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Atmospheric dispersion of trace metals between two smelters: An approach coupling lead, strontium and osmium isotopes from bioindicators

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Abstract

Bioindicators, by naturally cumulating the impacts of chemical contaminants over time, have demonstrated their added value in evaluating environmental quality. Mining in the Abitibi Gold Belt (Canada) started with the 1909 gold rush. The Archean Abitibi greenstone belt forms the local bedrock and is mainly composed of old compressed and metamorphosed volcano-sedimentary rocks. The Horne copper smelter, located in Rouyn-Noranda (Quebec province) near the Ontario border, is one of the main active smelters in the region. The smelter processes local and worldwide ores. It also is the largest recycling facility for used electronic and computer parts in North America. Two other active smelters, Vale Inco Copper Cliff and Sudbury Integrated Nickel Operation (Glencore), are located within the same geographical area ca. 300 km, in Sudbury (Ontario). The Vale Inco plant smelts nickel-copper bulk concentrates from various sources and the Glencore nickel-copper concentrates from Sudbury, Raglan and XNA (Australia) ores. The Glencore smelter also processes custom-feed materials in the form of concentrates and secondary products. Mosses and epiphytic lichens are widely recognised as reliable bioindicators for evaluating air quality due to their ability to accumulate chemical elements in amounts usually exceeding their physiological needs. This attribute is due to physiological properties such as a lack of cuticle, the absence of protective organs (which could limit the adsorption of toxic substances) and a large exchange surface. This is also why they are capable of absorbing both soluble and insoluble mineral nutrients; they survive by maximizing their uptake of atmospheric aerosols and precipitations while minimizing loss.

We studied Pb, Sr and Os isotope systematics from *Cladonia rangiferina* lichens collected along a transect between two smelting complexes located in Rouyn-Noranda and Sudbury (Canada) to identify sources of these metals in the Abitibi region and to delineate the extent of their respective emission plumes. Results show that metals present in the study area are explained by the contamination of the regional background by deposition from the atmospheric emissions of the different smelters over distances up to 250 km. A rough estimate of the respective metal contributions of each smelter to the lichen samples was calculated. At low metal concentrations, lichen samples indicate that dispersion plumes may differ for the Pb and Os contamination.