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Non-arid brine sources of Li: Using mine waters of the North Pennines, England to test near-surface measurements as a tool for assessing the Li resource of hydrothermal brines in granitic systems.

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Unprecedented global demand for Li and advances in extraction methods such as direct lithium extraction has reduced the Li concentration required for economic viability of brines. A major challenge for subsurface exploration is determining where to drill boreholes.

In the North Pennines (North-East England), Li enrichment was first found in the waters of the 100 m level of the Cambokeel fluorspar mine (40-70 mg/L). In 2004, an exploratory geothermal borehole was drilled ~500 m from the mine. Li concentrations increased with depth, 0.7-7 mg/L from 48-214 m, 7-40 mg/L by 335 m, and >90 mg/L from 411-995 m depth. Further Li exploration and development in the region has been inhibited by lack of knowledge of the geographic extent of the resource, or the location of potential high permeability structural features. High costs of drilling, and risks related to only having two points of elevated Li concentration in proximity, are a significant barrier to developing this resource.

In this study we examined 80 surface mine waters across the North Pennines using statistical modelling to determine signatures of Li rich brines, and identify locations with brine inputs. Looking at only Li, only Cambokeel mine's outflow showed concentrations >100 µg/L (784 µg/L). Further sampling was conducted from within selected mines. At Scraithole, Li concentration increased from 62 µg/L at the mine outflow to 120 µg/L 600m in. Scraithole is ~21 km from the Cambokeel mine, across the Burtreeford Distrubance, a major NE-SW fault that bisects the region.

Multivariant analysis showed at least 2 distinct geochemical signatures in the mine waters. The near surface signature was dominated by SO_4, Pb and Zn. In contrast, the deeper brine signature was composed of Li, Ni, F, Na, and Br. A simple mixing model found that Scraithole and Cambokeel mine outflows were 0.12% and 0.79% deep brine, indicating brines moving upwards via geothermal circulation.

These early results indicate that near surface water has potential as a low-cost exploration tool for determining high permeability structures and the geographic extent of deep Li brines, and can aid in identifying where to drill boreholes for exploration and extraction.