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Mineralogy and weathering of particulates from mines and smelters in soils from humid subtropical and semiarid areas

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Soils in the vicinity of non-ferrous metal smelters are often highly polluted by inorganic contaminants released from particulate emissions, which undergo weathering processes and release contaminants when deposited in soils [1]. For this reason, the mineralogical investigation of particulates emitted or windblown from smelters and mines is a suitable tool for understanding the origin and fate of metal(loid)s in these areas. Here we studied heavy mineral fraction separated from mining- and smelter-affected topsoils from a humid subtropical area (Mufulira, Zambian Copperbelt) and a hot semiarid area (Tsumeb, Namibia).

The topmost soil layers were highly enriched in metals and metalloids, e.g. up to 8980 mg Cu/kg near Cu smelters and up to 8170 mg Pb/kg near Pb smelters. The X-ray diffraction analysis of the heavy mineral soil fraction generally detected rock-derived phases (zircons, tourmaline, rutile, residual carbonates) and only rarely metal-bearing phases [2]. However, using scanning electron microscopy (SEM) combined with energy dispersion spectrometry (EDS) and subsequent electron probe microanalysis (EPMA) we identified numerous anthropogenic metal- and metalloid-bearing particles smaller than 80 μm in the most polluted soil layers at both sites. Whereas spherical particles were formed by the processes in the furnace or in the flue gas cleaning system of the smelters, angular metal-bearing particles originated from the mine tailing disposal sites [3]. Copper smelter-affected soils from the Zambian Copperbelt commonly contain spherical particles composed of covellite (CuS), chalcocite (Cu_2S), tenorite (CuO) and delafossite ($Cu^{1+}Fe^{3+}O_2$). Secondary weathering rims on Cu-Fe sulphides are often composed of Cu sulphates and/or Cu oxysulfates along with hydrated Fe-oxides [2]. Smelter-derived particulates from the Tsumeb site included frequent slag particles, sulphides, but also complex Ca-Cu-Pb arsenates and Fe- or Mn-oxides enriched in metals and As. At both sites, angular grains of chalcopyrite ($CuFeS_2$) and other sulphides with distinct weathering rims were attributed to mining-derived materials (tailings).

Interestingly, in contrast to soil environments affected by non-ferrous metal smelters in the temperate climate, significantly lower concentrations of metal(loid)s and smelter particulates were detected in wooded areas. We hypothesize that more frequent bushfires in the forested zones can be responsible

for the re-emissions of smelter particulates back to the atmosphere [2]. This study was supported by the Czech Science Foundation projects (GAČR 13-17501S and 16-13142S).

References:

[1] Ettler V et al. (2005) Chemosphere 105: 1449-1459

[2] Ettler V et al. (2014) Sci Total Environ 473-474: 117-124

[2] Ettler V (2016) Appl Geochem 64: 56-74