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Millennial-scale variations of sea-ice expansion and its relation to Okhotsk Sea Intermediate Water (OSIW) formation in southwestern part of the Okhotsk Sea during 120 kyr.

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Sea ice coverage in the Okhotsk Sea is sensitively affected by fresh water discharge from the Amur River, cold winter regime under the Aleutian Low, and global climate change. The sea ice formation in the Okhotsk Sea has a great impact for Okhotsk Sea Intermediate Water (OSIW) formation through cold Dense Shelf Water (DSF), which is originated as dense brine rejection during sea ice formation and is one of major components for OSIW. The fluctuation of ice-rafted debris (IRD) in a 58-m long sediment core IMAGES MD01-2412, recovered at the southwestern part of the Okhotsk Sea, was investigated in order to reconstruct sea ice history and to reveal its relation to the OSIW formation during 120 kyrs, Obvious stretching effect by giant piston coring was observed only in the top part of 4 m of the core by anisotropy of magnetic susceptibility and physical properties measurement. Age model of the core was obtained by AMS 14C dating of planktonic foraminifer shells, oxygen isotope stratigraphy for benthic foraminifer calcite, and tephra chronology, resulting 115 kyrs of the core bottom age. Millennial scale rapid warm and cold shifts in the core were identified in an alkenone-derived sea surface temperature record with GISP2 oxygen isotope data. Sea

ice expansion in the Okhotsk Sea was reconstructed by measurement of sand fraction IRD of terrigenous particles, dropstone, and magnetic susceptibility. Seasonal sea ice fluctuated abruptly with large amplitude during the glacial but with relatively small variation during the Holocene and the last interglacial. The millennial scale sea-ice expansion occurred at the timing of cold spikes of alkenone SST. It implied that autumn cold alkenone SST by reduced Amur River discharge (warm and fresh) in cold stadial periods resulted in huge expansion of sea ice coverage in the Okhotsk Sea. The millennial scale sea-ice variation was also correlated with the Polar Circulation Index (PCI) of GISP2 ice core that is a relative measure of the average size and intensity of polar atmospheric circulation. The enhanced polar atmospheric circulation during stadial regime have accelerated the large sea ice expansion in millennial time scale during the glacial (MIS 2, 3, and 4) coupled with the reduced Amur discharge. Therefore two main factors of enhanced polar atmospheric circulation and reduced Amur discharge would influence sea ice expansion at stadials. On the other hand, during the interglacial (MIS 1 and 5) when the polar circulation has not been intensified, sea ice also expanded in small amplitude in cold SST condition. At that time, weak Amur River discharge should have been dominant for sea ice formation. The founding the millennial scale sea ice expansion in the NPIW source region is as important evidence for the changes of the NPIW expansion. Vast sea ice expansion during cold stadials could precede the DSW formation resulting in increases of the OSIW formation and in the NPIW expansion during cold intervals.