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Editorial: Advances in the environmental distribution of less studied elements

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Editorial on the Research Topic
Advances in the environmental distribution of less studied elements

This Research Topic focused on the advancements in our understanding of the environmental processes governing the transport and fate of several elements within natural biogeochemical cycles. The target elements were a group characterized by potential environmental impacts, including emerging contaminants (e.g., critical elements) and radionuclides. For the case of radionuclides, the commonly used approach studying homologue stable isotopes of the elements of interest was also accepted, given the expected similar chemical behaviour. Thus, the Research Topic aimed at exchanging current knowledge on environmental trace elements such as Cs, Ga, Ge, In, Tl, Tc, I, Nb, Rb, Sb, Se, Sn, Sr, Te, PGEs, REEs, etc., including the existing, cutting-edge analytical techniques capable of boosting the state-of-the-art for both commonly studied and less monitored elements. Preference was given to articles focusing on single or a small group of elements rather than general overviews on many elements with limited detailed understanding of their individual cycles and reactivity. Any contribution dealing with the understanding of the environmental behaviour of the listed elements (i.e., stable or radioactive, anthropogenic or geogenic) was welcomed, ranging from the most fundamental approach to direct observations from environmental monitoring or bioaccumulation in organisms, based on field/laboratory experiments or review works.

Assuming that there is still a major lack of understanding on the reactivity, transport and fate of these elements in representative environmental settings, yet essential for watershed management and nuclear safety strategies, the Research Topic has gathered four original research articles, focused on field experiences that reflect recent trends in environmental geochemistry.

Current literature on the most studied radionuclides (e.g., ^{137}Cs) still tackle subjects such as aquatic dispersion, sediment accumulation/remobilization, transfer between environmental compartments, potential remediation techniques, and remnant conditions from historical accidents (e.g., Kim et al., 2021; Chelidze, 2023; Shinano et al., 2023; Smith et al., 2023). This is the case of the contribution by Lee et al., who investigated the dispersion of ^{137}Cs in subsurface waters in the North Pacific Ocean. In fact, they used the discharges of the long-lived ^{137}Cs from the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident in 2011 as a tracer to model ocean dynamics and predict future releases, including planned future discharges of contaminated water from the FDNPP. However, one should be cautious when applying such transversal knowledge to the dispersion of other elements and environments, given intrinsic differences in their chemistry and reactivities.

Other contributions highlighted the role of some target elements as valuable proxies of environmental processes. For instance, Davis et al. investigated the relevance of a multiproxy approach via Mg, Mn, Zn and Sr vs Ca ratios for reconstructing paleotemperatures, intensities and extent of oxygen minimum zones (OMZ) based on shells from foraminifera fossils. Likewise, Cobelo-García et al. highlighted the relevance and uniqueness of REE ratios as proxies of watershed signals in continent-ocean transition systems, distinguishing between geogenic and anthropogenic origin, including the influence of acid mine drainage (AMD) for the Gulf of Cádiz (Spain). Despite the growing number of publications describing the presence of anthropogenic Gd in aquatic systems (e.g., Brünjes and Hofmann, 2020; Trapasso, 2020), few report its reactivity along the salinity gradient combined with its oceanic dispersion and fate (Ma and Wang, 2023), given the high dilution effects once it reaches coastal areas.

However, the missing point for many of the elements of interest is actually the potential impact of environmental levels on human health. Classical elements and related health risks are very present in the literature and are commonly studied (e.g., Puspitasari et al., 2023; Dogruyol et al., 2024). This was the case of Bucşe et al., quantifying the bioaccumulation of As, Br, Cu, Hg, Se and Zn in wild mussels at the Agigea Port in Romania. Despite their anthropogenic origin, current bioaccumulation concentrations fall below maximum permissible levels, suggesting that for these metals, the studied bivalves are safe for human consumption. However, less studied elements including the so-called Technology Critical Elements (e.g., Ga, Ge, In, Nb, Te, PGEs and REEs) have no defined permissible levels, which together with analytical challenges contributes to the lack of environmental studies on these elements (e.g., Chelyadina et al., 2023).

Overall, this Research Topic brings forth that *detail* is the common keyword in current and future studies in aquatic geochemistry. Detail comes from studying specific environments (e.g., Davis et al. in OMZ, Cobelo-García et al. in AMD areas) where trace elements show characteristic behaviours, acting as valuable geochemical proxies and helping to understand aquatic dynamics. Detail is also pursued in modelling approaches, as understanding of trace element reactivity and bioavailability requires a systematic account for element speciation (e.g., Bucşe et al.) and reliable dispersion scenarios (e.g., Lee et al.) in order to produce robust predictions of element fate and impact in ecosystem health. Finally, detail is what future studies on Technology Critical Elements require, in order to achieve the same analytical quality, level of applicability and understanding as available for classical elements.

Author contributions

TG-D: Writing – original draft, Writing – review & editing. JS: Writing – review & editing. TS: Writing – review & editing. EE: Writing – review & editing. FE: Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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