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Metals on the move: Serpentinite weathering and metal accumulation in a natural Mg-carbonate playa

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Metal mobilization during weathering of serpentinites is commonly observed in both natural and anthropogenically-altered environments, and the fate of these metals has become a critical area of research for remediation, mineral exploration, and carbon capture strategies. This study investigates dissolved metal immobilization and microbial communities in secondary Mg-carbonate mineral precipitates within the natural hydromagnesite [$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$)]–magnesite ($MgCO_3$) playa located in Atlin, British Columbia. Metal sources and sinks were investigated at regional, local, and centimeter-length scales to better understand metal mobility. Whole rock chemistry of heavily serpentinized harzburgites, dunites, and listwanite collected from the playa and surrounding region indicate that these lithologies contain abundant Mg (15–32 wt.%), Fe (2–7 wt.%), and trace transition metals (e.g., Cr, Co, Ni, Mn). Water chemistry data from complementary surface and groundwater samples indicate the mobilization of these same elements upon serpentinite weathering. To determine the extent of localized metal mobilization from serpentinites and immobilization within the playa sediment, samples for bulk chemistry analysis were collected along several centimeter-scale (5–100 cm) horizontal transects relative to a large serpentinite outcrop located within the playa and several small, isolated boulders. There was a notable decrease in Cr, Mn, Ni, Co, Cu, and Zn concentrations with increasing distance from the serpentinite in all transects, with the majority of immobilization occurring within 10–20 cm of the source rock. The microbial community in the playa sediments included organisms known to mediate Mg-carbonate mineral precipitation (e.g. cyanobacteria), which may be partaking in small-scale metal immobilization through binding and co-precipitation processes. For comparison, a 100 m transect sampled across the playa did not display any noticeable trends in metal concentrations with distance from the outcrop, suggesting that the majority of metal immobilization within secondary Mg-carbonate minerals likely occurs within centimeter-scale proximity to weathered serpentinite formations. Overall, these results demonstrate that while natural serpentinite weathering mobilizes abundant Mg and transition metals at regional scales, these same metals can be re-immobilized over centimeter-scale distances in secondary carbonate precipitates. These findings provide insights into metal mobility in serpentine-rich lithologies that may be of interest in relation to carbon removal and critical mineral exploration.