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Lithium and Li-pathfinder dispersion halos as an exploration tool for Li pegmatites

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Lithium is critical to the energy transition towards a low-carbon footprint. The unprecedented demand for new Li resources requires innovative exploration methods. Soil geochemical surveys are underutilized in the exploration of Li pegmatites. Herein we investigate the distribution of Li and Li-pathfinders (Rb, K/Rb, B, P, Sn, Ga) in the metasomatic alteration aureole and soil cover of several spodumene-pegmatite dikes based on bulk-rock and soil geochemistry. The study focuses on Li-rich Florence County pegmatites and neighboring Bush Lake granite, northern Wisconsin, contrasting them with the Li-poor Dickinson County pegmatites, northern Michigan. The soils were sampled at depths <0.4 m (O, A, and E horizons) along the pegmatite outcrop, and transects perpendicular to both known outcrop and concealed hypothetical extensions, in glacial till-free areas. The analytical approach combining portable X-ray fluorescence (pXRF) and ICP-OES on acid-digested samples enabled systematic characterization of the dispersion aureole surrounding the pegmatites and a better understanding of the underlying mechanisms.

Soil compositions largely mirror the chemistry of the parent material. Soils formed on magmatic bedrock (two-mica granite, Li-poor pegmatites, and spodumene ± amblygonite ± lepidolite pegmatites) mimic the magmatic fractionation trend of increasing Li and B concentrations with increasing Rb and decreasing K/Rb ratio. Along the soil transects collected on host amphibolite and felsic metavolcanics, soil compositions mirror the contact aureoles caused by hydrothermal infiltration during pegmatite emplacement. The soil anomalies, with concentrations of Li<1250, Rb<1660, and B<3080 mg/Kg gradually declining to background values, extend <30 m from mineralized, 1-7 m wide dikes. Soil chemistry is affected by the degree of spodumene hydrothermal alteration specific to each dike, which may control the Li loss to the aureoles. Pedogenetic processes that affect the soil chemistry include contamination across lithologic boundaries caused by both detrital and soluble element transfer, vegetation cover, and topographic slope.

Soil-geochemical indicators (K:Rb < 275 coupled with Li>100 mg/Kg) suggest presence of Li mineralization within a distance of roughly 20 m and <0.5 m depth. We tested and validated these indicators on existing and newly discovered pegmatites from Wisconsin. They may be applicable to other underexplored glaciated areas in humid temperate climate.