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Impacts of deep-sea mining on Cu-speciation in polymetallic nodule provinces in the Pacific Ocean

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The rising demand for metals for use in the industrial and technology sector has led to a surge of interest in the exploitation of natural mineral resources located on the seabed. Deep-sea mining (DSM) activities, however, may expose the deep-sea and prevalent marine species to metal toxicity during different stages of the mining process, potentially leading to adverse ecosystem scale effects. It is thus important to quantify the environmental and ecotoxicological impacts associated with mining a particular mineral resource (i.e., seafloor massive sulfides, polymetallic nodules, or cobalt-rich crusts) prior to exploitation licenses being issued by regulating authorities.

The toxicity of metals is strongly influenced by their chemical speciation which for most metals of interest, such as copper (Cu), is dominated by organic ligand (L) complexation in seawater, with CuL complexes being considered less bioavailable and thus less toxic than free Cu^{2+}. The presence of CuL-complexes in deep-sea sediments has, however, not been systematically studied in the context of DSM, making the quantification and prediction of potential toxic and sublethal effects of DSM activities challenging. Consequently, we analysed the dissolved Cu concentration ([dCu]), Cu-binding L concentration ([L]), and DOC in deep-sea pore waters and bottom waters of two polymetallic nodule provinces in the Pacific Ocean (Peru Basin and Clarion-Clipperton-Zone). We compared undisturbed sites with 26-year-old disturbance track sites and one 5-week-old site, where a small sediment plume resettled, to study impacts of polymetallic nodule mining (PNM) on the overall Cu-biogeochemistry. We concluded that PNM activities are unlikely to cause a release of toxic Cu^{2+} levels ($[Cu^{2+}]$) to the surrounding seawater since > 99% of the Cu in the pore waters was organically complexed. Further, $[Cu^{2+}]$ was largely below toxic thresholds and the overall excess of L found in the samples, especially in shallow pore waters, implied that even with extensive Cu-release owing to PNM activities, Cu^{2+} will likely remain beneath toxic levels in the working area.

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