
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 g6(e7s(o)96.6Znd)-3wb(s)-7neea	

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	Stage III: Release of Sedimentary Material from Sea Ice during Melting · Sediment Release from One-Year Ice (Carpet-Like Release) on the Shelf · Sediment Release from Pack Ice in Remote Zones · Global Fronts of Pack Ice Sediment Release and Thermopocentres	109
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	203
8.3.1	Quantitative Distribution of Suspended Sedimentary Material in the Arctic Waters	206
8.3.2	Granulometric Composition of Water Suspension	216
8.3.3	Water Suspension Fluxes in the Arctic	218
8.3.4	Vertical Zonality of Suspended Matter	225
8.3.5	Spatial and Temporal Variations of Fluxes (4D Analysis of Fluxes)	225
8.3.6	Geochemistry of Water Suspension · Fluxes of Chemical Elements in the Arctic Ice Zones	225
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”	233
8.3.8	Mineral Composition of Water Suspension	237
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	238
8.4.1	Quantitative Distribution of Sedimentary Material, Sedimentation Rates, Breaks in Sedimentation and Thickness of Sedimentary Sequence	239
8.4.2	Mineral and Biogenic Material in Bottom Sediments	246
8.4.3	Geochemical Peculiarities of the Ice-Rafted Deposits	257
8.4.4	Avalanche Sedimentation and Gravitites in Ice Zones	259
8.5	General Regularities of Sedimentation in the Sea Ice Zone	265
8.5.1	Quantitative Distribution of Sedimentary Matter and Its Pathways in Ice Zones	266
8.5.2	The Role of Biogenic Matter in Transformation of Sediments	272
8.5.3	Granulometric Composition, Roundness, Surface Character, Textures	274
8.5.4	Petrographic and Mineral Composition of Sedimentary Material ...	275
8.5.5	Dynamics of Sedimentation in the Arctic – the Main Features	277
Part III Glacial (Iceberg) Sedimentation in the Ocean		286
9	Mechanisms of Sediment Incorporation in Continental Ice-Catchment Areas	285
9.1	Fracturing of Glacier Bed	285
9.2	Abrasion of Bed Rock	286
9.3	Deformation of Melted or Frozen Glacier Bed	286
9.4	Erosion by Subglacial Water	287
9.5	Erosional Forms and Correlative Deposits	288
9.6	Marine Periglacial · Valleys of Supercooled Runoff and Glacioturbidites · Abyssal Channels	291
10	Recent Iceberg-Rafted and Cryophilic Biogenic Deposits of Antarctica	299
10.1	Iceberg-Rafted Sediments in Antarctica	299
10.2	Biogenic Cryophilic Deposits	309
10.2.1	Siliceous Sponge Deposits of Ice Zones	309
10.2.2	Carbon-Bearing Deposits of Ice Zones	309
10.2.3	Diatom Sediments of Ice Zones	310
10.2.4	Volcanogenic and Volcanogenic-Siliceous Sediments	313

11	Geology of Ice-Catchment Provinces in Relation to Petrography and Mineralogy of Bottom Sediments · Possible Reconstructions of Geological Composition of Ice-Hidden Land	315
11.1	Coarse Material – Composition and Provinces	318
11.1.1	Distribution of Rocks of Different Genetic Types	320
11.1.2	Petrographic Provinces of Rock Material in Deposits and Ice-Catchment Zones	324
11.2	Mineralogy and Provinces of the Sand-Silt Fraction	327
11.2.1	Eastern Antarctic Provinces	327
11.2.2	Western Antarctic Provinces	328
12	Iceberg and Sea-Ice Sedimentation in the North Atlantic – Recent and Past	337
12.1	Distribution and Composition of Rock Material in Sediments of the North Atlantic	340
12.1.1	Composition of Rock Material · Petrographic Provinces of Rock Material and Relations to Ice-Catchment Provinces	342
12.1.2	Ice-Catchment Basin of the Eastern North Atlantic – the Eurasian Ice Sheet and Bottom Deposits Related to It	342
12.1.3	Ice-Catchment Basin of the Western North Atlantic · North American Ice Sheet and Bottom Deposits Related to It	353
12.2	Investigations of Iceberg-Rafted Sedimentary Material in Bottom Deposits Carried Out by Means of Submersibles, Side-Scan Sonar, TV and Photography	358
12.2.1	Petrography and Age of Iceberg-Rafted Debris in the King Trough Area	360
12.2.2	Rock Material in the North Atlantic Bottom Sediments and Its Sources	362
12.2.3	Criteria for Distinguishing Iceberg-Rafted Sediments on the Ocean Floor – Observations from Submersibles	364
12.2.4	Distribution and Composition of Sand-Silt Fraction in Bottom Sediments of the Ice and Temperate Zones of the North Atlantic	367
12.2.5	Distribution and Composition of Minerals of the Pelite Fraction in the Bottom Sediments of the North Atlantic	383
12.3	Conclusions	384
13	Lithology and Geochemistry of the Zones of Iceberg Sedimentation	387
13.1	Structure of Iceberg-Rafted Sedimentary Material	389
13.2	Form, Roundness and Surface Character of Ice-Rafted Particles	391
13.3	Textural Peculiarities	394
13.4	Geochemical Characteristics of Sea Ice and Iceberg Sedimentation	395
13.5	Petrography and Mineralogy	398
13.6	Biogenic Material as Marine Component of Cryogenic Sedimentation	400
13.7	Sedimentary Material in Suspension – Quantitative Distribution and Composition	405
13.8	Sediment Fluxes in the Zones of Sea Ice and Iceberg Sedimentogenesis	408
13.9	Denudation Rates in Ice-Catchment Basins and Cryosedimentation Rates · Rates of Sediment Release from Ice (Sediment Fluxes)	410
13.9.1	Denudation Rates in Ice-Catchment Zones – Rates of Sediment Input	410
13.10	Sedimentation Rates	413
13.11	Deposit Thickness	417
13.12	Volume of Sediments	417
13.13	Sedimentary Rock Basins (SRB) in the Zones of Glacial Sedimentogenesis	419
13.13.1	Sedimentary Rock Basins in East Antarctica	419
13.13.2	Sedimentary Rock Basins in West Antarctica	421
13.13.3	The Weddell Sea Megabasin	424
13.14	Modelling of the Glacial-Marine Sedimentation and the Processes of Iceberg-Rafting	428

14 Cryogenic Facies	433
14.1 Macrofacies of Subglacial Basins Below Sea Level (F-1)	435
14.2 Macrofacies of Glaciers Overlying Shelves (F-2)	436
14.3 Macrofacies of Tidewater Glaciers (F-3)	437
14.4 Macrofacies of Ice Shelves (F-4)	438
14.4.1 Subglacial Part of the Ross Sea	443
14.4.2 Subglacial Part of the Weddell Sea	444
14.4.3 Deltas 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