Determination of Penalty Elements in Iron Ore with the Thermo Scientific Niton FXL Field X-ray Lab

Exceptional XRF-based performance in a compact, portable package

Introduction

Waste elements other than iron (Fe) in iron ore dilute the overall grade of the ore and incur a smelter penalty. The ore beneficiation process at a mine is designed to remove as much waste and penalty elements as possible prior to transport and smelting. Further, penalty elements also change the physical properties of iron and can impede the proper operation of the smelting facility.

The phosphorous (P) content of the iron is a tightly controlled variable in steel making. It can increase the hardness and strength of steel when present between 700 and 1200 ppm, yet the presence of P > 2000 ppm can make steel brittle at room temperature.

Many iron deposits are hosted in banded iron formations (BIFs). These deposits are metamorphosed banded chert (a chemical precipitate in oceans composed mainly of SiO_2) and contain large amounts of hematite (Fe_2O_3). Silicon (Si) is a common penalty element in these iron ores. Most Si is slagged off during smelting, but at temperatures > 1300 °C (2327 °F) it can form an alloy with Fe.

Aluminum (Al) is present in clays, micas, and feldspars in some iron ore deposits and in limestone flux used in steel making. Small amounts of Al (< 1%) can increase the viscosity of the slag, which impedes the operation of the furnace.

Sulfur (S) can be present as sulfides in iron ore and the coal used in the smelting process. At concentrations > 300 ppm, S causes brittleness in hot iron and iron cannot be used in steel making. Modern steelmakers add manganese (Mn) in proportion to the S to remove it from the steel as a sulfide (MnS).

This application report demonstrates the performance of the Thermo Scientific Niton FXL field x-ray lab in determining Fe content and the penalty elements that affect its overall grade.

Thermo Scientific Niton FXL Field X-ray Lab

The Thermo Scientific Niton FXL field x-ray lab couples our proven, pioneering x-ray fluorescence (XRF) technology with true lab-quality performance. You can operate the compact unit from the back of a truck, mounted on a tripod, or in your on-site lab. With easy touch-screen operation, the Niton® FXL analyzer delivers fast, superior elemental analysis, outstanding performance, features, and mobility, and requires little operator training. This breakthrough instrument has an internal battery and is designed without compromise to operate reliably in dusty, harsh field environments. It's the perfect complement to our handheld analyzers, providing a total sample testing solution.

The Niton FXL field x-ray lab provides the iron and steel industries with the following key benefits:

- Faster throughput and lower detection limits for higher productivity
- Unparalleled accuracy for confident results every time
- Light element detection (Mg, Al, Si, P, S) without vacuum or He purge
- Lab-quality performance in a portable instrument
- Waterproof, dustproof, rugged housing for harsh environments

Method

Iron ore samples were pulverized and loaded into 32 mm XRF cups fitted with a 4 micron polypropylene suspension film. Polypropylene is required for light elements, i.e., S, P, Si, Al, and Mg.

For the purpose of direct comparison with laboratory data, both commercially available and 14 in-house lab-analyzed iron ore samples were analyzed using a Niton FXL. Though available, helium purge was not required for this analysis. The samples were analyzed for a total of 180 seconds (30 s main filter, 30 s low filter, 120 s light filter). Analysis time and filter requirement depends on analysis goals. For rapid screening, an analysis of 30 to 60 seconds may be acceptable. All data is shown in weight percent.

Results

Figures 1 through 5 show the correlation curves, comparing lab results vs. those obtained with the Niton FXL XRF analyzer, for Fe, Mn, SiO_2, P_2O_5, and Al_2O_3. For ease of reporting, elements can be displayed as both the oxide and as element. The coefficient of determination (r^2) for each element is provided in the figures. 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 of 1. Table 1 shows the repeatability for ten replicate measurements.

Comments

Results achieved using the Thermo Scientific Niton FXL field x-ray lab demonstrate excellent agreement with the certified results. Use of this instrument is ideal for iron ore composition analysis anywhere results are needed.

To discuss your particular applications or to schedule an on-site demonstration, please contact us by email at niton@thermofisher.com, or visit our website at www.thermoscientific.com/niton.

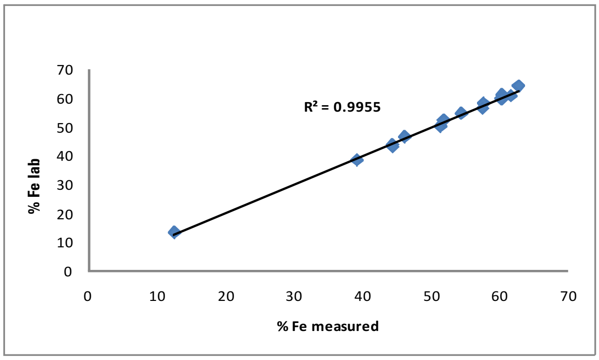

Figure 1. Correlation curve for Fe

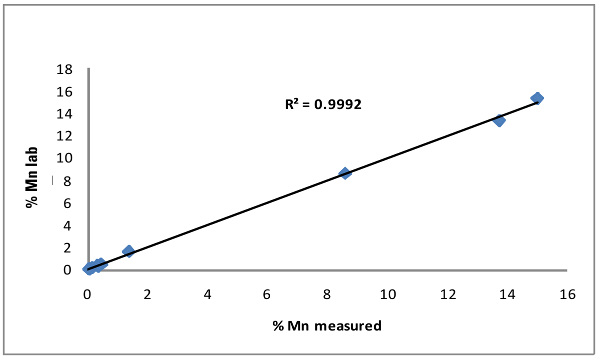

Figure 2. Correlation curve for Mn

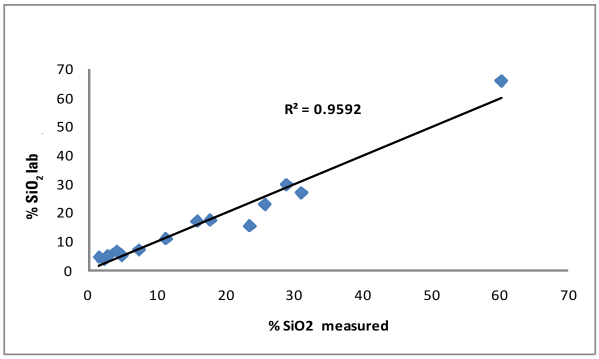

Figure 3. Correlation curve for SiO_2

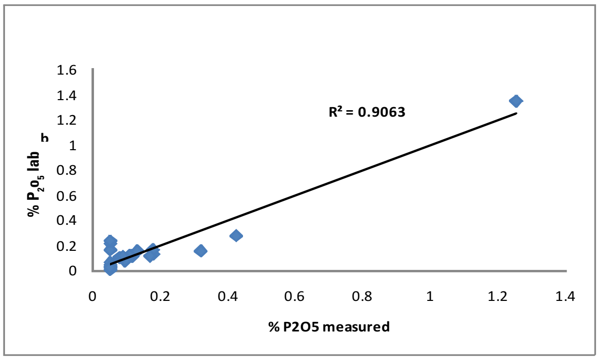

Figure 4. Correlation curve for P_2O_5

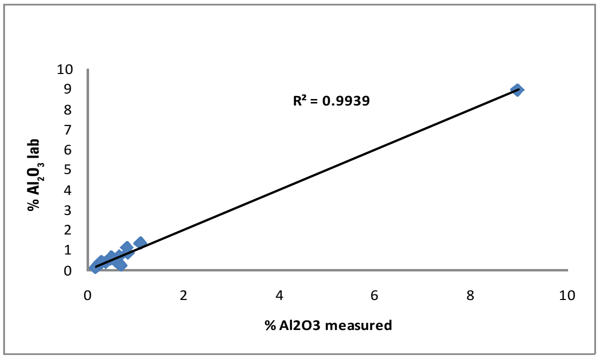

Figure 5. Correlation curve for Al_2O_3

	Fe %	% SiO_2
	51.30	17.21
	51.01	16.83
	51.53	16.93
	51.41	16.99
	51.63	17.03
	51.15	16.91
	51.60	17.14
	51.44	17.16
	51.51	17.31
	51.39	17.14
average	**51.40**	**17.07**
standard dev.	**0.20**	**0.15**
% rsd	**0.39**	**0.89**

Table 1. Repeatability of measurements

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