MINERALOGY AND LEACHABILITY OF IRON AND STEEL WORK SLAGS

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Iron and steel work slags are high value secondary resources, which are used in construction works due their beneficial mechanical properties (MOTZ & GEISELER, 2001). However, their application has become highly controversial due to their contents in steel alloy elements like chromium (PILLAY et al., 2003). In this study two different steel work slags (slag I and II) are investigated with respect to their chemistry, mineralogy and leachability. Chemical analyses of main and trace components by X-ray fluorescence spectroscopy (XRF) and ICP-MS, respectively, show that slag I is richer in Al_2O_3 and MnO, but poorer in CaO and MgO than slag II, whereas the Cr_2O_3 content is in the same range.

Mineralogical investigations by X-ray diffraction (XRD) and electron microprobe analyses (EMPA) reveal that one group of phases consisting of wuestite (FeO) and minerals of the melilite ($(Ca,Na)_2(Mg,Al)^{[4]}[Si_2O_7]$) and spinel ($(Mg,Fe^{2+})(Al, Fe^{3+}, Cr)_2(F,O)_4$) group is present in both slags. However, their particular chemical composition varies a lot due to substitutions of Mg^{2+} for Fe^{2+} in wuestite, between Mg^{2+} and Al^{3+} in melilite and especially between Al^{3+} and Cr^{3+} as well as of F^- for O^{2-} in the spinel group phases. A second group of phases including kirschsteinite ($CaFeSiO_4$) and bredigite ($Ca_{1.7}Mg_{0.3}SiO_4$) is only present in slag I. The third group of phases is only present in slag II and includes cuspidine ($Ca_4Si_2O_7(F,OH)_2$), merwinite ($Ca_3Mg(SiO_4)_2$), monticellite ($CaMgSiO_4$), calcio-olivine (Ca_2SiO_4), mayenite ($Ca_{12}Al_{14}O_{33}$), calcite ($CaCO_3$), magnesite ($MgCO_3$), fluorite (CaF_2), scheelite ($CaWO_4$), complex Ca-Nb-Cr-Al-Mg-Ti-F oxides and quartz (SiO_2). However, the most interesting aspect of this study is the first description of Mg-Al-Cr-F-spinels in slag II, in which up to 25 % of oxygen ions are replaced by fluorine!

Leaching experiments performed at distinct pH values show that the leachability of chromium, manganese, iron, barium, arsenic, molybdenum and selenium increases with decreasing pH, whereas the leachability of antimony shows a reverse behaviour. Interestingly, the leachability of chromium increases when F^- substitutes for O^{2-} in the spinel phases. Thus, attention has to be paid to the crystal chemistry of individual phases in which metal alloy elements are incorporated in slags as well as to the hydrogeochemistry of the aqueous solutions they interact with at the sites where the slags are used for construction purposes. If these aspects are considered, iron and steel work slags maintain environmentally friendly secondary resources for a broad range of applications.

MOTZ, H., GEISELER, J. (2001): Waste Management, 21, 285-293.
PILLAY, K., VON BLOTTNITZ, H., PETERSEN, J. (2003): Chemosphere, 52, 10, 1771-1779.