Energy Dispersive Spectrometry (EDS)

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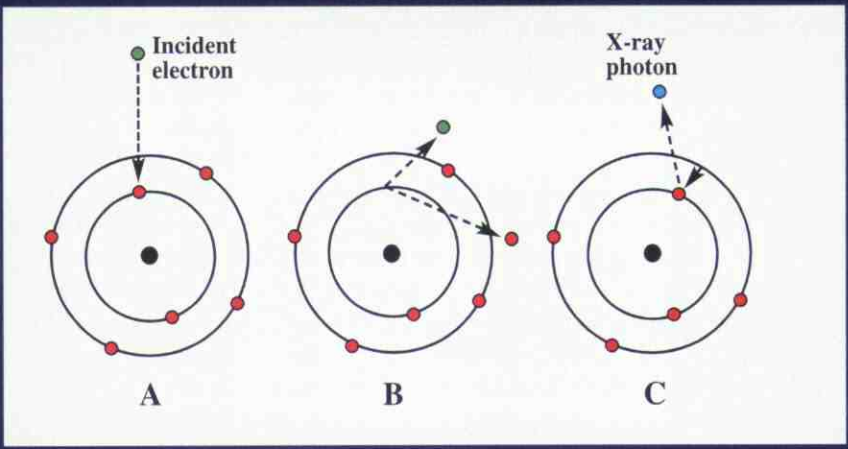

Figure 1. An example of X-ray fluorescence in a scanning electron microscope (SEM). A: An incident electron in the SEM travels into an atom within a sample. B: The incident electron knocks a K-shell electron out of the atom, leaving a vacancy in the K-shell. C: An electron of higher energy within the atom (i.e., an L-shell electron) moves into the vacant K-shell position. This electron transition results in the release of energy exactly equal to the difference in energy between the L-shell and the K-shell. As it turns out, this energy difference falls in the X-ray region of the electromagnetic spectrum; thus, an X-ray photon is emitted rom the atom. The exact energy of the X-ray photon is characteristic of the element from which it is emitted.

This issue of *Rocks & Minerals* features abstracts of presentations from the 2003 Rochester Mineralogical Symposium (see pages 186–189). Most of these mention the use of analytical techniques, such as cathodoluminescence (CL), X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive spectrometry (EDS), and so forth. There are literally hundreds of analytical techniques that are used to probe all aspects of minerals. Two of the defining properties of any mineral are atomic structure and chemical composition. Thus, methods for determining these properties are of great interest. Two of the most widely used methods for the characterization of chemistry and structure are EDS and XRD, respectively, and we focus our attention on these techniques in this and a future column.

Energy dispersive spectrometry is a technique used to collect and determine the energy and number of X-rays that are given off by atoms in a material (Goldstein et al. 2003). These X-rays can result from numerous physical processes, all of which involve excitation of a sample by some energy source (i.e., high-energy electrons in an electron microscope), transitions of electrons in the sample between different energy states, and the emission of excess energy from the sample in the form of X-rays (see fig. 1). This process is known as X-ray fluorescence. It is essentially the same process involved in visible fluorescence of a mineral that is excited by ultraviolet radiation. The energy and wavelength of the emitted X-rays are characteristic of the elements from which they originated; thus, they can be used to identify which elements exist in the sample and the absolute concentration of those elements. The actual analytical technique being used in such an experiment is X-

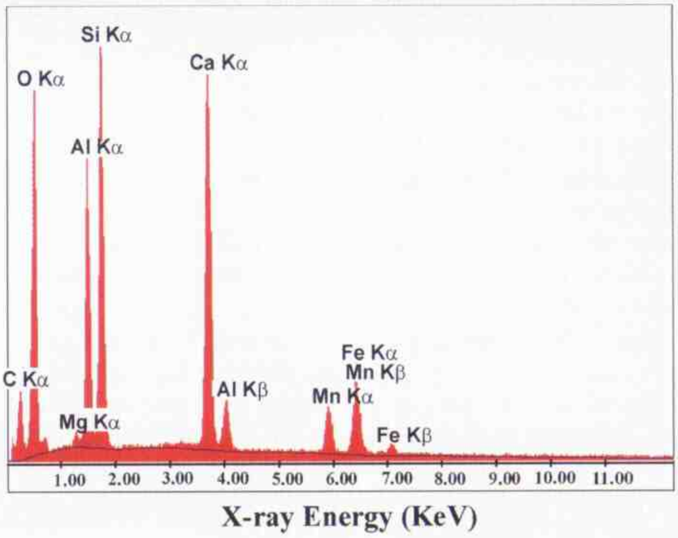

Figure 2. **EDS spectrum of X-ray fluorescence from a ferroaxinite, Lime Crest quarry, Sparta, New Jersey (see Wolf, Rakovan, and Cahill 2003). The peaks are labeled by their associated element (e.g., Fe) and the type of peak (e.g., Kα or Kβ). The carbon peak is from the carbon sample stub.**

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ray fluorescence analysis. Energy dispersive spectrometry is one of several methods used to analyze an X-ray fluorescence signal (i.e., the X-ray's energy is analyzed). Another common method is wavelength dispersive spectrometry (i.e., the X-ray's wavelength is analyzed).

It is an unfortunate result of history that EDS (a.k.a. EDX and EDAX) is widely used synonymously with or in place of X-ray fluorescence analysis. The following is an excerpt from a discussion that was posted on the Microscopy Society of America ListServer regarding the use of this name (Vane 2001):

> This name problem has been around for thirty years! Back in 1971 John Russ edited a little book called Energy Dispersive Analysis of X-rays, published by the ASTM. Then Nuclear Diodes, Inc., renamed itself EDAX, and the competition could not use that trademarked name. John worked for EDAX and promoted the technique as "EDAX." Kevex had a book published in 1973 called Everything You Wanted to Know about XES (X-Ray Energy Spectrometry), but that name did not stick. EDS and EDX have stuck and are the most popular.

Figure 2 shows a characteristic spectrum collected by EDS on an SEM. Peak positions give the energy of detected X-rays emitted from a sample as it is being bombarded by electrons in the microscope. By comparing the peak energies to the tabulated emission energies for all of the elements, the constituent elements of the sample can be identified. Furthermore, by comparing the area under each peak to a set of standards with known elemental concentrations, the concentration of the elements in the sample can be quantified, and a chemical formula for the sample can be calculated. In most studies EDS is used for semiquantitative analysis only.

ACKNOWLEDGMENTS

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REFERENCES

Goldstein, J. I., D. E. Newbury, P. Echlin, D. C. Joy, C. Fiori, and E. Lifshin. 2003. *Scanning electron microscopy and X-ray microanalysis*. New York: Plenum Press.

Vane, R. 2001. Microscopy Society of America ListServer Archives*. http://www.microscopy.com/.

Wolf, A., J. Rakovan, and C. Cahill. 2003. Ferroaxinite from Lime Crest quarry, Sparta, New Jersey. *Rocks & Minerals* 78:252–56. ❑

*The Microscopy Society of America ListServer Archives is an unrefereed source of information.