Impact of climate warming on the speciation and long-term stability of arsenic in sub-Arctic lakes: Implications for environmental monitoring of mine sites

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Climate change is influencing the biogeochemistry of northern lakes. These changes may affect the cycling of naturally occurring metal(loid)s and long-term stability of mining-derived contaminants. In sensitive subarctic environments, it is not known how cumulative effects of resource extraction and climate warming will influence geochemical baselines or the transport and fate of arsenic (As) in mining-impacted lakes. This study integrates As geochemistry, organic petrography, multivariate analysis of paleoclimate proxies (particle size, organic matter type and quantity), and radiometric dating (^{14}C and ^{210}Pb) to determine the influence of climate warming on the loading and cycling of As in lake sediments during late-Holocene (5,000 yr cal BP to present) warming episodes. Integrated paleoclimate and sediment geochemistry reconstructions of two sediment cores collected from lakes in the Courageous Lake Greenstone Belt, Northwest Territories, Canada, document increases in sediment and porewater As concentrations coincident with periods of warming. The presence of both primary arsenopyrite and secondary, authigenic As-bearing minerals (framboidal pyrite and Fe-oxides) (determined by SEM, EMPA and synchrotron-based bulk-XANES) suggest that enhanced weathering and active remobilization of geogenic As occurred in lake catchments during warming intervals. An association between As-bearing framboidal pyrite and reactive organic matter was observed through both geochemical analysis and ultraviolet light microscopy, indicating that changes to organic carbon have a significant influence on the fate of As. The findings of this study demonstrate that past climate warming has influenced As mobility and this finding is relevant for predicting future climate change-driven variations in metal(loid) cycling in sub-Arctic lakes. Knowledge from this study can be used to improve environmental monitoring and remediation strategies at future northern metal mines.