

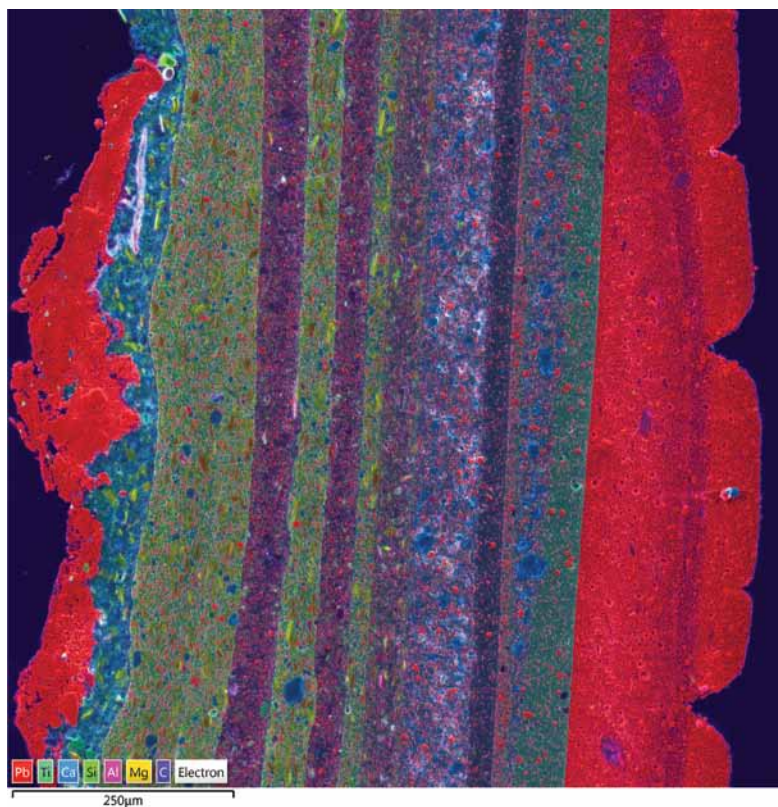
## Making a complex story...simple

### Introduction

It can often be a difficult task to make sense of an elementally complex specimen. Trying to determine how elements vary both individually and also in relation to each other can be a lengthy process. AutoLayer is a new way of automatically turning the information contained in a set of X-ray maps into a single image that helps you visualise both phase and Chemical variation. At the press of a button, AutoLayer:

- Instantly highlights what's important in a single layered image
- Uses colours on the Layered Image that are directly related to the X-ray map colours

The image below shows an AutoLayered image of a paint cross-section from the interior walls of a condemned building. With so many paint layers and varying compositions it would normally take a great deal of time to go through the individual X-ray maps to build an overall picture of the paint cross-section, but with AutoLayer the analysis is quick and automatic.



**Figure 1** AutoLayer image from cross-section of paint from the interior of a condemned building.

## Layered Image

The layered image is designed to allow the user to overlay X-ray maps on an electron image (SE or BSE), to create a coloured image which can show both topographical and compositional information. This combined image can then be used to present a complex set of results for easy interpretation.

**Overlays:** AZtec uses fully saturated hues to colour X-ray maps and assigns a number rather than names, which makes colour assignment easy to reproduce.

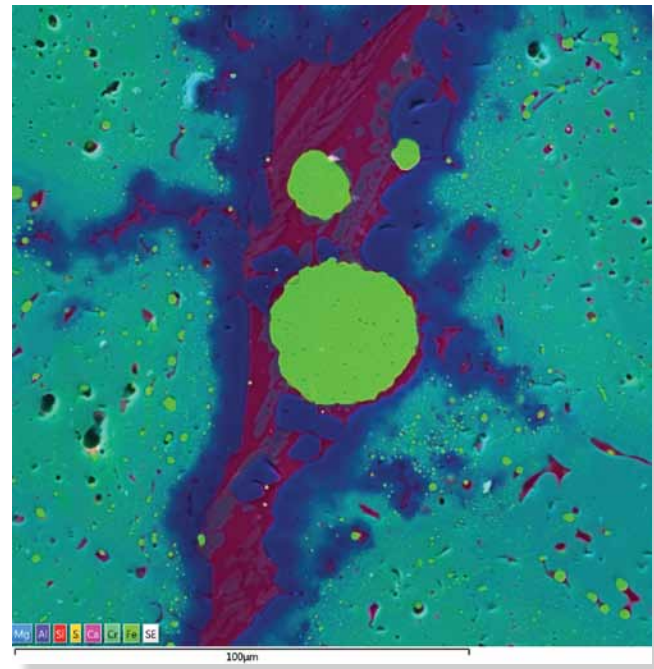
**Colour Key:** The colour key is overlaid on the Layered Image, and shows which X-ray maps have been included in the Layered image and what colour has been assigned to them.

**Annotation:** Users can put annotation on the Layered Image to further clarify the information they want to get across to their customers.

## AutoLayer

If after acquiring a series of X-ray maps, the user activates AutoLayer, then an innovative algorithm is used to analyze the spatial content in the maps to decide and select the best maps to use for the layered image. Contrast and brightness are adjusted and a suitable colour hue is assigned to each of the maps to give a useful/informative layered image. If maps have a lot of statistical noise, they are unlikely to be selected (if they were, the layered image would show lots of random coloured dots). When a set of maps show similar spatial content, they will be assigned the same hue, but only the best map will be chosen for the layered image. If a map has not been assigned a colour, it either has too much noise, or enough different maps have already been found to provide the correct representation of the specimen. The unused maps are not coloured and are displayed in grey level.

The result of this process is to produce an image which displays the phases of the specimen in different colours, and also shows major chemical composition variations within phases using colour variations. These colours can be related directly to the X-ray maps for comparison and more detailed study. If there is a region of the specimen where one of the selected element maps is dominant, then the Layered image will appear to have a similar colour to that map so the connection between the element concentration distributions and the different phases is intuitive.



**Figure 2** Layered image calculated by AutoLayer of an experimental slag specimen. The image clearly pinpoints both location and compositional changes of spinels in the specimen (blue and green).

Figure 2 shows an AutoLayered image of an experimental slag sample. This image pinpoints the phases in the sample, as well as chemical variations within the spinels, which dominate the image. AutoLayer has gone through the process of analyzing the spatial content of each map, assigning hues and deciding which maps should be used in the layered image. Figure 2 shows that Mg, Al, Si, S, Ca, Cr and Fe have been selected as the best candidates to make the layered image. Ni and Fe have been coloured the same, because they were seen as having similar spatial content, but Fe, which is present in much higher concentration, was selected as the map has a better signal to noise ratio (S/N). K and Zn were not chosen, because they have worse S/N compared to the other maps and would confuse the

colour schemes in the layered image. However, by inspection of these two maps it is clear that there are some small features with dominant K and Zn that are different from the main phases.

This automated and complex process can take just seconds, but in that time we have a rich and informative image. We can see that all the major phases have been picked out, and that the individual map colours correlate to colours on the image. The image also picks out chemical variations in the spinels. The edges are blue due to higher levels of Mg and Al, while the centre of the phase is green due to significant levels of Fe and Cr. This image is therefore clearly picking out the change from  $MgAl_2O_4$  to  $(Mg,Fe)Cr_2O_4$  in different parts of the spinel.

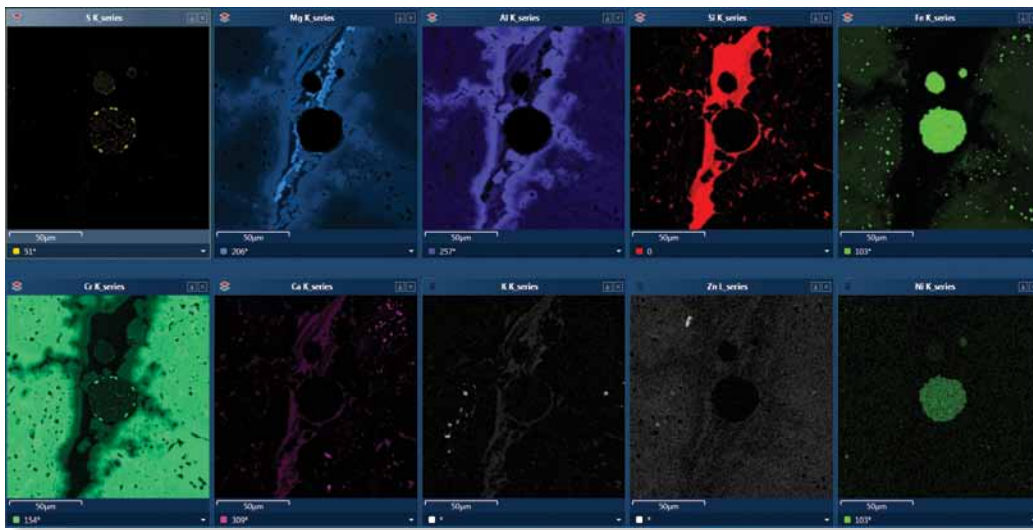


Figure 3 Individual X-ray maps for the slag sample shown in figure 2.

## Summary

Combining X-ray maps in a coloured overlay is an intuitive method to demonstrate chemical variation, but usually requires a lot of trial and error. By using AutoLayer, the process is completely automated so this is a huge boost to productivity when a quick assessment is required of a new sample. Instead of a lengthy report a single layered image alongside the original x-ray maps tells the full story in a way that is effective and easy to explain.

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