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Editorial: Geochemical Signals in Dynamic Sedimentary Systems Along Continental Margins

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Editorial on the Research Topic

Geochemical Signals in Dynamic Sedimentary Systems Along Continental Margins

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For decades, the mud depositing at the bottom of our oceans has been used by scientists as an archive of past environmental conditions, informing about the Earth's climate and helping to put current environmental and climate change into a long-term context. One fundamental condition in successful paleo-environmental reconstructions is the accurate "translation" of measurable chemical parameters in the sedimentary record (proxies) into relatable and relevant information about the ocean, which is most straightforward if sediments are accumulating in a regular pattern—a so-called steady state scenario. Of key interest are sedimentary records of when, why, and how the state of the ocean and Earth's climate changed in the past, and often it is this very environmental change that impacts the way marine sediments record environmental signals. Changes in sedimentation rates, the delivery of organic matter to the seafloor, the redox state of the overlying water column and the availability of certain dissolved chemicals in seawater can create a non-steady state situation where the continuity of the seafloor archive is not guaranteed, and diagenetic effects overprint the sedimentary succession (Thomson et al., 1984; Zabel and Schulz, 2001; März et al., 2008; Henkel et al., 2012). Such non-steady state diagenetic conditions are particularly prevalent in marginal marine environments, as these tend to be disproportionately affected by changes in, e.g., sea level, ocean currents, primary productivity, redox conditions, or riverine input (Aller, 2014; Wehrmann and Riedinger, 2016). In this Research Topic, the imprint of early diagenetic processes on sedimentary records on different spatial and temporal scales is illustrated and means of carefully and holistically assessing sedimentary archives to extract useful environmental information are presented.

Starting at the most marginal of marine environments, i.e., the coastline, Zhu et al. test a novel approach to track mm-scale iron and sulfide dynamics in modern salt marshes along the US east coast using two-dimensional sensors—not only showing how inter-annual (seasonal) changes in organic matter input, but also plant roots, can impact the chemistry of the sediments. Moving further offshore into a brackish, semi-enclosed ocean basin, Hardisty et al. study the response of diagenetic processes to changes in redox conditions in the southern Baltic Sea. The authors highlight that periods of restriction and bottom water anoxia impacted diagenetic processes in different parts of the basin in different ways, adding both a wider spatial (i.e., individual sub-basins within the Baltic Sea) and longer temporal (i.e., Holocene) perspective on geochemical proxy reconstructions. Staying with the intimate link between bottom water redox conditions and diagenetic processes at/below the seafloor, Chen et al. investigate how diagenesis in deposits underlying oxygen deficient zones along the eastern Pacific margin impacts the isotopic composition of sedimentary cadmium (Cd). This study shows that generally light Cd isotopes in these sediments could be a result of biogeochemical processes in the water column, and/or of diagenetic dissolution-precipitation reactions below the seafloor, calling into question the uncritical application of Cd isotopes as paleoenvironmental proxy. Even further offshore and back in time, Giresse et al. make use of glauconite grains in a sediment core from Demerara Rise reaching back ~60,000 years, to postulate that authigenic glauconite records the neodymium (Nd) isotope composition of contemporaneous seawater and thus offers a new archive for water mass distribution that rivals foraminiferal calcite or Fe/Mn (oxyhydr)oxides. The oldest record presented in this Research Topic by Dunn et al. deals with Ordovician (~460 million-year-old) ironstones deposited on an upwelling-affected shelf margin of the now subducted Rheic Ocean. This record appears to reflect not only the impact of variable upwelling and primary productivity on sediment composition (and potentially on biological diversification), but also the occasional reworking by storms—so a non-steady state depositional system forced by interacting physical and chemical drivers.

The generation of biogenic methane in marine sediments is fundamentally controlled by the input of organic matter. There are rather specific diagenetic processes associated with the methanic zone which has an upper boundary that can be found anywhere from a few mm to several tens of meters within the sediment of continental margins (Egger et al., 2018). Studying sediment cores from eutrophic locations off the southern tip of Finland, Jilbert et al. show how the dynamics of diagenetic processes can be shaped by human activity, in this case, commercial forestry: The input of terrestrial organic matter from wood logging and processing activities increased the diagenetic activity, specifically methanogenesis, in the deposits receiving this additional organic carbon loading. The potential issue of sedimentary methane emission to the ocean-atmosphere system is also highlighted by Zhang et al. but in a system offshore Japan where natural methane emissions from both cold seeps and hydrothermal vents are an order of magnitude higher than the global average, illustrating the poorly constrained spatial variability of methane emissions along continental margins worldwide. At locations where methane does not reach the sediment-water interface, this is often due to its anaerobic oxidation by sulfate (at the sulfate-methane transition, SMT), a process studied in detail by Bradbury et al. using sediment cores along a shelf to basin transect on the southwest Iberian margin. Combining chemical analyses with reaction-transport modeling, they propose a revised scheme of how to use the isotopic compositions of pore water sulfate-sulfur and dissolved inorganic carbon in combination to estimate which diagenetic processes (e.g., sulfate reduction, anaerobic methane oxidation, authigenic carbonate formation) are shaping the pore water composition. A similar modeling approach is used by Meister et al. to unravel the contribution of yet another diagenetic process, i.e., the transformation of silicate minerals to quartz and kaolinite (submarine weathering), to the diagenetic dynamics in several hundred meter deep sediments off the Peru margin. Specifically, silicate weathering produces additional alkalinity that can lead to the fixation of formerly organic carbon in the sediment as authigenic carbonates, preventing its recycling to the ocean-atmosphere system. This broad collection of articles enhances our knowledge of the complex interplay of processes at continental margins, which will enable more reliable interpretation of proxy records and diagenetic signals.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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