, 475

Slope stability analysis, 481

Subaqueous debris flows and turbidity currents, 484

Compaction, 490

#### Integrated models, 493

SEDFLUX approach, 493

Stratigraphic sequences, 501

#### Seismic models, 510

Physical properties, 510

Acoustic properties, 512

Seismic modelling, 514

#### The way forward, 515

Acknowledgements, 516

Nomenclature, 516

References, 519

Index, 531