SEM-EDS Workflows for Analytical Mineralogy

Analytical mineralogy workflows in the scanning electron microscope (SEM) rely on compositional information from complex and often heterogeneous geological materials. Whether the objective is ore characterisation, heavy mineral analysis, process mineralogy or geometallurgical evaluation, mineralogical interpretation depends on the quality of the underlying elemental data. Analysis of complex mineral assemblages must therefore balance data quality with acquisition time and sample throughput.

One recent development in SEM analysis is the Oxford Instruments Unity detector, which combines backscattered electron (BSE) and X-ray detection within a single package positioned beneath the pole piece, an approach known as BEX. It complements conventional Ultim Max Infinity energy-dispersive X-ray spectroscopy (EDS) detectors and the TruQ-IQ processing engine, providing rapid compositional imaging while retaining the spectroscopic information required for mineral identification, elemental characterisation and navigation across large or complex samples.

From Electron Imaging to Live Compositional Information

Traditional electron microscopy workflows for dealing with new samples often involve an iterative process of collecting BSE images, identifying regions of interest and subsequently acquiring EDS maps or point analyses. While highly effective, this approach can become time-consuming when analysing large specimens or searching for relatively rare mineral phases.

BSE and X-ray information are collected simultaneously, allowing chemically informed images to be viewed during sample exploration. For geological materials, where minerals with similar average atomic numbers may exhibit only subtle contrast differences in conventional BSE images, immediate visualisation of elemental variation can assist sample interrogation and the identification of features for further analysis.

This capability is particularly useful during sample reconnaissance. Complex mineral assemblages, alteration zones and trace mineral occurrences can be identified more readily when elemental information is available from the outset. The detector’s high solid angle allows combined BSE and X-ray images to be collected during navigation, enabling analysts to make decisions rapidly without repeated cycles of imaging and analysis.

For analytical mineralogy, this approach can improve the efficiency of initial investigations and exploratory analysis. Large areas can be screened before more detailed quantitative information is acquired from selected regions.

The Importance of Accurate Elemental Identification

Regardless of how quickly compositional information is acquired, the accuracy of mineral classification ultimately depends upon the accuracy of elemental identification.

Many mineralogical challenges arise from the presence of overlapping peaks, trace constituents and chemically similar phases. Distinguishing between minerals that contain subtle compositional variations often requires high-quality spectral data and sophisticated processing techniques. Errors in elemental identification can propagate through classification routines and result in incorrect mineral assignments, particularly when automated workflows are employed.

The Ultim Max Infinity detector family is designed to provide sensitive X-ray detection and consistent spectral performance across a range of detector sizes. In mineralogical applications, these characteristics support X-ray data collection under a range of operating conditions for both mapping and phase characterisation.

However, detector performance alone is only part of the solution. Accurate interpretation of EDS spectra also depends heavily on spectrum processing and peak deconvolution.

The TruQ-IQ processing engine uses the measured characteristics of the individual detector. This detector-specific characterisation supports peak fitting, artefact reduction and the separation of overlapping spectral features, improving elemental identification. In analytical mineralogy, where phase distinctions may depend on subtle compositional differences, reliable elemental identification is critical to subsequent mineral classification.

The combined approach therefore links compositional imaging with elemental analysis, providing information for sample navigation together with spectral data for mineralogical interpretation.

Addressing Challenging Geological Samples

Geological materials can be challenging to analyse. Many specimens contain rough surfaces, variable topography, fine-grained textures or fragile phases that make sample preparation difficult. In conventional EDS analysis, surface roughness can introduce shadowing effects that reduce X-ray collection efficiency and complicate interpretation.

Positioning the Unity detector beneath the SEM pole piece increases signal collection and reduces the constraints associated with conventional detector arrangements, particularly for rough, irregular or minimally prepared samples where detector shadowing can otherwise limit X-ray collection.

For analytical mineralogy laboratories, this geometry may allow certain workflows to be performed with reduced preparation requirements. While high-quality polished sections will remain essential for many quantitative applications, rapid screening or preliminary characterisation may be possible on less extensively prepared materials.

Examples include:

- Drill cuttings and exploration samples
- Heavy mineral concentrates
- Rock chips and hand specimens
- Core fragments
- Weathered geological materials
- Preliminary process mineralogy samples

Obtaining compositional information from less extensively prepared specimens may shorten turnaround times during exploration and research programmes. It may also help preserve delicate structures that could be altered by extensive polishing.

Importantly, reduced preparation requirements should not be viewed simply as a means of saving time. In some applications, maintaining natural surface morphology can provide valuable geological context that complements compositional information. The ability to analyse morphology and chemistry simultaneously therefore offers additional opportunities for interpretation.



Figure 1: Discovery stage of an unknown, minimally prepared sample. BEX map of a fractured surface of a suspected granodiorite. The sample was carbon coated for analysis but could have been analysed in variable-pressure (VP) mode if this had been available on the SEM.

Complementary Imaging and Automated Mineralogy Workflows

The Unity detector, AZtecFeature and AZtecMineral support distinct stages of an analytical mineralogy workflow: rapid compositional reconnaissance, automated feature analysis and mineralogy-specific interpretation.

AZtecFeature automates the detection and analysis of particles, grains and other discrete features using electron imaging and EDS, recording morphology, size and elemental composition for statistical population analysis. AZtecMineral classifies mineral phases and reports mineralogy-specific outputs.

For particulate samples, the latter can report mineral abundance, mineral liberation and mineral association. For solid samples, it can report mineral abundance and quantify common perimeter associations between adjacent mineral phases.

Unity supports initial sample reconnaissance and helps analysts identify areas for further investigation through rapid compositional imaging. AZtecFeature then combines electron imaging and EDS for automated feature analysis, while AZtecMineral can apply mineral classification and mineralogy-specific measurements where required.

Automated analysis is particularly important for heterogeneous materials containing thousands or hundreds of thousands of individual grains. Manual analysis is impractical at this scale. Consistent feature-level measurements can be acquired across large populations and converted into mineral classifications and mineralogy-specific metrics.

Accurate elemental identification supports reliable feature composition and dependable mineral classification. The resulting measurements and mineralogical outputs can provide statistically meaningful datasets for exploration, processing and research decisions.

Case Studies in Applied Analytical Mineralogy

A key focus of this work is the practical application of these technologies to real analytical mineralogy challenges.

The case studies in the accompanying presentation show how compositional imaging and detailed EDS analysis support elemental characterisation across a range of geological investigations, and how automated feature analysis enables systematic measurement of the resulting mineral populations.

Examples include the identification of trace mineral phases within complex assemblages, rapid characterisation of heavy mineral concentrates and the analysis of challenging samples containing significant surface topography. In each case, the objective is not simply to increase acquisition speed but to improve the efficiency with which meaningful mineralogical information can be generated.

The case studies also examine the relationship between data quality and mineral classification accuracy. Improvements in elemental identification can materially affect automated classification, particularly when distinguishing minerals with similar compositions.

They also highlight the advantages of integrating rapid compositional imaging into sample navigation workflows. Rather than collecting large volumes of data indiscriminately, analysts can use chemically informed imaging to focus detailed investigation on the most relevant regions of a specimen.

This targeted approach can improve productivity while reducing unnecessary data collection and processing.

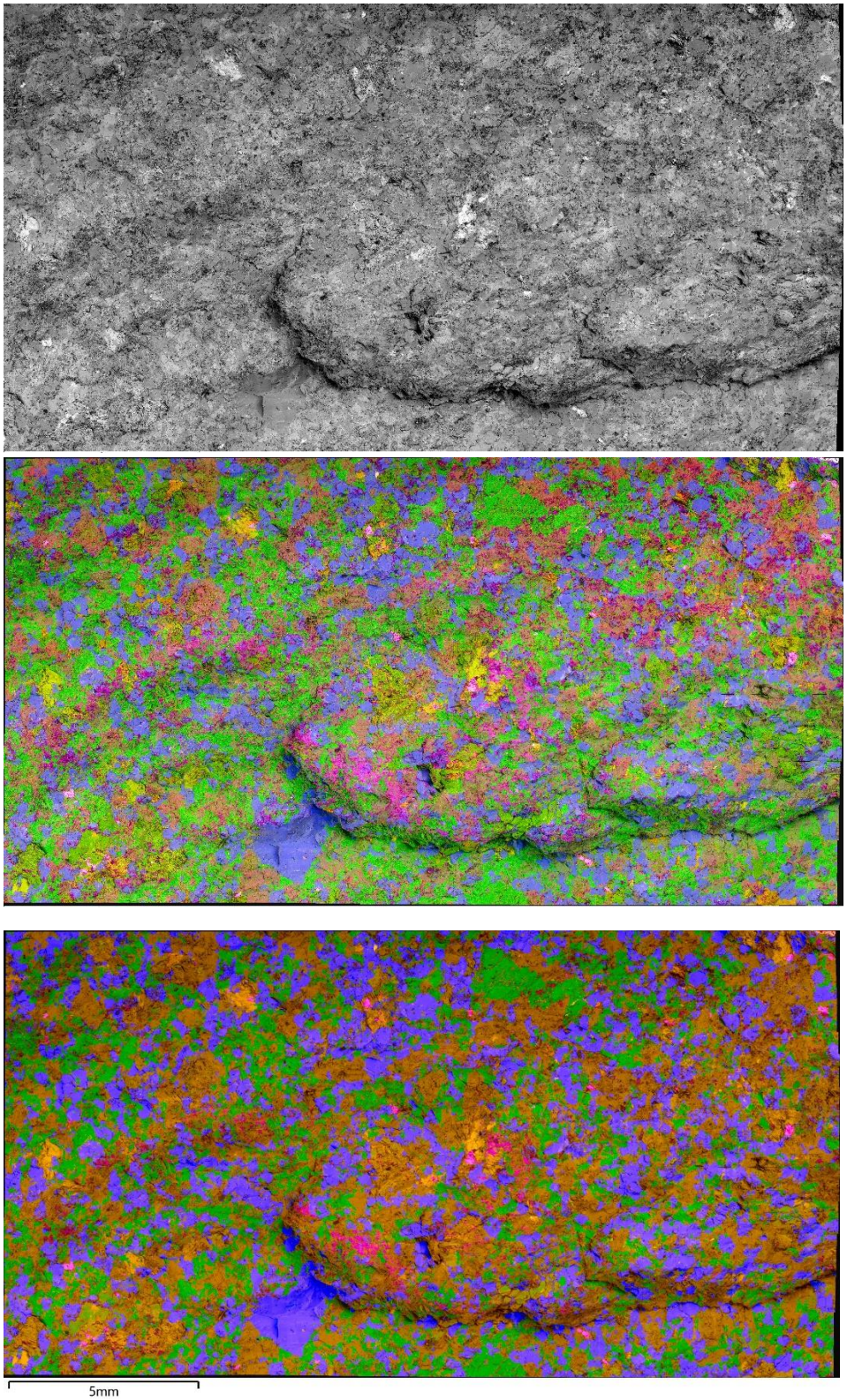

Figure 2: BSE image, layered BSE and X-ray image, and processed AutoPhaseMap of a suspected classic Cornish felsic granite from South West England. The mapped area is 22 mm × 12 mm and comprises 2240 fields of view.

Looking Ahead

Analytical mineralogy continues to evolve as detectors, processing algorithms and automated analysis systems become increasingly sophisticated. Future workflows are likely to place even greater emphasis on the rapid generation of high-quality compositional datasets and the automated extraction of mineralogical information from large sample populations.

Rapid compositional imaging and detailed elemental analysis can be combined with automated feature characterisation, mineral classification and mineralogy-specific metrics. These complementary capabilities address different analytical needs in modern mineralogy laboratories.

For organisations engaged in exploration, mining, geometallurgy or academic research, the ability to reduce time spent navigating samples, improve confidence in mineral classification and analyse large numbers of particles or grains efficiently is increasingly valuable.

Together, Unity, Ultim Max Infinity, TruQ-IQ, AZtecFeature and AZtecMineral support faster compositional reconnaissance, accurate elemental analysis, automated feature measurement and mineralogy-specific interpretation. Their continued development provides a practical route from compositional measurements to mineralogical information that can inform exploration, processing and research decisions.