STEM and SEM X-Ray spectral imaging with multivariate statistical analysis: Application to the microanalysis of meteorites

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Modern scanning electron microscopes (SEM) and scanning transmission electron microscopes (STEM) equipped with energy-dispersive x-ray (EDS) spectrometers are powerful analytical tools allowing for chemical analysis at resolutions of millimeters down to nm. Combined with spectral imaging, where a complete spectrum is acquired from each of an array of points, regions of bulk and thin specimens can be comprehensively analyzed. The problem is no longer acquiring the data but rather making the most of it. Manual analyses of spectral image data can be both tedious and prone to missing minor but important chemical features. We have developed fast, robust and unbiased data analysis methods that solve these important problems. The solution, based in part upon multivariate curve resolution (MCR) methods, was initially developed for analysis of SEM-EDS spectral images [1] but is much more general (e.g., EELS and ToF-SIMS) [2,3]. In this work we discuss the application of these methods to the analysis of both bulk polished surfaces [4] and TEM thin sections from chondrites [5].

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Microanalysis of particulate mineral material in the real world: How analytical errors affect results used by the health, regulatory, and legal communities

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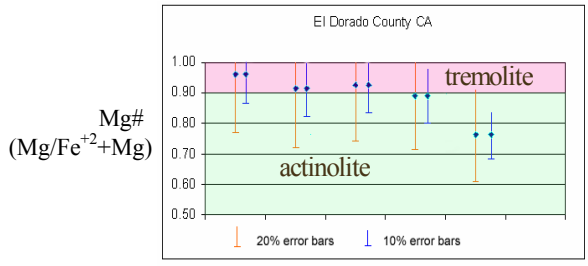
Most regulations and approved analytical methods for asbestos identify five regulated amphiboles: actinolite asbestos, tremolite asbestos, anthophyllite asbestos, amosite (asbestiform cummingtonite–grunerite), and crocidolite (asbestiform riebeckite). For the analyst using electron beam-based techniques, identification of these minerals is critical and must often be defended in court. Current mineralogical classification for amphiboles uses crystal site chemistry for identification. This requires accurate quantitative analyses of fibers much less than 3 μm in diameter. Commonly, errors of 20 percent or more affect such analyses under routine analytical conditions. Figure 1 shows examples for samples in the system tremolite-actinolite, defined by Leake et al., with ± 10 and 20 percent analytical errors for Fe. It is clear that misidentification of specific amphibole species is possible. It would, therefore, seem prudent to re-evaluate the requirements of requiring identification of specific asbestiform amphibole species for regulatory purposes and to modify the existing asbestos regulations accordingly.

Figure 1. Affect of analytical errors on accurate classification of tremolite and actinolite.



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