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# Orbital- and millennial-scale environment changes in the western Japan Sea since the last glaciation

Jianjun Zou (1,2), Xuefa Shi (1,2), and Sergey Gorbarenko (3)

(1) Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography (zoujianjun@fio.org.cn), (2) Laboratory for Marine Geology and Environment, Pilot National Oceanography Laboratory for Marine Science and Technology, (3) V.I. Il'ichev Pacific Oceanological Institute, RAS

The Japan Sea, one of the marginal seas of the North Pacific, communicates with adjacent seas through four shallow straits (<130 m) and the present environment in the Japan Sea is affected mainly by the Tsushima Warm Current and Liman Cold Current. Over glacial cycles, the eustatic sea-level exerts a great impact on variations in environment of the Japan Sea. Most of published proxy-based data for paleo-environmental reconstructions mainly derived from records of the central, eastern and southern Sea of Japan. However, the history of past environment in the western Japan Sea remains elusive. Here we examine the changes in terrigenous provenance recorded in core LV53-18-2 retrieved on the continental slope of the western Japan Sea over the last 30 ka using a suit of proxies of sedimentology and elemental geochemistry. The principal component analysis of grain size of core LV53-18-2 was conducted and four principal components were identified: 2-15$\mu$m and 31.25-105 $\mu$m (Factor1), 0.35-2$\mu$m (Factor 2), 18.58-31.25 $\mu$m (Factor 3), 210-1000$\mu$m (Factor4). The volumetric content of 10$\sim$15.6$\mu$m was deemed as an indicator of bottom current and Factor 4 as an indicator of sea-ice. Thereby we reconstruct the extent of sea ice and strength of bottom current in the western Japan Sea during the last glacial period. During the last deglaciation to early Holocene, the enhanced extent of sea ice was coeval with the intensification of East Asian Winter Monsoon on orbital timescale and was essentially driven by an increase in solar radiation at high latitudes and atmospheric $CO_2$ concentration. At millennial timescales, the intensity of the bottom current is out of phase with the strength of North Atlantic Meridional Overturning Current and increases significantly during HS1 and HS2 events, which is related to the strengthening of the East Asian Winter Monsoon and the invasion of high salinity Tsushima Warm Current into the Japan Sea. During the LGM through the Middle Holocene, the intensity of the bottom current was depressed significantly, which corresponded to enhanced stratification of upper water column and weakened Kuroshio current. Our geochemical data further indicate the sediment provenance varied before and after 8ka and there is significant positive Eu anomaly after 8ka. We postulated that high plagioclase contents could exist during the Holocene, which is related to the enhanced Liman Current. At orbital timescales, sea level is the primary factor controlling the sedimentary conditions of the Japan Sea. During the low sea level and high sea level periods, the East Asian Monsoon and Kuroshio Current play a secondary role, respectively.
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