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Toward a magnesium isotope mass balance in acidified small catchments

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Magnesium (Mg) is an essential nutrient having key physiological functions in plants. Depletion in the bioavailable Mg pool may threaten sustainability of forest ecosystems. Mg2+ cations are also involved in the global carbon cycle. The weathering of Mg silicates on continents consumes an important greenhouse gas, atmospheric CO_2. Subsequent deposition of Mg (and Ca) carbonates in the oceans plays a major role in regulating climate over geological time-scales. 26Mg/24Mg isotope ratios can provide new insights into Mg cycling in the Critical Zone. We studied Mg isotope systematics in four small upland catchments in the Czech Republic, differing in past acidification levels, and in bedrock. One of the sites (UDL) experienced spruce die-back in the years of peak industrial acid rain (1980s-1990s). Its bedrock is base-poor orthogneiss. The remaining three sites, located close to each other, are underlain by contrasting bedrock: serpentinite (PLB), amphibolite (NAZ), and leucogranite (LYS). Soil and water of these sites were also acidified, with needle yellowing at LYS. Input-output hydrochemical mass balances have been monitored with a monthly interval at all these sites. The time-series of Mg fluxes via atmospheric deposition and runoff have been constructed for 5 to 24 water years. Mg export via runoff from UDL and LYS, sites on base-poor lithologies, was significantly higher than Mg input via atmospheric deposition in open areas. A slight decrease in Mg runoff flux was observed between 1994 and 2017. Mean delta26Mg values of bedrock at UDL and LYS were relatively low (-2.5 and -3.4 per mil, respectively). Mean delta26Mg values of runoff from UDL and LYS were significantly higher (-1.5 and -0.8 per mil, respectively). In contrast, at the two base-rich sites, Mg of runoff was isotopically lighter than Mg of bedrock. Mean delta26Mg values of bedrock at NAZ and PLB were -0.3 and -0.5 per mil, respectively. Mean delta26Mg values of runoff at NAZ and PLB were -1.0 and -0.7 per mil, respectively. Delta26Mg of dolomitic limestone used for liming of UDL was also analyzed. The paper will additionally discuss Mg isotope systematics of stratified soil, canopy throughfall, spruce xylem, roots and needles. The ultimate objective is to constrain Mg mass balances by means of Mg isotope ratios, which may also reveal within-ecosystem dynamics in Mg retention.