Millenium-scale rapid and intensive cooling events and sea ice fluctuations in the Okhotsk Sea

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Expansion of seasonal sea-ice cover in marginal sea such as the Okhotsk Sea is sensitively effected by global and local climatic changes. Changes of expansion and recession of seasonal sea-ice cover during 100 kyrs are reconstructed by analysis for ice-rafted debris (IRD) in the marine sediment cores from XP98-99 cruise.

As a results, millennium abrupt and sudden cooling events occasionally occurs in the Sea of Okhotsk. Extreme cooling events corrsponds with Heinritch events and with global cooling. These millennium scale sea ice variations in the sea of Okhotsk should be closely related to polar atmospheric circulation.

Expansion of seasonal sea-ice cover in marginal sea such as the Okhotsk Sea is sensitively effected by global and local climatic changes. Changes of expansion and recession of seasonal sea-ice cover during 100 kyrs are reconstructed by analysis for ice-rafted debris (IRD) in the marine sediment cores from XP98-99 cruise. Objectives of this study are ; 1) to understand elementary process of IRD flux in the Sea of Okhotsk to construct sea-ice proxy, and 2) to reconstruct and spacial and time serial variations of sea-ice cover in the Sea of Okhotsk during 100 kyrs by applications of sea-ice proxy to downcores.

Ice Rafted Debris (IRD) in marine sediment is a useful proxy to reconstruct sea-ice history in geological time-scale. The existence of IRD in marine sediment means that drift ice has reached and melted at that points where sediment was collected. Grain size fraction over 63 micro meter is defined as IRD in the Okhotsk Sea based on XP98-00 sediment trap experiments.

We investigated three kinds of samples ; sediment trap, sea bottom surface sediment, and sediment core. Sediment Trap has been moored at M4 and M6 sites located off Sakhalin island from Aug, 1998 to July, 2000 by XP98, 99, 00 cruises . Bottom Surface Sediment were collected by XP- 98, 99, and 00 cruises , GH00 cruise(GSJ) , and MR00-K3 cruise(JAMSTEC) . Sediment Cores were taken at sites by XP- 98, 99 cruises . After removal of ororganic carbon, biogenic carbonate, and biogenic opal, grain size distribution and mineral assemblage of terigenous grains in sample were measureed by Laser diffraction grain size anakyser and X-ray diffractometer, respectibvely.

Sediment trap and surface sediments study show that 1) IRD drop down to bottom sediments during and just after sea-ice melting, 2) IRD consists of silt and sand size terrigenous grains. IRD is defined a series of grains over 63 micro meter in diameter, 3) The amount of coase grains in surface sediments are related to sea-ice extent, 4) IRD in northern and western side of the Sea of Okhotsk are rich in feldspar minerals. On the contrast, hornbkende minerals in IRD are rich in near Kamchatika peninsula and Kuril islands. Grain size fraction over 63 micro meter is clearly IRD which accumulated into bottom sediment during and just after sea-ice melting.

Because the existence of IRD in marine sediment means that drift ice has reached and melted at that points. we can reconstruct sea ic distribution thorough time. Modes of sea ice extent are divided into four situations with more than 5 volume % in bulk samples ; Mode I : minimum sea ice extent are defined by a existence of IRD only at core PC1. Mode II : moderate sea ice extent are deifined by a existence of IRD both at PC1 and PC2. Mode III : maximum sea ice extent are deifined by a existence of IRD every PC1, 2, and 4. Extra mode : Some abrupt peaks are only recognized at PC-1 which sea ice should has come from kamchatica glacier.

Sea-ice conditions in the Sea of Okhotsk should be seasonal and/or interannual melting sea ice condition during 100 kyrs. Sea ice should be expand during glacial periods with short-term variations in longer duration, larger volume, and/or higher formation rate, by cool climatic condition and/or by sea level drop, because background variation of IRD content in cores PC1 and PC4 increase during cool periods.

Millennium abrupt and sudden cooling events occasionally occurs in the Sea of Okhotsk. Extreme cooling events corrsponds with Heinritch events and with global cooling as shown by GRIP ice core oxygen isotopic ratio. Minimum sea-ice conditions appers around 5 kyrs and 48 kys, and 80 kys when middle of interstadial periods. Millennium scale sea ice variations in the sea of Okhotsk should be related to polar atmospheric circulation, because the reconstructed variation of sea-ice cover corresond to Polar Circulation Index (PCI) which is caliculated by Mayewski et al. (2000).