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Late Pleistocene glacio-marine sedimentation in the Chukchi Sea, the western Arctic Ocean

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In this study, we present the results of sedimentary and echo facies analyses of gravity cores and high-resolution sub-bottom profiling (SBP) data obtained during the 2011 Arctic expedition of R/V Araon (operated by KOPRI) in the Chukchi Sea, the western part of the Arctic Ocean. The gravity cores (248-548 cm long) at 3 stations were collected from the continental shelf and slope areas of the sea, and X-radiographs of sediment slabs were taken from the lengthwise-cut split cores to observe sedimentary structures. Grain size of core sediment was analyzed using standard sieves and a Micrometrics Sedigraph 5000D. High-resolution sub-bottom profiling (SBP) survey was also deployed during the Araon cruise to obtain information on seafloor topography and acoustic characteristics of subsurface sedimentary sequences.

On the SBP data (ca. 70 m of the penetration depth), 3 stratigraphic units (SU-1, 2, 3 in ascending order) are recognized by 2 distinctive reflectors within the sequence. In some places, the lowermost boundary (5-20 m deep below seafloor) between SU-1 and 2 is characterized by channel-shaped erosional topography, which is interpreted to have been originated from incision by grounded glaciers or fluvial channels during the sea-level lowstand, most probably LGM. The boundary between SU-2 and 3 is characterized by a prolonged reflection with a relatively flat and low-relief topography in the inner continental shelf, whereas it gradually changes into a higher-relief reflector with small hummocks in the outer shelf and slope areas. Such acoustic and topographic characters are interpreted to indicate the irregular surface of cohesive mass-flow deposits (e.g. debrites and slump deposits).

More specifically, the acoustic characters in the SBP data are classified into 5 echo facies on the basis of clarity, continuity, and shape of bottom and sub-bottom echoes together with seafloor topography. Echo facies IIA is most prominent type in SU-3 recorded from the continental shelf and slope areas, where it is characterized by semi-prolonged bottom echoes with discontinuous and weak intermittent sub-bottom reflectors. The seafloor associated with this facies shows a smooth or undulatory topography. This echo is interpreted to represent composite deposits consisting of several units of hemipelagites intercalated with turbidites or mud layers from turbid meltwater plumes. Echo facies IIB-2 consists of very prolonged bottom echoes with no discrete sub-bottom reflectors, showing hummocky, undulatory or irregularly-eroded seafloor topography. It commonly occurs in SU-1 and 2 of the continental shelf and the upper continental slope. The origin of this facies is interpreted as coarse-grained tills deposited directly from the bases or margins of the grounded glaciers. In some places of the continental slope, high-relief protruding seafloors are classified as echo facies IIIA which is characterized by distinct but irregular, overlapping hyperbolae with significantly varying vertex elevations (tens to hundreds of meters). This facies seems to be related with various irregular topography including structurally-deformed or deeply-eroded hard rock basement or semi-consolidated sediments, and volcanic edifices. Echo facies IIIB is mainly recorded from SU-2 and 3 in the restricted areas of the outer shelf and upper to mid continental slope. Acoustically, it is characterized by regularly-overlapping hyperbolic reflectors with slightly varying vertex elevations (tens of meters) and slightly prolonged sub-bottom reflection. This echo facies is interpreted to indicate deposits of slump/slide and debris flow.

Three sediment cores mostly recovered from the upper part of SU-3 consist mainly of clays (>60%) and silts with minor and occasional occurrence of sands and gravels. Based on grain texture and sedimentary structures of the core sediments, 5 sedimentary facies are classified: bioturbated or mottled mud, indistinctly- or wispy-layered mud, thinly-laminated mud or sandy mud, homogeneous mud, disorganized sandy mud. Bioturbated mud, the most predominant facies recognized in all cores, is attributed to hemipelagic deposition. Thinly-laminated mud/sand and homogeneous mud commonly occur as couplets, and are generally accepted as deposits of low-density fine-grained turbidity currents. Indistinctly- or wispy-layered mud was most likely emplaced by contour current, tail of turbidity current or melt water heavily laden with fine-suspended sediments. Disorganized sandy mud is interpreted to represent the settling of coarse debris from the drifting icebergs.