Manganese-iron exploration and mining with handheld XRF

Introduction

Manganese (Mn) is not a rare metal as it makes up about 0.1% of the earth's crust. The average concentration of manganese in soil is about 440 ppm, though it can range from 7 to 9,000 ppm depending on the soil type. Such concentrations can easily be detected by Thermo Scientific™ Niton™ handheld XRF analyzers.

Manganese ores usually consist of dark brown to black oxides, particularly pyrolusite (MnO_2) and psilomelane ($BaMn_9O_{18}$ $2H_2O$). Manganese carbonate (rhodochrosite, $MnCO_3$) and manganese silicate (braunite, $MnSiO_3$) may occur concomitantly, and all manganese minerals tend to show a close spatial relation to iron ores. Manganese is mined in countries such as South Africa, Australia, China, Brazil, Gabon, Ukraine, India, Ghana and Kazakhstan.

Handheld XRF Analyzers in Mining

X-ray fluorescence (XRF) is an analytical technique with the ability to deliver fast and accurate elemental analysis with little or no sample preparation. It can be applied in various stages of mining activity, from grass-roots exploration to exploitation, ore grade control, and even environmental investigations. Niton handheld XRF analyzers can detect a broad range of elements from magnesium (Mg) to uranium (U). These analyzers offer low limits of detection (LOD), provide accurate results over a wide range of samples, and have brought transformative improvements related to data acquisition time.

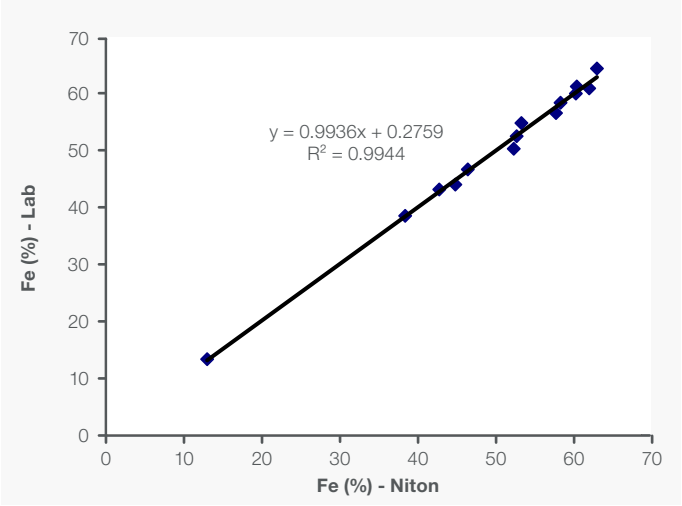
Application

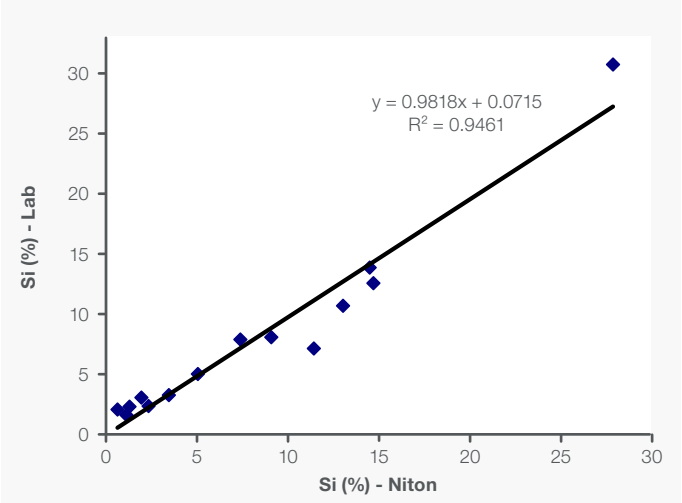
Manganese is very similar to iron in its chemical properties. As a result, manganese accompanies iron ores and, commonly substitutes for iron in small amounts in iron-based minerals. There are several types of manganese deposits worldwide: Precambrian manganese-formations (older than 541 million years), black shale-hosted manganese-carbonate deposits, shallow marine deposits, high-grade ores developed from low-grade ore (supergene deposits), and manganese crusts and nodules. It is notable that several billion tons of manganese nodules are estimated to exist on the ocean floors which are not being mined. About 85-90% of the world's Mn consumption is in the steel industry where it is used to form an alloy called ferromanganese. Mn is also used for various purposes in the chemical industry, for example as potassium permanganate for water treatment and purification and as manganese dioxide in dry cell batteries.

Method

This case study was carried out using a Thermo Scientific™ Niton™ XL3t GOLDD Analyzer with a Mining Mode calibration for a total time of 90 seconds (30 s for the main filter and 20 s each for other filters). 33 Fe-Mn ore samples from a Fe-Mn mine site were analyzed. Fourteen of these samples had lab assays that are included in this note for comparison purposes. Concentrations of Fe, Mn and Si (as a light element) in these samples, along with correlation with lab assay data, are shown in Figure 1.

In addition, one of the samples was analyzed 8 times under the same conditions to evaluate repeatability (precision) of the assay. The repeatability results are shown in Figure 2.





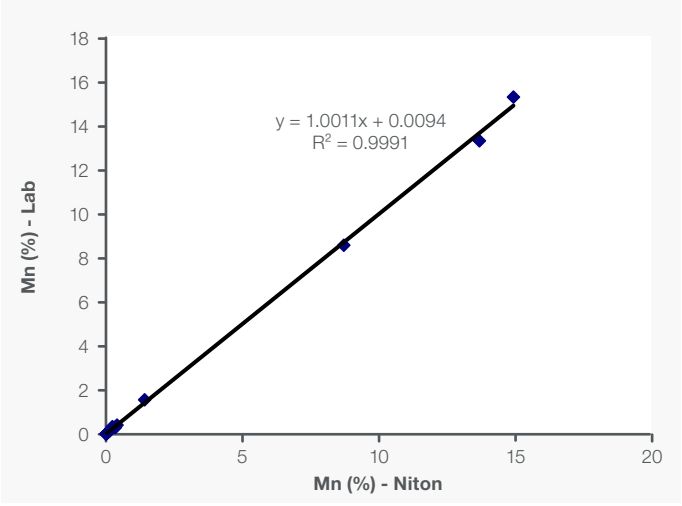
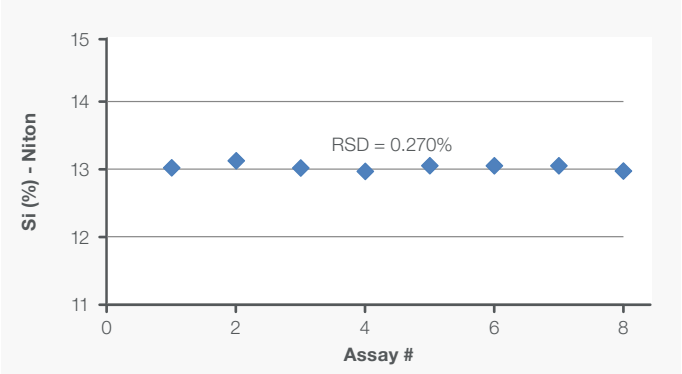


Figure 1. Correlation of Fe, Mn and Si data between portable XRF and lab in Fe-Mn ore samples.



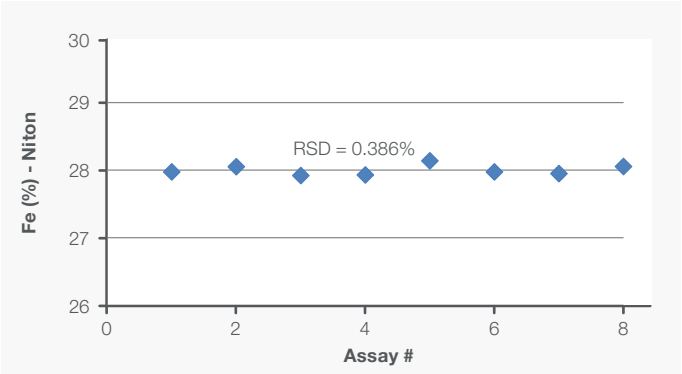


Figure 2. Repeatability (precision) of Fe and Si assays was tested by analyzing one sample 8 times.

Results

The coefficient of determination, the R^2 value, is a measure of how closely the data sets correlate with each other; a perfect correlation would have an R^2 of 1. The correlation for Fe and Mn was very strong with a R^2 of more than 99%. For Si the R^2 was 95% (see Figure 1). Also the assay data show high precision as evidenced by very low relative standard deviation (RSD) of 0.386% for Fe and 0.270% for Si.

Conclusion

Handheld XRF analyzers provide real-time nondestructive elemental analyses (for approximately 30 elements from Mg to U) to help geologists make timely process and planning decisions in the field. The analyzers can be used to reliably analyze many types of samples, from the exploration stage (low grade) through the ore grading stage (high grade).

The high threshold concentration of Fe and Mn in natural samples supports the application of this technique in Fe-Mn exploration and mining for accurate and precise data.

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