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Fingerprinting isotopic signatures for metal enrichment in European trees: Developing vectors for mineral exploration

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The trace-element geochemistry of native and common plant species in Ireland including ash, beech, blackberry, hawthorn, oak, poplar and sycamore was systematically determined above the Navan Zn-Pb deposit, currently mined by Boliden Tara Mines Limited. The study area represents a sub-outcropping carbonate-hosted base metal orebody characterised by a large shallow soil Zn-Pb anomaly.

The new results show that Zn contents in leaf materials across all species vary from 22 ppm to 735 ppm (dry weight) above the orebody while control sites concentrations ranged from 15 ppm to 263 ppm. The highest concentrations of Zn are observed in poplar trees (735 ppm) growing above the sub-cropping mineralisation. Levels of Pb are anomalously high (3.8 ppm, on average) in all investigated tree species compared to the background values from control sites (0.54 ppm, on average). Soil geochemistry determined above the deposit exhibited 1111 ppm of Zn and 390 ppm of Pb, on average. In order to better understand the source pathway of metal anomalies, stable metal isotopes were measured in plants, soil and tree cores to investigate typical ranges of Zn and Cu isotopes in the Navan deposit. The Zn isotope composition of hawthorn growing over unmineralised bedrock exhibits enrichment in heavy isotopes ($\delta^{66}Zn_{JMC}$ of 0.15‰ to 0.48‰). In contrast, much lighter Zn isotopes ($\delta^{66}Zn_{JMC}$ of -0.12‰ to -0.62‰) were detected in the same plant species above the Navan orebody (Nevinstown Zone). In addition, the Nevinstown area exhibits lighter Cu isotopes in hawthorn leaves ($\delta^{65}Cu_{mean}$ =+0.23‰) when compared to the control sites ($\delta^{65}Cu_{mean}$ =+0.55‰). Differences in isotopic signatures in vegetation can be interpreted as representing two possible Zn sources with signatures imparted on soil from: 1) Zn mineralisation (sphalerite), or 2) Zn contents in carbonate minerals within the host limestone sequence.

This study demonstrates that plant geochemistry at Nevinstown successfully detected Zn anomalies in all investigated species and hawthorn showed the clearest enrichment of Zn peaks and the lowest impact of seasonal variations. Plants are providing the geochemical signature of a large volume of soil horizons which is one of the advantages of using biogeochemical prospecting over traditional exploration methods. Furthermore, this research contributes to a better understanding of biogeochemical metal cycling in the surficial environment and for the development of new geochemical tools for Zn-Pb exploration in temperate European climates.

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