Zn-Cu isotopic study and speciation of airborne metal particles within a 5-km zone of a lead/zinc smelter

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We followed the fractionation of Zn and Cu isotopes throughout a pyrometallurgical process and emission of a metal aerosol plume in the atmosphere around one of the major Pb-Zn refinery located in the Northern France. Analysed samples encompass ores, and dusts collected in the main exhaust system inside the plant and within a 5-km size zone of smelting activities (dry deposition plates).

Cu and Zn isotopic ratios are measured on a Nu-Plasma MC-ICP-MS. Repeated measurements of Cu NIST and Zn JMC standards give an average of 0.00±0.03‰ for δ^{65}Cu and δ^{66}Zn (2 SD, n=100).

Samples collected inside the plant show δ^{65}Cu variations of 0.8‰, mainly reflecting mineralogical differences in enriched ores that feed the two refining processes: positive values (0.04-0.21) for ore and dust samples from the Zn refining line, and negative values (-0.22 to -0.62) for the Pb refining line samples. δ^{66}Zn show also a large range of values (0.8‰) with a strong shift to lighter Zn isotopic composition (-0.63) for the dusts collected in the main chimneystack. As experimental studies have shown, the negative δ^{66}Zn value may reflect a mass-dependent fractionation controlled by the reduction processes occurring in the furnace.

The dust samples collected downwind show δ^{66}Zn variations up to 0.7‰. Between 190 and 1250m from the center of the refinery, the dry deposition plates show large Zn-rich particles (>10 microns) with positive δ^{66}Zn values (0.02-0.19) reflecting their origin from resuspension of ore and slag heaps. From 1720 to 4560m, the deposition plates contain smaller Zn-rich particles (<10 microns) characterized by negative δ^{66}Zn values (-0.52 to -0.02), suggesting an origin from the emission of the chimneystack.

This study suggests that Zn isotopes might be used as reliable tracer of metallurgical Zn sources, while Cu isotopes variations mainly reflect mineralogy differences of ores processed by the refinery.