



## Application Note # 1101

# Bruker S1 TURBO<sup>SD</sup> for Iron Ore Mining

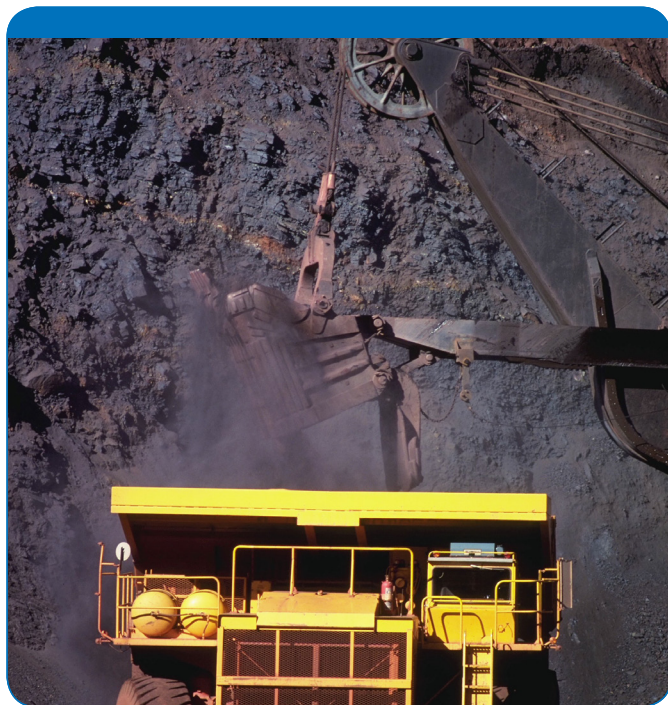
Geochemical analysis is important for a variety of different mining applications, ranging from exploration and survey to final processing. Handheld X-ray Fluorescence (XRF) is an effective tool to achieve quick, on-the-spot results of metal concentrations from many types of mining samples. The S1 TURBO<sup>SD</sup> LE, with Bruker's proprietary X-Flash® silicon drift detector (SDD), provides rapid analysis of mining and ore exploration samples. Offering count rates and resolution far superior to Si-PIN detector technology, this new detector provides faster analysis and lower detection limits for all elements analyzed. The S1 TURBO<sup>SD</sup> LE extends the range of elements which can be analyzed using portable XRF to include low atomic number elements, such as Magnesium, Aluminum, Silicon, Phosphorus and Sulfur.

In this application note, feasibility of the S1 TURBO<sup>SD</sup>'s ability to measure iron ore hematite (Fe<sub>2</sub>O<sub>3</sub>) samples is studied. Results obtained with the S1 TURBO<sup>SD</sup> handheld analyzer are compared with data from laboratory analysis.



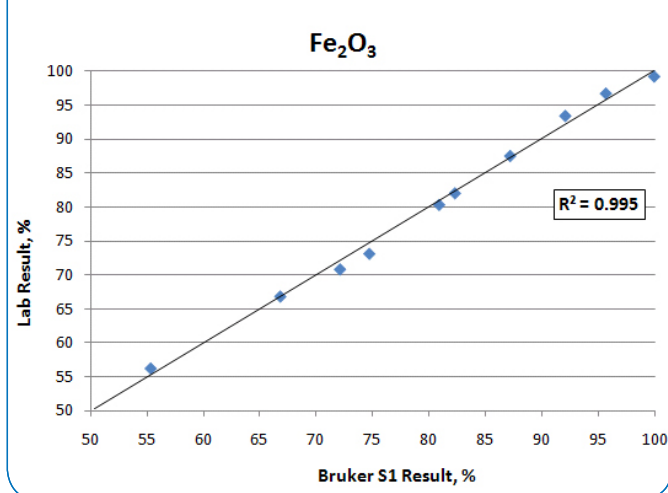
## Iron Ore

Iron ore is one of the most common industrial minerals. The iron itself is typically found in the form of magnetite ( $\text{Fe}_3\text{O}_4$ ), siderite ( $\text{FeCO}_3$ ), goethite ( $\text{FeO}(\text{OH})$ ), limonite ( $\text{FeO}(\text{OH}) \cdot n(\text{H}_2\text{O})$ ), and hematite ( $\text{Fe}_2\text{O}_3$ ).<sup>a</sup> Accurate mapping of the iron ore deposit is essential in order to define the feasibility of the deposit and to predetermine the amount of processing required. In addition to iron analysis, characterization of samples requires the ability to analyze other compounds and elements that significantly affect the steel-making process (e.g., alumina [ $\text{Al}_2\text{O}_3$ ], silica [ $\text{SiO}_2$ ], sulfur, and phosphorus).



Traditionally, iron ores have been analyzed using wet chemistry techniques or large wave length dispersive XRF laboratory analyzers. Although rapid, accurate, and simple analysis of the key elements of the iron ore at the mine site are desirable, laboratory analysis tends to be time consuming, causing delays and limiting the number of analyzed samples. Because of laboratory limitations, handheld XRF spectrometry is the ideal analytical technique for iron ore mining. Handheld XRF can be situated close to the mining process in a mobile lab. Analysis of prepared samples in bench-top mode provides close to laboratory quality analysis. In handheld mode, samples can be measured using a sample bag or directly from the ore. The Bruker S1 TURBO<sup>SD</sup> can perform the quantitative analysis of iron, alumina, silica, phosphorus, calcium, manganese, iron, and many other elements. The S1 TURBO<sup>SD</sup> LE can also report results as compounds, such as  $\text{Fe}_2\text{O}_3$  or  $\text{SiO}_2$ .<sup>b</sup>

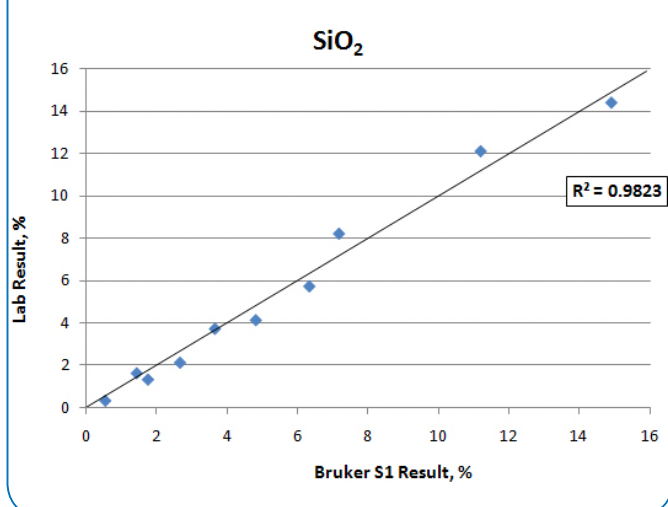
Figure 1:  $\text{Fe}_2\text{O}_3$  Correlation curve



## Sample Preparation and Test Method

Best results for hematite iron ore test samples were obtained by preparing the sample as fine powders placed in sample cups. Thin  $4\mu\text{m}$  Ultralene film was used for sample cups to enable accurate light element analysis. Particle size, sample homogeneity, and the sample cup film or plastic bag material are significant factors which may influence measurement accuracy and precision. Light element (Al, Si, S, P) analysis specifically requires careful sample preparation. All samples were analyzed using the Mining Light Elements calibration with a 60-second measurement time to enable good precision for all key elements. The factory calibration was optimized for tested ore type with type standardization. S1 TURBO<sup>SD</sup> LE test data was compared to laboratory data and correlation curves were established. Correlation curves for  $\text{Fe}_2\text{O}_3$  and  $\text{SiO}_2$  are presented in **Figures 1 and 2**. Precision of the analysis was tested by making repeat measurements; the results are presented in **Table 1**.

Figure 2:  $\text{SiO}_2$  Correlation curve



**Table 1: Repeatability Data**

	Fe <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	S	CaO	MnO
Meas 1	87.9	4.31	5.54	0.022	0.093	0.529
Meas 2	87.8	4.54	5.95	0.028	0.093	0.498
Meas 3	86.5	4.69	6.04	0.020	0.083	0.503
Meas 4	88	4.98	6.02	0.025	0.086	0.494
Meas 5	87.3	4.84	6.07	0.019	0.085	0.496
Meas 6	88	4.58	5.47	0.031	0.084	0.495
Meas 7	88.4	4.61	5.91	0.028	0.086	0.497
Meas 8	88.2	4.21	5.81	0.021	0.094	0.503
Meas 9	87.3	4.89	6.02	0.026	0.079	0.502
Meas 10	86.4	4.49	5.9	0.020	0.080	0.502
STD DEV	0.689	0.246	0.209	0.004	0.005	0.010
Average	87.58	4.61	5.87	0.024	0.086	0.502
Lab Results	87.15	4.47	6.35	0.029	0.098	0.439

## Summary

Based on test results, the S1 TURBO<sup>SD</sup> LE produced good linearity and repeatability over the wide iron ore concentration range, 50-100% Fe<sub>2</sub>O<sub>3</sub>. For all tested elements, the agreement between laboratory and S1 TURBO<sup>SD</sup> LE results was very good; typically, the correlation coefficient (R<sup>2</sup>) was better than 98%. Overall test results show that the S1 TURBO<sup>SD</sup> LE provides good accuracy for iron ore analysis; the light element capability provides additional valuable information for ore characterization with its ability to measure alumina (Al<sub>2</sub>O<sub>3</sub>), silica (SiO<sub>2</sub>), sulfur, and phosphorus. The Bruker S1 TURBO<sup>SD</sup> LE handheld XRF analyzer offers simplicity and ease of use while providing reliable results for all critical elements of iron ore, making it an equally effective tool for laboratory personnel and for operators.

<sup>a</sup> Hematite is also known as "natural ore", referring to the early years of mining when certain hematite ores containing up to 66% iron could be fed directly into iron-making blast furnaces.

<sup>b</sup> In this case, analysis is based on Fe or Si; the concentration of the oxide compound is reported based on stoichiometry.