Analyzing ore concentrates and grade control with handheld XRF

Introduction

Most natural ore deposits do not have high mineral or metal concentrations. As a result, ore grading and mineral concentration are necessary processes in making final product (i.e., metal) from the original raw material. While handheld X-ray fluorescence (XRF) analysis can be easily used to determine elemental constituents for most low-concentration natural samples, its application in concentrated ore samples can be more challenging.

Handheld XRF Analyzers in Mining

Handheld XRF has the ability to deliver fast and accurate elemental analysis results with little or no sample preparation in various stages of mining activity, from grass root exploration to exploitation, ore grade control, and even environmental investigations. Thermo Scientific™ Niton™ handheld XRF analyzers are used extensively throughout the global mining industry for measurements across a broad range of elements from magnesium (Mg) to uranium (U). Niton XRF analyzers, offer excellent limits of detection (LOD), provide accurate results over a wide range of samples, and have brought transformative improvements related to data acquisition time.

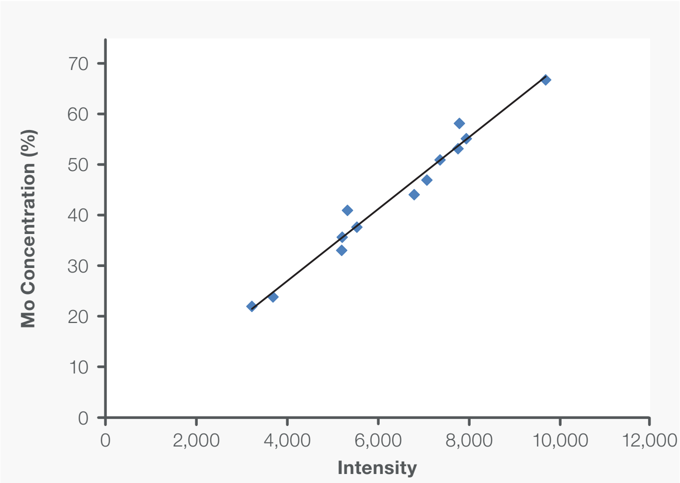

Figure 1. Example of generation of calibration curve.

Application

After being identified and extracted, ore minerals are often concentrated by a variety of techniques making use of both physical and chemical properties, including mechanical separation methods such as screening and chemical separation techniques including floatation and acid leaching. The product of such processing is a uniform and homogeneous mineral concentrate with relatively simple composition/mineralogy. Niton XRF analyzers have a function known as the UserMethod, sometimes called User Mode, that uses empirical calibration, which is a useful approach for analyzing concentrated samples of heavy metals. (Note: An important assumption that must be verified for this application is that the sample's composition is homogeneous.)

It is notable that the Fundamental Parameter (FP) factory mode is a general purpose mode that works well for a wide variety of sample types. The FP mode is also "standardless" and does not require known samples to obtain quantitative results; however, in high-concentration processed samples, the concentration of the metal of interest is, in some cases, reported as less than the true value if the regular FP mode is used. To obtain accurate quantitative results for such samples, it is recommended to use the UserMethod. With this method, samples are analyzed and the signals are reported as intensity (counts per second per microampere). Then calibration curves are plotted based on known concentrations (from laboratory values) and intensity (from HHXXRF results). The equation derived from trend line in the graphs in Figure 1 is used to convert HHXRF readings (in unknown samples) from intensity to elemental concentrations in weight percents or parts-per-million.

Method

This study was carried out using UserMethod on a Thermo Scientific™ Niton™ XL3t GOLDD analyzer on molybdenite (MoS_2) concentrate samples. The ore grade in such concentrates can vary from 25% to 65% Mo. Concentrations of molybdenum (Mo), iron (Fe) and copper (Cu) in these concentrates, along with correlation with lab assay data, are shown in Figure 2.

Results

The coefficient of determination, the R^2 value, is a measure of how closely the data sets correlate with each other, where a perfect correlation would have an R^2 value of 1. The correlation for Mo, Cu and Fe are 0.97, 0.99 and 0.97, respectively (see Figure 2). The value of the slope beside X in the trendline equation, when significantly different from 1, would indicate some systematic errors, also sometimes called biases. With all three elements showing values between 0.95 and 1.05, biases are low, and the measurements are accurate.

Conclusions

HHXRF is a very reliable and effective tool to analyze any type of mining or metal ore sample, from the exploration stage (low grade) to the ore grading stage (high grade). For concentrated mineral samples of heavy metals, the UserMethod can be an alternative to the standardless fundamental parameter calibration approach and can provide more accurate results in cases such as molybdenum or lead concentrates. Such results are displayed directly on the analyzer once a UserMethod is uploaded, thus providing the instant information required on the production line for maintaining the correct grade control.

Special thanks to Freeport–McMoRan Copper & Gold, Inc. for collaboration and providing the analyzed samples.

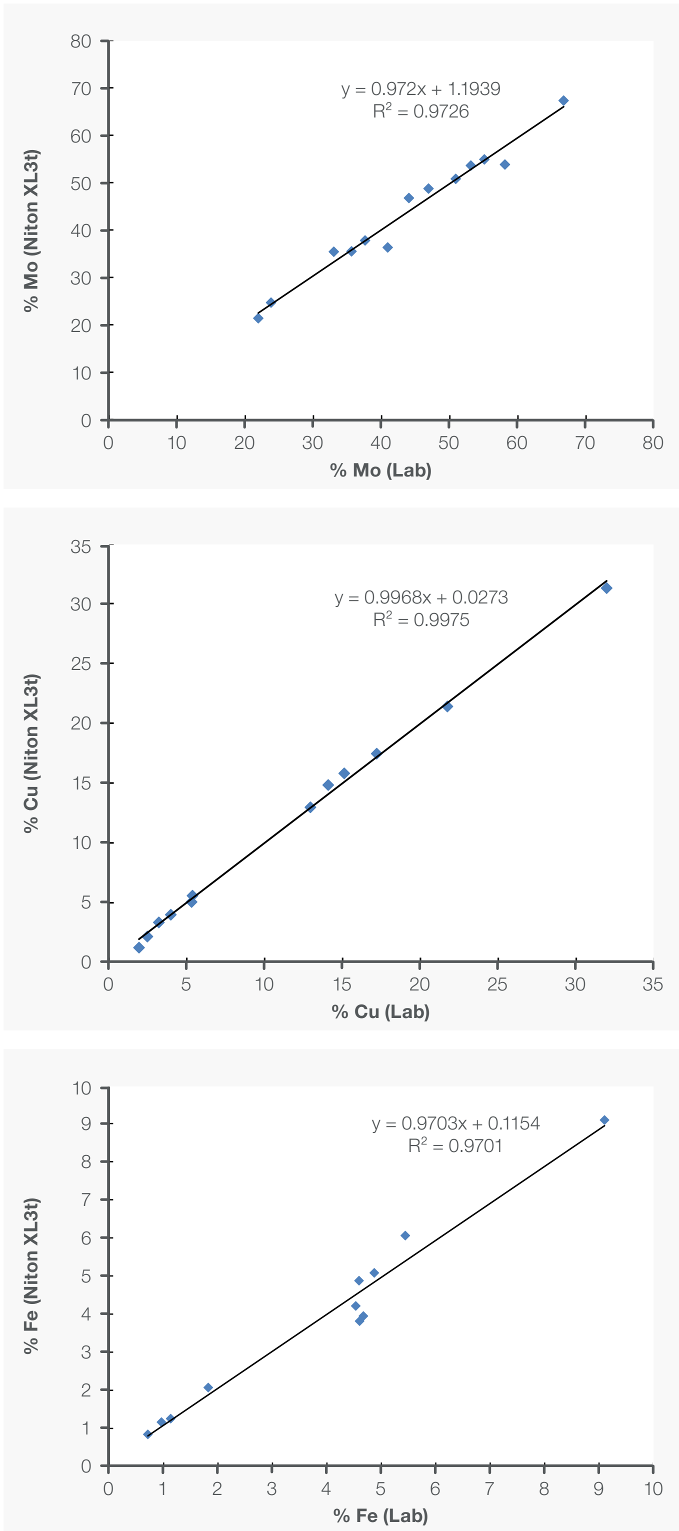

Figure 2. Correlation of Mo, Cu and Fe data between portable XRF and lab in molybdenite (MoS_2) concentrate samples.