Strata Formation on Russian Arctic Continental Margins

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LONG-TERM GOALS

The ultimate goal is to understand the creation of the preserved stratigraphic record, the bedform formation, and its modification over the Russian Arctic continental shelves as the product of geologic, biologic, cryologic and oceanographic processes with both spatial and temporal heterogeneities.

OBJECTIVES

A. To reconstruct the paleoenvironmental evolution of the chosen areas during the Late Pleistocene and Holocene on the basis of geological evidence (e.g. seismic record, lithoplogical and micropaleontological data) in order to link the past and recent environmental changes with possible future development of this region.

B. To study the morphology and dynamics of the coastal and shelf zones within the chosen areas and to outline patterns of their expected changes due to the future climate warming and sea level rise

C. Ice impact on strata formation

D. Oceanographic impact on strata formation

E. Riverine impact and development of coastal processes over various time scales and overall sedimentary budget

F. Sea-bed modification, slope instability

G. Impact of active tectonics

H. Modeling of shelf and coastal evolution

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APPROACH

As representative of the Russian Arctic glacially dominated shelves in three areas have chosen which differ drastically in their geologic and tectonic setting, glaciogenic evolution, oceanologic conditions, stratigraphy and geometry of preserved strata. These are the Northern Barents Sea , Eastern Laptev and near the Kurile Island Arc and offshore the northern Sakhalin Island in the Sea of Okhotsk

RESULTS

Glaciomarine shelves (GS) reveal a variety of physical processes affecting depositional environments and sea-bottom formation and modification. These, for instance, are ice-scouring and scavenging bottom currents, severe storms/floods and oceanic currents. Ice- and buoyancy-controlled fluxes are the prime processes for cross shelf sediment transport and vary geographically.

Tasks A,F and S.Drachev and G: B. Baranov

1. New data were obtained on the northern Sakhalin slope during the summer 2003 cruise. In general the structure of this area is simple. Minor complications of slope relief can be seen near its base and upper part, where they are formed by sand waves.

2.A previously unknown large N-W-striking fault was mapped on the northern Sakhalin slope at 54^0 N. This fault represents a distinct boundary between two types of slope. The slope slumping starts to appear to the north from it.

3. Analysis of bathymetry, seismic and 3,5 kHz echosounder profiles shows that on the northern Sakhalin slope certain structural directions exist along which gaseous seeps occur: NS, NW and NE. These directions apparently correspond to ruptures in landslide bodies serving as conduits for gas escape.

4. Interplay of the recent tectonic processes with cryogenic processes is one of the main factors shaping the Laptev seabed morphology and depositional environment. Scouring by icebergs from Severnaya Zemlya and an extensional sea-ice regime account for unique conditions. Seismicity reveals active normal faulting. Near-bottom sediments are affected by extensional dislocations, detected by high resolution seismic data. The faulted sea-bottom relief influences near-bottom currents, distribution and redistribution of sediment transport paths, and, consequently, the submarine landscapes. The latter are important factors shaping the depth of the submarine permafrost after its subsidence below sea level during the Holocene.

5. The submarine permafrost, one of the major components of the Laptev Sea environment, was the focus of a multiyear Russian-German Project. The roof of the permafrost has been mapped with high resolution PARASOUND and was drilled in some localities. The results obtained show that the permafrost top is located 0-25 m below the sea-bottom and is strongly modified both tectonically and erosionally. This interface is generally deepening within the major rifts being buried under thicker marine Holocene deposits, while it is found close to the seabed over the high-standing rifted blocks. Within areas of shallow permafrost its top represents a “hard ground”, whose relief controls ice-scouring patterns.

6. Active mass wasting is not characteristic for very shallow and generally flat Laptev Shelf. The slope instability is typical for area of the steep continental slope.

Tasks C and E: H.Eicken , A. Darovskikh and I. Dmitrenko

(1) Completed book chapter on the role of sea ice processes in determining entrainment, transport and deposition of organic carbon over Siberian shelves

(2) Continued data analysis and synthesis of remote sensing and field data to assess the importance of river discharge and related ice processes for shelf sedimentation (Eicken et al., in prep.), visit by A. Darovskikh in Fairbanks in November this year will allow us to complete this work and include comparative assessment for Kara, East Siberian and Okhotsk shelves

(3) Dmitrenko and Eicken continued work on satellite data and monitoring data to assess longer-term variations in Laptev Sea hydrography and impact on sedimentation regime

(4) Worked with Frank Niessen at Alfred Wegener Institute in Germany to complete data analysis and continue preparation on summary paper describing the role of ice gouging processes in stratigraphic evolution and surface geology in Laptev and East Siberian Sea (Niessen and Eicken, (in preparation)

Tasks B,D, and E: Shevchenko V.P

1). Aerosol studies in the Barents, Kara and Laptev seas and adjacent regions of the Arctic Ocean have shown that:

A. Quantitative distribution of aerosols is a fast changing value, which depends on combination of many regional and local factors. Average concentration of insoluble aerosols in marine boundary layer over the Russian Arctic seas is equal to 0.23 $\mu g/m^3$ at the standard deviation of 0.19 $\mu g/m^3$ (55 measurements). This is higher than the literature data on concentrations in open ocean areas, especially, in humid zones, but much lower than the aerosol concentrations in remote arid areas.

B. Our data, show that the contribution of aerosols to formation of the sedimentary material in the Arctic is close to the contribution of river sediments beyond the marginal filters of rivers. Previously, the aeolian material contribution in the Arctic was ignored. For many elements (Pb, Sb, Se, V etc.) the aerosol source is the primary one.

C. In general, in July-September catastrophic pollution of the Arctic aerosols from the anthropogenic sources were not present. Based on geochemical studies we have succeeded in determination the main local pollution sources which is Norilsk, Kola Peninsula.

2). Suspended particulate matter and vertical particle flux studies in the Laptev and Barents seas show that the distribution and composition of SPM and sedimentary matter is subjected to strong seasonal variations . At the river-sea barrier more than 90% of riverine suspended matter is deposited.

A. In August-October concentration of SPM in the central part of the Barents Sea is lower than 0.5 mg/1. It increases in the directions to shore and marginal ice zone. Near shore it is higher than 1 mg/1. The water column of the Barents Sea is characterized by two maximum of SPM concentration: above the picnocline and near the bottom (nepheloid layer).

B. Delivery of SPM to the Barents Sea by abrasion is an important source of particulate matter. Accordingly to literature data it could be about 50 * 10^6 t annually. Mostly this material is coarse-grained and it is deposited near the shore. Annual riverine input of SPM to the Barents Sea is estimated to be around 10.5 * 10^6 t, aeolian input - 0.9 * 10^6t. However, it should be kept in mind that the main portion of river suspension is deposited in marginal filters of rivers, at the river/sea barrier (Lisitzin, 1995). Only about 7% of riverine particulate matter passes through the filter, that is, only 0.74 *10^6 ton of riverine solid material is delivered to the open Barents Sea, The mostly important source of biogenic SPM —the primary production of phytoplankton.

C. Low values of the sediment fluxes (from 9.8 to 23.5 mg m^{-2} d^{-1}) and particulate C_{org} fluxes (from 0.82 to 7.72 mg C m^{-2} d^{-1}) from the euphotic zone were measured in the open sea. Particulate matter collected by sediment traps in these areas consists mainly of amorphous aggregates ("marine snow") and pellets of Crustacea. Much higher particle fluxes were registered in the outer part of Russkaya Gavan' Bay, Novaya Zemlya Archipelago (346 mg m^{-2} d^{-1} at 70 m depth) and in the Karskie Vorota Strait (up to 2040 mg m^{-2} d^{-1} in near-bottom nepheloid layer).

3. Studies of processes in glacier-influencing fjords of the northern Novaya Zemlya (western coast) show that glaciers are the main source of suspended particulate matter in fjords. In general, on Novaya Zemlya SPM mostly sediments in bays (fjords) and only small part of it is delivered to the Barents Sea because of the hydrodynamic conditions in the bays, the large size of the particles and morphological barriers in the relief on the enter of the bays. It is important for ecological purposes to know the ways of migration of the SPM with pollutants from bays to the open sea. But our investigations allowed us to say that the bays of the Novaya Zemlya Archipelago are the traps for the suspended matter from the glaciers and coast abrasion, and the pollutants from the Novaya Zemlya will stay in the bays.

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HONORS

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