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NEW FORMING MINERALS OF Cu AND Zn FROM THE SELF-BURNING SLAG OF ZINC SMELTING PLANT (BELOVO, WEST SIBERIA, RUSSIA)

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Heavy metal migration from waste piles is a severe problem in regions of coal and metal mining and in areas where ore smelting industries are concentrated. Approximately 70000 tons of slags, containing a high concentration of fine-grained carbon (up to 20%) and heavy metals (up to 2.5% Cu and up to 1.5% Zn) were accumulated in the town of Belovo (Kemerovo region, Russia) as a result of Zn-smelting between 1950 and 1994. The combustion of these wastes resulted most likely from spontaneous ignition of the fine-grained carbonaceous material, and is analogous to the process of self-burning, observed in coal mining waste dumps. Primary phases of copper are their alloys with iron and sulfur. Zinc was detected in Zn-Fe-S fusion, gahnite ($(Zn_{0.7}Fe_{0.3})(Al_{1.9}Fe_{0.1})O_4$), fayalite ($(Fe_{1.3}Mg_{0.5}Zn_{0.2})SiO_4$) and glass. In this study, we describe mineral associations forming in the waste heaps and compare the metal retention capability of primary and secondary phases.

The phases and minerals were studied with reflected light and scanning electron microscope (JEOL JSM-36), X-ray diffraction (Cu Kα radiation, DRON-UM diffractometer), and electron microprobe (CAMEBAX MICRO).

Spontaneous ignition of fine-grained carbonaceous material and the subsequent burning of the waste heaps produced a zonation pattern, which is characterized by three types of assemblages of Cu and Zn minerals. Each of the types is observed at different distances from the combustion centre of burned wastes.

The first assemblage occurs very close to the combustion centre and is presented by willemite (Zn_2SiO_4), zincite (ZnO) and johillerite ($Na(Mg,Zn)_3Cu(AsO_4)_3$), which covered hematite–magnetite aggregates. The second assemblage was observed in the weakly altered waste located away from the combustion centre. Minerals identified are: antlerite ($Cu_3(SO_4)(OH)_4$), devilline ($CaCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$), boyleite ($ZnSO_4 \cdot 4H_2O$) and two unnamed Zn-sulfates which are distinguishable on the basis of their XRD patterns and which can be described by the formulae $Cu_{1.5}Zn(SO_4)(OH)_3$ and $Na_2Zn(SO_4)_2 \cdot 4H_2O$ (JCPDS card numbers: #28-405 and #19-1263, respectively). The third assemblage was further found as crusts deposited on the surface of the waste heaps in the close vicinity of active fumaroles. These crusts are composed of chalcanthite ($CuSO_4 \cdot 5H_2O$), Mn-free gunningite ($ZnSO_4 \cdot H_2O$) and an unnamed mineral with the formula $Zn_3Al_4(SO_4)_9 \cdot 36H_2O$ (JCPDS card #28-1458).

Mineralogical compositions of different assemblages reflect stages of Zn and Cu-rich phase transformations. In chemical terms, the transformation patterns are schematically shown as follows: sulfide, oxide and silicate → oxide, silicate and arsenate → sulfate (for Zn); sulfide alloys → elements and arsenate → sulfate (for Cu). On the basis of these patterns, we can conclude that, as a result of combustion, metals were redistributed from relatively resistant phases into less resistant phases, and finally into relatively soluble minerals.

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