Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18006

Unraveling trace metal co-variation patterns in coastal marine sediments: anthropogenic, redox, and diagenetic controls

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Coastal marine environments are highly vulnerable to anthropogenic pressures. During the past century, human activities in industry, urban areas, agriculture, and transportation have led to a drastic increase in metal pollution in many coastal marine environments. In addition to anthropogenic forcing, secondary factors, such as redox conditions, organic matter loading, Fe-/Mn oxide shuttling, and distance to shore may also influence the fate of such anthropogenic metals in coastal marine sediments. However, both the importance of these factors and interaction between them are still poorly constrained. Interpreting sedimentary trace metal contents as archives of recent environmental change requires filling these knowledge gaps.

Here we investigate correlation patterns between enrichments of metal(loids) (Pb, Cd, Cu, Zn, Sb, Sn, As, Ni, Tl, V, Mo, U, Re, Fe) – often linked to anthropogenic pollution and ambient bottom water redox conditions – across nine coastal depositional environments with varying bathymetrical, hydrological, and biogeochemical characteristics (e.g., water depth and salinity). We discuss the impact of primary and secondary factors explaining the differences in metal sequestration patterns in coastal marine sediments.

Sedimentary Pb, Cd, and Cu contents show a strong covariation across all sites, indicating that anthropogenic enrichments of these metals are relatively robust against influences by site-specific redox, or diagenetic controls. However, lower than expected correlations between certain anthropogenic metals (e.g., Pb and Zn), and positive correlations between redox-sensitive metals of marine origin (e.g., Mo and U) and anthropogenic metals (e.g., Zn and Sb), suggest that under certain conditions, secondary factors can obscure the primary environmental information stored in these sedimentary metal contents. Unraveling these secondary factors will improve the reliability and applicability of trace metals as proxies for historical environmental changes and using metal enrichments as sediment dating isochrones.