Variability of surface productivity in the Japan Sea during the last 350ky based on high resolution chemical analysis of MD01-2407

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Distinct alternations of the dark and light colored layers in hemipelagic sediments of the Japan Sea during the last glacial cycle reflect drastic changes in paleoceanographic conditions in the sea. The dark layer deposited during LGM is thick, thinly-laminated, relatively low in org-C, and high in pyrite-S/org-C ratio. Other dark layers are thinner, less distinctly laminated, higher in org-C, and lower in pyrite-S/org-C ratios. These thinner and higher org-C dark layers are thought to reflect either increasing productivity or decreasing bottom water oxygenation level during interstadials of the Dansgaard-Oeschger Cycles [DOC] (Tada et al., 1999). However, there are no studies that examined the individual dark layers from this respect because of the limitation of sampling resolution.

Here, we applied our new XRF micro-scanning method (using Horiba XGT-2700) to wet sediment core of MD01-2407 obtained from the south central part of the Japan Sea to conduct high-resolution (1.25 cm interval) quantitative analysis of the major elements. We measured concentration of Al, Si, K, Ca, Ti and Fe and the water content estimated from the transmitted X-ray intensity index (TXI). Using these data, we evaluated variability of major components such as biogenic silica, biogenic carbonate, and terrigenous material, and calculate their mass accumulation rates (MARs). We compared them with L (gray scale) to examine their relation with the dark layers.

The individual element concentrations for subsamples from MD01-2407 core measured by XGT are in good agreement with those measured conventional XRF method except for Al and Si in the interval between 0-3.3 mbsf. This interval is moderately disturbed and characterized with water contents higher than 60% which is not suited for Al and Si measurement by XGT because evaluation of absorption effect by water is difficult.

We calculated contents of biogenic silica, biogenic carbonate, and terrigenous components from XGT result based on the following equations: 1) biogenic silica(%)=(SiO_2-3.18*Al_2O_3)*1.11, 2) biogenic carbonate(%)=(CaO-0.035*Al_2O_3) *1.79), 3) terrigenous material(%)=5.22*Al_2O_3 (Irino and Tada, 2000).

We slightly modified the age model developed by Minami and Tada (2003MS) for MD01-2407 during the last 350ky, which is constructed based on oxygen isotope stratigraphy with two marker tephra layers and two dark layer horizons dated by 14C at nearby site as additional time controls.

The result suggests that the biogenic carbonate content shows several hundred to thousand years scale variations during the last 130ky. Especially, higher contents of biogenic carbonate are observed in the dark layers during MIS 3 that were correlated with interstadials of the DOC. The relationship between dark layers and the biogenic carbonate is reversed during MIS1, 4, and 5. These dark layers are characterized with better preservation of lamination than that of the sediment core KT94-15-PC-5 recovered from 2845m water depth in the northern part of the Japan Sea. Since its water depth is about 1900m deeper than MD01-2407 core, the better preservation of lamination suggests that they were deposited under higher surface productivity conditions, and biogenic carbonate could have been dissolved in these layers (Watanabe, 2004MS). We suspect that surface productivity increased during deposition of these dark layers, which caused shoaling of CCD and resulted in dissolution of biogenic carbonate. The biogenic carbonate content also shows several intervals of very low contents for several thousand years between the 130 to 350ka when the content of biogenic silica is relatively high. Especially, the content of biogenic silica doubled during interglacial maxima such as MIS1, early 5.5, 7.5 and 9.3 and contents of biogenic carbonate are very low during these intervals. These results suggest that the surface productivity was dominated by biogenic silica during these periods.