Critical elements and emerging contaminants in smelting slags from northern Namibia

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Previous metallurgical processing of non-ferrous metallic ores in northern Namibia left huge amounts of waste materials considered as sources of pollution but also of technologically critical elements. We focused on slag samples from Tsumeb and Berg Aukas exhibiting extremely high concentrations of major contaminants (up to 1.1 wt% As, 2.4 wt% Cu, 10.6 wt% Pb, 23.9 wt% Zn). The slag samples also contained substantial amounts of emerging contaminant and critical elements such as Ga (up to 172 ppm), Ge (365 ppm), Sb (6400 ppm) at Tsumeb and V (9980 ppm) at Berg Aukas, respectively. Mineralogical investigation using a combination of XRD, SEM/EDS and EPMA indicated that the slags were composed of olivine-, melilite- and spinel family phases, clinopyroxenes, metal(loid)-rich glass and sulphide/metallic inclusions. In the Tsumeb slags, Sb was mainly found in intermetallic phases occuring as droplets trapped within the silicate matrix and in residual glass (up to 3.4 wt%), whereas major carriers of Ga and Ge were spinel-family oxides (up to 200 ppm Ge and 1890 ppm Ga). At Berg Aukas, clinopyroxenes were major carriers of V (up to 3.4 wt%). Leaching experiments confirmed that the majority of metal(loid)s exhibit pH-dependent leaching behaviours with substantial release at low pH. Understanding of specific binding of individual contaminants and critical elements is crucial for potential recovery of valuable compounds from these slag materials. This study was supported by the Czech Science Foundation project (GAČR 19-18513S)