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Editorial: Geochemical Cycling of ^{210}Po and ^{210}Pb in Marine Environments

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Editorial on the Research Topic

Geochemical Cycling of ^{210}Po and ^{210}Pb in Marine Environments

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INTRODUCTION

The radioactive isotope ^{210}Po ($T_{1/2}$ = 138.4 days) and its grandparent ^{210}Pb ($T_{1/2}$ = 22.3 years) have been increasingly used to trace particle dynamics and the biogeochemical cycling of chemical species in aquatic environments over recent decades (Verdeny et al., 2009). This Research Topic provides a set of new studies focusing on the biogeochemical cycling of both ^{210}Po and ^{210}Pb in the marine environments. A total of 11 articles were published on this Research Topic, covering the biogeochemical behaviors of ^{210}Po and ^{210}Pb in various oceanic settings, their ability to bind with diatom- and coccolithophore-associated biopolymers, the utilization of ^{210}Po/^{210}Pb to quantify the sinking flux of particulate organic carbon and the residence times (or ages) of particulate matter in a variety of environmental settings, and the coupled application with other radionuclides and soot to expand their utilities as biogeochemical proxies.

GEOCHEMICAL BEHAVIORS OF ^{210}Po AND ^{210}Pb

An understanding of the geochemical behaviors of ^{210}Po and ^{210}Pb is the foundation for their applications in constraining particle dynamics. In studying this Research Topic, Seo et al. observed contrasting behaviors of ^{210}Po and ^{210}Pb over the productive East China Sea Shelf, showing a net addition of ^{210}Po and a net removal of ^{210}Pb from the water column. The regeneration of ^{210}Po from organic matter in the sinking particles and sediments was suggested to explain the difference in behavior, which is also supported by the observation that ^{210}Po was mainly bound to more hydrophobic (high protein to carbohydrate ratio) nitrogen/sulfur-enriched organic moieties, whereas the strongest ^{210}Pb binding agents were phosphate-containing molecules based on coccolithophore (*Emiliania huxleyi*)- and diatom (*Phaeodactylum tricornutum*)-associated biopolymers (Lin P. et al.). These results highlight the role of marine organisms in affecting the disequilibrium between ^{210}Po and ^{210}Pb

and lend support for the potential application of ^{210}Po as a proxy for sulfur group elements (S, Se, and Te) (Seo et al.) and nitrogen cycling. Based on a direct assessment of ^{210}Po and ^{210}Pb in marine organisms, Sun et al. reported bioconcentration factors (BCFs) up to 3–4 orders of magnitude higher for ^{210}Po than for ^{210}Pb, indicating that bioconcentration might, particularly in productive waters, affect the disequilibrium between ^{210}Po and ^{210}Pb. The close relationship between the ^{210}Po deficit and the dissolved silicate concentration in the upper 200 m of the water column also highlights the influence of organisms (i.e., phytoplankton growth) on the disequilibria between ^{210}Po and ^{210}Pb (Ma et al.). All these results confirm the important roles of marine organisms in affecting the deficit of ^{210}Po in the upper ocean.

TRACE PARTICLE CYCLING USING ^{210}Po AND ^{210}Pb

One of the applications of ^{210}Po and ^{210}Pb is the quantification of the sinking fluxes of various particulate components such as particulate organic carbon (POC; Stewart et al., 2007; Verdeny et al., 2009), particulate nitrogen (PN; Yang et al., 2011), and biogenic silica (BSi; Friedrich and Rutgers van der Loeff, 2002). In studying this Research Topic, Bam et al. reported the highest fluxes of POC and PN in rarely studied ice-covered areas near the North Pole compared with other non-permanent ice-covered areas, based on ^{210}Po-^{210}Pb disequilibria. In addition, extremely low BSi and particulate inorganic carbon (PIC) fluxes were observed, suggesting the absence of ballast effects in the Arctic Ocean. Such a high POC flux scenario, independent of the ballast effect, indicates differences in the biological carbon pump below the sea ice compared with other oceanic environments. Hu et al. found a significant positive correlation between POC and the partitioning of ^{210}Po between particles and seawater, lending support for the application of ^{210}Po-^{210}Pb disequilibrium in evaluating the POC fluxes in Prydz Bay, Antarctica. A similar investigation was conducted in the western North Pacific Ocean (Zhong et al.), which showed enhanced POC export fluxes near the continental shelf corresponding to a moderate biological carbon pump efficiency, compared with the high-latitudinal Arctic and Southern Ocean (Bam et al.; Hu et al.). In addition, Lin F. et al. evaluated organic carbon transport from the surface to deeper sediment by benthos using excess ^{210}Pb relative to supported ^{210}Pb (^{226}Ra; i.e., the difference between total ^{210}Pb and supported ^{210}Pb from ^{226}Ra) in the sediment of the Tropical Northwest Pacific, highlighting the driving relation between POC flux and the benthic ecosystem.

NOVEL APPLICATION OF THE ^{210}Po/^{210}Pb PAIR

The expansion of ^{210}Po and ^{210}Pb in constraining geochemical processes is of great importance to the field of isotopic marine chemistry. In studying this Research Topic, Baskaran and Krupp proposed a novel application of the ^{210}Po-^{210}Pb pair as a chronometer to date the age of snow, the formation time of ice cores and melt ponds, and the residence time of ice-rafted sediment in the Arctic Ocean. These timescales constrained a series of crucial parameters for certain geochemical processes, e.g., the age of snow and the elapsed time of ice-rafted sediment after incorporation into ice. Yang et al. quantified the laterally contributed sinking flux of soot (the refractory fraction of black carbon) using ^{210}Po-^{210}Pb disequilibria and discriminated locally settled POC fluxes from those contributed by sediment resuspension coupled with lateral transport over the slope region of the northern South China Sea, which enables the ^{210}Po-^{210}Pb disequilibrium method to quantify the efficiency of the biological carbon pump in marginal seas with intensive cross-shelf material exchange. In combination with ^{7}Be, Schmidt et al. used excess ^{210}Pb to estimate the residence times of total suspended sediment (TSS) in Galveston Bay, thus constraining the cycling of TSS within shallow, dynamic marine environments.

CONCLUSION

This Research Topic expands our knowledge of the biogeochemical cycling of ^{210}Po and ^{210}Pb and their applications to understanding different biogeochemical processes in the marine environments. Overall, the collected articles enhance the understanding of the behaviors of ^{210}Po and ^{210}Pb and the potential roles of various organic components and marine organisms in affecting the scavenging and phase partitioning of ^{210}Po and ^{210}Pb, validate the applicability of ^{210}Po/^{210}Pb disequilibrium in quantifying POC fluxes in various oceanic settings, and apply the pair in the dating of snow, ice, and ice-rafted sediment. Still, future studies are needed to improve our understanding of the biogeochemical behaviors of ^{210}Po and ^{210}Pb and to expand their applications.

AUTHOR CONTRIBUTIONS

All authors listed have made intellectual contributions to this Research Topic and approved it for publication.

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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.