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Editorial: Celebrating 1 year of Frontiers in geochemistry

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Editorial on the Research Topic

Celebrating 1 year of Frontiers in geochemistry

The launch of Frontiers in Geochemistry marked a new venue for cutting-edge research across the diverse fields of geochemistry. The journal covers five specialty sections (Biogeochemistry, Environmental Geochemistry, Mineral Geochemistry, Organic Geochemistry, and Solid Earth Geochemistry), reflecting the breadth of chemical processes operating in Earth's systems. This Research Topic celebrates the first anniversary of the journal by assembling contributions from these specialty sections to present cutting-edge advancements, provide new insights, and reflect on the current state of geochemistry. The collected articles explore past and present chemistries within different geological systems, offering readers exciting concepts and insight into the future of geochemistry research.

[Shao et al.](#) present a structured review of carbonate weathering in karst surface waters, emphasizing the importance of aquatic photosynthesis. From this review, it emerges that dissolved inorganic carbon is converted into autochthonous organic carbon by photosynthetic activity, which can subsequently be buried in sediments, forming a stable and long-term carbon sink. The authors highlight a historically underestimated factor: the limitation of aquatic primary production by carbon availability. To address this, the addition of dissolved CO₂ to karst surface waters has been proposed as a solution to enhance not only autochthonous carbon production but also to promote the coprecipitation of soluble reactive phosphorus with calcium carbonate. Hence, carbon sequestration and phosphorus removal through CO₂ fertilization of water is a nature-based solution to mitigate both atmospheric carbon levels and aquatic eutrophication.

As demand for lithium-ion batteries soars, the extraction of lithium from granite-pegmatites, like any other mining activity, yields enormous volumes of mineral waste. [Hudson-Edwards](#) presents a timely review of the geochemical and mineralogical characteristics of these wastes, showing that they contain not only residual lithium but also by-products such as quartz-feldspar sand and trace critical elements, including rubidium, cesium, and beryllium. The review highlights the potential of mine tailings to transform these environmental liabilities into secondary resources, such as ceramics, construction materials, or even additional critical metals. At the same time, the review underscores the importance of assessing risks associated with these wastes and elements

such as uranium and thorium, which, although generally present at low concentrations, are radioactive.

Anthropogenic impacts on water chemistry in urban settings are also addressed in this Research Topic. Smith et al. investigate the evolution of surface water as it flows from an agricultural landscape into an urban environment. Their study integrates analyses of major ions, nutrients, and stable water isotopes to disentangle how urban infrastructure and activities change water chemistry. Results show a shift from calcium carbonate-type water to sodium chloride-type water driven by inputs from subterranean stormwater outfalls, which contribute elevated concentrations of salts and minerals (e.g., Na, Cl, Ca, sulfate, silica) largely from road de-icing salts, concrete pipe weathering, and treated municipal effluent. While urban waters are enriched in dissolved solids, the river still transports higher concentrations of nitrate and phosphate from upstream agriculture, creating a complex mixture of rural and urban geochemical signatures. The study documents clear evidence of emerging freshwater salinization syndrome, a growing concern for cities worldwide. This work extends concepts of the geochemical evolution of natural waters to urban contexts, with a focus on their modification within an urban karst system.

Sims et al. highlights how novel applications of geochemical methods are expanding our understanding of Earth's deep history, presenting a novel application of uranium-series disequilibria to date young submarine volcanic rocks at unprecedented temporal resolution. They analyzed short-lived isotopic ratios ($^{210}\text{Pb}/^{226}\text{Ra}$), together with longer-lived ($^{226}\text{Ra}/^{230}\text{Th}$) disequilibria in young oceanic basalts from an active hydrothermal vent field in the Lau Basin. Excess ^{210}Pb measurements yielded eruption ages on the order of decades, further refined with model age calculations, which estimated more than half of the sampled flows erupted within the past ~60 years, with some likely only a few decades old. This study provides the first high-resolution U-series chronology for an active mid-ocean ridge vent site. It demonstrates the feasibility of dating recent oceanic crust on decadal scales, an achievement unattainable with traditional radiometric methods.

Geochemical innovation is also enabling unique insights into the archaeological record. Reay et al. offer us an interdisciplinary study that brings organic geochemistry into the realm of archaeology to solve a historical question: which tree species were venerated at one of Buddhism's most sacred sites over two millennia ago? Lumbini in Nepal, the birthplace of Buddha, features an ancient temple complex with evidence of a tree shrine dating back to the 6th century BCE. Therein, Reay and colleagues applied a biomarker approach to extract and identify leaf wax lipids (triterpenoid esters) preserved in the archaeological soils. By comparing these molecular signatures to those from modern sacred trees, they found chemical evidence for the presence of *F. religiosa* within the oldest shrine levels and surrounding strata. Their results confirm that *F. religiosa* occupied the "central open space" of the shrine and likely formed a grove at the site's periphery, shedding new light on the trees that figured in early Buddhist worship and landscape use. This work demonstrates a new science-based approach for archaeology: using geochemical fingerprints to reveal biological and cultural information that is invisible to conventional excavation. Equally important, the study exemplifies how geochemistry can bridge natural and social sciences.

In summary, the articles gathered in "Celebrating 1 Year of Frontiers in Geochemistry" collectively illustrate the innovative

character and expansive scope of geochemistry. From tackling climate change and pollution through nature-based solutions and sustainable resource strategies, to pushing analytical boundaries that unlock both geological and historical knowledge, these studies demonstrate how geochemistry lies at the forefront of addressing scientific and societal questions. As Frontiers in Geochemistry grows, the advances highlighted here affirm the journal's mission to foster high-impact, interdisciplinary research. By celebrating cutting-edge advancements, whether it be conceptual, methodological, or applied, this Research Topic not only reflects on past and present chemistries but also calls for future explorations in geochemistry. We hope the geochemical sciences community finds inspiration in this Research Topic.

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