Open-System Processes Revealed by Melt Trace Element Inversion from Calcic Amphiboles

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Water mass, as the material transporting carrier, its analysis is important but difficult since water masses often have various origins with complicated structures especially in marginal seas and open-ocean interaction dominated areas. To characterize and analyze the water mass structures and to quantify the contributions with high-resolution, multiple trace elements and isotopes are used. Together with salinity and temperature, typical elements for water mass analysis are the heavy rare earth elements (HREEs) with their relative long residence times (thousands of years) in seawater. The effect of dissolution/desorption between suspended particle and seawater is small so they can be considered conservative tracers. In this study, the data sets are selected from the central shelf towards the edge of the East China Sea (ECS) including the adjoining Kuroshio area. Water mass sources are defined by multiple tracers, including salinity, potential temperature and REEs, etc. These sources include mixed shelf water (MSW), Kuroshio surface water (KSW), Kuroshio tropical water (KTW) and Kuroshio intermediate water (KIW), with only the latter enriched in nutrients. High-nutrient water mass was observed in the central shelf bottom water (100-130 m) and considered mainly a mixture of MSW, KTW and KIW. The mixing ratios of the three water sources are calculated using both conventional tracers (salinity and potential temperature) and four HREEs by the least squares method. Comparable estimations were obtained suggesting HREEs, like temperature and salinity, are conservative and perform as useful tracers to characterize the various water masses. Using HREEs together with salinity and temperature, fractions of four possible water masses, MSW, KSW, KTW and KIW, were calculated in the entire vertical water column on the central shelf. The estimated KIW accounts for 12–63% of the bottom water, which supplies 63±32% of NO_3+NO_2 and 46±20% of phosphate. It indicates that the KIW is the major nutrient source in the bottom water of the ECS shelf. Approximations using global rare earth element data sets for several other study areas where connecting marginal seas and basins are also acceptable.