

New tracer of deep-water ventilation based on stable Pb isotope in the Ulleung basin, East/Japan Sea

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Lead (Pb) primarily enters the ocean through atmospheric deposition and is transported into the interior via deep water formation and circulation. As anthropogenic Pb emissions decline and their isotopic composition shifts over time, the oceanic Pb signature also evolves. To investigate Pb sources, distribution, and the influence of circulation on Pb isotope ratios, seawater samples were analyzed for Pb concentrations and ²⁰⁷Pb/²⁰⁶Pb and ²⁰⁸Pb/²⁰⁶Pb ratios in March 2024 from the Ulleung Basin, East/Japan Sea.

Pb concentrations peaked at the surface and declined rapidly with depth. Surface Pb concentrations were comparable to those in the Northwest Pacific Ocean but higher than in the western Philippine Sea, likely due to the downwind location of the site from Pb source area. Pb isotope ratios closely matched those of northern China coal, indicating coal combustion as the dominant Pb source.

North Korea Cold Water (NKCW), East Sea Intermediate Water (ESIW), and East Sea Central Water (ESCW) in the intermediate layer exhibit distinct Pb isotope ratios, with regional variability. In the continental shelf and slope, NKCW has the lowest Pb concentration at shallow depths, while ESIW shows the highest Pb isotope ratios, influenced by formation regions (PGB or west of 131°E) and Pb input from freshwater sources. In contrast, in the basin, ESIW remains distinguishable in the T-S diagram, but its Pb isotope ratios similar to ESCW. The ESCW showed a Pb concentration increase at 500–750 m, while its isotope ratios remained consistent. These ratios closely matched aerosols measured around Ulleung Island (2003–2006), reflecting the period influenced since ESCW formation.

In the deep layer, East Sea Deep Water (ESDW) and East Sea Bottom Water (ESBW) exhibited distinct Pb isotope compositions, distinguishing them from ESCW and sediment. A linear trend between ESCW and ESDW suggested a like-mixing pattern, with ESBW as an end-member. Near the seafloor, Pb concentrations increased due to diffusion from sediments but Pb isotope ratios remained stable, preserving the isotopic characteristics of each water mass. Shift of Pb isotope system in ESDW and ESBW compared with 5 years ago could be a new tracer of deep-water ventilation in the East/Japan Sea.