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THE SHALLOW-WATER CONTOURITE DRIFT FORMATION IN THE KARA SEA

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Abstract. The bottom sediments of the upper part of the contourite drift located in a narrow linear depression belonging to the central part of the Kara Sea shelf were studied for the first time. According to the grain size distribution of the sediments, the drift belongs to the muddy contourites. Three main horizons of sedimentation were identified in three sediment cores up to 7 m long. The previously dated magnetic susceptibility peak at the base of the sediment cores indicates that the formation of the drift began in the postglacial period, more than 10 kyr ago. Local sedimentation conditions during the Holocene were influenced by repeated increases in river discharge, as indicated by the presence of desalination-tolerant species in the benthic foraminiferal assemblages. The increase in thickness of sediment core layers and drift deposits in general from south to north indirectly indicates the presence of a general submeridional trend in the Holocene and earlier bottom current.

Keywords: *Kara Sea, sediments, muddy contourite drift, Holocene, core scanning, bottom currents*

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INTRODUCTION

Contourite drifts are defined as sedimentary deposits that form on seas and oceans floors affected by constant bottom currents and have been described in detail for many areas of the World Ocean [19, 23, 27]. Various types of contourite drifts (hereinafter drifts) are known, differing in size and volume, sediment thickness, deposition depth, and association with different morphostructural elements of the bottom and granulometric types of sediments [25]. One of the least studied types is muddy contourites, whose sediments can consist of more than 50% pelitic silt with up to 15% sand fraction and contain up to 10% calcareous siliceous skeletal remains of organisms, the organic matter of which is often replaced by hydrotroilite inclusions during diagenesis [25]. In rare cases, muddy contourite deposits have a primary stratification based on the color of the sediments and the presence of poorly sorted interlayers, more coarsely grained material [26]. The study of muddy contourite drifts in the Arctic shelf seas makes it possible to reconstruct the dynamics of bottom currents over short time intervals and with small changes in sedimentation conditions.

A contourite drift was first discovered on the Kara Sea shelf during an analysis of bathymetric and seismoacoustic data [1] on cruise 41 of the R/V "Akademik Nikolai Strakhov" in 2019 [12]. The drift is located in a narrow closed depression on the Kara Sea shelf within the Western Kara step (Fig. 1). It extends submeridionally, 18 km in length; the width varies from 1.5 to 3 km, and depth reaches 240 m. The transverse profile of the depression is trough-shaped, the angles of inclination of the slopes are on average 15°–20°, and in the steepest sections, they reach 27°–30° [16]. Its bottom is inclined to the east, and seismoacoustic data indicate that the inclination is due to sedimentary body at the base of the western slope of the depression. This sedimentary body is distinguished as an upper seismic unit with inclined reflectors that unconformably overlie on horizontally layered horizons of the lower seismic unit. The latter's sediments fill the base of the depression (Fig. 2, profile 1).

In the bottom relief, in two areas, there is a rise up to 20 m, which has an asymmetrical profile and is bounded on both sides by ditches. In the northern part of the depression, the ridge extends for a distance

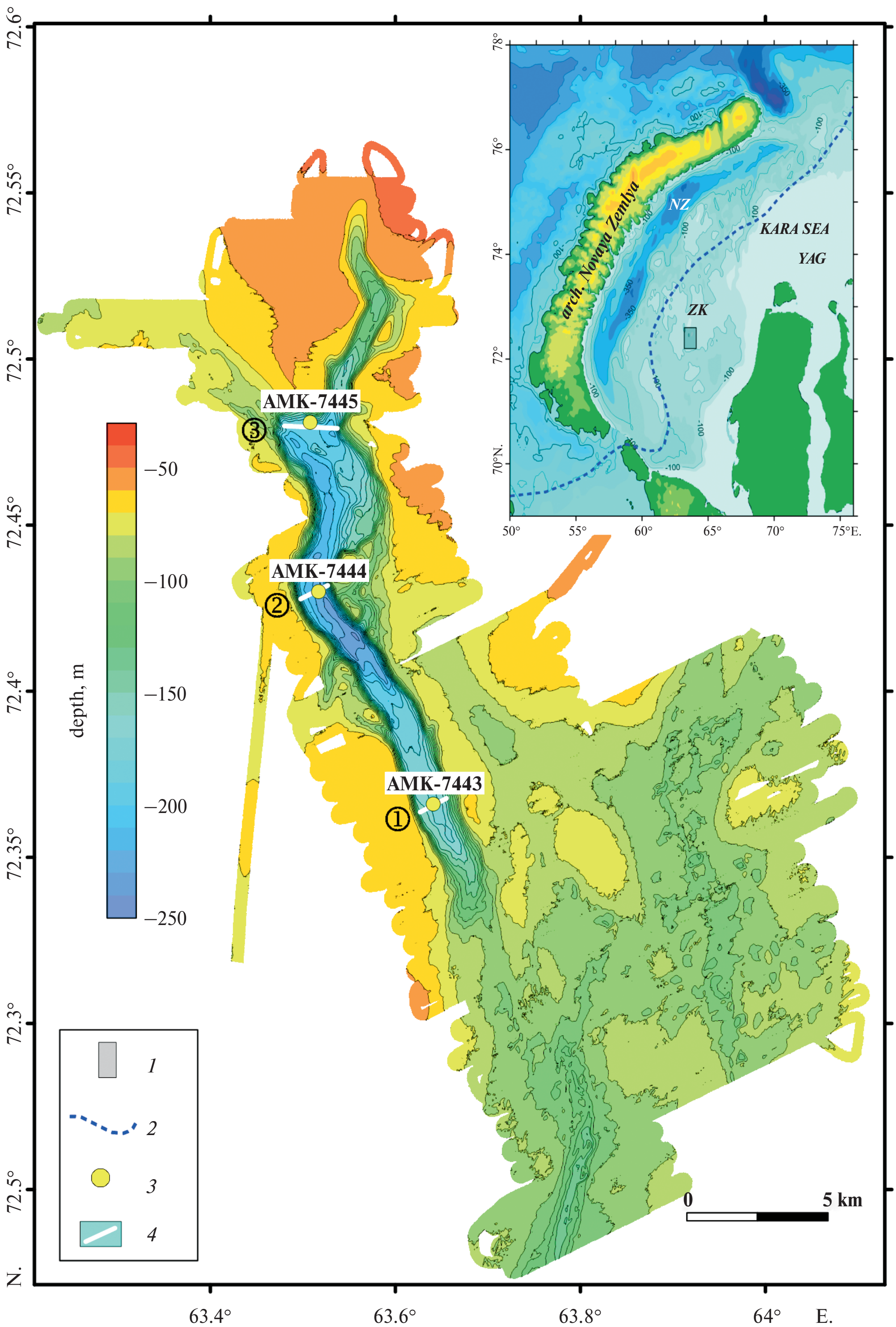

Fig. 1. Bathymetric map of the linear depression in the Kara Sea [13], hosting considered contourite drift: inset: *1* – position of depression (according to map from [11]); *2* – eastern boundary of Barents-Kara ice sheet during the Last Glacial Maximum, after [32]; *3* – sediment sampling stations during cruise 89 (stage 1) of R/V Akademik Mstislav Keldysh in 2022 and their numbers; *4* – position of seismoacoustic profiles 1–3 shown in Fig. 2.

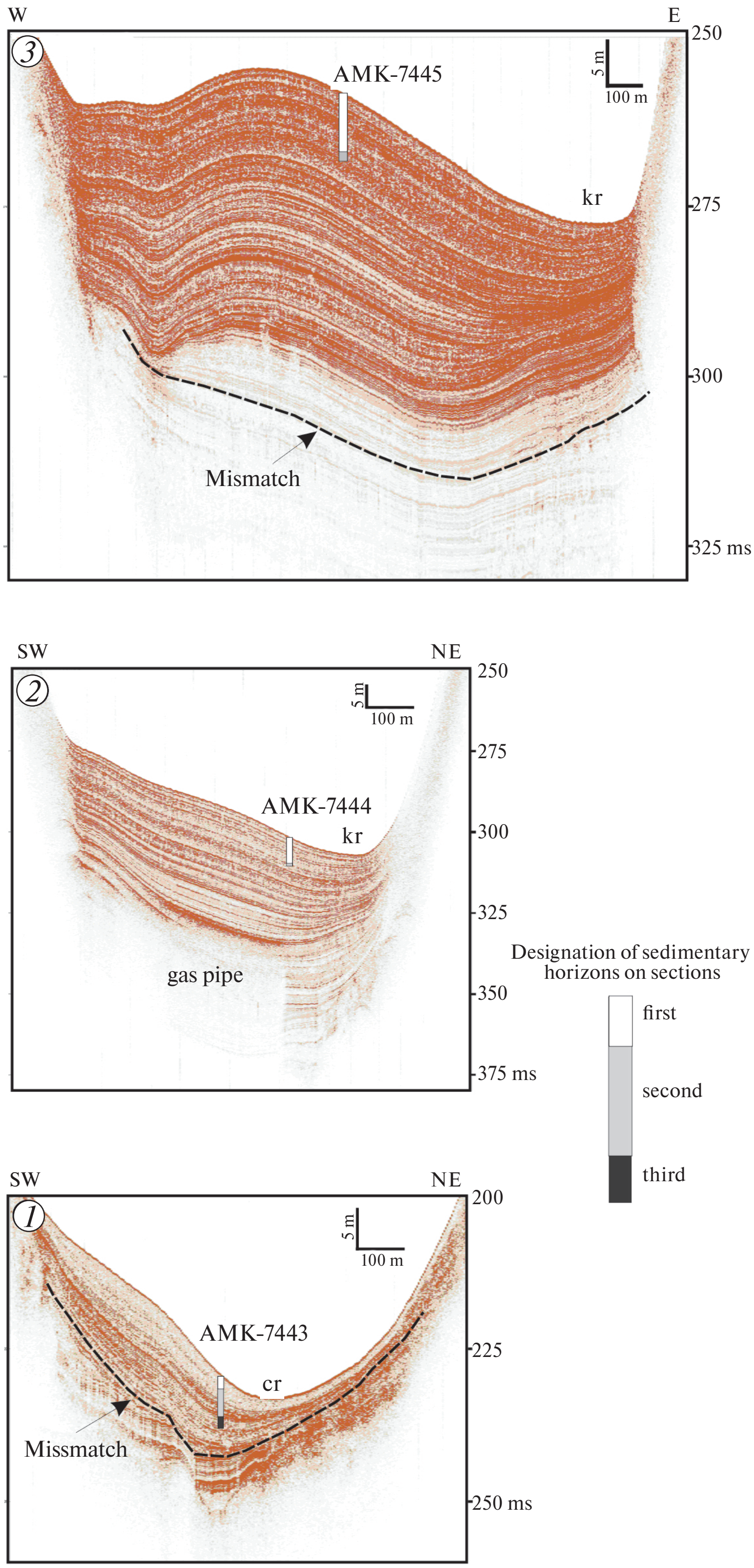

Fig. 2. Fragments of seismoacoustic profiles showing location of bottom sediment core samples. Contourite ditch (CD) is distinguished by its ability to migrate up the eastern slope of depression. Unconformity separates upper and lower seismic units in sections 1 and 3. In section 2, unconformity is masked by gas pipe. Vertical scale is double travel time of wave in ms. For profiles position, see Fig. 1.

of about 3.5 km, with a width of up to 700 m; for the southern part, these values are 5 km and 700 m, respectively. Two seismic units separated by an unconformity are also visible in the sedimentary cover on profiles crossing the rise. The lower unit is represented by a layered sedimentary sequence with parallel reflect lying horizontally or slightly depressed in the central part of the depression. The upper seismic unit is also layered, but has a lenticular shape, caused by upward bending of individual reflectors, which leads to the formation of a ridge at the bottom (Fig. 2, profile 3).

The structural position of the sedimentary filling of the depression, and the features of its morphology and structure, discussed above, give grounds for interpreting its upper seismic unit as a confined contourite drift according to the classification from [25].

During the cruise 89 (stage 1) of the R/V "Akademik Mstislav Keldysh" in 2022 [8], the drift sediments were obtained for the first time with a gravity corer (GC) in the central and distal parts of the sedimentary body (Fig. 1). The aim of the study was to investigate the formation conditions of the contourite drift on the Kara Sea shelf. A lithological-stratigraphical study was carried out on three cores collected from different parts of this sedimentary body including a (1) analysis of the lithological and geochemical characteristics of sediments; (2) identification of relationships between the main color characteristics of the sediments and their magnetic susceptibility (MS), as well as identification and correlation of individual horizons in the selected cores; (3) determination of the type of contourite drift according to the classification accepted in the literature [19].

MATERIAL AND METHODS

Cores AMK-7443, AMK-7444, and AMK-7445 were collected with the GC (outer diameter 127 mm) in the southern, central, and northern parts of the sedimentary body, respectively (Fig. 1, Table). The lengths of the cores reached 7 m. To correlate the sedimentory horizons and reflecting horizons, sampling was done based on data from three seismoacoustic profiles obtained with an EdgeTech 3300 high-frequency profiler (USA) with a frequency of 2–12 kHz during the cruise 41 of the R/V "Akademik Nikolai Strakhov" in 2019 as part of the program of comprehensive geological, geophysical, and geomorphological studies of the Shirshov Institute of Oceanology, Russian Academy of Sciences (IO RAS) on the shelf of the Barents and Kara seas (Fig. 2) [12].

A macroscopic lithological description of the sediments was carried out on board the vessel according to the methodology [10]. Sediment color was determined using the Munsell soil color chart [22]. Each core on board the ship was divided along the axis into an archival and a working part. The archival parts of three bottom sediment cores were photographed and immediately hermetically packed on board the vessel, then studied in the laboratory of IO RAS using the Geotek MSCL-XYZ automated complex core scanning system (UK). This system is equipped with an MS3 Bartington Instruments (UK) point magnetic susceptibility sensor, a Konica Minolta (Japan) CM-2300d spectrophotometer, and a Geotek XRF (15 W/50 kV, Rh anode) X-ray fluorescence (XRF) sensor with a helium chamber (15×10 mm, 1 s time) and tube settings of 10 kV (70 μA) and 40 kV (95 μA, with a 125 μm Ag-filter) [23]. Scanning of cores allowed us to obtain data on the sediment mass fraction (MS) in SI units, reflected light (L* lightness) and color intensity (a* and b*) characteristics, and geochemistry (elemental composition) using XRF with a resolution of 10 mm. The spectral data from XRF analysis were processed using bAxil software and the results were presented as elemental signal ratios (count second) and/ or normalized signal values for an individual element. To minimize the influence of sediment moisture, the peak areas of the elemental profiles are normalized to the total scatter, which includes incoherent and coherent scattering [21].

The working parts of the cores are divided into samples with a step of 1 cm. On board the vessel, an express analysis of the total content and species

Table. Location of studied sediment cores

Core no.	Latitude, N.	Longitude, E.	Depth, m	Core length, cm
AMK-7443	72°21.970′	63°38.463′	177	670
AMK-7444	72°25.823′	63°31.000′	228	619
AMK-7445	72°28.839′	63°30.484′	193	784

composition (%) of benthic foraminifera (BF) shells in the core sediments was carried out with a sampling frequency of every 10 cm. Sediments were rinsed through a 63 μm sieve and viewed under a Zeiss Stemi 508 binocular (Germany) at a magnification of × 25.

Granulometric analysis of sediments was performed for the central core of the AMK-7444 profile. The analysis was carried out on a SHIMADZU SALD 2300 laser diffraction particle size analyzer (Japan) in individual samples every 20 cm along the entire length of the core. The total (C_{tot}) and organic (C_{org}) carbon was carried out using AN 7529 automatic coulometric analyzer (Belarus) in the sediments of two cores (AMK-7443 and AMK-7444) every 10 cm (analyst Popova M.A.). Calcium carbonate content (weight %) was calculated using the formula $CaCO_3=(C_{tot}-C_{org})\times 8.3$, using on stoichiometric coefficients.

RESULTS

In ***core AMK-7443*** from the southern part of the drift, sediments are represented by silty pelite of dark (5Y/4/1) and greenish gray (5Y/4/1, Glay 1/3/10Y) shades with varying contents of sand and hydrotroilite admixtures. At a depth of 540–670 cm, layers and lenses of dark gray (5Y/4/1) sand up to 5 cm thick were noted, the frequency of which increases downcore. The upper boundary of the layer at a level of 508–540 cm is very distinct and represented by a layer of dark gray pelitic sand. Above the sand interlayer at a depth of 185–508 cm lies silty sandy pelite of predominantly dark gray in color (5Y/3/1) with frequent hydrotroilite nodules and admixtures the amount of which decreasing above 217 cm. In the middle part of the core (depth 376–387 cm) interlayers and lenses of sand are noted. The upper interval (depth 2–185 cm) comprises dark gray silty pelite (5Y/4/1) with hydrotroilite admixtures and nodules. Its main difference from the underlying layers is the nomerous inclusions of fragments of bivalve shell.

It is known that changes in the MS values of sediments directly depend on the content of ferromagnetic minerals (mainly of terrigenous origin), while diagenetic processes contribute to the redistribution of iron with the formation of sulfide minerals with a lower MS [20]. In the AMK-7443 core, the MS varies widely from 10 to 177×10^{-5} SI. The maximum values are noted in the range of 540–670 cm, and in the upper ranges (0–170, 170–540 cm), the MS does not exceed $10–40\times10^{-5}$ SI.

An equally important indicator in the lithological composition of sediments is the distribution of their lightness (L*). Its value depends to a greater extent on the content of carbonate particles in the sediments and to a lesser extent on the presence of light-colored or transparent minerals (for example, quartz) [17]. In the AMK-7443 core, it changes significantly from 20 to 44 units, but in the range of 170–540 cm, it remains within 20–27 units.

To assess the role of coarse-grained material supply to the Kara Sea shelf in the AMK-7443 core, the Si/Al ratio was used, which changes depending on the proportion of abiogenic quartz contained in the sand fraction and aluminosilicates [18]. The Si/Al ratio varies in the core from 7 to 22 with a maximum at 540–690 cm, while above the 540 cm horizon, the Si/Al values do not exceed 13.

Foraminifera analysis revealed, no planktonic species benthic foraminifera were found only in the 0–540 cm interval, represented by 22 species. In the 170–540 cm interval, BF assemblages are dominated by the species *Cassidulina reniforme, Elphidium clavatum* and *Nonion labradoricum. C. reniforme* is a typical Arctic species associated with cold and saline Arctic waters and with a type of sedimentation characteristic of glacial marine environments [7]. The oportunistic species *E. clavatum*, which is almost ubiquitous in the Arctic, often reaches high numbers in stressful environments with a pronounced seasonality of nutrient supply during freshing due to melting ice. *N. labradoricum*, is a species common in the Arctic seas in a zone with extremely high seasonal productivity, considered an indicator of the near boundary of seasonal ice [7]. In addition, *C. reniforme and N. labradoricum* are typical representatives of the middle shelf (river-intermediate) community for the Kara Sea according to the classification of L. Polyak et al. [24]. In the 0–170 cm range, the BF assemblages are represented by the species *Cibicides lobatulus, Islandiella norcrossi, E. incertum, Haynesina orbiculare, Buccella frigida, and E. bartletti. C. lobatulus* is characteristic of an active hydrodynamic environment [7]. *I. norcrossi* marks Arctic conditions with high seasonal productivity. In general, *C. lobatulus* and *I. norcrossi*, together with *Melonis barleeanus*, belong to species that characterize the community of the outer shelf (river-distal), remote from the influence of river waters [23]. The community of species *E. incertum, H. orbiculare, B. frigida*, and *E. bartletti* is attributed to typical Arctic species tolerant to decreased salinity (down to 25 eps). In the Kara Sea, they form the river-proximal community that is strongly influenced by river runoff [23].

Sediments of ***core AMK-7444*** from the central part of the drift are represented by a homogeneous dark gray pelite (5Y/4/1), compacting towards well bottom. Numerous vivianite grains were noted in the sediments [5].

MS values of the sediments vary from 12 to 25×10^{-5} SI. Their maxima are recorded in the range of 575–619 cm, and above it varies from 12 to 18x10–5 SI. The sediment lightness values L* in the AMK-7444 core range from 19 to 40 units. They are maximum from 32 to 40 units in the 0–200 cm range and minimum from 20 to 30 units in the range of 200 to 575 cm. There is also a sharp increase in L* values in the 575–619 cm layer.

According to the results of granulometric analysis of the sediment, core AMK-7444 is composed of silty pelite with a pelite content up to 98%. It is important to note that in the lower part of the core in the interval 575–619 cm, there are 3% of sand-sized particles that were not found in the overlying horizons. Thus, the visual description of the sediment did not reveal any significant differences in lithological composition, however, based on the results of core scanning and granulometric analysis, a horizon of 575–619 cm was identified. The coarse index of the sediment Si/Al varies within the core from 8 to 10. The average distribution of this ratio is 9 units.

The BF composition in core AMK-7444 is represented by 23 species and differs little from that in core AMK-7443. Planktonic foraminifera species are also absent from the sediments, while BFs are found throughout the interval. In the 510–611 cm interval, BF is represented by the species *E. clavatum* and *C. reniforme*. In the 230–510 cm, interval the BF composition is enriched in the species of *I. norcrossi, N. labradoricum, E. incertum, B. frigida, E. bartletti*. The upper 10–230 cm interval is characterized by the species of *E. clavatum, B. frigida* and *E. bartletti*.

Sediments of core AMK-7445 from the northern part of the drift are represented by dark gray aleuropelitic pelite of (5Y/4/1), rich dark gray (5Y/2.5/1) and black (5Y/2.5/1, Gley 1/2/5/N) colors with different hydrotroilite contents. At a depth of 685–784 cm, denser layers of silty pelite to 2 mm in size were noted, the frequency of which increased towards the well bottom. In the overlying horizon 28–685 cm, interlayers of silty pelite with an admixture of sand fraction have been noted at depths of 648–652 and 654–656 cm. The upper horizon of the 0–28 cm core differs from the underlying ones by its dark brown (7.5YR/3/2) color and more intense bioturbation.

The MS values in core AMK-7445 vary from 10 to 31×10^{-5} SI. Maximum MS values from 20 to 31×10^{-5} SI have been noted in the 0–685 cm range, and down section, they ange from 15 to 20×10^{-5} SI. Lightness values L* vary from 17 to 40. It is important to note that below 685 cm, there is a sharp (from 35 to 40 units) increase in L* values. The coarse index of sediment Si/Al varies within the core from 7 to 11, and its peak values are found in the 0–100 cm.

The BF assemblages are represented by 16 species, while no planktonic foraminifera species were found. BF are consitanly found in the 0–540 cm interval and single finds were noted at 730 and 770 cm depths. The interval 180–540 cm is characterized by species of *I. norcrossi, E. clavatum, N. labradoricum, C. reniforme*. In the interval 80–160 cm, BF assemblages are represented by species *I. norcrossi, E. clavatum, N. labradoricum, E. incertum, B. frigida, E. bartletti*. A poorer composition of BF (*E. clavatum, C. reniforme* and *E. incertum*) is found in the upper 0–80 cm range.

DISCUSSION OF RESULTS

Comparison of the lithological description of the core sediments with spectrophotometric and MS data, geochemical parameters, and BF distribution allows the identification of three main lithological-stratigraphical horizons in core AMK-7443 and two in cores AMK-7444 and AMK-7445 (Fig. 4). The sediments of lower horizon (**horizon III**) were only exposed in the southern part of the drift (core AMK-7443) at a depth of 691–540 cm (Figs. 3, 4a). They are represented by dark gray pelite alternating with sand layers up to 5 cm thick and silty pelite, 5-30 cm. Increased MS, L* values are Si/Al are noted here. They are very poor in organic matter and are devoid of foraminifera. On the seismoacoustic profile to which the AMK-7443 core is confined, a high-amplitude reflector is prominent and can be traced throughout the sedimentary body, corresponding to the top of horizon III at a depth of 540 cm (Fig. 2, section 1). This is probably due to the removal of coarse-grained terrigenous material, as confirmed by the increased MS and Si/Al values. However, the AMK-7443 core did not reach the disagreement, which, according to seismoacoustic data, is located at a depth of 10.5 m from the bottom.

The middle horizon (**horizon II**), revealed in cores AMK-7443 (540–170 cm), AMK-7444 (from the bottom to 575 cm), AMK-7445 (from the bottom to 685 cm), comprises dense silty pelite with interlayers of sand and silt with sand admixture in the southern part of the drift. In seismoacoustic sections 2 and 3, the boundaries between the first and second horizons correspond to distinct reflectors, but below and above them the recording values do not change significantly (Fig. 2), indicating a similar lithological composition of sediments. In the southern part of the drift (core AMK-7443), the llithological boundary between the second and third horizons is represented by a thick layer of gray sand and corresponds

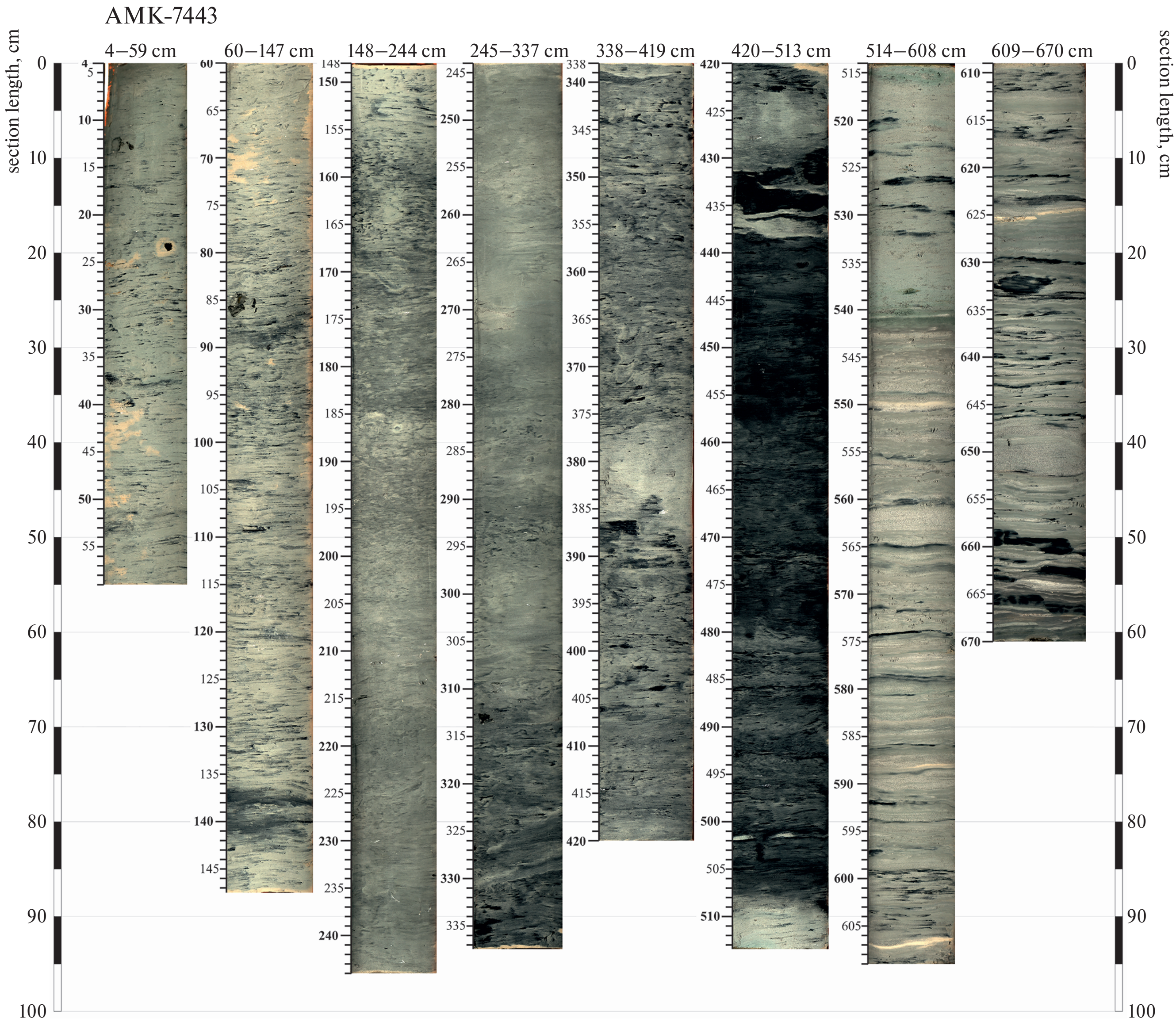

Fig. 3. Photographs of section of the bottom sediment core AMK-7443, taken with the linear camera of MSCL-XYZ GEOTEK complex core scanning system.

to a high-amplitude reflecting boundary on the seismoacoustic profile (Fig. 2, section 1). Compared to the lower horizon III, the sediments of this horizon are characterized by a decrease in the values of MS, Si/Al and L*. The lightness of sediments decreases due to the increase in hydrotroilite content. Starting with the second horizon, the sedimentary layer of the middle and northern parts of the drift is composed mainly of silty pelite. This horizon is characterized by an increase in the proportion of organic matter (OM) up to 0.7% in the composition of sediments, which contain fragments of bivalve mollusks and hydrotroilite nodules. The BF assemblages include the indicator species of stressful situations *E. clavatum*, as well as species typical of mid-shelf environments, *N. labradoricum* and *C. reniforme*. According to the species ecology, it is possible to assume that the increased productivity of waters during this phase of drift sediment formation is likely due to the activity of bottom currents and the close position of the seasonal ice boundary. The influence of fresh water during the accumulation of horizon II is confirmed by the indicator species of desalinated environments of the inner shelf *E. incertum*, *B. frigida* and *E. bartletti*. The composition of the BF assemblages is dominated by representatives of the middle shelf. According to express analysis, sediments of the second horizon accumulated in stops typical of the harsh conditions of the Arctic sea basin with a significant influx of freshwater [7, 15, 24].

Sediments of the upper horizon (**horizon I**) in cores AMK-7443 (170–0 cm), AMK-7444 (575–0 cm) and AMK-7445 (685–0 cm) are represented by soft, homogeneous olive-colored silty pelite of without carbonate material inclusions. The boundary between horizons I and II is not expressed and the transition is gradual; sediment layers are distinguished by increasing C_{org} content and hydrotroilite nodules. They are characterized by reduced MS, Si/Al and L* values. The species *C. reniforme, E. incertum and C. lobatulus* represent communities of both the outer, middle (predominant), and inner shelf. The mixed type of BF communities may indicate an active hydrodynamic environment within the studied depression. In addition, the transport of inner-shelf shallow-water BF communities can also occur via ice, as shown in [6, 15, 24].

The considered contourite drift consists mainly of fine-grained material. In its southern part (core AMK-7443), a well-defined lithological boundary was established at a depth of 540–510 cm, below which more coarsely grained sediments were exposed (horizon III, Fig. 3). This boundary is distinctly expressed in the bottom sediments throughout the entire Kara Sea and presumably characterizes the transition from glacial marine to marine sedimentation, according to data [28], about 10 ka cal BP.

The sediments of horizons I and II on the seismoacoustic profiles have well-defined layering (Fig. 2), and their composition is characteristic of muddy contourite drift [31]. The mechanisms of formation of deposits of this type are still poorly understood [31]. In the Arctic seas, the closest analogues of the sedimentary body considered include the high latitude Kveitola drift, located in the trough of the same name on the western continental margin of the Barents Sea [31]. The formation mechanism for this drift is well described in the cited work. However, the intensity of bottom currents in the Kara Sea is an order of magnitude lower than on the western continental margin of the Barents Sea [1], and the material that makes up the drift is finer-grained, which makes it difficult to study.

According to [25], sediments of the "classical" muddy contourite drift have signs of strong bioturbation and primary lamination. In terms of lithological composition, structure and formation conditions, the contourite drift of the Kara Sea is more similar to the contourite drift of the Baltic Sea [27]. In [27] it is noted that the structure of the horizons of shallow-water muddy contourite drift differs significantly from the classical contourite sequence of horizons in that lamination is present throughout the the entire depth of the core, while there is virtually no bioturbation.

Foraminiferal, spectrophotometric, and magnetometric data indicate that the sedimentation environments likely changed multiple times during drift formation. The revealed sawtooth distribution of L* and MS can hardly be explained solely by the influence of bottom currents [1]. The fine-layered sediment texture characteristic of muddy contourites is visible in high-resolution linear camera images (Fig. 3) and is also present in seismoacoustic profiles in the southern part of the drift, while the central and northern parts show on layering due to the finer-grained sediment structure (Fig. 2).

Within the Western Kara step depressions are widespread (Fig. 5a), similar to the structure considered in [11]. They are extended in the submeridional direction and are interpreted as modern subsidence grabens formed as a result of tectonic creep of the crust during its bilateral stretching [2]. The presence of such depressions on the Kara Sea shelf, similar to the one considered, gives grounds to suggest the possibility of the formation of contourite drifts in these structures, similar to what happens in the one we have considered.

The depression containing the sediments of the drift in question is located to the east of the boundary of the Barents-Kara ice sheet during the maximum of the last Quaternary glaciation (26–20 ka cal. BP), which is marked by the position of numerous terminal moraine ridges confined to the modern 100 m isobath in the Kara Sea (Fig. 1) [14]. The jets of the main currents are confined to a depth difference within the 50- and 100-m isobaths [4], which in turn control the transport of SPM to the central part of the middle shelf of the Kara Sea [9]. In this area of the shelf, a hydrological front is formed, separating different water masses [4], facilitating the deposition of suspended sedimentary matter and, ultimately, forming deposits of, contourite drift.

According to direct inclinometric measurements, the northern direction of the bottom current in the depression is currently maintained [1]. Measurements carried out over 4 days revealed tidal currents in NE and SVW directions, the average speeds of which near the bottom were 3 cm/s, and the maximum speeds reached 10 cm/s [1]. The obtained data on the direction of currents in the studied area correspond to measurements teken during the year in the southwestern Kara Sea [3].

The arid climate of the marginal periglacial zone led to the formation of an unconsolidated sedimentary cover, easily washed away by rivers during the degradation of the ice sheet around 19 ka and contributing to the subsequent accumulation of fine-grained material on the bottom of the modern sea basin

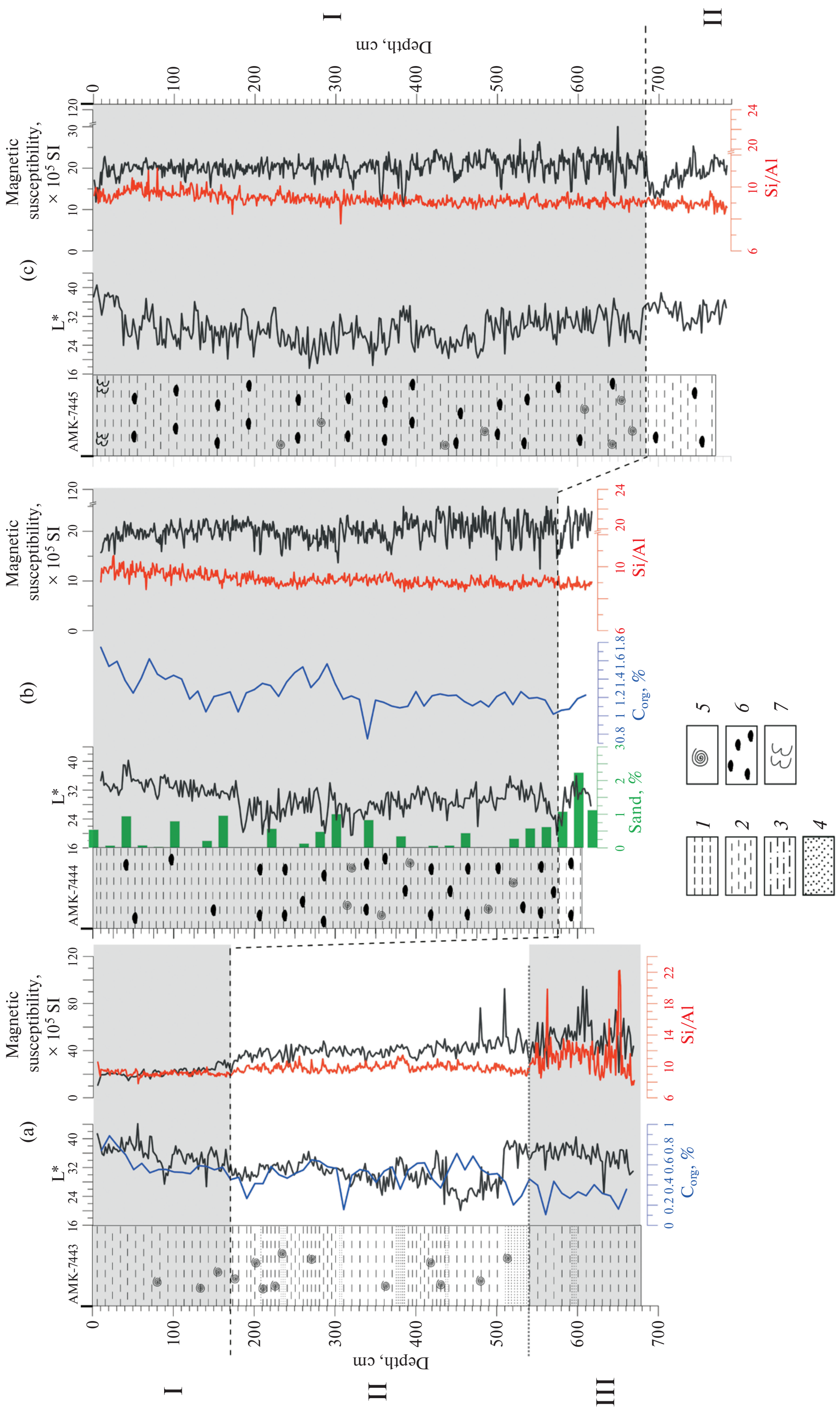

Fig. 4. Types and characteristics of sediments according to lithological description, color characteristics (lightness L*), C_{org} content (AMK-7443 and AMK-7444), Si/Al ratio, distribution of sand fraction >1 mm (AMK-7444) and magnetic susceptibility of sediments: a) cores AMK-7443, b) AMK-7444, c) AMK-7445; *1* – pelite, *2* – silt, *3* – sandy silt, *4* – sand, *5* – fragments of bivalve shell, *6* – hydrotroilite inclusions, *7* – traces of bioturbation.

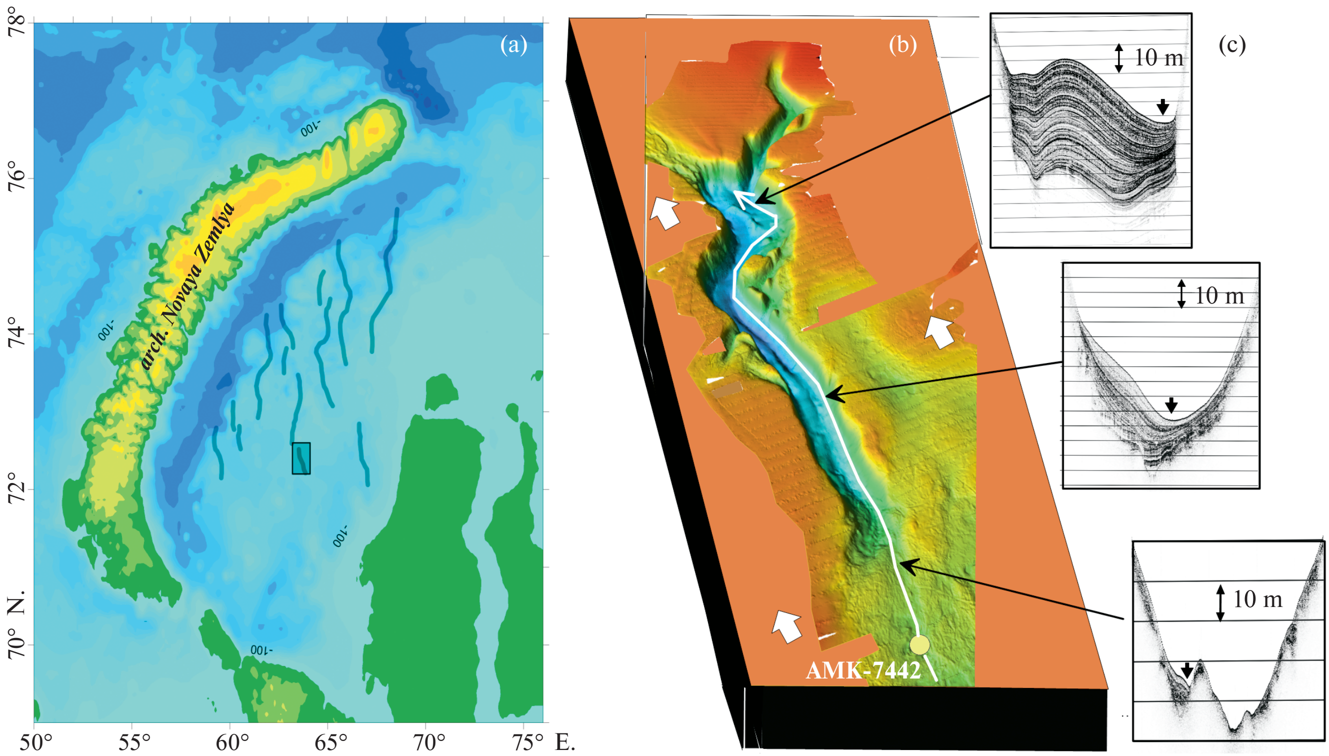

Fig. 5. Sketch map of depressions in the Kara Sea, compiled from map [11] with 20-m isobath section. Rectangle shows study area (a), three-dimensional image of study area, a thin white line with arrow indicates focused water flow in the depression confined to the contourite ditch, thick arrows indicate bottom currents on shelf, a numbered filled circle marks measurement point of of the direction and velocity of bottom current (b), seismoacoustic profiles show increasing in thickness contourite drift from south to north. Arrows indicate the contourite trench (c).

[30]. The abrupt deglaciation led to a rise in the level of the World Ocean by a total of 120 m, and the shelf of the Kara Sea was flooded in three stages (18, 11, and 9 ka cal BP), during which the coastline corresponded to modern isobaths of 100, 50, and 30 m, respectively [29]. The normal marine sedimentation that was established after 9 ka cal BP led to the periglacial landforms being smoothed out and partially eroded under the influence of currents and waves.

CONCLUSIONS

For the first time, the lithological composition of shallow-water muddy contourite drift from the Kara Sea has been studied and the mechanism of its formation has been discussed. It is shown that the sediments of the third horizon (near the drift base) accumulated under glacial-marine conditions of the Arctic basin with a significant influx of coarse-grained material, as evidenced by high values of magnetic susceptibility and the Si/Al ratio. The transition from glacial-marine to marine types of sedimentation, characteristic of the Kara Sea, was noted around 10 ka cal BP [28] by a sharp decrease in coarse grain size, an increase in the proportion of OM in the sediment composition, a decrease in L* due to the formation of hydrotroilite and the appearance of BF tests. For the second horizon, the marine sedimentation conditions were reconstructed with the inlux of freshwater river runoff and possible growth of seasonal biological productivity. The sediments of the first horizon were formed under normal marine conditions, close to the modern sedimentation environment and with the influx of of material from the inner shelf areas.

According to MS data, the age of the contourite drift and the age of the stable bottom current is more than 10 ka. The increase in thickness of the first horizon in the cores in the northern direction allows us to judge the long-term transport of sedimentary material, i.e., the stationary direction of the flux, at least since the beginning of the Holocene. The transport of sedimentary material in the northern directions over a longer period is confirmed by the increase in thickness of drift deposits at the northern closure of the depression compared to its southern end. This occurred due to the focused flow of the bottom current confined to a contourite ditch.

The study of accumulative sedimentary bodies such as contourite drifts or sedimentary waves can be used to reconstruct bottom currents [33]. A comprehensive study of contourite drifts provides information on the characteristics of hydrodynamic and sedimentary processes that arise and exist during the formation of bottom current systems, especially in young shallow basins of the Arctic region.

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CONFLICT OF INTERESTS

The authors of this paper declare that they have no conflict of interest.

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