Handheld XRD Methods for Mining and Related Applications

G. M. Hansford

University of Leicester, Space Research Centre, Dept. of Physics and Astronomy, University Road, Leicester LE1 7RH, UK.

The application of energy-dispersive X-ray diffraction (EDXRD) in a back-reflection geometry, with 2θ close to 180°, results in a method that is insensitive both to the precise positioning of the sample and its morphology[1-4]. This technique can therefore be used to analyse unprepared samples such as whole rock specimens. Implementation of the method can be achieved with the use of the energy-dispersing capability of silicon drift detectors together with miniature X-ray tubes such as utilised in handheld X-ray fluorescence (XRF) instruments. Indeed, the back-reflection EDXRD technique can be applied in a handheld instrument format through a modest adaptation of the geometry of handheld XRF devices. This presentation will focus on the results derived from an instrument modified in this way.

As the described technique is inherently a powder XRD method, the sample must conform to the usual powder-averaging criterion in order that the diffraction peak intensities are representative. This criterion is met for a large proportion of natural geological samples and, in a mining context, powder samples are usually readily available in any case. The spectral resolution of diffraction peaks afforded by a handheld instrument is low relative to standard laboratory diffractometers. Nevertheless, results show that mixtures of iron oxides can be identified and approximately quantified in iron ore samples, for example. Another mining application is the phase analysis of limestones for which the presence of dolomite [$CaMg(CO_3)_2$] alongside calcite ($CaCO_3$) represents considerable added-value in the use of limestone in iron blast furnaces. Furthermore, the same instrumentation can be used downstream in the phase and texture analysis of a variety of metals and alloys.

The capability to analyse unprepared samples is highly favourable for mining and related activities because the time required for sample preparation is avoided. This method offers *in situ* measurements that are much faster and more cost effective than sending samples to a laboratory for analysis, enabling rapid decision making, better production control and cost savings.

References

1. G. M. Hansford, "Back-Reflection Energy-Dispersive X-Ray Diffraction: A Novel Diffraction Technique with Almost Complete Insensitivity to Sample Morphology", *J. Appl. Cryst.*, **44**, 514-525 (2011).
2. Graeme M. Hansford, "X-Ray Diffraction without Sample Preparation: Proof-of-Principle Experiments", *Nucl. Instr. and Meth. A*, **728**, 102-106 (2013).
3. G. M. Hansford, S. M. R. Turner, D. Staab and D. Vernon, "The suppression of fluorescence peaks in energy-dispersive X-ray diffraction", *J. Appl. Cryst.*, **47**, 1708-1715 (2014).
4. G. M. Hansford, S. M. R. Turner, P. Degryse and A. J. Shortland, "High-resolution X-ray diffraction with no sample preparation", manuscript submitted to Acta Crystallographica Section A: Foundations and Advances (2017).