

# Systematics of aluminum, manganese, iron, cobalt, and lead in the North Pacific Ocean observed during ocean-section study of GEOTRACES Japan

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Trace metals in seawater are critical parameters in oceanography as trace nutrients for organisms, tracers in the modern ocean, and proxies in paleoceanography [1]. The international study programme GEOTRACES based on intercalibrated methods is revealing global distributions and temporal variations of trace metals in the ocean (<http://www.geotraces.org>). We have developed a method for multielemental determination of Al, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb in seawater using NOBIS Chelate-PA1 resin [2, 3], and revealed basin-scale and full-depth sectional distributions of the trace metals in the North Pacific during three GEOTRACES Japan cruises of R/V Hakuho Maru: a 160°W section during KH-05-2, a 165°E section (GP18) during KH-11-7, and a 47°N section (GP02) during KH-12-4. The elements showed different speciations and distributions. The fraction of labile particulate (lp) species was calculated as the difference between the total dissolvable (td) species and dissolved (d) species. The lpM/tdM ratio, where M refers to an element, is highest for Al, at  $0.66 \pm 0.31$  (average  $\pm$ sd,  $n = 489$ ), and lowest for Pb, at  $0.02 \pm 0.08$  ( $n = 575$ ). The distribution of each element is uniquely related to ocean circulation. We propose that the enrichment factor of dM, defined as  $EF(dM) = (dM/dAl)_{\text{seawater}} / (M/Al)_{\text{upper crust}}$ , where  $(M/Al)_{\text{upper crust}}$  is the molar ratio in upper crustal abundance, can be a good parameter for the sources. As an example, the  $EF(dPb)$  found in this study is on the same order of magnitude as the  $EF$  values for aerosols found in the literature, suggesting that the deposition of aerosols is a major source for dPb. The lpFe dominates tdFe and is strongly correlated with lpAl:  $lpFe = 0.543 lpAl - 0.12$ ,  $r^2 = 0.968$ ,  $n = 510$ . The results also indicate that the dFe concentration corrected for lithogenic contribution improves the linear relationship with phosphate. Thus, we suggest that the mechanism controlling a scavenged element of Al significantly affects the biogeochemistry of Fe. Based on the concurrent observation of these metals, we confirm that the width of the boundary scavenging zone is approximately 500 km off the Aleutian shelf. We estimate an inventory of tdFe in the North Pacific as  $1.1 \times 10^{12}$  mol, and this is approximately four times that of dFe. The results emphasise the potential importance of lpFe in the ocean iron cycle.

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キーワード：微量元素、海水、多元素分析、GEOTRACES、北太平洋

Keywords: trace metals, seawater, multielemental determination, GEOTRACES, North Pacific Ocean