Application of Principal Component Analysis and ToF-SIMS to Mineral Recognition, Surface Chemistry and Separation by Flotation

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In surface analysis of mineral particles from ores, process and waste streams, different mineral phases are normally identified by imaging for a major element of their composition (e.g. Cu, Fe, Zn) but this selection can be difficult with many multi-metal minerals (e.g. chalcopyrite, pyrite, sphalerite) and with precipitated, adsorbed, reacted and contaminant species in the outermost molecular layers. Hence, a challenge in studying surface chemistry and reactions of specific minerals is to find more reliable methods of mineral phase recognition in these complex surface chemistries. This paper will show that principal component analysis (PCA) provides improvement in phase recognition, particle selection, surface chemical changes and associated surface species.

Statistical methods based on the monolayer-sensitive time of flight secondary ion mass spectrometry (ToF-SIMS) technique have been utilized to differentiate surface chemical factors promoting (hydrophobic species) or inhibiting (hydrophilic species) flotation Species recognition based on the PCA method clearly identified a statistical difference in copper intensities between the sphalerite and pyrite phases [1[.The method has also been applied to concentrate and tails samples collected from the Inco Matte Concentrator demonstrating extensive Cu and Ni transfer between chalcocite and heazlewoodite minerals.

PCA of ToF-SIMS imaging data has elucidated surface chemical factors that differ between samples which have undergone high intensity (shear) conditioning (HIC) and those which have not in parallel laboratory floats where sphalerite was separated from a complex sulphide ore which includes pyrite other gangue minerals. A 5% increase in the overall Zn recovery was reported in the HIC test. The statistical analysis has elucidated differences in surface chemistries which illustrate the discriminating depressant action of adherent aluminosilicate (gangue) fine particles and adsorbed ions on the surface of sphalerite grains as well as significant transfer of Cu and Zn to pyrite surfaces in the non-HIC samples resulting in collector adsorption and inadvertent flotation. In the flotation test concentrates, HIC conditioning resulted in the removal of these gangue fines improving surface collector attachment and sphalerite recovery.

This method can be applied to core and crushed samples for information on relative reactivity and adsorption.

References
[1] Hart B., Biesinger M.C., Smart R.St.C. (2006), Min. Eng., 19, 790-798.