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Implications of Color and Lightness Characteristics for Lithostratigraphy of Bottom Sediments from the Chukchi Plateau, Arctic Ocean

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Abstract—Marine sediment cores from the Chukchi Plateau are used to demonstrate the efficiency of digital photographic determination of sediment color and lightness, supplemented with the statistically processed data on sediment composition, for lithostratigraphy and paleoreconstructions. Several clusters were established that correspond to brown and gray sediment layers, carbonate-rich beige interlayers and specific segments of unclear lamination and/or lens-like intercalation of brownish and grayish beds. Correlation of the studied cores with other sediment cores from the region with well-established stratigraphy revealed good correspondence (though with certain specific features) to the conventional model of the Late Pleistocene–Holocene sediment accumulation in the offshore Arctic Ocean beyond shelf areas with clearly defined glacial–interglacial cyclicity. It was shown that enhanced red-color component corresponds to the enrichment of the interglacial brown sediment layers with manganese and accompanying elements. Glacial gray layers with enhanced green-color component are enriched in iron, as well as rubidium, vanadium, titanium and yttrium and bear evidence for considerable diagenetic transformations. Blue-color component is related to the high calcium content (carbonate rock fragments) in the carbonate-rich interlayers accumulated during the periods of active disintegration of continental ice sheets and iceberg-rafting of terrigenous lithic fragments. Intermediate values of the studied parameters are likely indicative of specific sedimentation environments.

Keywords: Arctic Ocean, Chukchi Plateau, bottom sediments, color, lightness, geochemical, grain-size, and micropaleontological characteristics, lithostratigraphic correlation, Late Pleistocene, Holocene, glacial and interglacial sedimentation environments

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INTRODUCTION

Color of marine bottom sediments (sum of colors) is an important parameter applied in lithostratigraphy to subdivide and correlate geological sequences. Sediment color can be used to estimate the texture, structure, and composition of sediments, sedimentation environment and its change with time (paleooceanological, paleogeographical reconstructions), as well as the degree and pattern of postsedimentation transformations. At the same time, the description of color and associated parameters of sediments strongly depends on the individual abilities of researcher, illumination, as well as color and lightness contrast of sediment relative to surrounding light sources. Additional difficulties are related to the preservation, processing, and interpretation of a great body of factual material and obtained information. Therefore, colors should be estimated using highly objective and operative procedures. The most suitable and promising method is digital photographing with subsequent processing of the images using the methods of mathematical statistics. The analysis and interpretation of color and lightness characteristics of bottom sediments presented in this study in combination with geochemical, grain-size, and micropaleontological data provide insight into conditions and regularities of sedimentation, and lithostratigraphic subdivision and correlation of sedimentary cover.

MATERIALS AND METHODS

Materials. The study objects were sediment cores HCG-12, HCG-14, HCG-15, HCG-16, and HCG-17 taken by a grab hydrostatic corer on the southern flank of the Chukchi Plateau within the bottom crater field resembling pockmarks (Mayer, 2003; Astakhov et al., 2010) (Fig. 1). Sampling was carried out in the framework of the Russian–American RUSALCA program in addition to the hydrochemical and hydrobilolgical research activities (R/V *Professor Khromov*, 2009). Samples were taken at water depths of 556–635 m. Sediment thicknesses of the recovered cores is 86–250 cm. The obtained material is a unique source of information for the poorly studied region of the Arctic Ocean. The Chukchi Plateau is located in the offshore part of the Arctic Ocean (Amerasian Subbasin) at water depths of 500–800 m and is ascribed to the borderland of the Chukchi Sea. Rock composition of the plateau basement is known from the geological study of the nearest Mendeleev and Northwind ridges (Grantz et al., 1998; Kaban'kov and Andreeva, 2008). The plateau is covered by a relatively thin (a few tens of meters?) Cenozoic sediment cover, the composition of which up to now remains unknown.

According to the initial lithological description, sediments recovered by cores are sufficiently homogenous viscous silty mud and clay of various colors: from almost white, beige, olive, olive-gray, gray, and dark gray to light brown and brown (Astakhov et al., 2010, 2014; Logvina et al., 2011). Films and thin interlayers of hydrotroilite were noted only in core HCG-12 within the core depth range of 108–166 cm. At present, all material has been studied to different extent. Core HCG-12 taken at the closest distance to the crater bottom was studied in more detail. Sediments were analyzed for distribution of petromagnetic parameters, organic remains, some compositional peculiarities; the carbon and oxygen isotopic composition was analyzed in carbonate rocks and organic matter. A model of fluid dynamics and evolution of presently inactive bottom craters was developed. The results are reported in (Astakhov et al., 2010, 2014; Logvina et al., 2011; Malakhov et al., 2013), and some data are additionally presented in the current paper..

Methods. Sampled material was photographed in a cube softbox 50 × 50 × 50 cm in size. Sediment samples were preliminarily dried to reach homogenous consistence without sieving. The softboxes are used to exclude overexposure during photographing of samples with light-reflecting surface. In our case, these are the detrital grains of quartz, feldspars, micas, and other minerals with variably expressed, mainly glassy luster and uneven surface. The internal volume of the softbox was covered by acrylic dull white paint. Light-emitting diode bands were glued on walls and ceiling, five contours per side. The light flow and power of light diodes per a band meter were 780–900 lm and 14.4 W, respectively. A white silk scattering screen was mounted in front of the light diodes to provide even diffuse light within construction, which is devoid of halos from local light sources (lamps), and to avoid highlights and shadows on the photographed samples. Sediment samples were thoroughly mixed, placed on a while paper sheet in the center of the softbox and smoothed by cover slip. Digital Canon EOS 50D mirror camera with Canon EF28 mm f/1.8 USM lens (exposure of 1/100 s, diaphragm f11, photosensitivity ISO of 100) was used for photographing. After obtaining the photo in the digital RAW-format (analogue of negative) using Adobe Camera RAW (application to the Adobe Photoshop graphical editor), the exposure and color were calibrated for the reference white color (professional white balance card) mounted strictly in the left corner of shot. Then, the data on the content of red, green, and blue colors (RGB-range) as well as lightness per 4 cm^2 of each sample were taken from the camera matrix. The central spot of the shot was practically completely devoid of the effect of lens vignetting. Geometric aberrations were corrected using the sample software Adobe Camera RAW. Owing to the maximum closure of the system, the steady and equal conditions were created for samples. Thus, all sediment cores were photographed with a step of 1 cm (in total, 885 samples). Then the data were averaged to obtain similar resolution for all analyses.

The chemical composition was analyzed for sediment cores HCG-12, HCG-15, HCG-16, HCG-17 with resolution of 5 cm (146 samples, in total) on an ARL Quant'X energy dispersive X-ray fluorescence spectrometer (Thermo Fisher Scientific, US) using the Method Explorer software. Ten reference samples were used for calibration. Powdered samples were measured in air using primary collimator beam 3 mm across. Measurement conditions varied for different elements: nickel, copper, gallium, and arsenic were analyzed at an electric voltage of 30 kV, current of 0.2 mA, palladium filter 0.05 mm thick; potassium, calcium, titanium, vanadium, chromium, manganese, and iron were analyzed at electric voltage of 15 kV, current of 0.3 mA, aluminum filter 0.13 mm thick; rubidium, strontium, yttrium, zirconium, niobium, molybdenum, lead, and thorium were analyzed at 50 kV, 0.20 mA, palladium filter of 0.13 mm; barium, lanthanum, and cerium were analyzed at an electric voltage of 50 kV, current of 0.40 A, and copper filter 0.62 mm thick. Each line was measured three times, and the obtained data were averaged.

The grain-size analysis was carried out for sediment core HCG-17 with a step of 5 cm (50 analyzed samples in total). The carbonate content was analyzed preliminarily. Carbonates were extracted by sample boiling in 5% HCl solution. The clay fraction was extracted by decantation, while sand–silt material was separated by sieving. Clastic particles were classified according to the classification proposed by Rukhin (1969).

Taxonomic composition and abundance of planktonic and benthic foraminifers were determined in the fractions >125 μm and 63–125 μm of core HCG-14 with a step of 5–10 cm. The procedure was verified on other Arctic objects (Chistyakova et al., 2010).

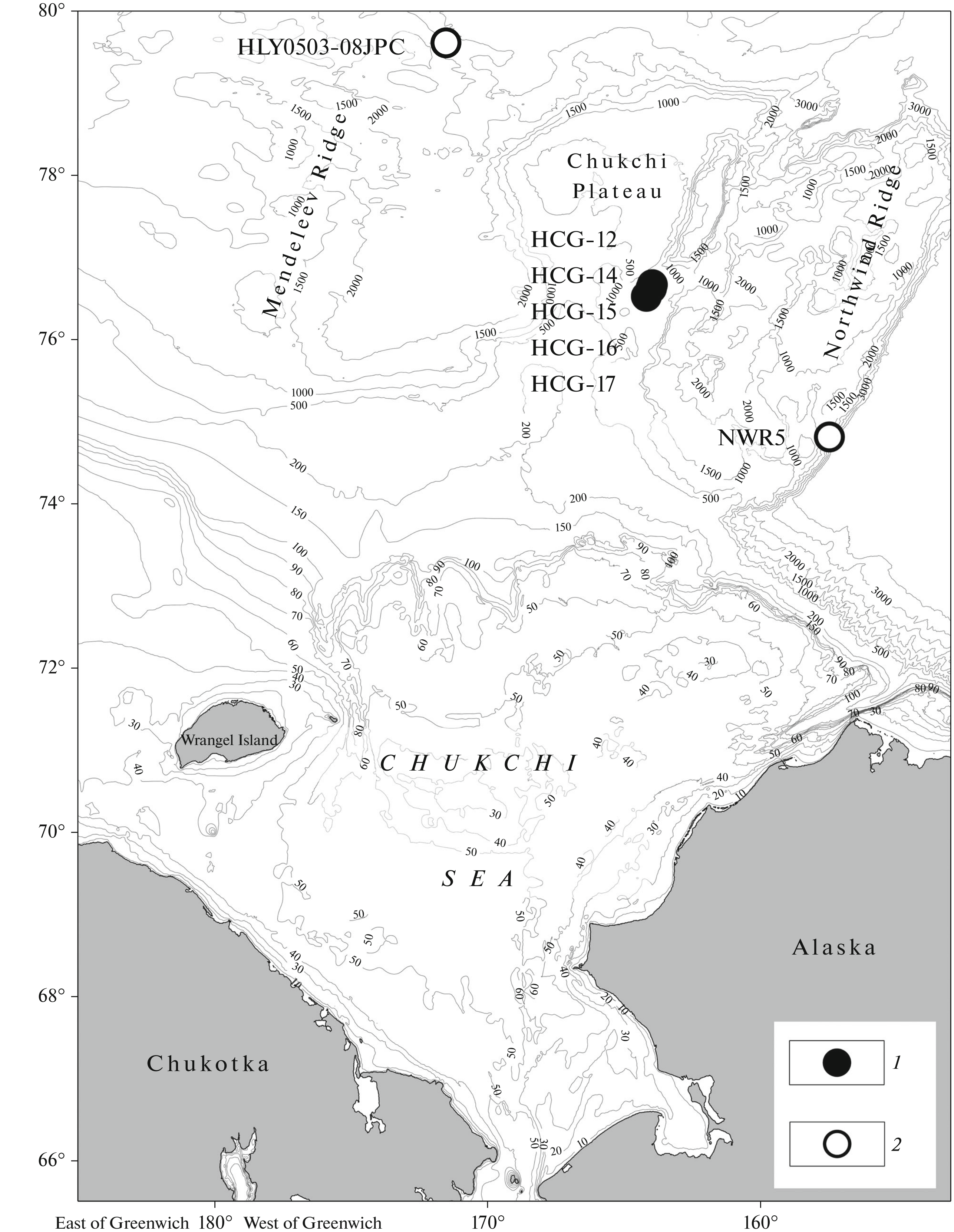

Fig. 1. Map of the Chukchi Sea borderland with indication of sampling stations: (*1*) sediment cores from the Chukchi Plateau (factual material); (*2*) sediment cores from the Mendeleev and Northwind ridges used for correlation (Poore et al., 1993, 1994; Yamamoto and Polyak, 2009). Topographic base was prepared using International Bathymetric Chart of the Arctic Ocean (IBCAO Version 3.0).

Colorimetric, geochemical, and grain-size data were compiled in a general data base (6898 values) and processed using the methods of mathematical statistics, which are successfully applied in studying the sedimentary sequence of the Arctic Ocean (Rusakov et al., 2010, 2012; Levitan et al., 2012, 2014; Levitan and Syromyatnikov, 2016). Special attention was given to the cluster and correlation analyses conducted using a Statistica 8 software. The cluster groups were distinguished using a complete linkage clustering (furthest neighbor method) with a Pearson correlation coefficient as the measure of similarity. The coefficients of paired (linear) correlation were calculated using the Pearson's test. The correlation was taken to be statistically significant if correlation coefficient was less than −0.175 or more than 0.175 at error probability of 0.05.

RESULTS AND DISCUSSION

Clusterization of geochemical, colorimetric, and grain-size data with involvement of data on the distribution of foraminifer shells in the sediment core of the Chukchi Plateau made it possible to distinguish four clusters, which in general correspond to the main stratigraphic units of the upper part of sedimentary sequences of the Arctic Ocean (Fig. 2). Based on the aforementioned parameters, the analyzed sections are well correlated with cores taken on the Mendeleev and Northwind ridges (Poore et al., 1993, 1994; Yamamoto and Polyak, 2009).

Cluster 1 includes brown pelite and pelite–silt sediments with fragments of rocks and minerals. The sediment color in the RGB-range is characterized by the highest value of red-color parameter (R-component) at minimum lightness (L-component) (Table 1). These sediments show the peak (hereinafter, with respect to sediments of other clusters) contents of manganese and molybdenum (these elements demonstrate a tight relation with R-component, (Fig. 3a)), strontium and some other elements, as well as maximum Mn/Fe and V/Cr ratios at the lowest V/(V + Ni). It is highly probable that the strontium peak and high barium content are mainly of biogenic nature. The sediments are enriched in microfossils, with the high content of benthic foraminifers, minimum content of planktonic forms, and extremely diverse species composition. The sediments of cluster 1 and the entire sequence are dominated by planktonic foraminifers of the species *Neogloboquadrina pachyderma* sinistral typical for the Arctic. At the same time, unlike other clusters, sediments of this cluster also contain warm-water species *Neogloboquadrina pachyderma* dextral. Among benthic foraminifers, the most abundant is *Cassidulina neoteretis*, the index species of Atlantic waters. In the cores, sediments ascribed to cluster 1 alternate with sediments of cluster 2 and in general correspond to interglacial sediment horizons B1–B7 (Fig. 4). During these relatively warm epochs, shelves were occupied by seas (transgressions); thick ice sheet

Table 1. Average values of color, lightness, grain-size and geochemical characteristics of the sediment cores from the Chukchi Plateau for established clusters

Parameters	Clusters			
	1	2	3	4
Grain-size fractions and carbonate content, %				
Psammite	5.5	2.9	6.0	3.5
Silt	22.4	24.2	19.2	20.8
Pelite	49.7	58.8	49.7	56.6
Carbonate	20.8	12.7	23.5	17.8
Color in RGB-range and lightness, %				
R, red	39.1	38.3	38.1	38.5
G, green	35.2	35.8	35.1	35.8
B, blue	25.6	25.8	26.6	25.8
L, lightness	107.3	130.0	134.3	128.7
Trace elements, wt %				
Ca	2.43	0.53	8.76	0.66
Fe*	4.43	5.59	3.10	5.52
K	2.15	2.41	1.83	2.38
Mn	0.2040	0.0654	0.1048	0.0668
Ti	0.434	0.543	0.298	0.541
Trace elements, ppm				
As	30.2	32.3	16.4	31.6
Ba	630	639	370	639
Ce	66	73	54	71
Cr	85	117	72	116
Cu	39.5	34.1	32.4	34.4
Ga	17.73	22.02	13.36	21.74
La	34.5	38.0	30.3	38.0
Mo	5.05	2.87	1.58	3.04
Nb	12.65	13.24	8.85	13.27
Ni	55.6	48.1	31.3	48.6
Pb	23.1	24.1	16.9	23.7
Rb	116	148	87	147
Sr	147	128	135	127
Th	7.83	7.44	5.24	7.39
V	114	132	72	131
Y	28.7	32.1	22.2	31.8
Zn	112	131	68	128
Zr	162	165	136	166
Geochemical ratios				
Mn/Fe	0.05	0.01	0.03	0.01
V/Cr	1.34	1.13	1.00	1.13
V/(V + Ni)	0.67	0.73	0.70	0.73

Peculiarities in the distribution of grain size fractions and carbonates are considered for core HCG-17, other parameters are shown for cores HCG-12, HCG-15, HCG-16, and HCG-17. The values of the parameters were determined with different accuracy and are not reduced to the general digits capacity in the framework of this study. Description of clusters corresponding to the main layers and interlayers of sediments are given in the text. Chemical elements in the Table are arranged in alphabetic order.
* Total ferric and ferrous iron.

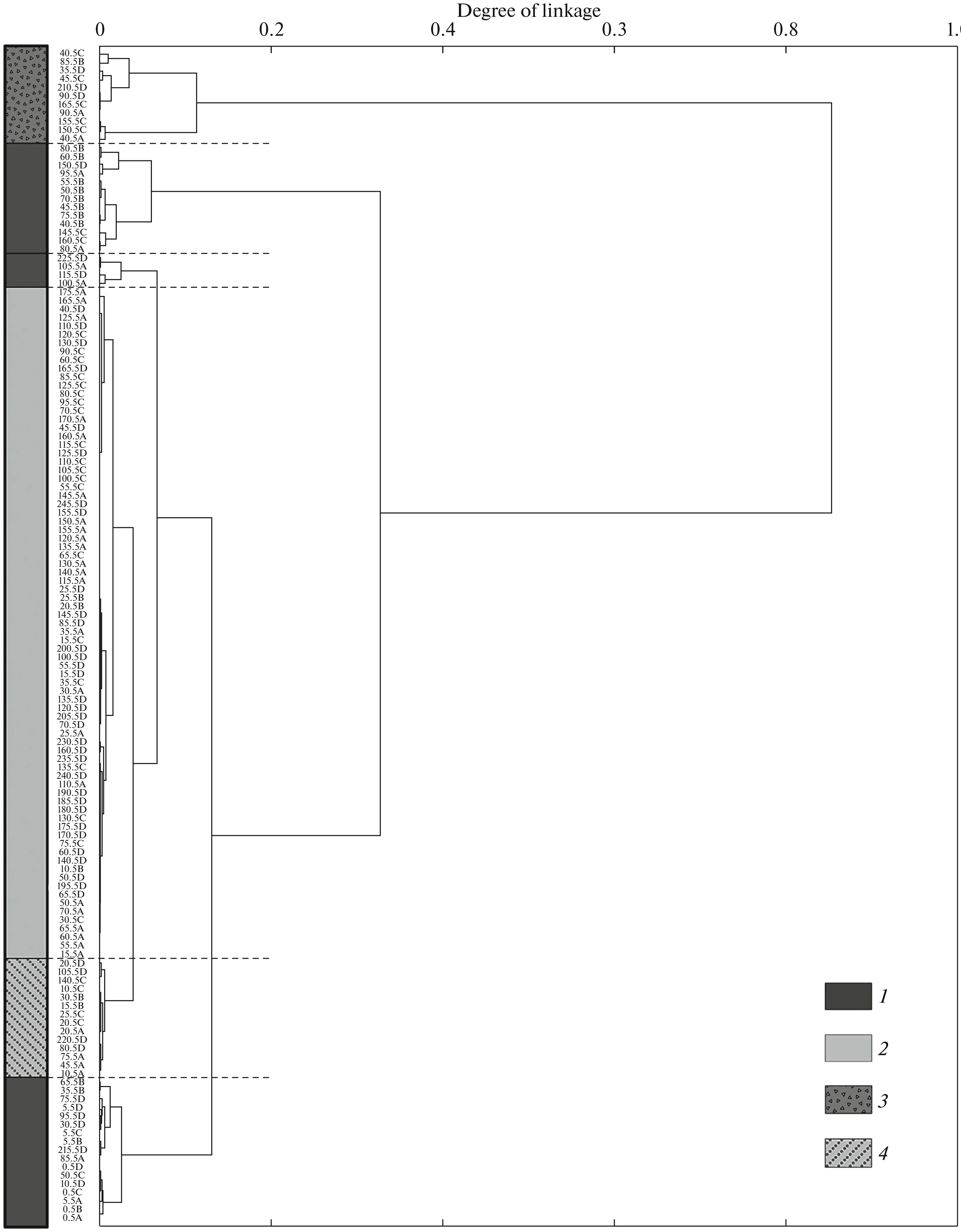

Fig. 2. Q-type cluster dendrogram for sediment cores from the Chukchi Plateau. (*1*–*4*) clusters corresponding to the main established sediment layers and interlayers: interglacial brown sediments (*1*); glacial gray sediments (*2*); beige sediments enriched in fragments of ice-rafted carbonate rocks (*3*); transitional varieties (*4*). For more detailed description of the clusters (layers, interlayers), see text and Table 1. The numeral–letter abbreviations along Y-axis denote sediment samples united in clusters. Numerals correspond to the interval of sampled sediments, letter marks the core number. (A) core HCG-12, (B) core HCG-15, (C) core HCG-16, (D) core HCG-17.

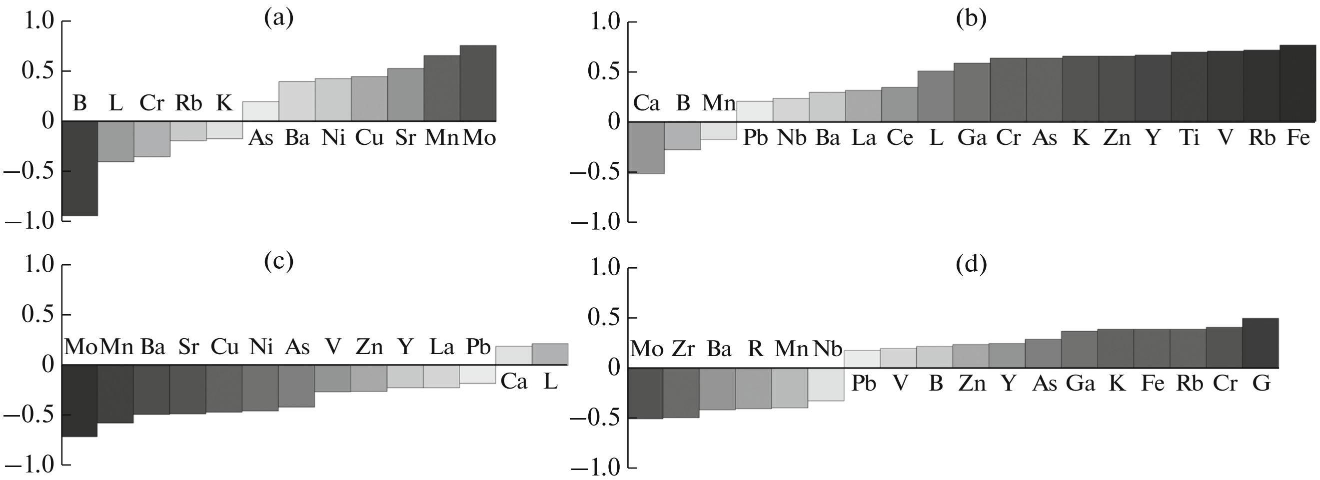

Fig. 3. Statistically significant correlation between color characteristics (a–c), lightness (d), and content of chemical elements in sediment cores from the Chukchi Plateau. Correlation coefficient is shown along Y-axis. In addition to chemical elements, letters denote: R—red color, G—green color, B—blue color, L—lightness.

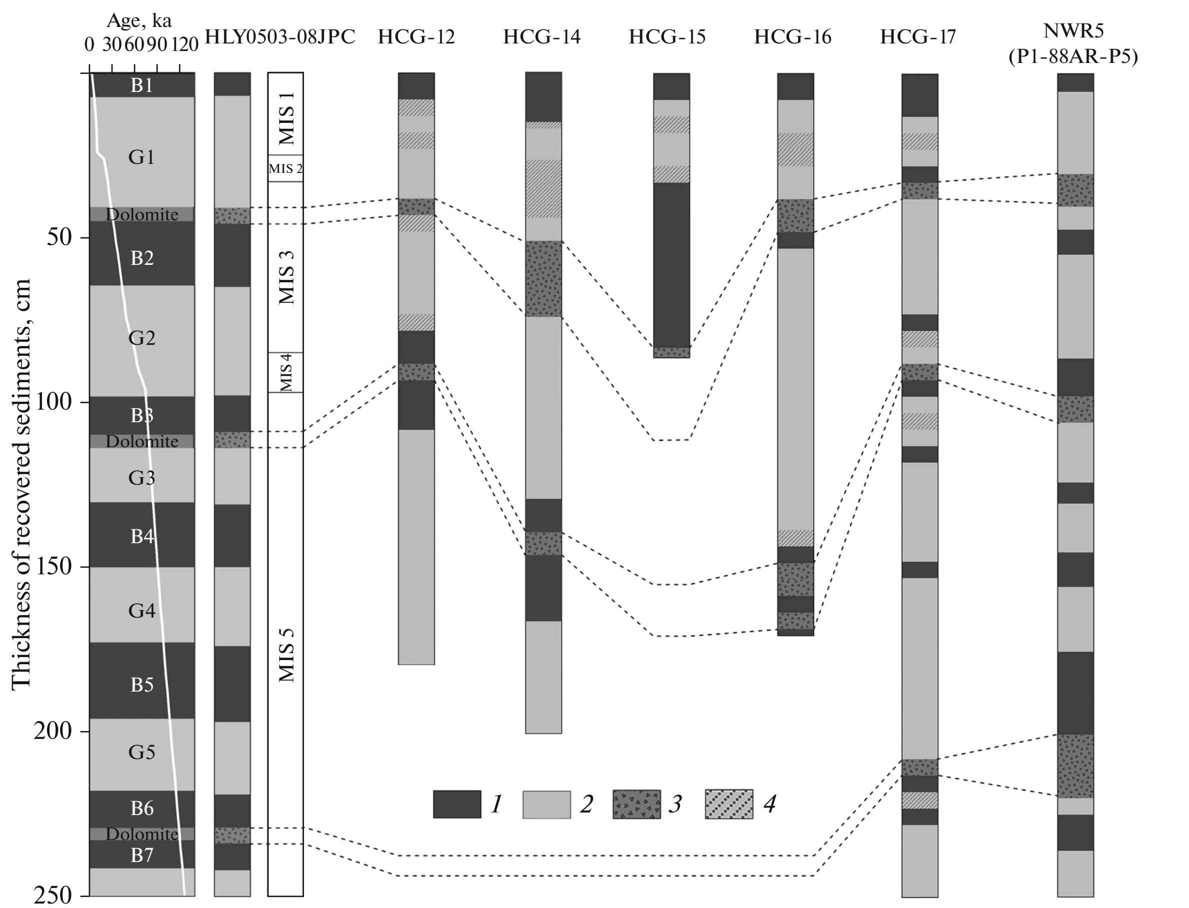

Fig. 4. Lithostratigraphic correlation of bottom sediments of the Chukchi Plateau (cores HCG-12, HCG-14, HCG-15, HCG-16, HCG-17), Mendeleev Ridge (core HLY0503-08JPC; Yamamoto and Polyak, 2009) and Northwind Ridge (core NWR5; Poore et al., 1993, 1994). (B1–B7) interglacial brown sediment layers/ Dolomite—sediment interlayers enriched in fragments of carbonate rocks, mainly dolomite. (MIS 1–5) Marine Isotope Stages. (*1–4*) clusters corresponding to the main established sediment layers and interlayers. Clusters (layers, interlayers) are described in the text and Table 1.

existed only in Greenland, and terrigenous material and dissolved manganese were mainly supplied by rivers and through coastal abrasion (the characteristics are given according to Levitan, 2015). Sediments were practically devoid of diagenetic potential due to the sufficiently deep transformation of organic matter (Levitan et al., 2014). It is more reasonable that sedimentation occurred under oxidizing conditions at high positive values of redox potential, relatively free ventilation of deep waters and their saturation in oxygen. Biological productivity was elevated; interglacial sediments contain significant amounts of fossil organisms and traces of their vital activity.

Cluster 2 includes gray pelite and pelite–silt sediments with rare fragments of rocks and minerals. In the color RGB pattern, they are distinguished by the high contribution of green color (G-component) (Table 1). The characteristic chemical features of these sediments are maximum contents of iron (strongest linkage with G-component, Fig. 3b), titanium, chromium, vanadium, zinc, some other elements, and high V/(V + Ni) ratio at minimum contents of calcium, manganese, and Mn/Fe ratio. The elevated arsenic content is likely explained by its incorporation in authigenic iron sulfides (hydrotroilite, pyrite). The highest barium and rubidium contents in these sediments as compared to other clusters are likely determined by the elevated content of feldspars (our unpublished data on core HCG-17). The latters frequently contain admixture of BaO and/or Rb_2O (Betekhtin, 2007). Biogenic influx of barium in almost microfossil-free sediments of cluster 2 is hardly probable. The presence of benthic *Oridorsalis tener* among foraminifers indicates conditions with low nutrient content (Mackensen et al., 1985). In the cores, sediments of cluster 2 alternate with sediments of cluster 1 and in general are correlated with glacial sediment horizons G1–G5 (Fig. 4). During glacial epochs, unlike interglacials, the spacious areas of modern shelves and adjacent continental areas were occupied by large ice sheets (low sea level); sedimentary material in small amounts was mainly supplied with glacial agents. Bering Strait was closed, and water was exchanged with the World Ocean only through Fram Strait (characteristics are given according to Levitan, 2015). Glacial, stadial, and deglacial sediments were accumulated under possibly weakened bottom water ventilation and, as a result, Fe^{3+}/Fe^{2+} ratio decreased under remaining oxidizing conditions. These sediments are characterized by the elevated content of labile terrigenous organic matter and the depletion in fossils, largely represented by cold-water forms. Gray sediments of cold epochs exhibit well expressed diagenetic signals (Levitan et al., 2014).

Cluster 3 includes beige, light-beige pelite and pelite–silt sediments with elevated psammite content, which are enriched in carbonate rock fragments. These sediments are distinguished by the highest contribution of blue color (B-component) in the RGB pattern at maximum lightness (L-component) (Table 1). Sediments of this cluster are characterized by the peak representation of calcium in the chemical composition (relation with B-component, Fig. 3c) at minimum contents of practically all other elements, except for manganese and strontium. The V/Cr ratio is also minimal. Microfossils occur sporadically and in minor amounts. The appearance of benthic foraminifer species *Stetsonia horvathi* in 63–125 μm fraction indicates a permanent ice cover during sedimentation (Wollenburg and Mackensen, 1998). In the cores, sediments of cluster 3 are correlated with carbonate-rich interlayers (Fig. 4). It was previously shown that the most carbonate-rich sediments of the Chukchi Plateau (cores contain up to three carbonate-rich interlayers) are represented by the polymineral mixture of quartz, dolomite, calcite, and albite; clay component occurs in subordinate amount and consists of layered silicates (Logvina et al., 2011). As compared to other parts of the sequence, carbonate-rich interlayers show the lightest carbon $\delta^{13}C$ and oxygen $\delta^{18}O$ isotopic composition, which is likely related to the predominance of terrigenous (clastic) carbonates. The average values are −1.1 (VPDB) and −5.6‰ (VPDB), respectively (Astakhov et al., 2014). Isotopic data suggest also the presence of organogenic (foraminiferal tests) and authigenic (diagenesis) carbonates in the cores (Astakhov et al., 2014). At the same time, the model calculations indicate the predominant dissolution of carbonate minerals, without newly formed crystals (Logvina et al., 2011). Carbonate-rich sediment interlayers are typical for topographic rises of the Amerasian Subbasin. It is believed that they were formed due to ice rafting of clastic carbonates, mainly dolomites, from Paleozoic sequences of the islands of the Canadian Archipelago during active degradation of the North American ice sheet; some amount of carbonates could have been also supplied from the Brooks Ridge in northern Alaska (*The Geology...,* 1994; Bischof et al., 1996; Stein et al., 2010). Carbonate-rich interlayers were used by us as stratigraphic markers for correlating sediment sections (Fig. 4).

Cluster 4 consists of transitional, frequently variegated varieties of samples. They have much in common with sediments of cluster 2. The main difference consists in the elevated contents of psammite-size carbonate particles and, correspondingly, calcium at maximum Mo/Mn ratio (Table 1). Benthic and planktonic foraminifers occur sporadically. In the cores, cluster 4 is correlated with zones of unclear lamination and/or lens-like alternation of brown and gray sediments, including so-called brecciated interlayers saturated in dense clay inclusions up to 1 cm in size in the clay matrix (Astakhov et al., 2010, 2014; Logvina et al., 2011) (Fig. 4). The presence of such interlayers, which were also found in other regions of the Amerasian Subbasin (Poore et al., 1993, 1994; Phillips, Grantz, 1997; Stein et al., 1999, 2010; Polyak et al., 2004; März et al., 2011), is explained by the gravity flows of sediment masses. It is highly probable that their formation was assisted by pulsed fluid fluxes, especially given the morphology of the bottom structures of the Chukchi Plateau (craters), where the sampling was carried out (Judd and Hovland, 2007; Logvina et al., 2011; Astakhov et al., 2014).

Based on the results of correlation with dated cores of the Mendeleev Ridge and the continental margin of the Chukchi Sea (Poore et al., 1993, 1994; de Vernal et al., 2005; Yamamoto, Polyak, 2009), the studied sediments of the Chukchi Plateau were accumulated during approximately the last 120 kyrs (Late Pleistocene, Holocene) with an average sedimentation rate of 1–2 cm/kyrs under conditions of glacial–interglacial cyclicity of sedimentation environments (Fig. 4). According to another age model (Jakobsson et al., 2000, 2001), the studied sediments can have a much younger age and higher accumulation rates. The Chukchi Plateau is located in the junction zone with continental slope beyond the permanent ice cover, and together with the Mendeleev and Northwind ridges, gains sufficiently abundant input of terrigenous sediment material. However, the presence of the Beaufort Gyre circulation system leads to the sharp decrease of sedimentation rates (Levitan, 2015). Sedimentation rates and the general pattern of lithostratigraphic sequence represented by alternating brown and gray layers with beige (carbonate-rich) interlayers are typical for the Amerasian Subbasin of the Arctic Ocean. At the same time, in sediment cores of the Chukchi Plateau the typical Upper Quaternary sediment sequence is complicated by horizons (lenses) of vaguely laminated sediments of insignificant thickness, which were accumulated during intervals of the rapid changes of redox conditions. This could be related to the crater deepening and fluid discharge at the seafloor. It is suggested that the last period of relatively active defluidization occurred around 30 ka (Astakhov et al., 2014).

CONCLUSIONS

For the first time a high-resolution record of changes in the color and lightness characteristics was obtained for the Upper Pleistocene–Holocene sediments from the region of bottom craters (pockmarks?) on the Chukchi Plateau. The obtained data expand the available concepts concerning the chemical and grain-size composition of the recovered sediment sequences and provide the first insight into the taxonomic composition of calcareous microfossil assemblages (foraminifers). Four clusters were established by processing geochemical, colorimetric, and grain-size data. Two main clusters correspond to the brown and gray sediment layers. Their cyclic alternation reflects a change in the sharply contrasting interglacial and glacial sedimentation conditions. These stratigraphic elements are typical for the offshore regions of the Arctic Ocean. The third cluster unites sediments of carbonate-rich interlayers. They are correlated with episodes of iceberg-discharge by glacial tongue sliding down from the margin of the North American ice sheet that possibly contained Paleozoic carbonate fragments from the islands of the Canadian Arctic Archipelago and Brooks Ridge in Alaska. Such interlayers occur over the entire Amerasian Subbasin of the Arctic Ocean and the North Atlantic. The last, fourth cluster includes transitional varieties of sediments. In the cores, they correspond to the segments with unclear lamination and/or lens-like interlayers of brown and gray bottom sediments, including those with signs of gravity movement. The latter is supposedly related to the deepening of bottom craters of the Chukchi Plateau. Comparison with the regional cores with well-established stratigraphy showed that the studied sediments accumulated during the last 120 kyrs and, in spite of some peculiarities, represent a part of the sequence typical of the deep-water regions of the Arctic Ocean.

The consistency between the obtained results, previously published data and correspondence to the general pattern of the Quaternary sedimentation in the Arctic Ocean indicates the efficiency of applied technique of color and lightness examination and its possible use in the further similar studies (for a more reliable interpretation it is desirable to use additional, in particular, geochemical and grain size data). In spite of some schematic character, this method has some advantages over traditional lithological description. It is suitable for work with fresh and collection material, has a simpler algorithm, is not a time-consuming (express) method, it provides objective determination of color characteristics of sediments, and allows for a repeated (infinite) consideration of initial material in digital form. Results obtained using this technique make it possible to accomplish a purposeful sampling for detailed analytical works.

Strong correlations revealed between some color characteristics and chemical elements allowed us to recommend these parameters as a reference for an initial estimation of the chemical composition and lithostratigraphic description of sediment cores from the Arctic Ocean. Elevated contribution of the red-color component in the RGB pattern implies the enrichment of sediment in manganese and associated elements and affiliation to interglacial brown layers, which were formed at determinative role of sedimentation factor and minimum contribution of diagenetic processes. The elevated green-color component primarily suggests an increase of iron content (reduced forms), as well as rubidium, vanadium, titanium, yttrium, and accumulation of sediment within glacial gray layers with strong diagenetic signal. Thus, the green-color component may indicate sufficiently significant postsedimentation transformation of sediment. The blue-color component is mainly determined by the amount of calcium in sediments, which is reasonable to take into account in distinguishing the carbonate-rich interlayers in sediment sequence. These interlayers are frequently used as lithostratigraphic markers for regions, which were supposedly affected by iceberg-rafting of clastic material from the Canadian Arctic Archipelago, as well as from Brooks Ridge in Alaska. Changes in the trajectory of iceberg movement depending on certain climatic conditions must be taken into account in lithostratigraphic correlation.

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