

The geochemistry, mineralogy and environmental impact of heap leaching in subtropical Zambia and Namibia

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The heap leaching is a common method of wet metallurgy used to recover precious metals. We studied geochemistry and mineralogy of heap leaching products in subtropical central Zambia at Kabwe site and north Namibia at Tschudi site.

At Kabwe site, leachate solution disposed in uncovered lagoons is of Na-Mg-SO₄ type with pH of 2.89. The principal secondary minerals are gypsum (CaSO₄·2H₂O), moorhouseite (Co_{0.6}Ni_{0.3}Mn_{0.1}(SO₄)₆·6H₂O), bloedite (Na₂Mg(SO₄)₂·4H₂O), starkeyite (MgSO₄·4H₂O), chalcantite (CuSO₄·5H₂O), and kroehnkite (Na₂Cu(SO₄)₂·2H₂O). In the evaporation experiment performed with collected leachate, more hydrated phases such as bieberite (CoSO₄·7H₂O), precipitated first and Mg-minerals such as epsomite (MgSO₄·7H₂O), precipitated the last. In the dissolution experiment which used precipitated efflorescent minerals, the pH dropped from neutral value to less than 4.0 in seconds and electrical conductivity (EC) of leachate was increasing gradually. The heap leaching wastes at the Kabwe site represent a long-term source of contamination.

At Tschudi site, the leached solution is of Mg-SO₄ type with high Al and Fe concentrations and pH~1.21. The source of Mg and Al in the leachate might be the alteration of micas such as Mg-bearing muscovite. The principal secondary minerals identified in the leached ore are gypsum (CaSO₄·2H₂O) and jarosite (KFe₃(SO₄)₂(OH)₆). The study of δ⁶⁵Cu fractionation indicated that unleached ore has higher values (avg. δ⁶⁵Cu -1.47 ‰), compared to leached ore values (avg. δ⁶⁵Cu -6.01 ‰) with apparent isotopic fractionation Δ⁶⁵Cu_{leached ore-unleached ore} of about -4.54 ‰. There is isotopic enrichment of leachate in heavier ⁶⁵Cu isotope (leachate δ⁶⁵Cu 0.34 ‰) with apparent isotopic fractionation Δ⁶⁵Cu_{leachate-unleached ore} value of +1.81 ‰. At this site, dissolution of secondary jarosite and residual acid leachate are the principal sources of contamination.

The residuals of heap leaching in subtropical Africa are sources of acidity and dissolved metals and represent a serious environmental problem. They must be carefully deposited and isolated to prevent their contact with rainwater in the precipitation period.

Acknowledgments: This study was completed within the Project No. 23-05051S “Metals and their isotopes in active and abandoned mining areas of sub-Saharan Africa – towards