Contents

1 Introduction ................................................................................................................. 1

Part I The Earth’s Cryosphere and Peculiarities of Sedimentation in It .................. 11

2 Materials and Methods ............................................................................................. 13

3 The Cryosphere and the Peculiarities of Glacial Environment – Fresh-Water and Sea Ice · Continental Ice (Glaciers and Permafrost) ..... 17
3.1 Fresh-Water and Sea Ice ......................................................................................... 17
3.2 Continental Glaciers and Marine Glaciation .......................................................... 19

4 Types of Continental and Marine Glaciations · Preparation and Transportation of Sedimentary Material · Lithology and Geochemistry of Weathering Crusts in Ice Zones · Transportation of Sedimentary Material in Continental Drainage Basins .................................................. 27
4.1 Peculiarities of Mobilization and Transportation of Sedimentary Material in Ice-Catchment Basins of Cryogenic Zone ............................................................. 29
4.2 Lithology and Geochemistry of Weathering Crusts and Soils in Permafrost Zones ......................................................................................................................... 34
4.3 Granulometric Composition – Cryogenic Disintegration (Aleuritization, Acquisition of Loessial Appearance) of Rocks and Minerals ......................................................... 37
4.4 Formation of Cryogenic Aggregates (Cryogenic Coagulation) ................................ 39
4.5 Mineralogy of Cryogenic Weathering Crusts · Cryogenic Resistance of Minerals ................................................................................................................................. 40
4.6 Diagenetic Alteration in Weathering Crusts and Deposits of the Drainage Areas ................................................................................................................................. 44
4.7 Peculiar Geochemical Features of Drainage Areas in Ice Zone .............................. 44
4.7.1 Iron ....................................................................................................................... 44
4.7.2 Organic Matter ................................................................................................. 45
4.8 Transportation of Sedimentary Material in Continental Drainage Basins ............ 47
4.8.1 Transportation along Slopes ............................................................................. 47
4.8.2 Transportation by Rivers .................................................................................. 48
4.9 Quantitative Characteristics of the Processes of Sediment Preparation in Drainage Basins of Ice Zone ................................................................................................. 49

Part II Sea-Ice Sedimentation in the Ocean ................................................................. 51

5 Supply of Riverine Sedimentary Material in Ice Zones · Arctic Marginal Filters · Sediment Input Due to Cryoabrasion · Longshore Drift of Sediments ......................................................... 53
5.1 Supply of Riverine Sedimentary Material in Ice Zones ........................................... 53
5.2 Marginal Filters in the Arctic .................................................................................. 63
5.3 Sediment Supply Due to Coastal Abrasion and Longshore Drift ......................... 72
5.4 Longshore Drift ...................................................................................................... 77
6 Stages of Lithogenesis in Ice Zones · Three Types of Sea Ice
Sedimentation and Two Vertical Levels of the Process .................................................. 79
6.1 Stage I: Sediment Incorporation by Sea Ice · Types of Incorporation .................. 79
  6.1.1 Contact Mechanisms of Sediment Incorporation by Sea Ice .................. 79
  6.1.2 Contactless Mechanism of Sediment Incorporation by Sea Ice ....... 93
6.2 Stage II: Sediment Transportation at Two Vertical Levels: Over the Sea Surface and with Bottom Nepheloids · Transformation of Sedimentary Material during Transportation · Cryodiagenesis .......... 101
  6.2.1 Sediment (Cryosol) Transportation over the Sea Surface · Distribution and Composition of Cryosol · Processes of Cryodiagenesis ................................................................. 101
  6.2.2 Transportation of Sediments with Bottom Brines Formed at Ice Freeze-Up (Nepheloid Layer) .................................................. 107
  6.3.1 Cryosol Release in Remote Zones – The Fram Strait (Cryosols, Hydrosols, Bottom Sediments) ........................................ 110
7 Sedimentary System of the Far Eastern Seas and North Pacific .................. 117
  7.1 Bering Sea ........................................................................................................ 117
    7.1.1 Rock Material .................................................................................. 117
  7.2 Sea of Okhotsk ................................................................................................ 137
    7.2.1 Rock Material (>1 mm) ....................................................................... 138
    7.2.2 Sand and Silt ...................................................................................... 139
  7.3 North Pacific ..................................................................................................... 142
    7.3.1 History of Investigations .................................................................. 143
    7.3.2 Distribution of Rock Material ......................................................... 143
    7.3.3 Petrography of Rock Material .......................................................... 148
    7.3.4 Origin of Rock Material on the Northern Pacific Ocean Floor and Its Pathways .......................................................... 156

8 Sedimentary System of the Arctic Ocean – Interactions between Outer and Inner Geospheres .................................................. 161
  8.1 Sedimentary System of the Arctic Atmosphere · Snow and Sediment Fluxes .......................................................... 161
    8.1.1 Aerosol Content .................................................................................. 164
    8.1.2 Granulometric Composition ............................................................... 166
    8.1.3 Mineral Composition ......................................................................... 166
    8.1.4 Chemical and Isotopic Composition .................................................. 167
    8.1.5 Types of Transportation, Provinces, Trajectories and Fluxes of Aerosol Material in the Arctic .......................................................... 177
    8.1.6 Changes Occurring on the Way of Distant Transportation of Aerosol and Composition of Aerosol in the Arctic .................................................. 182
    8.1.7 The History of Aerosol in the Arctic .................................................. 185
  8.2 Sedimentary System of Sea Ice and Sediment Fluxes .................................. 186
    8.2.1 Quantitative Estimations of Cryosol Content in Arctic Ice .................. 187
    8.2.2 Granulometric Composition of Cryosol .............................................. 191
    8.2.3 Mineralogy of Cryosol and Biogenic Remains ................................... 193
    8.2.4 Geochemistry of Pack Ice ................................................................. 197
    8.2.5 Types of Cryosol – Its Fluxes, Trajectories and the Areas of Sediment Release .......................................................... 199
    8.2.6 Conclusions ......................................................................................... 202
8.3 Sedimentary System of Sea Water and Sediment Fluxes

8.3.1 Quantitative Distribution of Suspended Sedimentary Material in the Arctic Waters

8.3.2 Granulometric Composition of Water Suspension

8.3.3 Water Suspension Fluxes in the Arctic

8.3.4 Vertical Zonality of Suspended Matter

8.3.5 Spatial and Temporal Variations of Fluxes (4D Analysis of Fluxes)

8.3.6 Geochemistry of Water Suspension - Fluxes of Chemical Elements in the Arctic Ice Zones

8.3.7 Biogenic Matter in Water Suspension - Its Distribution and Composition - Fluxes of Biogenic Matter in the Arctic and Antarctic - Types of Biofilters - “Sea Snow”

8.3.8 Mineral Composition of Water Suspension

8.4 Sedimentary System of Bottom Sediments - Sediment Fluxes, Sedimentation Rates and Absolute Masses - Terrigenous and Biogenic Material in Bottom Sediments (Mineralogy, Geochemistry, Biomarkers) - Avalanche Sedimentation and Gravitites in the Zone of Sea Ice Sedimentation

8.4.1 Quantitative Distribution of Sedimentary Material, Sedimentation Rates, Breaks in Sedimentation and Thickness of Sedimentary Sequence

8.4.2 Mineral and Biogenic Material in Bottom Sediments

8.4.3 Geochemical Peculiarities of the Ice-Rafted Deposits

8.4.4 Avalanche Sedimentation and Gravitites in Ice Zones

8.5 General Regularities of Sedimentation in the Sea Ice Zone

8.5.1 Quantitative Distribution of Sedimentary Matter and Its Pathways in Ice Zones

8.5.2 The Role of Biogenic Matter in Transformation of Sediments

8.5.3 Granulometric Composition, Roundness, Surface Character, Textures

8.5.4 Petrographic and Mineral Composition of Sedimentary Material

8.5.5 Dynamics of Sedimentation in the Arctic - the Main Features

Part III Glacial (Iceberg) Sedimentation in the Ocean

9 Mechanisms of Sediment Incorporation in Continental Ice-Catchment Areas

9.1 Fracturing of Glacier Bed

9.2 Abrasion of Bed Rock

9.3 Deformation of Melted or Frozen Glacier Bed

9.4 Erosion by Subglacial Water

9.5 Erosional Forms and Correlative Deposits

9.6 Marine Periglacial - Valleys of Supercooled Runoff and Glaciotorbidites - Abyssal Channels

10 Recent Iceberg-Rafted and Cryophilic Biogenic Deposits of Antarctica

10.1 Iceberg-Rafted Sediments in Antarctica

10.2 Biogenic Cryophilic Deposits

10.2.1 Siliceous Sponge Deposits of Ice Zones

10.2.2 Carbon-Bearing Deposits of Ice Zones

10.2.3 Diatom Sediments of Ice Zones

10.2.4 Volcanogenic and Volcanogenic-Siliceous Sediments
14 Cryogenic Facies

14.1 Macrofacies of Subglacial Basins Below Sea Level (F-1) ........................................... 433
14.2 Macrofacies of Glaciers Overlying Shelves (F-2) ......................................................... 435
14.3 Macrofacies of Tidewater Glaciers (F-3) .................................................................. 436
14.4 Macrofacies of Ice Shelves (F-4) ........................................................................... 436
  14.4.1 Subglacial Part of the Ross Sea ................................................................................. 443
  14.4.2 Subglacial Part of the Weddell Sea ........................................................................... 444
  14.4.3 Delta of Outlet Glaciers .............................................................................................. 446
14.5 Macrofacies of Smaller Glaciers Ending on Shelves  
  (Glacier Tongues) (F-5) ............................................................................................... 447
14.6 Macrofacies of Glaciers Ending in Bays and Fjords  
  Palimpsest Sediments (F-6) .......................................................................................... 448
14.7 Macrofacies of Shelf Seas and Open Shelves Adjacent to the  
  Coasts of Antarctica (F-7) ............................................................................................. 453
14.8 Macrofacies of Continental Slopes  
  Avalanche Sedimentation of the Second Global Level in Cryozones (F-8) ........................................... 455
14.9 Macrofacies of Pelagic Parts of Oceans  
  Oceanic Iceberg-Rafted Sediments and Biogenic Sediments in Cryozones (F-9) ....................... 459
14.10 Facies of Advancing and Retreating Glaciers  
  Progradation and Retrogradation of Cryolithozones  
  Temporal and Spatial Migrations of Facies ...................................................................... 460

PART IV Glacial Sedimentogenesis in the Earth's Geological Past ........................... 465

15 The Late Cenozoic and Earlier Glaciations ................................................................. 467
15.1 The Late Cenozoic Glaciation of Land and Ocean .................................................... 467
15.2 Antarctica during Interglacials ............................................................................... 473
15.3 Ancient Glaciations ................................................................................................. 477

PART V Basis for the Analysis of Cryogenic Formations  
  Tectonic Zonality ......................................................................................................... 481

16 Cryogenic Formations of Passive Margins, Ice Shelves and  
  Continental Slopes  
  Cryogenic Formations of Active Margins  
  and the Regions Composed of Oceanic Crust ................................................................. 483
16.1 Cryogenic Formations as Combination between Cryogenic Conditions,  
  Sediments, Organisms and Tectonics ........................................................................... 483
16.2 Cryogenic Formations of Passive Margins .................................................................. 484
  16.2.1 Formations of Shelves in the Regions of Glaciation ...................................................... 484
  16.2.2 Formation of Continental Slope ................................................................................. 486
  16.2.3 Hemipelagic and Pelagic Formations in Glaciated and  
    Oceanic Periglacial Regions .......................................................................................... 487
16.3 Cryogenic Formations of Active Margins .................................................................. 487
16.4 Comparative Analysis of Glacioformations .................................................................. 488

17 Conclusions ................................................................................................................ 491

References ..................................................................................................................... 499

Additional References .................................................................................................. 525

Index .............................................................................................................................. 541
Sea-Ice and Iceberg Sedimentation in the Ocean
Recent and Past
Lisitzin, A.P.
2002, XI, 563 p., Hardcover
ISBN: 978-3-540-67965-3