

Characterization of organic matter in bottom sediments of Ivashkina Lagoon, Laptev Sea

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Abstract. Here we present lithological and geochemical characteristics of the core drilled in coastal part of the Laptev Sea (Ivashkina Lagoon, Bykovsky Peninsula). It is shown that for sediments accumulated in specific lagoon conditions the increased content of organic carbon is confined to fine-grained lacustrine and lagoonal sediments in the uppermost layers. Pyrolytic analysis results indicate a sharp variability in the content of total organic carbon and volatile organic compounds across the studied horizons. The distribution of n-alkanes is characterized by the dominance of high molecular weight homologues, which indicates the ubiquitous contribution of higher terrestrial vegetation discharged with river and coastal thermo abrasion fluxes to the organic matter of bottom sediments.

1 Introduction

The interactions between climate and carbon cycle in the Arctic region are undergoing substantial changes due to destabilization of vulnerable permafrost carbon pool followed by massive thaw-release of organic carbon. This process triggers many complex biogeochemical mechanisms including intensive mobilization and increasing supply of terrigenous organic carbon to the coastal ocean, which have been the subject of growing scientific interest in recent years [1-2]. Organic matter (OM) contained in bottom sediments on the continental shelf accumulates heterogeneous signals of various processes of carbon transport and transformation and therefore acts as a unique indicator of its sources. Sedimentological and geochemical instruments allow us to obtain important information on potential input of both allochthonous and autochthonous components to organic matter contained in coastal surface sediments.

In present study we investigate bottom sediments accumulated in the specific lagoon conditions of the coastal part of the Laptev Sea (Ivashkina Lagoon, Bykovsky Peninsula). A core was collected from the well drilled in the central part of the Ivashkina lagoon (VD-13) as part of the 2013 spring research expedition. Here we focus on the uppermost layers, using grain-size, pyrolytic and GC-MS analyses.

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2 Methods

Core sampling from the VD-13 well was carried out using the URB-4T exploratory drilling unit as described by [3]. Grain size composition was determined using a laser microanalyser (Analysette 22, Fritsch) in the Arctic Research Laboratory (POI FEB RAS). Lithological classifications based in the three-component classification according to the content of sand fractions (1–0.1 mm), silt (0.1–0.01 mm) and clay (<0.01 mm).

The total content of organic carbon, the content of volatile organic compounds, the amount of biogeopolymers degradation products were determined on a Rock-Eval 6 Turbo pyrolyzer (VINCI Technologies). Samples were first pyrolysed from 200 °C to 650 °C at a rate of 25 °C / min. Analysis of the extracts was performed by gas chromatography-mass spectrometry using a Bruker SCION 436 GC TQ instrument using an HP-5MS quartz capillary column (length 30 m, internal diameter 0.25 mm, film thickness 0.25 µm).

3 Results and discussion

Ivashkina lagoon is a former thermokarst lake transformed into a lagoon through the thermo abrasion of the runoff channel during marine transgression in Early Holocene[4]. The uppermost interval at first 1.5-2 m of the studied core is characterised by fine-grained deposits formed under lacustrine and lagoonal conditions. Alternations between silt-dominated and sand-dominated taberites – thawed Late Neopleistocene Ice Complex deposits – appear deeper in the core, at the 3.7-11 m depth. They were compacted in a lake talik and redeposited *in situ* after primary thermokarst lake had been formed in early Holocene. Taberites composition remained unchanged but the structure was affected by thawing and compaction. Deposits underlying the taberites are comprised mainly of sand-dominated sediments with contributions of both silt and detritus which are presumably of alluvial origin and probably have Mid-Pleistocene age.

According to the pyrolysis data (Table 1), the highest content of organic carbon (TOC) is observed at 1.59-2.4 m depth. TOC unevenly decreases with increasing depth; a sharp spike is observed at 5.58-6.94 m depth.

Table 1. Rock-Eval and GC-MS analysis data.

Sampling depth, cm	S1, mg/g	S2, mg/g	Tmax, °C	HI, mg/g	OI, mg/g	TOC, % wt	CPI
36	0.20	2.17	423	108	167	2.00	4.65
159	0.21	2.52	424	108	175	2.33	5.99
240	0.22	3.43	429	154	160	2.23	4.18
390	0.12	2.78	424	150	193	1.85	4.41
558	0.06	1.33	421	100	302	1.33	3.84
694	0.00	0.04	-	10	349	0.41	-
827	0.00	0.15	-	28	283	0.54	-
940	0.00	0.06	-	20	450	0.30	-
1023	0.00	0.11	-	16	639	0.67	-
1126	0.00	0.06	-	11	156	0.55	-
1228	0.06	0.57	-	57	151	0.96	-
1290	0.00	0.00	-	0	433	0.09	-

1405	0.00	0.09	-	24	145	0.38	-
1524	0.00	0.00	-	0	353	0.15	-
1624	0.00	0.00	-	0	325	0.08	-
1710	0.00	0.00	-	0	455	0.11	-
1790	0.01	0.00	-	0	468	0.19	-

Note: TOC - total organic carbon (amount of organic carbon),% by weight; S1 – amount of volatile (300 °C) organic compounds, mg/g of rock; S2 – amount of volatile organic matter degradation products, mg/g of rock; HI – hydrogen index S2x100/TOC, mg of degradation products/g of organic carbon. CPI – carbon preference index

The increased TOC and HI values in the upper most clay-dominated layers indicate reducing conditions of sedimentation occurring in lacustrine and lagoon environment (Fig.1a, b). Increases in OI corresponding to the TOC decreases indicate ancient alluvial or fluvial deposits (Fig.1a, c). This variability of TOC, HI and OI observed within the core apparently reflects uneven distribution of organic matter in laminated alluvial layers.

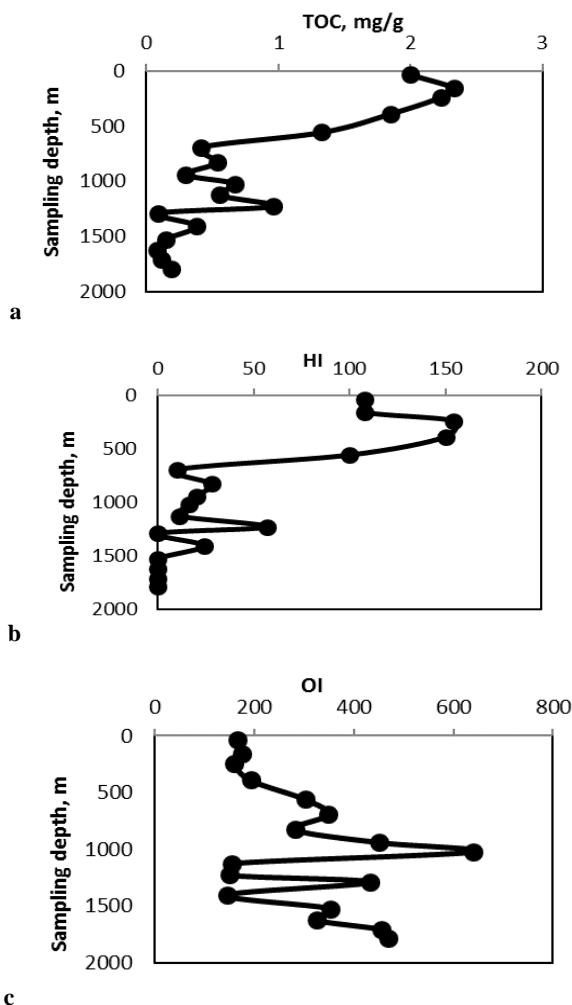


Fig. 1 Correlation of TOC (a), hydrogen (HI) (b) and oxygen (OI) (c) indices and depth (cm).

Samples from the uppermost horizons (0.36–5.58 m depth) were selected for the GC-MS analysis, since they found to contain sufficient quantities of volatile organic compounds (S1, Table 1). Obviously, terrestrial input is a main contributor to the organic component of the studied sediments. High molecular weight (HMW) n-alkanes dominated by C₂₇, C₂₉, C₃₁ with a distinct odd-over-even carbon prevalence act as markers of higher terrestrial vegetation coming with river discharge and thermo abrasion material. Even middle- and low molecular weight homologues formed as a result of bacterially-mediated HMW n-alkanes transformation indicate the autochthonous biogenic component. High values of Carbon Preference Index (CPI) (>> 3) within the core overall show a prevalence of vascular land plants as a source of organic matter and minor microbial degradation. The highest index value is observed at 1.5-2 m depth interval which is composed predominantly of fine-grained lacustrine and lagoonal sediments.

3 Conclusion

According to the initial results, a sharp variability in the content of organic carbon and volatile organic compounds along the studied core was revealed. Increased organic carbon content is confined to the fine-grained lacustrine and lagoonal sediments, whereas overall variability in organic carbon content might be caused by uneven distribution of organic matter in laminated alluvial layers. The n-alkanes distribution is characterized by the dominance of high molecular weight homologues, which indicates the ubiquitous contribution of higher terrestrial vegetation discharged with river and coastal thermo abrasion fluxes to the organic matter accumulated in surface sediments.

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