

Paleoceanographic reconstructions in surface to subsurface water depths around the Ryukyu Islands for the last 70,000 years

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Ocean circulation at the surface to intermediate water depths exerts a fundamental control on heat transport, marine biological productivity, and ocean-atmosphere CO₂ exchange in the North Pacific Ocean. Recently, the subsurface water masses in the northwestern Pacific Ocean, such as the North Pacific Mode Water and the North Pacific Central Water, have attracted considerable interest due to large amounts of heat and CO₂ absorption for the former and increasing salinity for the latter under recent global warming. However, variations in dynamics and physical/chemical composition of the subsurface layer under different climatic conditions, e.g., glacial periods, still need to be better understood, resulting from a limitation of paleoenvironmental studies using sediment cores from its water depths. Here, we analyzed the oxygen isotope composition ($\delta^{18}\text{O}$ values) of four surface-to-subsurface species of planktic foraminifers (*Globigerinoides ruber*, *Trilobatus sacculifer*, *Neogloboquadrina dutertrei*, and *Pulleniatina obliquiloculata*) and neodymium isotope composition (ϵNd values) of bulk benthic foraminifers to elucidate paleoceanographic conditions and water mass exchanges in surface to subsurface water depths around the Ryukyu Islands, southwestern Japan, for the last 70,000 years. The sediment core (YK12-15 PC02) used in this study was recovered from the water depth ~400 m off Ie Island, west of Okinawa Jima. Our results indicate that $\delta^{18}\text{O}$ profiles of the four surface-to-subsurface planktic foraminifers varied synchronously throughout 70,000 years, except for the upper thermocline species of *T. sacculifer*. The extent of $\delta^{18}\text{O}$ differences between *G. ruber* and *T. sacculifer* and between *T. sacculifer* and *N. dutertrei*/*P. obliquiloculata* changed significantly in centennial to millennial timescales, suggesting large fluctuations in the thickness of the mixed layer and the degree of surface water stratification around the Ryukyu Islands. In contrast, ϵNd values of bulk benthic foraminifers showed a significant fluctuation between -7.8 and -5.3, displaying centennial to millennial variations with an abrupt change at approximately 8 ka. Such changes in ϵNd of subsurface water are considered the balance of contribution of seawaters derived from the North Pacific Mode Water and the North Pacific Intermediate Water. These results indicate that paleoceanographic conditions in the subsurface water depths around the Ryukyu Islands changed in response to variations in the atmosphere-ocean interaction and ocean circulation (e.g., surface and intermediate currents) under glacial and interglacial climate changes.

Keywords: Oxygen isotope composition, Neodymium isotope composition, subsurface water, Ryukyu Islands