Particle Size Effects in X-ray Fluorescence Analysis of Iron and Copper Minerals

Brianna Ganly[1,2] and James Tickner[1,3]
[1] CSIRO Mineral Resources, Australia
[2] University of New South Wales, Australia
[3]Chrysos Corporation Ltd, Australia

Our group develops industrial X-ray fluorescence (XRF) instruments designed to measure the concentrations of precious and base metal such as gold, platinum, nickel and copper in mineral slurries. The intensity of characteristic fluorescent radiation from mineral phases in a slurry is affected by the particle size of the ore being measured. This particle size effect can lead to substantial analysis errors, but is usually ignored in practice in on-stream applications where no control of particle size is possible.

Theoretical models predicting the relationship between the intensity of characteristic fluorescent radiation and particle size in powdered samples date back to the 1960s. While there is reasonable agreement between these theoretical models and experimental data, a detailed comparison is limited by the quality of the experimental results. For example, particle size measurements often have large errors due to the limitations of using sieves to separate out different size fractions. To be mathematically tractable, simple theoretical models also have to make significant assumptions and approximations.

Monte Carlo methods provide an alternative modelling approach which allows a more realistic simulation to be performed, including detailed X-ray physics, an accurate geometry model, and a polychromatic X-ray source. Methods developed by our group for simulating X-ray transport in stochastic media also allow the effects of particle size and shape distributions to be modelled.

We report on experiments to measure particle size effects in the fluorescence of iron and copper, using both pure elements and commercially important copper minerals. A cyclosizing technique was used to achieve more accurately separated particle size fractions than is possible using sieving, and optimal sample preparation methods were developed to simulate the measurement of these elements in slurries. Measurements of two different copper minerals, chalcopyrite and chalcocite, also show the interrelation of mineralogical and particle size effects.

We present a comparison of our experimental results with both our Monte Carlo simulations and existing theoretical models. We discuss the significance of particle size effects in applications such as industrial on-stream XRF analysis of slurries.