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The zinc stable isotope signature of waste rock drainage in Arctic Canada

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Leachate emerging from a pilot-scale waste rock pile of the Diavik diamond mine, Northwest Territories, was monitored. The well-characterized waste rock consists of granite, pegmatitic granite and biotite schist with an average total sulfur and carbonate carbon concentration of 0.053 and 0.027 wt. %, respectively. During the field seasons of 2011 and 2012, the Zn stable isotope footprint was characterized alongside standard monitoring parameters. pH ranged between 4.3 and 6.8 and carbonate alkalinity was low or undetectable. Al and Fe concentrations averaged 6.78 mg L-1 and 175 μg L-1, respectively. The pH and metal mobility were governed by sulfide oxidation and sorption and co-precipitation onto iron and aluminium hydroxides. The main processes controlling zinc mobility in the range of 0.4 and 4.7 mg L-1 was the oxidative dissolution of sphalerite (ZnS) in the biotite schist and the attenuation of zinc onto secondary iron and aluminium hydroxides and desorption upon the pH declining below the pHpzc. The isotope ratios between -0.16 and +0.19 ‰ (δ66Zn, avg = +0.05 ‰ n = 43) are consistent with values reported from other sphalerite containing deposits. Zn isotope ratios and concentrations were largely uncorrelated suggesting that the processes affecting Zn mobility had little or no impact on the Zn isotope signature. Data indicate, that the Zn isotope ratios of the waste rock leachate may be used as a fingerprint to track anthropogenic, mine-derived Zn sources under varying environmental conditions.